Socio-Technical Perspectives on Digital Photography: Scientific Digital Photography Use by Marine Mammal Researchers

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Dedicated to:

Rob Kling, who helped me start

Howard Rosenbaum, who helped me finish

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ABSTRACT

Eric T. Meyer

Socio-Technical Perspectives on Digital Photography: Scientific digital photography use by marine mammal researchers

This dissertation examines the intersection between technology and scientific practice for marine mammal scientists who use digital photography. Scientists studying marine mammals use a technique called photo-identification to identify individual animals such as whales and dolphins in the wild. This technique involves photographing the animals, and later matching these images to catalogs of previously sighted and identified individual animals. This information then contributes to understanding the population parameters, behaviors, and other information about the animals. These methods have been in widespread use since the 1970s; recently, however, most scientists in this field have switched from film photography to digital photography.

This research demonstrates that this change, which seems at first glance to be a simple matter of swapping one three-pound piece of equipment loaded with film for another similar looking three-pound piece of equipment equipped with a digital sensor and computer memory cards, has had important consequences throughout this scientific domain. Some of these consequences were intended, others were unintended. Among the unintended consequences, some are positive, some are negative, and some are still being negotiated. The consequences range from the benefit of having instant feedback in the field, which improves accuracy and efficiency in the data collection process, to the cost of dealing with the increasingly complex information systems needed to work with the large flow of information through the labs.

Digital photography has rapidly replaced film photography in many domains over the last decade. Even though digital cameras are becoming nearly ubiquitous in every domain where photography plays and important role, however, very little research has attempted to understand the socio-technical nature of digital photography and what the consequences are of this change. This social informatics study uses Kling's Socio-Technical Interaction Networks (STIN) strategy to analyze the regular uses of digital photography within this scientific field, and to understand the consequences of this technology for the practice of science. The research involved interviews and observations of 41 scientists working at thirteen laboratories, plus the analysis of supporting documents.

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CHAPTER 1: INTRODUCTION

1.1 Overview

This project studies the consequences of the computerization of photography for scientists, specifically marine mammal researchers. This research applies Kling's Socio-Technical Interaction Network (STIN) strategy (Kling, McKim, & King, 2003), which analyzes socio-technical systems by integrating the social and technical to develop a more nuanced understanding of technology in society than is possible with alternative strategies; the STIN strategy extends Actor-Network Theory (Latour & Woolgar, 1979).

Digital photography is a recent, novel information technology that has been widely and rapidly adopted across a variety of domains. To understand the role of digital photography as a technology used in scientific work, this study will examine marine mammal researchers who use photo-identification as a tool for gathering, organizing and analyzing data about whales, dolphins, otters, seals, manatees, and other marine animals. Many marine mammal researchers have recently switched from film to digital photography, and we will see that this seemingly minor change has contributed to a number of fundamental alterations to the ways in which they do their scientific work.

The study itself examines the role of new technologies entering scientific practice and regular use by focusing on digital photography. Orlikowski calls this perspective the "practice lens" for studying technology:

> Rather than trying to understand why and how a given technology is more or less likely to be appropriated in various circumstances, a practice lens focuses on knowledgeable human action and how its recurrent engagement with a given

> technology constitutes and reconstitutes particular emergent structures of using the technology (technologies-in-practice). (Orlikowski, 2000, p. 421)

The central goal of using this approach in this research project is to understand the consequences of this digitization and computerization of photography for marine mammal scientists. It is also hoped that this research will contribute in general to a fuller understanding of the roles technologies can play in regular use.

1.2 The Approach

The project was conceived and designed as a social informatics research study. Social informatics in North America is a relatively new approach to studying socio-technical systems[1], first entering regular use[2] at a meeting of similarly minded researchers who gathered for an NSF-workshop at Indiana University in 1997:

> The main purpose of this workshop was to clarify systematically the domains of social informatics by exploring the state of knowledge about the integration of computerization and networked information into social and organizational life, and the roles of information and communication technology (ICT) in social and organizational change. (Kling, Crawford, Rosenbaum, Sawyer, & Weisband, 2000, p. 205)

Since that time, there have been several notable efforts aimed at explicating some of the central propositions in social informatics (Kling, 1999; Kling, Rosenbaum, & Sawyer, 2005; Sawyer, 2005; Sawyer & Eschenfelder, 2002). In this section, we will discuss

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[1] The term social informatics has been in use longer in Europe, where the earliest departments of social informatics date back at least as far as the 1980s, and possibly earlier (Vehovar, 2006).

[2] Kling mentions that the idea of coming up with a better term for this type of research first arose at an NSF-funded workshop on digital libraries held at UCLA in 1996, and social informatics was one possible term offered as a replacement for the variety of terms in use "including 'social analysis of computing,' 'social impacts of computing,' 'information systems research,' and 'behavioral information systems research'" (Kling, 1999, p. 13).

several of these central propositions, and show how they informed the research presented in this dissertation.

A recent book by Kling, Rosenbaum and Sawyer (2005) offers a look at the central themes and concepts in social informatics research on ICTs (information and communication technologies). Among the many social informatics (SI) concepts discussed in the book, the authors identify three key themes that are central to much of SI research: embeddedness, configuration, and duality. They define embeddedness as the notion that technologies are not isolated from their social and institutional contexts. Configuration is explained as the uses of an ICT that are not completely determined by the design of the ICT; there is flexibility in how they are used. This in turn influences the consequences of using the ICT. Finally, duality means that “ICTs have both enabling and constraining effects” (Kling et al., 2005, p. 54).

In this research, we will see examples of all of these key themes as we examine the role that digital photography has come to play in the field of marine mammal science. Throughout the results, we will see evidence of the embedded nature of digital photography, as we learn how the possibilities and limitations of photography influence interactions with wild animals, how researchers spend their time after a day collecting photographs, how they spend their time back at the lab, how work is divided, and what scientific results are available. We will also see, however, the configurational nature of digital photography, as we examine evidence that not only *can* digital photography systems take different configurations that have different consequences, but we have considerable evidence that they *do* take on different configurations in different projects and at different labs. Furthermore, we will present evidence that these variations influence the consequences of using digital photography. Finally, the duality of digital photography—its enabling and constraining effects—will be visible throughout our discussion of the benefits, conflicts, and costs that have been observed during the course of this research.

Much of social informatics research boils down to the notion that technology does not independently cause changes in the social order; instead, it often has measurable consequences, both positive and negative, both intended and unintended, in social settings where technology is put to use.

1.3 The Domain

1.3.1 Marine mammal science

In Chapter 5, we are introduced to the field of marine mammal science. This field of study has an estimated two thousand practicing marine biologists who carry out research on a variety of species of whales, dolphins, seals, manatees, and sea otters. Their methods vary and include acoustics, genetics, and the technique that sits at the focal point of this research, photo-identification. Photo-identification is a process described in great detail in Chapter 6. Briefly, however, the general process is that field biologists on small boats approach an animal or group of animals and take photographs that can be used for identifying individual animals. The most important feature for identification varies by species. Humpback whales are identified by the coloration and patterns of marks on their flukes (tails), while blue whales are identified by the blotchy patterns of coloration on their backs. Bottlenose dolphins are identified by the nicks and notches in their dorsal fins, while manatees are identified by scars on their backs, received primarily from boat hits.

Once these photographs are made in the field, they are brought back to the lab and undergo an extensive process involving documentation, organization, and categorization, again described in detail in Chapter 6. One of the most time-consuming parts of the entire process is ‘matching’, the process of starting with a photograph of an unknown animal collected in the field and comparing it to all previously identified known animals to look for a match, thus allowing a positive identification of the new animal. These identifications are then used for a wide variety of scientific purposes.

Marine mammal science is a highly visible field due to the level of public interest in whales, dolphins, seals, manatees, otters and other marine mammals. While the scientific publications are not necessarily consumed by the public, the research process and the activities of the scientists are frequently reported in the media and through environmental organizations and their publications. In Chapter 5, the argument is made that the public nature of this field has resulted both in increased funding and in increased scrutiny and regulation. Both of these have in turn influenced the development of non-lethal and minimally invasive methods such as photo-identification. Because photo-identification meets the criteria both of being non-injurious to the animals and of being an excellent scientific tool for gathering the data needed to answer scientific questions, photography has become a mainstay in the field. Many of the participants in this study report spending between half and nearly all of their time working with photography in one way or another. As a result, this scientific field offers an excellent case study for understanding how digital photography plays a role in a domain which relies heavily on photographic data.

1.3.2 Digital photography

Chapter 3 includes an extensive discussion of the field of photography, the shift from film-based photography to digital photography, and some of the most important tensions that have emerged from this change. Since very little research has been done on the socio-technical nature of scientific photography, we instead draw from the much more developed literature on general photography, photojournalism, and amateur photography. In this chapter, a model for distinguishing between amateur and professional photographers is offered, as well as a way to separate individuals who have a primary role that identifies them as ‘a photographer’ from those who merely *use* photography but do not necessarily consider themselves to be ‘photographers’.

Even though there has been extensive writing and research about the nature of photography, the artistic elements of photography, and about the social roles of photography, there have been relatively few attempts to understand photography from a socio-technical perspective. Most studies treat cameras as mere artifacts, put into use by their human users. This study, on the other hand, will examine how a seemingly innocuous three pound hunk of metal can have widespread consequences throughout a domain or a community of practice.

1.4 The Research Questions

The broadest question that this research was designed to address is “what is the relationship between information technologies and social change?” This, of course, is far too abstract to answer in any single research project, but instead represents a broad research agenda shared by a number of social informatics researchers. A somewhat more specific but still broadly defined question that has motivated this study is “how is digital photography socially constructed, and what are the social implications of digital photography, particularly in professional communication regimes which are heavily invested in using photography as a communication medium?”

The specific focus of this research can be thought of in terms of the following research problem. Digital photography has recently and rapidly almost universally replaced traditional film-based photography in most domains that utilize photographic methods, including photojournalism, advertising, police forensic photography, feature photography, and others (Glaser, 2001). A variety of tendencies and tensions accompany this shift, and purely digital photo-centric domains are heavily dependent on information technologies (Chakravorti, 2004; Mitchell, 2001). However, there has been little comparative research that considers both the social and the technical dimensions of digital photography as an information technology.

This study addresses this gap in the literature by conducting case study research in a professional scientific domain (marine mammal science) and comparing and contrasting a) how the socio-technical systems related to photography have changed within the domain once film-based photography has been replaced by digital photography, and b) how the digital photography systems represented in the case study differ from one another based on locally specific conditions at the research sites.

The following set of research questions form the basis for this research, and are reflected in the set of interview topics listed in the appendices. These questions were formulated using the STIN (Socio-Technical Interaction Network) strategy as a guide (see section 2.4 on p. 59 for additional details). In short, the STIN strategy is an analytic strategy designed to highlight the connections between the social aspects and the technical aspects of a socio-technical system. Unlike other socio-technical approaches, the STIN strategy emphasizes understanding the technical aspects of a socio-technical system, but without privileging either the social or the technical. Both are considered equally.

1. Who are the relevant actors within the systems supporting photo-identification research, and what are the core groups both related and unrelated to photography to which these actors belong?
2. What are the pressures/incentives or impediments to adopting digital techniques?
3. How is knowledge about how to use digital photography technology obtained (e.g., is it formal or informal, what role do other researchers play, who in the scientist's networks participate in the learning)?
4. What are the resource flows (e.g., to pay for equipment, staff, field work, new specialists in digital technology, etc.) that the scientists have mobilized to pay for their photo-identification work?
5. Who becomes involved in the photo-id process for the first time when scientists adopt digital photography; which formerly involved actors and technologies are excluded; and how are peripheral actors affected?
6. What conflicts arise over the digital photography computing package in routine use, and what are the biggest benefits of digital photography in routine use?
7. How are the data shared with other scientists?
8. What are the architectural choice points for the system (e.g., what choices are made over time that influence the current configuration of the computing package), and what are the rejected alternatives? What are the other elements of the total computing package (e.g., databases, GPS, etc.) used to support photo-identification? Have these changed?

9. What technological alternatives would be desirable to improve the existing system (e.g., if one were not limited to existing technology, what sort of system could respondents imagine that would make their research more effective)?

Taken together, these questions aid in the understanding the socio-technical systems within which marine mammal scientists doing photo-identification routinely operate, and allow us to understand how this socio-technical system has developed. The mapping between these research questions and the specific interview questions is indicated on the interview schedule in Appendix 2.

1.5 The Methods

This research used a multi-site case study approach. The data were gathered using primarily qualitative methods, including interviews and observations. In addition, public and private documents such as memos, handbooks, websites, and newsletters were analyzed. The 'case' under consideration in this research is marine mammal photo-identification by marine biologists. The multiple sites within this case allow for comparisons between specific sub-cases to gain a better understanding of the nuances of the overall case. For this study, 13 sites were included within the case. Nine of these sites were visited in person; four had participants interviewed via telephone. A total of 41 scientists were interviewed for this research over a period of 8 months; the transcripts for these 54 hours of interviews total over 1,100 pages. A complete discussion of the methods used for this research is included in Chapter 4 and Appendix 1.

1.6 The Results

The results of this study are presented primarily in Chapters 5, 6 and 7. Chapter 5 provides an introduction to the field of marine mammal science, and explains how photo-identification of marine mammals came to be an important tool for the scientific study of these animals. The argument is made that marine mammal science as a field has undergone processes of social construction, and that photo-identification is, in part, a response to social and legal forces influencing the field.

Chapter 6 presents the bulk of the research findings. The main source of evidence presented here is the extensive information culled from the transcripts and documents collected and analyzed for this study. To show the richness of the data, and to allow the voices of the participants to come through the research, a number of quotations from the research participants is included in appropriate places. The overall structure of the chapter begins with an overview of some of the general field methods of photo-identification, and a description of the techniques used to process, organize, and analyze the photographs collected in the field. In this first section, variation between sites already begins to be apparent.

Next, each of the research questions guiding this research is answered in turn. Over the course of nearly 90 pages, we examine the major elements of this socio-technical system. Among these are the primary actors, actants and social groups operating in the domain, the incentives and impediments experienced during the period of switching to digital photography, the processes of knowledge transmission within the domain, the resource flows of equipment, personnel, and expertise, and the newly included and excluded actors. We continue with a discussion of the clear benefits of the technological change to digital photography, the areas where there is either conflict about or competing interpretations of the impact of the new technology, and areas where the change has clearly incurred a cost. Finally, we consider data sharing, the choice points in moving the digital photography and the other elements of the total computing package, and some of the technological alternatives possible in this domain.

Chapter 7 turns to a discussion of these research results in light of the original statements about theory made at the beginning of this study. The chapter begins with a consideration of the value of the framing concept of communication regimes, and concludes that the concept offered little value in understanding this case. Next, we consider the STIN (Socio-Technical Interaction Network) strategy used to develop the research questions and to approach the research topic and conclude that the strategy was very successful, and offers promise for future studies in social informatics. Next is a re-consideration of the SCOT (Social Construction of Technology) and ANT (Actor-Network Theory) positions and a discussion of their utility for this research. We conclude that while both offered elements that guided aspects of this study, using either exclusively would have resulted in a less rich understanding of this domain.

Chapter 7 concludes with a discussion of the lessons that information scientists can take away from this research, including the observation that dealing with the complexity of information systems is a major challenge for small-scale scientific projects, and that the lack of highly flexible yet robust organization systems is a continuing problem for many fields. The lessons learned from this research, and a discussion of the future of the project concludes the dissertation.

1.7 The Significance

1.7.1 Intellectual merits

The field of social informatics is a new interdisciplinary approach to the study of technology in society (Kling, 1999). The researcher on this project worked closely with Rob Kling, the founder of social informatics in the United States, until his death in 2003. He has published in the area of social informatics and on the topic of digital photography. This particular research project is original because it examines how a new technology (digital photography) is being used in an understudied scientific field (marine mammal research) and because it tests and develops one of the central propositions of social informatics: that information and communication technologies (ICT) have important and sometimes unforeseen consequences in social settings, but that these outcomes are determined not only by the technology but also by complex socio-technical networks.

1.7.2 Broader impacts

This research broadens the understanding of the relationship between new technologies and changes in social organization and behavior. Even though digital photography has become ubiquitous, very little systematic research has been done to understand the measurable consequences of this new technology. This study contributes to a broader research agenda aimed at understanding how digital photography and other new technologies can be understood and theorized as they enter into routine use, which is a major research concern of social informatics. Also, by engaging the STIN strategy, this research helps to develop this relatively new approach to understanding the role of technology in society. This research also contributes to the literature on technological changes in scientific communication practices, which continues earlier research completed by the author.

The results of this research will be disseminated as a completed dissertation which will be available on the Internet, through publication of journal articles based on this research, and through presentation conference papers based on this research. One particular audience that the author will try to reach is marine mammal scientists. By disseminating this research to these scientists, the hope is that they can use the theory and data from this research to improve their practice of digital photography.

CHAPTER 2: THEORY REVIEW

In this chapter, several theoretical perspectives applicable in varying degrees to the study of digital photography as an instrument of social change will be discussed in detail. First, communication regimes will provide a conceptual tool for framing the most basic question of this research: “how is digital photography socially constructed, and what are the social implications of digital photography, particularly in professional communication regimes which are heavily invested in using photography as a communication medium?” As we will show, communication regimes are closely tied to professional and organizational modes of behavior and help to identify the boundaries between the professional and amateur domains discussed in Chapter 3.

The next three perspectives are closely related to one another, and each deal with increasingly specific aspects of technology and social change. Social Construction of Technology, or SCOT, is a perspective developed in the field of sociology beginning in the early 1980s that provides a broad understanding of how and why technology is socially constructed by human actors. Latour’s Actor-Network Theory (ANT) was developed in the mid-1980s, and is related to SCOT; ANT focuses more specifically on how technological and human “actants” are part of a social network that is involved in strategic negotiation and mobilization of support for particular actants. ANT is particularly focused on organizations. Next, Kling’s Socio-Technical Interaction Network (STIN) approach is discussed; this is an even more specific perspective using some of the tools of ANT but applying them to understanding that actants are not only engaged in social negotiation but are themselves also both enabled and constrained in their actions due to the complex social networks of which they are a part.

2.1 Communication Regimes[3]

When this research was designed, the concept of “communication regimes” was proposed as a way to frame and organize this research into professional domains. Table 1 outlines the working definition of a communication regime, and a full explanation of each component of this definition is discussed below, following a brief history of the concept. Interestingly, however, the research found something more interesting than a simple communication regime operating in the scientific data collection process being followed by marine biologists. In the results and discussion chapters (starting on pages 141 and 249, respectively), we will see that a much more interesting picture emerged from the data. In short, while scientific publication generally appears to follow the agreed upon standards of a stable communication regime, data collection practices are much more fragmentary, less well documented, less standardized, and in short, less clearly part of a communication regime at all. However, it is still important to understand the elements that make up an expected communication regime, in order to better understand how and why scientific data collection practices do not appear to fit neatly within this scheme.

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[3] An earlier version of this section of the thesis was published in the *2005 Proceedings of the Annual Meeting of the American Society of Information Science and Technology (Meyer, 2005a).*

Table 1: Communication regimes defined

A communication regime is…

1. …a loosely coupled social network in which the communication and the work systems are highly coupled.
2. …a system with a set of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge.
3. …a system in which the types of communication are tightly coupled to the production system in which they are embedded.
4. …a system with institutions that help to support and to regulate the regime.
5. …a system within which there are conflicts over control, over who enforces standards, over who bears the costs of change and who reaps the benefits of change.

Communication regimes were introduced to information science only recently by Kling et al. (Kling, Spector, & Fortuna, 2004), who relied on Hilgartner's (1995) use of the concept as it applied to scientific communication (see also Bohlin, 2004). Discussing the changes that occurred as E-biomed was transformed into PubMed Central, Kling et al. argue that various aspects of the biomedical science journal publication communication regime, including "those regarding gate-keeping, the business model, speed of information sharing, mobilization of authors, and the communication infrastructure" were fundamentally altered. "Examining the transformation of E-biomed to PubMed Central from a 'communication regime' viewpoint, we see that significant changes to the biomedical science journal communication regime existed in the original proposal" (Kling et al., 2004, p. 140). Also, Kling et al. argue that their case study illustrates that the transformative effects did not spring autonomously from the technology (in this case, the Internet), but were shaped by various groups seeking to serve their own interests. Hilgartner, likewise, saw the transformative effects of biomolecular databases on the communication regimes of biomolecular journal publication. “Clearly, public biomolecular databases have become much more than simply computerized versions of print-based publications: they represent new forms of scientific interaction based on novel and rapidly evolving communication regimes” (Hilgartner, 1995, p. 258). Hilgartner is careful to point out that in his conceptualization, there is not a singular communication regime representing biomolecular publication. Instead, he identifies a variety of related and interconnected communication regimes, including services that abstract from journals and the process of direct submission to journals, which he considers to be niches within a “broader ecology of biomolecular knowledge” that can support a variety of communication regimes.

While Kling, Hilgartner, and Bohlin all use the concept of communication regimes to understand scientific communication, this research originally proposed that expanding the concept to other areas, including digital photography, may be a legitimate extension. The case for using the concept in this instance is described below. First, however, it is instructive to look at how the concept of a regime developed, and what elements of regimes may be useful to information science.

Kling’s desire to bring the concept of a communication regime into information science was based at least partly on his familiarity with Hilgartner’s use of the phrase[4]. Hilgartner, in turn, developed communication regimes “as a sort of grounded, or even

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[4] Although Kling has only one published reference to this concept, he and the author engaged in extensive discussions on this concept in the months before his death in 2003. Much of the definition developed in this paper arose from these conversations.

rough-and-ready, concept for bringing into focus how patterns of control, power, institutional re-engineering, and inter- and intra-actor relations were being reshaped in both the 'small' and the 'large' changes underway [in science communication]" (S. Hilgartner, personal communication, 09/15/2004). Both Kling and Hilgartner were using an existing concept, that of regimes, and moving it into a communication and information specific context.

Of course, the concept is clearly related to Foucault's treatment of "regimes." Foucault rejected 'truth' as an absolute, preferring to discuss less "what happened" than "how were people brought to think what happened." He likewise discussed the non-absolute nature of power, which Foucault understood as being dispersed through a network of relationships that make up society and are based in discourse.

> 'Truth' must be understood as a system of ordered procedures for the production, regulation, distribution, circulation, and operation of statements. 'Truth' is linked in a circular relation with systems of power which produce and sustain it, and to the effects of power which it induces and which extends it. A 'regime' of truth. (Foucault, 1984, p. 74)

Just as Foucault understood truth and power to be both non-absolute and related to each other through social networks, it is arguable that this point of view (common among anthropologists, for instance[5]) will help illuminate our understanding of communication within organizations.

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[5] See Boyer (2003) for a discussion of the ubiquity of Foucault's concepts among contemporary anthropologists.

The concept of regime itself, of course, is most frequently used in the popular political realm when discussing the regimes of various political leaders[6], but it can also mean, more generally “the set of conditions under which a system occurs or is maintained” (OED Online, 1989). It is this more general concept that has been used predominantly in academic political science discourse. Lord discusses how the concept of a regime has developed in the political science literature:

> Regimes are classically defined in International Relations theory as the voluntary convergence of actors on a shared set of norms, meanings, expectations and procedures for communicating, co-ordinating and acting. Self-enforcement, the internationalization of conventions and low level of institutionalization are thus key elements that distinguish regimes from alternative forms of political cohesion. (Lord, 1999, p. 3)

This definition, while intended for the analysis of international political organizations, is general enough to be applicable potentially to other types of organizations. This is even clearer in some of the seminal work in international relations on regime theory[7]. While International Regime Theory was first introduced in 1975 in a special edition of

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[6] A recent example widely covered in the news was frequent discussions of *regime change* in regard to the Bush administration’s policy toward Iraq in the 2002-2003 run up to the Iraq war. A Lexis search for “regime iraq” for the first six months of 2003, for instance, turns up 632 news items referring to regimes. This also points to one of the difficulties with the popular use of the word regime, which has come more often to be applied to governments which Western nations, and the United States in particular, consider politically undesirable.

[7] Habermas (1996) has also discussed regimes in ways that are primarily outside the scope of this paper. His argument is that regimes regulate power and that regulations are a way for reconciling differences between facts and norms and thus for addressing both social situations and aspirations. The extent to which there is “agreement between words and deeds may be the yardstick for a regime's legitimacy” (Habermas, 1996, p. 150). For the purposes of this research, Habermas’ work has limited applicability because it tends to focus on macro settings. However, it will be useful to keep in mind the notion of legitimacy and to attempt to look for evidence of legitimate regulation in terms of the day to day practices of organizations.

International Organization (Gale, 1998), the most widely accepted definition of an international regime comes from Krasner:

> Regimes can be defined as sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge…Principles are beliefs of fact, causation, and rectitude. Norms are standards for behavior defined in terms of rights and obligations. Rules are specific prescriptions or proscriptions for action. Decision-making procedures are prevailing practices for making and implementing collective choice. (1982, p. 186)

Regimes, in this conceptualization, are comprised of the "underlying principles of order and meaning that shape the manner of their formation and transformation" (Ruggie, 1982, p. 380). Ruggie argues that these regimes are embedded in a larger social order. By embedded, Ruggie is referring to Polanyi's argument that in pre-industrial societies, economic behavior was a function of, and was contained within, social behavior, and not a separate activity[8].

One criticism of regime theory is that it emphasizes static descriptions of systems, dealing predominantly with the status quo (Strange, 1982). This criticism should be kept in mind when translating this concept to communication regimes. If indeed we are interested in examining change in communication regimes due to the influence of technology, in this case digital photography, we must be careful *not* to imply that the previous state of the communication regime was a static and unchanging set of principles, norms, rules and decision-making procedures. Economic, cultural, social, and

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[8] Polanyi also argued that even with the onset of a separate "economy" in industrial societies, there was still not a detachment between the social and the economic, just a reversal of the relative importance of each: now the social relations became embedded within the economic system as it assumes primacy (Block, 2001). This idea that the social and the economic are tightly coupled has clear ties to social informatics.

organizational changes will have happened previously, and changes both large and small will be occurring independently of technological innovation even at the same time as technology-influenced change is occurring. Kling et al. (2004) and Hilgartner (1995) however, as discussed above, specifically choose to use the concept of communication regimes to illuminate a period of change and demonstrate for us the viability of using the concept to aid in understanding changing, not static, systems. Also, more recent international relations applications of regime theory are specifically targeted at understanding social change:

> Students of regime theory, interested in employing the regime concept within a critical theoretical framework to reveal the political and economic struggles among state and social forces over a regime's normative content, procedures and compliance mechanisms, will find much fascinating material in the recent literature on global civil society. It is evident that global social change organizations (GSCOs) are engaged in an ongoing struggle to restructure existing international regimes in the interests of peace, human rights, improvements in the status of women, environmental protection, forest conservation and sustainable trade. (Gale, 1998, p. 279)

Also, since the basis of regime theory is in analyzing international relations and the behavior of governments and other international organizations, it is not possible to apply all of the theory's elements directly to smaller organizations in non-governmental settings. But as the preceding quotation makes clear, it may be useful to draw on the theory when looking at social change. Modifying this specific formulation to one more useful to understanding information and communication technologies (ICT's) and social change in communication-intensive organizations[9] will be of benefit not only to this research, but also to others researching similar domains in information science.

At the beginning of this section, Table 1 (p. 16) offers a definition of a communication regime. Next, we will examine this definition in more detail by looking at each element of this definition in turn and discussing briefly how each might manifest itself in (for simplicity's sake) one particularly well-documented communication regime, photojournalism. Even though photojournalism is not the photographic domain being researched in this study, it is much better documented and understood than scientific photography at this point. As a result, many of the preconceptions and hypotheses used in forming this research were drawn from an understanding of photojournalism. As we will see later, however, the data show something very different going in scientific photography.

1. A communication regime is a loosely coupled social network in which the communication and the work systems are highly coupled.

Professional photojournalists and their news editors are part of a communication regime. The members of this regime are part of a shared social network, as are people in most workplaces, but in addition, the nature of their work is highly coupled to the communication of visual information. In the case of photojournalism, the social network

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[9] It is important to note that communication regimes as conceptualized here are interested in organizational communication at both internal and external levels of analysis. The external aspect of communication regimes is that the organizations that will be discussed are communication-centric organizations: organizations that have a primary purpose of communicating information for external consumption (e.g., news organizations, scholarly publications, etc.). The internal aspect includes the intra-organizational structures, norms, etc. that may be invisible to outside consumers of information but nevertheless influence the forms that external communications eventually take.

of photojournalists is quite loose – photographers and journalists assigned to presidential campaigns, for instance, travel with candidates for months at a time and develop loose social associations (Columbia Journalism Review Editors, 2004; Crouse, 1974), and photojournalists have a loose social association with the other people within their news organization (Fahmy & Smith, 2003). However, communication is central to the work activity of photojournalists, tightly coupling their activity as photographers to their behavior within the work system (Russial & Wanta, 1998).

2. **A communication regime is a system with a set of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge.**

This element is borrowed directly from Krasner's (1982) definition outlined above. For photojournalists, their principles (beliefs of fact, causation, and rectitude) include the notion that different types of photography are inherently subject to different standards:

> The categorization of photo types – spot news, feature, illustration – creates a distinct continuum that can predict when newspaper editors are more willing to allow the digital manipulation of a photograph. Newspaper editors appear to discriminate between hard news and soft news, and this distinction influences their tolerance toward digital manipulation. (Reaves, 1995, pp. 712-713)

The issue of digital manipulation as a reflection of a group struggling to define their principles has been one of the primary areas of research for those studying the shift to digital photography (Russial & Wanta, 1998).

Norms (standards for behavior in terms of rights and obligations) are reflected partially in hiring practices: while "the shift from chemical to digital processing has led to a relative lack of concern among photo editors about the need for chemical darkroom skills…new technical skills, such as the use of digital cameras and the web, are growing in importance…” (Russial & Wanta, 1998, p. 593). Rules (specific prescriptions or proscriptions for action) include the codes of ethics for journalists discussed below in element four below. Bisell discusses decision-making procedures (prevailing practices for making and implementing collective choice): while “personal opinion was a part of decision-making [in selecting photographs to run]…other influences on news content were evident. According to the photo editor, the newspaper never rejected photographs from local photographers [regardless of quality]…In this sense the publisher dictated photographic content” (Bissell, 2000, p. 89).

3. A communication regime is a system in which the types of communication are tightly coupled to the production system in which they are embedded.

The practices of creating, selecting, manipulating, and publishing the photographs are part of the broader production system of the news outlet, which may be newspapers, magazines, or websites. Even something mundane like whether a photograph will be reproduced in black and white or in color is tightly coupled to the production system, and more subtle choices such as how many elements can be included in a photograph based on its eventual production size and resolution are part of the communication regime. “The practice of newspaper journalism historically has entailed some level of production responsibilities for news workers…In some current job categories, such as…photographer, news workers have a greater production role than others in the newsroom, in part because of their closer tie to the actual manufacture of the newspaper as a product…” (Russial, 2000, p. 69).

4. **A communication regime is a system with institutions that help to support and to regulate the regime.**

The institutions that support and regulate the photojournalism regime include the news organizations, the professional associations for journalists, photojournalists and editors, and the public for whom the news is created. Some of the clearest examples of the reinforcement of group norms by professional organizations can be seen in the various codes of ethics adopted by these organizations. The codes of ethics of The American Society of Media Photographers (1992), the National Press Photographers Association (1991; 2003), and the Society of Professional Journalists (1996) all clearly and specifically say that it is wrong to alter the content of photographs in any way, either in the darkroom or digitally, except in the case of non-news (feature) photographs, and even then the alteration should be clearly disclosed. These clear statements help establish the public trust for the communication regime of photojournalism[10].

5. **A communication regime is a system within which there are conflicts over control, over who enforces standards, over who bears the costs of change and who reaps the benefits of change.**

When change occurs, it is nearly inconceivable that there will not be conflicts that arise. A number of questions can be asked to begin to understand these conflicts in a system changing from traditional to digital photographic methods. Are existing photographers used, or does the person assigned to taking photographs change? What training and re-training, if any, are required? What new business processes are going to

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[10] This is an example of the day to day legitimate regulation of the regime that helps to unify facts (e.g., photoshopping pictures is easy and can make more compelling pictures) and norms (e.g., photoshopping news images is wrong because it may reduce public trust in photojournalism), as discussed by Habermas (1996).

be instituted to deal with new flows of information, in this case photographs? What will happen to the people who used to be responsible for getting rolls of film, processing them, selecting images from proof sheets, enlarging them, and retouching them? If a photojournalist is in a location distant from the paper, such as foreign correspondents, do processes for transmitting photographs change? Will previous gatekeepers (lab managers, photo editors) be bypassed by reporters sending digital images via computer network directly to editors?

Russial (2000) reports that 66% of photo editors (n=214) surveyed felt that the workload of the photo department was “much heavier” or “somewhat heavier” once digital imaging was adopted by a newspaper. In addition, Russial argues that the perceived increase in workload is not dependent on the length of time a newsroom has been using digital imaging, indicating that it may indicate a permanent shift in work responsibilities instead of a temporary period of learning new technology followed by a return to more traditional work patterns. Other findings include factor-analysis results suggesting that photographers feel a loss of control over their images, while desk editors experience a gain in control. Fahmy & Smith (2003), on the other hand, argue that the ability to delete photographs on location affords photographers with greater control over their images as they decide what to keep or delete.

The research described in this dissertation addresses professional communication regimes (e.g., those in quadrants I and II of Table 2 on page 88) as opposed to more informal types of photographic communication (e.g., by family photographers, artists, or photobloggers in quadrants III and IV), although the latter may be studied in future extensions of this work. The reason for limiting the research to professional regimes is that professionals using digital photography as part of their work have both intensive and extensive involvement with photography as part of their professional communication. Less formal communication regimes, on the other hand, are often made up of people who spend less of their time engaged in digital photography (such as hobbyists) and/or are less dependent on photography for their personal income and prestige within the regime. Thus, the concept of communication regimes explained above provides a framing device for the research, establishing boundaries that can be used to carve out one portion of the vast landscape of varieties of photography.

Where do marine mammal scientists fit in this framework? As we have hinted and as will be discussed in greater detail in the discussion chapter below, in practice it appears that they, surprisingly, do not fit this model very well. At the outset of this research, however, we speculated that the model would be a good fit for marine mammal scientists, based on the limited publications about marine mammal scientists' work and on informal discussions with marine biologists prior to the research. The scientists are clearly parts of loosely coupled social networks (element 1 of the communication regime definition), maintained by professional memberships in organizations such as the Society for Marine Mammalogy, and the communication of their scientific results through scientific meetings and journals is a key part of their professional activity. The principles and norms for their behavior (element 2) as measured by their visible output (scholarly articles) are enforced both by these professional organizations and by the peer review process for their scientific publications. The types of communication (element 3), both in terms of their scientific publication and in terms of their sharing of databases of photographs of individual animals, are very tightly coupled to the production system for these images and data. The institutions that support and regulate this regime (element 4) are the local institutions for which the scientists work, the professional organizations to which they belong, and the collaborations in which they engage. Finally, initial evidence suggested that there have been and continue to be conflicts (element 5) over standards, funding, sharing, and dissemination of photo-identification data among marine mammal scientists. Some of these notions were supported by the research, but we will see that overall, it can be argued that one of the more interesting features of marine mammal photo-identification, and possibly of many scientific methods, is the high degree of local idiosyncrasy and lack of need or desire for the more formalized rules and norms imposed by a communication regime.

While communication regimes helped to form the conceptual boundaries for this study, the concept does not provide an adequate theoretical basis for examining the socio-technical system of scientific photography. Thompson (1995, p. 11) argues that "mediated communication is always a contextualized social phenomenon: it is always embedded in social contexts which are structured in various ways and which, in turn, have a structuring impact on the communication that occurs." To understand these social contexts, the relationship between technologies and the social contexts in which they operate will be expanded below in the discussion of SCOT, ANT and STIN.

2.2 Social Construction of Technology (SCOT)

The Social Construction of Technology (SCOT) theory is a radical constructivist approach to understanding the development of science and technology (Bijker, 2001). Developed in 1982 primarily by Trevor Pinch and Wiebe Bijker, SCOT represents an effort to bring a social constructivist approach, already in common usage in the sociology of scientific knowledge, to the understanding of technology (Bijker, Hughes, & Pinch, 1987). A major initial impetus for the development of SCOT was a rejection of technologically deterministic approaches to understanding technological change over time:

> Technological determinism was taken to comprise two elements: (a) technology develops autonomously, and (b) technology determines societal development to an important degree. This view was seen as intellectually poor and politically debilitating. Technological determinism implies a poor research strategy, it was argued, because it entails a teleological, linear, and one-dimensional view of technological development. In addition, it was considered politically debilitating because technological determinism suggests that social and political interventions in the course of technology are impossible, thus making politicization of technology a futile endeavor. (Bijker, 2001, p. 15523)

To understand SCOT and its contributions, it is helpful to discuss a number of main assumptions and elements of the approach. First, the concept of social construction predates SCOT and forms an essential foundation for SCOT. Second, SCOT has a number of central concepts that form its core: ‘relevant social group,’ ‘interpretive flexibility,’ ‘technological frames,’ ‘closure,’ ‘stabilization,’ and ‘mutual shaping’

(Bijker, 2001). Finally, SCOT relies heavily on case studies[11] as a way to understand the relationship between technology and society. This section will discuss each of the elements in turn.

2.2.1 Social construction

The term "social construction" in SCOT comes from the sociology of scientific knowledge (SSK) tradition. SSK relativists, led by Bloor (1973), used social construction to understand how knowledge is constructed within science.[12] In SCOT, social construction is both a part of the name of the sub-field and a central concern of its practitioners:

> It is often believed that at the beginning of the process of innovation the problems to be solved are basically technical and that economic, social, political, or indeed cultural considerations come into play only at a later stage… [However,] right from the start, technical, scientific, social, economic, or political considerations have been inextricably bound up into an organic whole. Such heterogeneity and complexity, which everyone agrees is present at the end of the process, are not progressively introduced along the way. They are present from the beginning. (Callon, 1987, p. 84)

In other words, the process of social construction of an artifact is occurring throughout the artifact's development process, whether analysts recognize it or not. For SCOT, this tells analysts both to include the social considerations from the beginning of their research and also to recognize that social considerations play an important part of

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[11] A number of case studies are briefly summarized and discussed in this section. The descriptions of these cases are by necessity brief and are being used to illustrate important aspects of SCOT. The original case studies, however, are in all instances highly detailed and extremely rich accounts of how various technologies have been socially constructed. The reader is advised to refer to the original sources of these case studies to understand their richness of detail.

[12] For a complete discussion of the development of SSK, see Collins (1983) and Shapin (1995).

the construction of an artifact during its development process. Indeed, as we will see below in the discussion of the development of Bakelite, even before the artifact itself can be considered to be undergoing development, the human actors are part of a social system that is influencing how they will come to understand the artifact.

An example from Callon (1987) illustrates the social construction process. In the early 1970s, a group of engineers at Electricité de France (EDF) proposed the introduction of an electric car (VEL) in France. Callon argues that the engineers moved seamlessly from technical design into social and political discussions that showed a sophisticated sociological understanding of the social nature of the automobile in western society.

> EDF's engineers presented a plan for the VEL that determined not only the precise characteristics of the vehicle it wished to promote but also the social universe in which the vehicle would function…In addition to their technical know-how the engineers of EDF used skills more commonly found in social scientists. (Callon, 1987, p. 84)

Among the social arguments used by the engineers were discussions of how to improve life in crowded cities with poor air quality, which ministries would be responsible for subsidizing electric vehicles, which corporations would be responsible for building various components of the VEL, and how social groups interested in a modern, post-industrial world would find the VEL to be, unlike the internal combustion vehicle, a simple and useful object. Thus, Callon argues, the attempt to produce the VEL was socially constructed. Even the failure of the VEL was socially constructed: the researchers charged with developing sufficient batteries were unable to develop a reliable and non-contaminating product, and Renault engineers opposed the VEL by arguing that France needed reindustrialization, not a post-industrial society.

2.2.2 Relevant social group

A central claim of SCOT is that understanding social groups can help us to understand technology. Bijker (1995) argues that it is necessary to "identify the social groups that are *relevant for the actors*…[and also to determine the] social groups *relevant for the analyst*" (pp. 45-46) [emphasis original]. Bijker identifies two methods for determining the relevant social groups: snowball sampling and following the actors. In snowball sampling, the researcher asks each initial actor who else is likely to provide useful information. Once an initial list of social groups is made from this snowball sample, the researcher follows the actors to learn about the social groups in more detail. Finally, once the researcher finds that the groups in actors' accounts are stabilizing and little new information about groups is arising, the analyst uses this information to delineate relevant social groups from one another.

In Kilker & Gay's (1998) SCOT study of the *Making of America* digital library developed by Cornell University and the University of Michigan, they identified a number of relevant social groups:

> The boundaries were clear in this DL (digital library) project. The [relevant social] groups included the project's funders, faculty, librarians, software developers, students, and evaluators. Within each group is a variety of subgroups; for example, the 'librarians' group consists of library management, reserve specialists, preservationists, and so on. (Kilker & Gay, 1998, p. 63)

Often, the relevant social groups are relatively easy to uncover. In the digital library example above, none of the identified social groups fall very far from what someone familiar with libraries would guess based on common sense. In the French electric car example, while most of the relevant social groups are fairly obvious, it is not clear that without the SCOT methodology that it would have been easy to show the clear differences between two groups of engineers: the pro-VEL engineers at EDF and the anti-VEL engineers at Renault. In the next example below, however, the relevant social groups were far less clear in advance when trying to understand the Ordinary bicycle.

2.2.3 Interpretive flexibility

Interpretive flexibility refers to the notion that artifacts and experiences can be understood in a variety of ways. "We take words and world to be interpretively flexible and therefore grant that they may be perceived in different ways (that they may have different ontologies for different actors)" (Roth & Duit, 2003, p. 875). Bijker's (1995) analysis of the social construction of the safety bicycle in late 19th century makes use of the concept of interpretive flexibility. One of the early types of bicycle is the high-wheeled 'Ordinary,' a Victorian-era bicycle with one large wheel in the front and a small wheel in the rear and driven by direct turning of the large wheel rather than by gears and a chain. This bicycle had several features important for understanding its social development: it had a tendency to topple over, mounting and dismounting the seat was difficult, and it was generally risky to ride. For nonusers, their interpretation of this situation was that these features made the bicycle unsafe. However, Bijker points out that for another relevant social group, young and generally upper-class men:

> …this was one of its attractive features. [They] could display their athletic skills and daring by showing off in the London parks. To impress the riders' lady friends, the risky nature of the Ordinary was essential. (Bijker, 1995, pp. 74-75)

Thus, this group interpreted the bicycle as having a macho nature. Bijker's argument is that there is nothing inherent in the nature or design of the Ordinary that allows us to understand whether the bicycle was functional or not. For one relevant social group, nonusers, the Ordinary was a non-functional, unsafe contraption. For another relevant social group, daring young men, the Ordinary was a highly functional way to demonstrate their daring and athletic prowess. Thus, interpretive flexibility allows SCOT researchers to look past the intrinsic technological characteristics of an artifact and deconstruct the artifact into multiple socially interpreted artifacts.

2.2.4 Technological frames

A technological frame is used in SCOT to designate the interactions among the actors of a relevant social group.

> A technological frame is built up when interaction 'around' an artifact begins…If existing interactions move members of an emerging relevant social group in the same direction, a technological frame will build up; if not, there will be no frame, no relevant social group, no future interaction. (Bijker, 1995, p. 123)

Bijker argues that technological frames are somewhat similar to Kuhn's (1962) 'paradigms'. In determining the elements of a technological frame, an analyst needs to consider how members of a relevant social group attribute meanings to artifacts and how the artifacts themselves are constituted. Among the elements Bijker identifies are goals, key problems, problem-solving strategies, system requirements, theories, tacit knowledge, procedures, methods, practice, perceived function, and exemplary artifacts.

Bijker discusses technological frames extensively in his case study of the creation of Bakelite plastic as a means of bridging the gap between “an individual actor’s thinking and acting and the social dimensions of the SCOT approach” (1995, p. 102). Bakelite, the first truly synthetic plastic, appears on the surface to be resistant to the SCOT approach since, according to most standard accounts, it was invented by a lone inventor, Leo Baekeland, in 1907 in a flash of individual creative brilliance. Bijker argues, in contrast, that Baekeland was operating in a well-defined and stable technological frame of celluloid plastics scientists. Celluloid had been developed as a substitute for natural plastics in the production of “fancy articles and dress items” (1995, p. 125), including billiard balls that were in scarce supply due to the difficulty of obtaining ivory. However, celluloid chemists lacked a chemical theory for why celluloid behaved the way it did (including its high flammability), and were not pursuing alternative approaches. While most of the chemists in this technological frame were subject to these limitations, Baekeland was also part of another technological frame, electrochemistry, which allowed him to become an agent of change. Unlike celluloid chemists at the time, electrochemists had a focus on reaction variables that allowed Baekeland to analyze his experiments with phenol-formaldehyde that led to his creation of Bakelite.

The importance of the concept of a technological frame is that it allows SCOT to incorporate both social and technological elements, and reconcile aspects of purely social constructivist views and technological determinist views of technology. “A technological frame describes the actions and interactions of actors, explaining how they socially construct a technology. But since a technological frame is built up around an artifact and thus incorporates the characteristics of that technology, it also explains the influence of the technical on the social" (Bijker, 2001, p. 15526).

2.2.5 Closure and stabilization

Closure and stabilization are a stage in a technological controversy where the artifact has stabilized and the problems (identified because of the interpretive flexibility of the artifact) have 'disappeared' (although that does not necessarily mean they have been solved) (Pinch & Bijker, 1987). Closure is necessary because even though "there is nothing in principle that cannot be disputed, negotiated, or reinterpreted…if everything were endlessly negotiated, the effort might exhaust the time and resources of actors and render change impossible" (Misa, 1992). Bijker distinguishes between closure and stabilization as follows:

> These actually are two aspects of the same process…The concept of closure relates to the interpretive flexibility argument, and is analogous to the discussion of closure of scientific controversies in recent social studies of science…[and] means the interpretive flexibility of an artifact diminishes. The concept of stabilization is grounded in a critical evaluation of the naive invention-as-an-act-of-genius approach to the study of technology… [with a] focus on the development of an artifact within one relevant social group. (Bijker, 1995, pp. 85-86)

Closure is a central focus of Misa's (1992) case study of American steelmaking. The two controversies Misa identifies in steelmaking were first, a late 19th century patent dispute, and the second, a dispute over classification methods for separating iron from steel. The patent dispute arose over two competing claims on the patents for steelmaking that were limiting the ability of potential steelmakers to build steel plants without infringing on unsettled patent claims. The method of closure was organizational: two groups pooled the disputed patents and split the proceeds in an out-of-court settlement. This allowed the new industry to develop but also locked out other potential competitors who were not part of these two groups. The second dispute, over classification, resulted from a lack of a definitive standard at the time for how to measure (mechanically, physically, or chemically) whether a substance was iron or steel. Two rival classifications arose, which had legal and commercial ramifications. This controversy reached closure due in part to pressure from the railroads on the steel industry; railroad tracks built from 'steel' according to the 'fusion' classification were less likely to crack than those built from 'steel' according to the 'carbon' classification.

Bruheze discusses stabilization in more detail in his case study of radioactive wastes:

> In order to promote their views on waste, relevant actors within the AEC [Atomic Energy Commission] used strategies to limit the number of participants. In particular, to stabilize a set of social and technical relations in the AEC, these actors sought to bureaucratize and technologize social and political problems, even though these did not have to do with waste. (1992, p. 141)

Bruheze argues that during the post-World War II period, a number of actors within relevant social groups had an interest in radioactive waste. This includes AEC scientists and administrators, the military, private and university researchers, 'the public', and various professional scientific groups. Rather than reach closure among relevant social groups, the AEC reached stabilization by holding hearings followed by a report in 1959 that declared that waste problems were manageable and essentially an administrative issue. As the most powerful player in the game, by reaching a shared internal view, the AEC's job then was to defend this stabilized view to other relevant social groups.

Bruheze is careful to point out, though, that this case study does not address the long-term stability of a stabilization approach without closure, since the nuclear waste controversy stabilized in 1959 would re-erupt in the 1970s and result in the end of construction on new nuclear energy facilities in the United States.

2.2.6 Mutual shaping

Mutual shaping of technology refers to the ongoing interaction between humans and technological artifacts, a process recognized as early as Marshall McLuhan's (1964) discussion of the media, where he observed that "we shape the tools and they in turn shape us." While not overtly emphasized by Bijker and other SCOT founders, mutual shaping has been discussed by other authors as a logical part of SCOT studies (Boczkowski, 2004b; Lievrouw, 2002). Boczkowski in particular is an advocate of this view, stressing the importance of understanding the ongoing and reciprocal nature of shaping while cautioning that:

> This does not mean that the evolution of all new media artifacts is marked by ongoing technological and social transformations, or that these transformations are constant. What a mutual shaping approach implies, though, is that it is in principle possible that these transformations can occur at multiple points in the shaping and diffusion of the artifact. (Boczkowski, 2004b, p. 257)

Boczkowski uses a case study of videotex to illustrate his point. Videotex was first introduced by the British Post Office in the early 1970s as a means of transmitting information in a closed, subscriber-based network. Early interest in videotex came from governments hoping to deliver information to remote areas and from newspapers interested in developing new ways to reach consumers in the face of declining subscriber bases for their print editions. A major effort to introduce videotex was Knight-Ridder's Viewtron project, which installed free terminals for several weeks at a time in a Florida community in 1980. This successful field test led to changes in the terminals and eventual market trials in 1983. These later trials were disappointing – few people proved willing to pay for the relatively expensive service, and the technology proved slow. A last-ditch effort to provide the service through personal computers rather than dedicated terminals proved to be too little, too late, and electronic news mostly withered until the web became available in the mid-1990s. Boczkowski explains how the rise and fall of videotex was the result of mutual shaping:

> Rather than first constructing the artifact and then diffusing it through society, actors seamlessly wove these two dimensions of new media evolution in an ongoing fashion…changes in one dimension influenced alterations in the other at a later stage. For instance, the creation of the Videotex Industry Association, something that could be seen as a 'social' event trying to shape the conditions for diffusion, quickly led to a 'technical' initiative in interface standardization to foster further market acceptance of videotex. Along the same lines, the increased penetration of personal computers in the home, coupled with the lower than predicted Viewtron sales, triggered the hardware and software transformation that enabled the system to be accessed through non-dedicated terminals with the hope that this would accelerate its rate of adoption. (2004b, p. 262)

This notion of mutual shaping can be productively combined with ANT's concept of black-boxing, discussed below, to show how technological systems are transformed, to use Boczkowski's term, or translated, to use Callon and Latour's term discussed below, as they undergo the process of social construction.

2.2.7 Case studies

As should be clear by now, a central methodological technique in SCOT is the use of case studies for understanding how technology is socially constructed. Whether a researcher is analyzing electric cars, bicycles, plastics, digital libraries, steel, radioactive waste, or videotex, for SCOT theorists, case studies are seen as a useful method for gaining entrée into a socio-technical system. SCOT uses a three-step research process to understand case studies:

1. sociological analysis of an artifact to demonstrate its interpretive flexibility
2. description of the artifact's social construction
3. explanation of this construction process in terms of the technological frames of relevant social groups

(Bijker, 2001, p. 15525)

Can this approach be applied to digital photography? Certainly, the social construction of photographic content has been discussed:

> It seems a bit foolish, for example, to dismiss a number, chunk of text, or photograph just because it has been 'socially constructed.' It is difficult to imagine anything that is not! A better bet would be to examine the construction process itself for what we can learn about not only the number, text chunk, or image but also the social contexts in which they are shaped and distributed. (Wagner, 2004, p. 1481)

While there is not room here for a full SCOT interpretation of digital photography, we can briefly examine one aspect of digital photojournalism to understand how SCOT can help us to interpret this domain. Even though digital cameras appear to be similar to film cameras in design, the processes required to move from images in the world to images inscribed on computer screens and on paper are very different for film and digital. One of the contentious areas in this shift relates to the ease of manipulation of digital photographs using readily available software such as Photoshop. We can define a manipulated digital photograph as an artifact by recognizing that it resides at the intersection of digital cameras, computers, image processing software, and the actual bits contained in the data file. What are some relevant social groups, and how have they interpreted this artifact?

Again, to be brief, we identify just two relevant social groups of the many involved in this technological frame. Many photojournalists interpret easily manipulated photographs as a potential threat to their credibility with the reading public. The National Press Photographers Association, for instance, includes the following in their code of ethics: "As journalists, we believe that credibility is our greatest asset. In documentary photojournalism, it is wrong to alter the content of a photograph in any way (electronically or in the darkroom) that deceives the public" (1991). However, there are photojournalists who view digital manipulation as a readily available way to correct a photograph that otherwise may not be published that can be considered analytically to be a relevant social group. One does not need to ascribe nefarious goals to this relevant social group of 'photographic manipulators'; in many cases, they may be making simple changes that, in their opinion, better reflect their vision of reality than the image captured by their camera. Los Angeles Times reporter, Brian Walski, for instance, was fired after admitting that his front page image of an American soldier in Iraq in front of a group of refugees was actually a montage of two images taken right after each other, but facing in opposite directions. In an interview after his firing, Walski said:

> When I saw it, I probably just said, no one is going to know. I don't know. I've tweaked pictures before—taken out a phone pole. It's not a common practice, but

> you can do it. I can't speak for anyone else, but I imagine they've done it here and there. This was going overboard—taking pictures and putting them together. I think it's just that I wanted a better image. Then when I did it, I didn't even think about it. (Walker, 2003)

To understand the technological frame of digital manipulation, refer back to the earlier discussion of communication regimes. The examples in that section show how the technological frame for digital photography has been built up in photojournalism. Compare the language used in discussing communication regimes above—principles, norms, procedures, institutions, and conflicts—to the language used in SCOT—goals, key problems, strategies, tacit knowledge, procedures, methods—and the congruence between the two becomes clearer. Both are geared toward understanding the frameworks within which technological artifacts are situated and constructed. Communication regimes refer to a more specific communication-intensive setting, whereas SCOT is more general, but both are efforts to build similar structural pictures of constellations of actors, frames and artifacts.

Digital photographic manipulation in photojournalism has probably not reached closure at this point, but rather stabilization. The Walski example and others (Meyer & Kling, 2003) demonstrate that while the official organizations have a clear and definitive position on digital manipulation, individual photographers in the 'digital manipulators' group continue to manipulate their photographs, even at the potential of risk to their careers.

2.2.8 Critiques of SCOT

Although the above examples have demonstrated the elegance of SCOT in helping to understand a wide variety of technologies in social settings, SCOT is not without its critics. One key critic is Winner who, while acknowledging SCOT's valuable aspects—"its conceptual rigor, its concern for specifics, its attempt to provide empirical models of technological change that better reveal the actual course of events" (1993, pp. 367-368)—nevertheless finds a number of problems with the SCOT approach, which he believes reflect the theory's narrowness in a number of dimensions. First, Winner believes that SCOT has "an almost total disregard for the social consequences of technical choice" (1993, p. 368). SCOT's focus on the creation and shaping of technology leaves a gap in understanding the impact of the construction process on society during and after the process SCOT theorists describe. Second, the focus on relevant social groups ignores 'irrelevant' social groups, which are most often silent or voiceless groups which will be impacted by technological changes but are not in a position to shape the technology in any way. This bias results in telling the stories of technology from the point of view of powerful players at the expense of the less powerful and the excluded. Winner's third criticism is that SCOT is narrow in its view of society. By focusing on social groups, SCOT theorists discount or ignore more deeply seated sociological, cultural and economic processes, a point also made by Rosen (1993). Finally, Winner acknowledges that interpretive flexibility is useful for understanding the relativistic nature of experience, but argues that SCOT takes this too far and as a result "they have no theoretical or practical position on technology and human well-being at all" (1993, p. 372). The relativism in SCOT has also been criticized (Sismondo, 1993b), but this is an argument mainly among philosophers of science who themselves acknowledge that it lies primarily on a metaphysical plane (Cetina, 1993; Sismondo, 1993a).

Winner's comments have merit, but are not fatal to SCOT by any means. Although Winner was the target of heated criticism (Elam, 1994) particularly for his final point regarding the necessity of becoming social activists with our knowledge, taking into account social consequences, excluded social groups, and broader social forces all appear to be valid and useful considerations. As Brey points out, "most of Winner's criticisms…do not point to internal methodological flaws in social constructivism, but criticize the narrowness of its scope and the consequently limited social and political relevance of its studies" (1997, p. 4) and argue that many of Winner's criticisms would have been weaker six years later when Brey was writing due to a number of new studies that addressed many of these issues. Indeed, Bijker and Pinch (2002) argue that one of SCOT's strengths is that later scholars have extended and improved their original models by considering additional factors.

Several critiques of SCOT rest on specific criticisms of Bijker's analysis of the development of the safety bicycle discussed above (Bijker, 1995). Buchanan (1991) argues that the bicycle case presents a neat conceptual model, but does little to extend our knowledge of the development of the bicycle. Clayton also takes Bijker to task for the details of the bicycle narrative, arguing the "small coterie of self-proclaimed bicycle historians" found "conspicuous factual errors in the narrative and on Bijker's maverick analysis of the development of the safety bicycle" (2002, p. 355). Of note is that all these bicycle-specific critiques appear to have been written by historians. As Law points out, "narrative history and social science theory are driven by different kinds of concerns and interests. One is not inherently superior to the other. They are merely different" (1991, p. 377). One may speculate that part of the disconnect is in their evident focus on the details of the case study, while Bijker appears to be more interested in defending the sociological usefulness of the theory. Responding to Clayton, Bijker and Pinch acknowledge that others may be more accurate in their details of the history (what they call 'naïve empiricism'), but that "the test for a conceptual framework such as SCOT is thus whether it helps the researcher to make sense of case studies" (2002, p. 368). Epperson (2002) agrees that while Clayton is an acknowledged bicycle expert, minor factual errors do not diminish the overall usefulness of SCOT as an approach.

Generally, the criticisms of SCOT raise important but non-fatal problems with certain aspects of the approach, and some of these weaker aspects are dealt with in the Actor-Network Theory (ANT) and Socio-Technical Interaction Networks (STIN) perspectives below. In particular, SCOT's inability to explain the mechanisms ('how' and 'why') for resolving controversies between different relevant social groups (Bruun & Hukkinen, 2003) is directly addressed in Actor-Network Theory, to which we now turn our focus.

2.3 Actor-Network Theory (ANT)

Actor-Network Theory (ANT) has become a major force among those in Science and Technology Studies (STS) and Sociology of Scientific Knowledge (SSK) theorists over the past 25 years. ANT can be viewed as a subset of SCOT, when SCOT is broadly defined (Bijker, 2001). The origins of ANT come from Latour's early work describing how scientific facts were constructed at the Salk Institute, based on two years of anthropological research among the scientists there (Latour & Woolgar, 1979) and has been extended by Latour, Callon, and Law, among others. Despite ANT's origins in laboratory studies, the concepts of ANT have been applied to a wide variety of topics; a recent special issue of *Information Technology and People*, for instance, presented ANT studies of a web portal, health information on the web, PDAs, web browsers, and computerized baggage-handling systems (Hanseth, Aanestad, & Berg, 2004).

Actor-network theory has been widely discussed, summarized (Law & Hassard, 1999; Shapin, 1995), criticized (see below), and applied, and adding yet another summary to the literature would not serve any useful purpose. Instead, this paper will look at some of ANT's central concepts and discuss their applicability to this study of digital photography in professional settings. While ANT relies on a number of concepts, here we will limit the discussion to *actants*, *black-boxes*, *translation*, *enrollment*, and the methods used by ANT, as well as a brief discussion of some of the critiques of ANT.

2.3.1 Actants

Latour (1987) proposed the term actant as a way to refer to both "people able to talk and things unable to talk" (p. 83) as analysts seek to understand behavior within socio-technical networks. The inclusion of non-human artifacts as sources of action within a network is non-trivial. Sociological theory, for instance, rarely views technological artifacts as more than a peripheral element that human actors manipulate

(Latour, 1988; Star, 1988); conversely, technological deterministic approaches, which as noted above are strongly criticized by SCOT analysts, that focus on the “impacts” of technology are mechanistic and causal (Griffith & Dougherty, 2001). In ANT:

> …elements of any kind may be included: humans, technological artifacts, organizations, institutions, etc. ANT does not distinguish between or define a priori any kind of elements…all networks are heterogeneous or socio-technical. There are no networks that consist of only humans or only of technological components. All networks contain elements of both. (Hanseth et al., 2004, p. 118)

Latour argues that the most mundane of artifacts can be actants in socio-technical systems; his analysis of door closing mechanisms as actants is probably the clearest illustration. Latour describes how the simple technological combination of door hinges, which allow walls to temporarily and easily open, with hydraulic spring-operated door closers, which gently restore the wall to an unbroken surface, serve as relatively skilled actants in a socio-technical system allowing human actants to reversibly walk through walls and work in non-entombed but enclosed spaces (Latour, 1988). This understanding of technological artifacts as potentially important but non-deterministic forces in socio-technical systems is an important addition to SCOT theory. The Ordinary bicycle discussed above has features that allowed for interpretive flexibility, but was still perceived as an essentially inactive artifact upon which humans layered meanings within a dynamic social, political and economic milieu. An ANT analyst would also stress that the Ordinary bicycle translated a major effort (running in order to cross long distances quickly) into a minor effort (pedaling the large wheel to quickly cross long distances). In doing so, the bicycle becomes a nonhuman character in the socio-technical system involved in moving daring young men from place to place while impressing their admirers.

In the discussion of communication regimes above, the tight coupling between the practice of photojournalism and the production of media product was noted. In a tightly coupled system such as photojournalism, the active role played by technology such as digital cameras is fairly obvious. Just as automatic door closers take on the roles that would otherwise require grooms and doormen, digital cameras take on roles previously filled by darkroom technicians, communications operators to transmit photos by wire, archivists, and others. Thus a major effort is reduced to a minor effort by the active role played by the digital camera. Like the door closer, it should not be assumed to be the dominant actant in the photojournalism socio-technical system, but neither should its role be assumed to be minor and submissive. The relationship, in ANT terms, between photojournalists and digital cameras is treated with agnosticism (analytic impartiality between human and non-human actants) and generalized symmetry (explaining conflicting viewpoints using a neutral vocabulary for both human and non-human actants) (Tatnall & Gilding, 1999).

Just as Latour’s door-closers translate the major effort of walking through brick walls into a minor effort of pushing open a door, cameras translate the major effort of manually creating a detailed and naturalistic image of a scene through painting or etching into the minor effort of pushing a button and developing the latent image, or having others develop it for you. Digital photography in turn translates the relatively complex and labor-intensive chemical processes of traditional photography into a relatively simple and accessible set of steps required to view the resulting images on a computer or print them out for viewing. Traditional-film based cameras can be considered analogous to Latour's doors that required grooms to await people who may want to pass through the doors, while digital cameras are like Latour's automatic door closers that allowed human actors to walk through walls without additional human input once the socio-technical system was in place. Traditional cameras generally speaking require photo lab technicians and an array of human actors associated with the developing and printing process, but digital cameras reduce the number and types of human actors required to go from a scene-in-the-world to an image that in some sense represents that scene. By standing in for human actors, the digital camera is an actant in terms of its contribution to the socio-technical network and in terms of its role in the mutual shaping that occurs among actants in the system.

Actants are not limited to human actors and technological artifacts; actor-networks consist "of heterogeneous 'actants' the most durable of which—people, institutions, tools, texts, money, technologies, information, etc.—flow through the network" (Ekbia, 2004). Thus photojournalists, newspapers, magazines, digital cameras, printing presses, editing computers, web editions, budgets, etc. are all potential actants within photojournalism's actor-network.

2.3.2 Black-boxing

Black-boxes play two complementary roles in ANT. First, the creation of black-boxes is an essential task of actors seeking to build support for their position. Second, opening these black-boxes is a key methodological tool for the ANT analyst seeking to understand how socio-technical networks have been constructed. We will leave the second role temporarily and revisit it in the methodological discussion below. The first role, however, is central to understanding how actor-networks are created.

> Black-boxing involves drawing a boundary around a particular sub-network, specifying the inputs and outputs at the interfaces between the sub-network and the remainder of the actor network and specifying the expected performance of both the sub-network and the consequent performance of the entire network of which it is a part. When a sub-network is successfully black-boxed or closed, it can be treated as a simple input/output device that performs in accordance with a clear and unambiguous set of specifications…The output of one black-box is readily transferred to another black-box…The black-box can simply be treated as another actor in the network. Crucially, black-boxes are always the outcome of socio-technical negotiations — it takes continuing work both to create them and to hold them in place. Closure is neither complete nor final. (Kaghan & Bowker, 2001, p. 258)

Black-boxing involves getting to the point that SCOT theorists above called closure and stabilization but pays much greater attention to the processes required to achieve this temporarily closed or stable and accepted system.

Latour (1987) offers an example of black-boxing in his discussion of Growth Hormone Releasing Hormone (GHRH). This story is told in great detail, but it is possible to understand the essence of the argument without getting too bogged down in details about various bioassays. The short version is that one scientist, Schally, made a claim about the structure of GHRH and supported this claim by introducing a measurement technique using a rat tibia cartilage bioassay. A challenger to this claim, Guillemin, showed that Schally's bioassay, which Schally had tried to black-box, could be used to draw other conclusions, including the possibility that growth might not only <u>not</u> have been caused by GHRH but may not have occurred at all. Guillemin, having demolished

Schally's black-box in a series of harsh papers, proceeded to build his own, much stronger black-box for GHRH measurement based on a rat pituitary cell culture. Guillemin's black-box involved a much more complicated process but gave less equivocal results, and due to the fact that its level of complexity required a much higher degree of knowledge to be able to criticize. Thus, Guillemin successfully created a strong black-boxed system while also destroying a competing and less robust black-box.

In digital photography, the treatment of digital photographs by the courts is a good example of a black-box in the process of being constructed. Regarding the submission of photographs as evidence in court proceedings, traditional photographs only require a witness with personal knowledge of the subject depicted for admission into evidence; the actual photographer need not lay a foundation, nor is there any requirement for expert testimony showing the film's chain of custody (McEntee, 2001). From the point of view of the court, which includes judges, juries, prosecutors and defendants, the taking of photographs to represent evidence has been successfully black-boxed. Judges need not peer into the black-box to accept the output. With digital photographs, however, the black-box has not yet been created, and the process of taking digital photographs and ensuring their accuracy is still open to questioning. With the advent of digital cameras in police work, debates have arisen in the legal community over whether digital photographs should be treated differently from film (Berg, 2000; McCarvel, 1995; Shaw, 2002), and there have been suggestions to amend the Federal Rules of Evidence to more clearly account for digital photographs (Bianchini & Bass, 1998). Berg (2000) points out that "if a defendant alleges an image has been altered, or could have been altered, the burden of proof falls upon the state to prove otherwise…In many cases, the success of the argument will hinge upon the procedures used to safeguard the security of the images" (p. 5). The chain of custody begins with the first responders to a crime scene and continues through the investigation process, prosecutorial preparation, introduction into trial, and deliberation. During the investigation process, investigators are responsible for preparation, preservation, collection, examination, analysis and presentation of evidence (Carrier & Spafford, 2003). It is here that tension arises:

> Law enforcement digital evidence examiners…try to adhere to a general practice of functioning as evidence specialists to avoid the certain pitfalls associated with declaring themselves to be "technology experts." We do not yet have a generation of forensic investigators, examiners, and members of the legal profession who are equally adept at conducting sound, objective thorough investigations and positioning findings in the form of sound litigation in matters involving digital evidence. (Talleur, 2002, p. 2)

Thus, the black-box is not closed, and until the process is successfully closed, digital photographs will continue to be questioned in the courts.

2.3.3 Translation and enrollment

The creation of actor-networks is not automatic. It takes more than the presence of social networks involving technological artifacts for the successful creation of new actor-networks. Latour (1987) argues that socio-technical change requires that actors whom he calls fact-builders must both enroll others in participating in the construction of the fact and also must control their behavior to prevent them from transforming the claims beyond recognition. This is what Schally, discussed above, failed to do with his bioassay for GHRH and how Guillemin managed to displace Schally's facts with his own. The process by which this occurs is *translation* and *enrollment*.

Translation can refer to the entire process of creating an actor-network (and ANT is sometimes called the sociology of translation (Callon, 1986)), but is easier to understand by looking at the more specific meaning of translation within the context of constructing common definitions and meanings for scripts, black-boxes, processes and other actants. "Translation does not here have only its linguistic meaning but also the religious one, 'translation of the remains of St. Christel,' and the artistic one, 'translation of the feelings of Calder into bronze'…[the direction] goes from a provisional less reliable [script] to a longer-lasting, more faithful one" (Latour, 1988, p. 306). It is through translation that a fact-builder seeks to make a set of beliefs and interests appealing to other actants by translating them into forms that will also attract others. Law (1999) argues that translation is the process that is used to make dissimilar things become equivalent to each other. In Allen's (2004) ANT analysis of the PDA industry, for instance, PDA companies took the small hand-held computers they were building and translated them to potential purchasers as "organizers," something many people had experience with in their paper versions. This translation was necessary as PDA companies hoped to enroll business partners, other technologies that could work with PDAs, potential users and other actants into their actor-network, which leads us to the final concept to be discussed here: enrollment.

Enrollment is when a fact-builder is able to successfully recruit other actants to support their translated concepts, the black-boxes they are constructing, and thus enroll them into their actor-network. Guillemin enrolled other scientists into the GHRH rat pituitary cell culture actor-network, Palm enrolled users into their PDA actor-network, and police photographers using digital photographs in evidence collection are still trying to enroll judges, juries and prosecutors into their actor-network.

These elements of actor-network theory help to explain some of the “how” and “why” questions raised by SCOT as various social groups come into contact and, potentially, conflict as they construct technology. To understand how ANT theorists peer into the black-boxes actants have created and how they describe the actor-networks that have been created, it is helpful to look at ANT’s methods.

2.3.4 ANT methods

A central goal for the ANT analyst is to reopen the black-boxes discussed above and peer inside in the hopes of understanding how processes have been translated, actants enrolled, and systems black-boxed in the creation of the socio-technical system in question. This is done in ANT in much the same fashion as in other SCOT research mentioned above: by following the actors and examining what ANT analysts call inscriptions. “If we want to understand social life then we need to follow the actors wherever they may lead us” (Law & Callon, 1988, p. 284). Latour (1987) includes seven rules of method, but Bowden (1995) argues that all but one are more properly called methods of explanation rather than methods of data collection. Only Latour’s first rule applies to data collection: “We study science *in action* and not ready made science or technology; to do so, we either arrive before the facts and machines are blackboxed or we follow the controversies that reopen them” (1987, p. 258). His other rules of method, while important, tend to come at the analytic stage. These include focusing on how claims are transformed, avoiding using Nature or Society to explain how controversies have been settled since Nature and Society are the result of the controversies, and to remain undecided when following the actors.

Latour's field methods in his initial study (Latour & Woolgar, 1979) were anthropological in origin, and this bias toward ethnographic methods can be seen in ANT. Recall that this initial work involved spending two years among scientists working in a research laboratory and doing a great deal of actor following. In addition, Latour stresses examining inscriptions: those writings and artifacts created by an actor-network as the product or output of the system. These will give the analyst clues about what the actants consider to be important.

> The function of literary inscription is the successful persuasion of readers, but the readers are only fully convinced when all sources of persuasion seem to have disappeared…There is an essential congruence between a 'fact' and the successful operation of various processes of literary inscription. A text or statement can thus be read as 'containing' or 'being about a fact' when readers are sufficiently convinced… (Latour & Woolgar, 1979, p. 76)

In general, however, beyond these essential exhortations to ANT analysts, actor-network theory is marked more by multiple methods and approaches as dictated by the requirements of the research setting and the training of the analyst than by disciplinary standards (Bowden, 1995). This flexibility has allowed the application of ANT approaches to a wide variety of topics, as mentioned above.

2.3.5 Critiques of ANT

Of course, any theory that has been as widely adopted as ANT is bound to attract criticism, and some of the most reflective comments have come from its founders: “I will start by saying that there are four things that do not work with actor-network theory; the word actor, the word network, the word theory, and the hyphen! Four nails in the coffin” (Latour, 1999b, p. 15). Callon, Law and Latour were among those who participated in a volume deconstructing ANT (Law & Hassard, 1999) because they recognized that ANT itself had become blackboxed. Rather than being used critically, many of those using some variety of ANT were taking elements of the theory (as, admittedly, has been done in this paper) and applying them uncritically (which hopefully has not been done in this paper) without sufficiently grasping that ANT represents a dynamic and changing set of explanations meant to understand, and more importantly to embrace, complexity. The attempts to reify ANT and convert it into a fixed theory are both counterproductive and not in keeping with the spirit of ANT: “Only dead theories and dead practices hang on to their names, insist upon their perfect reproduction….there should be no identity, no fixed point” (Law, 1999, p. 10). Of course, accepting this argument that ANT is ever-changing and flexible makes it difficult to meaningfully critique, but several elements of ANT have drawn particular criticism.

One of the major sources of criticism of ANT stems from ANT’s controversial “claim that there are no differences between non-human and human forms of agency; that animals, machines, or even electrons can be ‘actors’ in the same sense as human are” (Bruun & Hukkinen, 2003, p. 103). However, Bruun & Hukkinen continue by pointing out that this criticism is based on an overly simplistic reading of ANT. Yes, non-human actants may have agency (the capacity to act) in the sense that agency is about connecting things and intervening in the world, but that does not require that non-living entities have the capacity for intentional behavior, they argue. Instead, it requires that analysts discard purely humanistic notions of action and agency. “Actor-network theory is 'co-constructionist': it seeks to identify how relations and entities come into being together” (Murdoch, 2001, p. 111).

Some of the early responses to Latour’s (1987) *Science in Action*, which laid out the basic precepts of ANT as Latour envisioned them at the time, were not only negative but actually mocking in tone. Reviews by Shapin (1988) and Amsterdamska (1990) were both openly derisive of Latour and ANT. Amsterdamska entitled her article, “Surely You Are Joking, Monsier Latour!” and accused Latour of pursuing a social science “whose only goal is to tell inconsistent, false, and incoherent stories about nothing in particular” (1990, p. 503). Shapin (1988) labeled Latour’s approach as Machiavellian and fraught with military metaphor. “Technoscience [ANT] is war…[and] its object is domination and its methods involve the mobilization of allies, their multiplication and their drilling, their strategic and forceful juxtaposition to the enemy” (p. 534). Later work, however, points out that one has to be careful not to view the translation and enrollment process as an overly Machiavellian process. Allen (2004) argues, for example, that “enrollment is not only a matter of negotiation and power plays. Enrollment is also a matter of redefining the technology, including and excluding different network elements” (p. 181).

Later criticisms were much better argued and reasoned than Shapin and Amsterdamska's rather knee-jerk reactions against Latour. Bloor (1999a) challenges what he sees as Latour's attacks on the sociology of knowledge traditions and argues that ANT is in fundamental opposition to social constructivist approaches, and particularly the Strong Programme which seeks causal explanations for systems of belief. Latour (1999a) and Bloor (1999b) respond vigorously to each other in a series of replies to the original article. Much of this particular debate, however, is primarily of concern to those in the sociology of knowledge field, and does not necessarily have a great impact on those exporting useful concepts from ANT to other disciplines.

While many of the controversies over ANT are within what Latour refers to as "a miniscule sub-field of sociology" (2000, p. 107) that he likens to a small mammal in the age of dinosaurs, in the same article he argues that some of the concepts of science and technology studies (STS) are readily transportable to other fields of study. A major insight is the realization that social science can study situations other than as a causal string of socially meaningful events. This extension beyond the realm of what is traditionally called "social" to mechanisms, processes and systems is consistent with what has been discussed in this paper: that understanding people, technologies, organizations, networks, communication, and information in an ecological system is more likely to yield useful information about the complex nature of socio-technical phenomena than will reductionist and positivistic approaches. The final approach to understanding socio-technical systems that will be addressed in this paper specifically addresses the need to appreciate this complexity in information technology networks, Kling's STIN approach.

2.4 Socio-Technical Interaction Networks (STINs) [13]

Kling, McKim, & King's (2003) article on electronic scholarly communication forums is Kling's attempt to detail the assumptions and use of what he called the Socio-Technical Interaction Network (STIN) methodology. This STIN strategy is an elaboration of Kling's earlier web models (Kling, 1992b; Kling & Scacchi, 1982) designed to give social informatics scholars and other researchers a tool for understanding socio-technical systems in a way that privileged neither the social nor the technical. Unfortunately, Kling's untimely death in 2003 left the STIN strategy without its prime evangelist. Other researchers, however, are taking up the STIN strategy in an attempt to test and develop the concept more fully.

This section is organized in the following manner. First is a discussion of Socio-Technical Interaction Networks (STINs) and their salient features. Next is a discussion of some of the studies that have used STINs in a variety of settings. Third, the methods used in STIN research are discussed. Next is a discussion of the weaknesses and limitations of STINs. Finally, the section concludes with some thoughts for the future of STIN research.

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[13] An earlier version of this section was published as Meyer, E.T. (2006). "Socio-technical Interaction Networks: A discussion of the strengths, weaknesses and future of Kling's STIN model." In Berleur, J., Numinen, M.I., Impagliazzo, J., (Eds.), IFIP International Federation for Information Processing, Volume 223, Social Informatics: An Information Society for All? In Remembrance of Rob Kling (pp. 37-48). Boston: Springer.

2.4.1 Similarities and differences between Bijker, Latour and Kling

Kling's STIN approach (2003) is "an emerging conceptual framework for identifying, organizing, and comparatively analyzing patterns of social interaction, system development, and the configuration of components that constitute an information system" (Scacchi, 2005, p. 2). The STIN model is a more fully developed version of what Kling earlier (Kling, 1992b; Kling & Scacchi, 1982) referred to as web models:

> Web models conceive of a computer system as an ensemble of equipment, applications and techniques with identifiable information processing capabilities…as an alternative to 'engineering models,' which focused on the equipment and its information processing capabilities as the focus of analysis, and formal organizational arrangements as the basis of social action. (Kling, 1991)

The STIN approach draws both on the Social Construction of Technology (SCOT) approach associated with Bijker, Pinch and others, and on Actor-Network Theory (ANT), which is associated with Latour, Law, Callon and others. As we have seen above, while these approaches are related, they are not identical. All are approaches which help to understand the role of social behavior in the of creation and use of technological artifacts, and all reject technological determinism as being too simplistic (Bijker, 2001, p. 15523). SCOT is particularly interested in the social construction process, wherein relevant social groups establish technological frames which help to understand the interpretive flexibility of artifacts and help to move toward a state of closure or stabilization (Bijker, 1995, 2001; Callon, 1987; Pinch & Bijker, 1987). ANT can be viewed as a subset of SCOT, when SCOT is broadly defined (Bijker, 2001). ANT adds a number of elements to other SCOT research, including the idea that non-human actants can have agency (Hanseth et al., 2004; Latour, 1988), and that the closure discussed in SCOT results in black-boxing artifacts after a process of translation and enrollment (Callon, 1986). The processes by which translation and enrollment occur are particularly important they help to explain some of the “how” and “why” questions raised by SCOT as various social groups come into contact and, potentially, conflict as they construct technology. As we will see below, the STIN approach differs from ANT in being much more conservative in attributing agency to non-human actants, is more prescriptive than SCOT or ANT, and focuses on patterns of routine use more frequently than patterns of adoption and innovation. The STIN approach is consistent with SCOT and ANT, however, in the sense that the identification of relevant social groups, understanding interpretive flexibility, and examining processes of translation and enrollment are crucial to developing a STIN model.

2.4.2 Socio-Technical Interaction Networks (STINs)

The STIN approach emphasizes that “ICTs do not exist in social or technological isolation” (Lamb, Sawyer, & Kling, 2000). According to Kling:

> Several fundamental assumptions underlie the application of the STIN methodology, and drive the methods used to construct STINs. These assumptions include [1] the social and the technological are not meaningfully separable…, [2] Theories of social behavior…should influence technical design choices…, [3] system participants are embedded in multiple, overlapping, and non-technologically mediated social relationships, and therefore may have multiple, often conflicting, commitments…, [and 4] sustainability and routine operations are critical. (Kling et al., 2003, pp. 56-57)

The first assumption, that the social and technological are not meaningfully separable, should be familiar to those familiar with the theoretical approaches of SCOT (Bijker, 1995; Pinch & Bijker, 1987) and ANT (Latour, 1987; Latour & Woolgar, 1979;

Law, 1999), particularly ANT's concept of actants that can be human or non-human participants in a socio-technical system. The STIN approach extends SCOT and ANT, however, by problematizing information technologies and making the "association between STS [Socio-technical systems] concepts and IS research [which] is often not explicitly articulated as such in contemporary literature" (Lamb et al., 2000, p. 1). One of the major differences between Latour's and Kling's approached is that "Latour theorizes about how new technologies come to be; Kling and Scacchi theorize about how new technologies come to be used" (Orlikowski & Iacono, 2001, p. 126)[14]. The STIN approach is also less committed to ANT's concept of "radical indeterminacy" (Hanseth et al., 2004; Latour, 1988) and is "much more conservative in attributing action to nonhuman agents" (Kling et al., 2003, p. 66).

Kling argues that this integrated concept of socio-technical systems is more useful than the more common use of the term socio-technical to argue merely that technologies have consequences for social and organizational behavior. This highly intertwined nature of the social and the technical is central to the STIN approach.

The second and fourth assumptions reflect a normative element of the STIN approach. Arguing that theories of social behavior should influence technical design choices and that it is critical to consider the sustainability of socio-technical systems both reflect Kling's background in computer science and concern for social issues. This differs from SCOT, which does not generally concern itself with such prescriptive concerns, and

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[14] Some recent SCOT studies, however, have started to pay more attention to the role of technology users and technology in routine use; see Oudshoorn (2005).

also differs from ANT, which is much more theoretically oriented, to the extent that even ANT's methodological prescriptions are primarily methods of analysis and not methods of collection (Bowden, 1995). While Kling did not reference the Technology Assessment (TA, or *Technikfolgenabschätzung*) literature, his interest in improving future technological systems based on outcomes of STIN research is consistent with TA's emphasis on influencing policy and communicating the results of socio-technical studies with a wider audience (Mohr, 1999).

Kling's third assumption regarding the multiplicity of social relationships and commitments for system participants is the key to understanding the contribution STIN makes to research into change in socio-technical systems. This ecological element of the STIN approach looks beyond the socio-technical system under study and also examines how other portions of an actor's social world are connected to their use and understanding of technology. Thus, when analyzing the physics pre-print online server arXiv.org, a STIN model includes not just authors, readers and file servers, but also institutional linkages, funding models, the non-technical social responsibilities of authors, the nature and size of research collaborations, and the socio-political behavior of arXiv's founders (Kling et al., 2003; Meyer & Kling, 2002).

Another concept that Kling was also involved in developing ties in with the STIN framework, the social actor concept as an alternative to the concept of technology users: "A social actor is an organizational entity whose interactions are simultaneously enabled and constrained by the socio-technical affiliations and environments of the firm, its members, and its industry. In short, social actors are not primarily users of ICTs" (Lamb

& Kling, 2003, p. 218). The social actor concept allows for analysis of less computer-intensive professionals who nevertheless routinely use information and communication technologies (ICTs) which shape what they do, how they perceive themselves and others, and how they interact with others. They are influenced by their affiliations, environments, interactions and identities as they shape and are shaped by ICT use (Lamb & Kling, 2003).

2.4.3 STIN studies

Despite its relatively recent introduction, the STIN approach has been used to study a growing number of IT topics, including scholarly communication forums (Kling et al., 2003), democratization of scholarly publishing (Meyer & Kling, 2002), web information systems (Eschenfelder & Chase, 2002), online communities (Barab, Schatz, & Scheckler, 2004), digital libraries (Joung & Rosenbaum, 2004), and free/open source software developers (Scacchi, 2005). A common element of these studies is that all not only deal with complex social systems, but also make use of the STIN approach to explain the complexity rather than reduce it to overly simplistic terms. This is one way that the STIN approach shares a common view with both SCOT and ANT; all three approaches reject simplistic, positivistic explanations for complex social systems all too common among more mainstream sociological approaches (Star, 1988). One way this complexity is addressed in the STIN approach is that many of the studies include STIN diagrams, graphical representations of the relationships between various elements within the STIN, including technologies, human actors, institutions, relationships, roles, and other relevant elements.

Kling et al. (2003), in their main article laying out what they call the STIN ‘methodology’, examined electronic scholarly communication forums (e-SCFs) including arXiv.org, Flybase, ISWORLD, and CONVEX. Among the conclusions offered in the article are that technological developments themselves will not overcome issues embedded in the social contexts into which the technologies are introduced. Fast connections and good interfaces, they argue, would not have caused medical researchers to support PubMed Central, since the primary reasons for their non-support were based on long-standing institutional arrangements and the vested interests of gatekeepers and various interest groups.[15] They also found that for the e-SCFs, understanding the business models of the supporting organizations was necessary for understanding the STIN, and that understanding the social relationships embedded in the STIN helped to explain how the technological innovations of electronic publishing are used and sustained.

Scacchi (2005) uses STINs to understand Free and Open Source Software Development (F/OSSD) and argues that STINs have formed most clearly in four areas: joining and contributing to F/OSSD, building communities of practice, coordinating projects, and co-evolving systems for F/OSS. These STINs are not independent of one another, but interdependent and overlapping. Scacchi argues that using STINs to understand F/OSSD is particularly appropriate since the F/OSS developers are only loosely connected through a fragile web of alliances and communities, and thus the social connections within the STIN are often as important as the technological innovations of

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[15] This case is more thoroughly described in Kling, Spector, & Fortuna (2004).

the software in explaining how well the web of relations of any given F/OSS project hold together over time.

In Scacchi's article, STINs are treated as entities that independently arise in the world and that researchers are then able to uncover using the STIN 'conceptual framework' (in his terms). This is a somewhat different approach than Kling et al. (2003) took in which the analysts constructed STIN models that were somewhat simplified views of reality. This underscores one of the ambigous aspects of STINs: are STINs entities that occur in the world, or are they models that reflect patterns of organization in the world?

Eschenfelder & Chase (2002) use the STIN 'framework' as a *post hoc* 'heuristic tool' (again, their terms) to understand web information systems at four large U.S. manufacturing companies. A key finding in this study was that some nominally peripheral actors, such as order fillers and professional peer groups, were key players in the success and use of the web IS. The various players identified in the research participated in the social construction of web IS by lobbying for configurations most suited to their needs, with the interests of some groups inevitably being privileged over those of other groups.

Barab et al. (2004) use STINs to understand the Inquiry Learning Forum (ILF), a web-based forum for math and science teachers. One important aspect of this study is that it combines STIN explanations with a theoretical perspective (activity theory) drawn from the authors' main field of education, an approach they argue synergistically "provides a richer view of the design activity and community functioning than either can offer in isolation" (p. 27). This points to one aspect of STIN research, and social informatics in general, that is worth noting. Social informatics is both by circumstance and design a transdisciplinary approach (Lamb & Sawyer, 2005) that offers researchers perspectives that can be applied to studying technology in a variety of settings, particularly when the more traditional fields studying various groups have not adequately problematized technology in their domain. So, in the case of education where technology may be viewed as a straightforward phenomenon, social informatics and STIN offers a way to bring the technical more into consideration in an educational socio-technical system.

Meyer & Kling (2002) use STINs to examine arXiv.org, the electronic pre-print archive for physics and math research papers and to examine the claims of the Standard Model (as evidenced by numerous claims by arXiv's founders) that the resource served as a democratizing influence in scientific research. By analyzing the authors posting articles to arXiv.org over time, Meyer & Kling find that the resource is not functioning as a leveling resource with regards to authorship and use a STIN model to explain how other social factors limit who publishes articles to arXiv.org.

Joung & Rosenbaum (2004) argue that it is possible to distinguish between successful and unsuccessful STINs in their discussion of whether the Library of Congress' American Memory Project was widely used. Although they don't fully engage the question of what it means for a technical system to be successful, this raises a point for those interested in STINs: are they to be judged as successes or failures, and by what criteria? It is important, of course, not to exclude failed STINs, or even technology-implementation attempts that failed to develop any sort of sustainable network, from our analysis. Failures can be telling, often more so than uncomplicated successes (Brown & Capdevila, 1999; Markus & Keil, 1994; Suchman, 1996).

2.4.4 STIN methods

Kling et al. (2003) identify a list of heuristics for researching STINs that is meant to be illustrative rather than exhaustive. These steps constitute a method for modeling a STIN. The eight steps are:

1. Identify a relevant population of system interactors
2. Identify core interactor groups
3. Identify incentives
4. Identify excluded actors and undesired interactions
5. Identify existing communication forums
6. Identify resource flows
7. Identify system architectural choice points
8. Map architectural choice points to socio-technical characteristics

(Kling et al., 2003, p. 57)

Some of these steps share elements with SCOT and ANT, but with important differences. For instance, Kling is careful to point out that while identifying the relevant interactors is similar to ANT's following the actor, in STIN research the analyst also attempts to understand the ecology of the interactors <u>before</u> undertaking the field work to identify likely interactors and, in step 2, likely groups of interactors. Step 3 involves understanding incentives (and thus, potential motivations) for interactors.

Step 4 is an important but often overlooked step in other types of socio-technical research[16] – identifying actors who are left out of the socio-technical system and interactions that are undesirable to interactors. In most network diagrams, these actors and interactions would exist only in the white space between nodes and connections, but they may play a key role in influencing the system's outcomes. Step 5 involves examining communication systems, which ties back into the communication regime framework discussed at the beginning of this paper. Step 6 can be thought of, according to Kling, as 'following the money.'

The last two steps are what allow STIN researchers to analyze social change in socio-technical systems. By examining choice points where alternatives are available to interactors within the STIN, the analyst can map those choice points onto the socio-technical characteristics of the STIN identified in the earlier steps of the research.

In reality, STIN research tends to also create a "Standard Model," which is subsequently disassembled. Kling et al. (2003) discuss in great detail the Standard Model of e-SCFs, which includes beliefs in easy and ubiquitous access, low costs of production, and fast publication leading inevitably to widespread adoption of e-SCFs by scholars who will come to see the value of these technological systems and alter their behavior accordingly. Joung & Rosenbaum (2004), argue that the Standard Model of the American Memory Project focuses on the technology needed to digitize historical materials and create search interfaces and "assumes that if digital libraries adopt these processes, they

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[16] Recall that this was one of Winner's criticism's of SCOT theory discussed above (see p. 43).

will have been constructed successfully, independent of the types of libraries and fields to be serviced by them" (p. 30). Eschenfelder & Chase (2002) identify a range of studies that contribute to the Standard Model of web IS research,[17] which views post-implementation processes as essentially an "orderly logical process unaffected by social phenomena", studies that "overlook the wide array of social influences continually shaping web IS" (p. 2).

This raises a point: if there is no Standard Model, no widely accepted understanding of technology held by those within the system and those operating within disciplinary boundaries, does the STIN approach work? Does using STINs require something to demolish? More importantly, is it engaging in the construction of straw persons? We argue that this is not the case. Instead, the creation of a Standard Model is both part of the critical perspective inherent in social informatics research (Lamb & Sawyer, 2005) and part of the storytelling that makes the arguments more accessible to the transdisciplinary audience for STINs.

Storytelling was one of the tools Kling used in his research, in his public speeches, and in his teaching. Many is the time that he would listen to several people debating a topic and then cut in with "Look, it is a simple story…" and then proceed to tell a compelling story that also incorporated elements of complexity in the data that made his story seem more plausible than the "common-sense" explanation that was dominating the public discourse on a topic. This storytelling approach is inherent in how

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[17] However, the authors don't actually use the term 'Standard Model' in their paper.

he chose to explain STIN research. First, set up a story about what “everyone believes,” present data that draws these beliefs into question, and then tell a better, more analytical, and rigorously evidence-based story that incorporates social realities with technological features. While an anecdotal, public understanding of a phenomenon is not required before being able to approach a problem using the STIN strategy, the presence of such anecdotal evidence about a technological phenomenon is in practice often what attracts the attention of a social informatics researcher. After research has been completed, the goal of using rigorous empirical evidence to construct a more compelling story reflects the desire of many social informatics researchers to translate their research on socio-technical systems to a wider audience.

2.4.5 STIN weaknesses and limitations

One of the weaknesses of STIN that must be acknowledged is that to date it has mainly been adopted by close colleagues and former students of Rob Kling. If the STIN strategy is to have any longevity either in information science or in other fields that use the transdisciplinary approach of social informatics, it must be cited, used, modified and extended. Actor-Network Theory, for instance, has achieved widespread use beyond its initial audience in science and technology studies. Even ANT, however, did not achieve instant success. The earliest complete explanation of ANT is probably “Science in Action” (Latour, 1987). While this work has been cited over 2000 times by the end of 2005 according to the Social Science Citation Index, in the first two years after its publication it had been cited a comparatively modest 38 times. Kling’s main STIN paper (Kling et al., 2003) has been cited in 18 published articles by mid-2007, and in a number of other unpublished manuscripts and conference papers, some of which have been discussed in this paper. One test will be to see whether this number increases in the coming years.[18]

Robbin (2005) has argued that Kling's publication record in general did not "create, (re)construct, or extend theory, or create new methodologies for understanding the empirical world of computers in organizations" (p. 23). Instead, Robbin argues, Kling took a practical approach to appropriating theory and method as necessary to explain computerization in organizations and to build a corpus of empirically-based research that "made the unobvious, the taken-for-granted, and the ignored explicit, problematic, and visible" (p. 24).

As might be obvious from the discussion of selected STIN studies above, there is some lack of clarity regarding the language of STINs. STINs are described as a methodology (Kling et al., 2003), a type of entity (Barab et al., 2004; Scacchi, 2005), a framework (Barab et al., 2004; Eschenfelder & Chase, 2002; Scacchi, 2005), and a *post hoc* heuristic tool (Eschenfelder & Chase, 2002).

We would like to suggest that a better term to describe STIN research is to refer to the "STIN strategy." It is fairly clear that STIN does not reach the level of theory, nor is it a proper methodology. STIN is really an analytic strategy. No particular methods are tied to STIN research; in fact, STIN research, like most of social informatics, is wide-ranging

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[18] The current count of 18 shows a slow, but steady increase from the 10 published citations at the end of 2005.

in the selection of specific methods that can be used to gather the data necessary to construct STIN explanations at the analytic level.

The term STIN strategy is appropriate in the sense that a strategy is a goal-oriented plan of action. The goal in this case is to find more complete explanations and thorough understandings of the relationship between the social and the technical in socio-technical systems. Strategies are ways of going about things. STIN diagrams can help visualize relationships and important network nodes, but they are not a method in and of themselves. The STIN strategy leads to choosing particular methods and to favoring certain kinds of understandings about the world, but it maintains the overall social informatics open-mindedness towards a variety of methods and a preference for multiple method approaches to research questions. The STIN strategy is really an analytic perspective based on a strategic way of seeing the world. It is a strategy of approach, research problem selection and analysis, not a strategy of method.

At meetings of social informatics researchers, it has been remarked that in some sense we study the hyphen in socio-technical systems, the area where the connections between social organizations (as studied by sociologists and political scientists) and the technological artifacts (as studied by computer scientists and engineers) lie. Kling argues that “the STIN model shares the views of many socio-technical theories: that technology-in-use and a social world are not separate entities—they co-constitute each other. That is, it is fundamental to STIN modeling that society and technology are seen as ‘highly’ (but not completely) intertwined” (Kling et al., 2003, p. 54).

One of the main concerns that has been expressed by several people in personal communications about the STIN strategy is whether a system that embodies both people and technology can be demonstrated not to be a STIN. In other words, is the notion that a system can be analyzed using the STIN strategy amenable to the null hypothesis that system X is not a STIN for reasons Y and Z? If this is not the case, then everything involved with technology becomes a STIN, which weakens the argument that STINs actually shed light on particular sorts of behaviors and institutional arrangements. This is not a resolved issue and is an area where future research will clarify the STIN strategy.

Some of the weaknesses of STIN, while not published, have been discussed informally among social informatics researchers. For instance, the STIN strategy's inherently organizational bias limits its ability to deal with the broader non-organizational social implications of technology. Another limitation that STIN shares with social informatics research in general stems from its use of a variety of methods: "combining the need for extensive data collection with the complex conceptualizing of socio-technical phenomena means it is a difficult methodological toolkit for many scholars" (Sawyer, 2005, p. 12). This also points to another STIN limitation: the ability to identify successfully and to analyze STINs is heavily dependent on the skill of the investigator at eliciting information from respondents and gaining access to individuals and organizations.

2.4.6 Future of STIN studies

A primary test of using STINs as a research and analytic strategy is whether scholars begin to adopt, test, modify, and extend the strategy in their studies. While some of Kling's close colleagues and former students are pursuing the STIN strategy, there has not yet been much adoption beyond this. Horton & Davenport, however, write that the STIN model is one of the "five 'big' ideas to come out of Kling's social informatics work, arguing that "the tight integration between social and technical in the STIN model provides richer explanatory power [than alternative models]…and is a useful foil in examining over-exuberant claims about CoPs [communities of practice]" (Horton & Davenport, 2005, p. 61). It is hoped that this dissertation adds additional clarity and suggests productive ways to use and extend the STIN strategy for social informatics research.

The next step for the STIN strategy is to test it rigorously against empirical data. There are key questions researchers doing this should ask. First, is the STIN strategy falsifiable? Can it be shown that there are boundaries beyond which the STIN strategy fails to be useful? What types of problems exist within those boundaries? In other words, what is the appropriate STIN problem space? Second, for the problems that exist within the STIN problem space, is the STIN approach the most fruitful way to understand the problem at hand? What does the STIN approach offer that other, more widely adopted approaches cannot offer? What kinds of problems within the problem space are most amenable to STIN research?

A third challenge is a practical one necessary if more researchers are to be enrolled into using the STIN strategy: to articulate more clearly the methods and tools one would use to undertake a study using the STIN strategy. While it is not desirable to have a simplistic approach that involves plugging data into a rigid framework, at the current time the STIN strategy is probably too nebulous to attract the interest of new researchers and graduate students who may understandably be drawn to more concrete approaches. Part of this challenge is more clearly defining the terminology related to the STIN strategy. For instance, as mentioned above there is confusion over whether STINs are entities that occur in the world or models that reflect patterns of organization in the world. In other words, does one *uncover* a STIN that exists independently of the analyst, or is a STIN a model *constructed* by an analyst to understand the world better?

Sawyer & Tapia (2005) argue that while theory building is desirable in the extension of a new field like social informatics, a "more modest approach is to focus on developing, demonstrating and exporting analytic approaches…to bring theory and evidence together" (p. 13) and cite the STIN model as an example. The STIN strategy allows for a nuanced examination of socio-technical systems by integrating the social and the technical, and provides a useful addition to SCOT's focus on case studies of mutual shaping and ANT's methods of following the actants, opening blackboxes, and examining inscriptions. STIN's inclusion of the social roles of interactors beyond their roles specific to the socio-technical system under analysis, its ability to track social actors whose roles are not primarily technical, its attention to excluded actors and undesirable interactions, and its focus on the importance of social change in socio-technical networks all make STIN a worthwhile addition to the social studies of technology and social informatics literature. Together, these approaches offer a set of analytic concepts and tools for studying technology in society.

2.5 Conclusion

So, why use the STIN strategy at all? Why not just do a SCOT or ANT study? Certainly, it would be easier to defend a project that uses a widely accepted theoretical perspective, even one borrowed from a field outside of information science. The problem is this: both SCOT and ANT have elements that are simply not amenable to social informatics research without bending or stretching those theories, possibly beyond recognition. Social informatics, as articulated by Kling (1999), as a field tends to be fairly moderate in balancing the ideas of social constructivism with a preference for evidence-based research that is at least somewhat positivist. As Williams and Edge (1996) point out, the social construction perspective, for its most relativist practitioners, can lead to arguments that artifacts are entirely socially constructed and embody no objective reality whatever. Kling (1992c) was responding to this perspective when he argued that while he agreed "that the capabilities of technologies are not fixed and depend upon social relationships between users, technologies, and other 'close-in' participants" (p. 381), nevertheless one does not need to be a technological determinist to understand that:

> physical objects like guns and roses have some capabilities that are not only arbitrarily derived from the talk about them. It is much harder to kill a platoon of soldiers with a dozen roses than with well-placed high-speed bullets. (Kling, 1992a)

The STIN strategy allows us to draw on the useful insights of SCOT and ANT but does not wholly embrace a relativist perspective and is skeptical of the possibility that non-human actants can exert agency in social situations. Because the STIN strategy is not a theory *per se*, many of the observations in the results section of this dissertation are grounded simultaneously in social informatics knowledge and social reality as observed during the research. One could argue that this means that social informatics uses a form of grounded theory (Strauss, 1993), but one that is more strongly informed by socio-technical knowledge of a research domain than grounded theory, which is arrived at entirely inductively. Thus the research questions for this project are informed by social informatics knowledge as reflected in the STIN strategy but are also open to new, unexpected socio-technical behaviors and relationships emerging from the data collected for the research.

CHAPTER 3: DIGITAL PHOTOGRAPHY AS A SOCIO-TECHNICAL PHENOMENON[19]

Digital photography is a relatively new topic for scholarly study in the area of social informatics. Photographic technologies were only first computerized in the 1990s but have rapidly supplanted older film technologies for a majority of professional uses. Digital photography has not simply substituted silicon chips for film, but also has brought about rapid changes throughout the photographic process as photography entered the realm of information technology. This chapter presents a typology for approaching the study of photography as a socio-technical phenomenon and then presents several examples illustrating the consequences digital photography has for amateurs and professionals. Examples include photojournalism, scientific photography, photography in the legal system, and personal photography.

3.1 Background

Digital photography rapidly emerged as a technology during the 1990s and achieved high levels of adoption during the first decade of the 21st century. This new computer mediated form of photography had long been anticipated. Vannevar Bush (1945) discussed the development of photographic technology in his influential *Atlantic*

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[19] A chapter containing portions of this section has been accepted for publication as Meyer, E.T. (2008). Digital Photography. In St. Amant, K. and Kelsey, S. (Eds.), *Handbook of Research on Computer Mediated Communication.* Hershey, PA: Idea Group Reference. Copyright 2006, Idea Group Inc. www.idea-group.com. Used with permission of the publisher.

Monthly article “As We May Think.” Among his predictions were miniature, wearable cameras, capable of holding 100 images, that used fixed focus and auto-exposure to achieve high-quality results. He also predicted that ‘dry’ non-chemical photography would result by developing still cameras that used similar principles to television, using moving beams of electrons to record images. While the details of the modern process differ from Bush’s predictions, by the 1990s digital cameras were developed that achieved these feats and more.

Digital photography has all but replaced traditional film photography in recent years. By 2006, all the major camera and film manufacturers had discontinued the manufacture of most types of film and film cameras (Fackler, 2006). Minolta, in fact, went so far as to cease all production of cameras and film, abandoning their photography division entirely in March 2006. While there has been some attention to how this shift away from film and away from traditional camera manufacturers has affected companies in the photo industry, many of the most interesting consequences of digital photography are reflected in the use of photography by professionals. Even though digital photography has become ubiquitous in the last five years amid claims that it is a ‘revolutionary’ technology (Ritchin, 1999), there has been relatively little research into digital photography as a socio-technical phenomenon.

Why would an information scientist study digital photography from a social informatics perspective? Except for research into digital image libraries and HCI research on personal photography software, information scientists have not written extensively about photography.[20] Certainly scholars in other fields including art history, journalism, and cultural studies have built an extensive literature on photography and are beginning to address digital photography. How can a social informatics perspective help understand either the technology or the socio-technical networks in which digital cameras operate? There are at least three compelling reasons to consider digital photography from a social informatics perspective.

First, much of the scholarship on photography treats the technology of cameras as a completely black-boxed phenomenon.[21] Serious scholarly literature focuses primarily on the images created by black-boxed cameras and their effects (Squires, 1999) while paying little attention to how the technology itself has been constructed, but one notable exception is Maynard (1997). On the input side of the black-boxes are rays of light and on the output side an image, either a latent image on film or a set of 1s and 0s representing the light falling on a silicon chip. “Photography is nothing other than…a technique of inscribing…a stable image generated by a ray of light” (Damisch, 1978/1980, p. 287). This inscription serves the same purpose as Latour’s inscriptions in actor-network theory: “A text or statement can thus be read as ‘containing’ or ‘being about a fact’ when readers are sufficiently convinced…” (Latour & Woolgar, 1979, p. 76). This process of inscription and black-boxing results in a tendency for researchers not

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[20] Searching JASIS and JASIST for the term photography, for instance, yields only three articles, all on aspects of retrieval of items from libraries of images.

[21] Blackboxing and inscriptions are discussed in more detail above in the Actor-Network Theory section.

to question the nature of photographic technology and its role in the social systems where it is put to use.

The perception that cameras record reality in an unbiased fashion has helped to give photographic inscriptions their power. Freund (1980) argues that the camera’s “inherent ability to transcribe external reality gives it documentary validity—it is, seemingly, both accurate and unbiased” (p. 4), although in practice it allows distortion through selection of point of view and mode of presentation. Photography has long been perceived as evidentiary in the sense that viewers of photographs tend to feel that what they see has a strong correspondence to reality (Mitchell, 2001, p. 24). That the camera and positivism emerged simultaneously (Berger & Mohr, 1982; Stanczak, 2004) is not coincidental. “Both this technology and this philosophical framework stem from the notion that the Truth could be discerned from the objective facts as observed in the world, and that documentation of these facts could lead to the harnessing of certain social processes and outcomes” (Stanczak, 2004, p. 1471).

With digital photography’s advent as a new kind of photography using very different techniques for the production of photographs, we have the opportunity to re-examine the socio-technical features of the technology by comparing and contrasting digital and traditional cameras as they have been black-boxed. From the mid-19th century until the 1990s, photography was a purely analog medium, using light and chemical processes to inscribe images. However, the introduction of the combined package of digital cameras, scanners, editing programs like Photoshop, and the widespread popularity of these packages moves photography into the realm of computer technology as computerized photographs are shared on web pages and photoblogs, published on Internet news sites, and transmitted via networks by scientists, police and other professionals. Prying open long-sealed black-boxes may allow us to understand better the complex interaction among actants within the socio-technical interaction network of photography.

Second, cameras have not been analyzed as actors involved in the mutual shaping that occurs as cameras affect human actors, including photographers, their subjects, and their viewers. In turn, the cameras are socially constructed by human actors. Digital photography translates (in Latour's (1988) meaning of translation) the relatively complex and labor-intensive chemical processes of traditional photography into a relatively simple and accessible set of steps required to view the resulting images on a computer or to print them out for viewing.

Finally, very little literature has attempted to discuss directly the socio-technical interaction networks that include cameras, digital or otherwise. Most of the literature on photography examines photographers solely in their role as photographers and does not discuss how they are also social actors with multiple, overlapping roles and expectations. By following the STIN approach, however, this research will try to peel back the layers of complexity in the socio-technical networks of which digital cameras are a part.

Together, these three reasons provide a basis for arguing that social informatics has something to offer the literature on digital photography. In addition, digital photography offers to social informatics and information science not only an interesting case study but also the opportunity to examine a pervasive communication technology that has thus far not been the subject of a great deal of research.

3.1.1 Traditional photography

Traditional film-based photography has long been discussed as a revolutionary force for social change in the world by historians of photography and photojournalism. Most of these accounts are in the mode of standard “effects of technology” stories rather than a more SCOT-like social constructivist view, but they nevertheless recognize the camera as a potent technology with implications in the social world. Regarding even photography’s earliest days, Marien writes that “one of the earliest indications of the conversion of photography from an invention to an active agent in the social world was the patenting of both the calotype and daguerreotype processes [in 1839]” (2002, p. 25). An essential element of photography’s revolutionary nature was that it automated the artistic process in ways that painting or sculpture could never hope to:

> By this process, without any idea of drawing, without any knowledge of chemistry and physics, it will be possible to take in a few minutes the most detailed views, the most picturesque scenery, for the manipulation is simple and does not demand any special knowledge. (Daguerre, 1839/1980, p. 12)

Szarkowski argues that this “mechanical and mindless process” was a “radically new picture-making process…based not on synthesis but on selection” (1966/2003, p. 97). The notion that photography, as a technological innovation and as a socio-technical system, is a potentially revolutionary and radical force for social change recurs again and again among photography’s leading critics. Jenkins (1975) argues that the creation of the amateur photography market by George Eastman “revolutionized both the photographic industry and the social role of photography" (p. 1). Freund writes that "the camera has become an instrument of major significance to our society" (1980, p. 4), while Sontag adds that "photography has become almost as widely practiced an amusement as sex and dancing…it is mainly a social rite, a defense against anxiety, and a tool of power" (1977, p. 8).

The social impact of photography can be discussed on multiple levels: from the social changes associated with the easy production of family snapshots used to record personal histories to the social impact felt by influential photographs that have been used to document the range of human experience and suffering in the world. From Matthew Brady's Civil War photographs, to the WPA photographers who documented America in the depths of depression, to Vietnam-era images of war and protest, to digital photographs of torture in Iraqi prisons, photographs have influenced public perception of events and molded public reaction to public policy (Berger, 1980/2003; Eco, 1986/2003; Marien, 2002; Sontag, 2003; Sturken & Cartwright, 2001). An in-depth study of this topic would require much more space than is available here, but it is useful to note this phenomenon to help put digital photography in perspective. The recurring references to the social impact of photography on society demonstrate the socio-technical nature of photography and indicate that a SCOT/STIN approach could yield useful insights into the mutual shaping and interactions among elements of this socio-technical system.

3.1.2 Digital shift

A frequent reference in the popular and professional press discourse on digital photography is that it is part of the 'digital revolution.' Ritchin, for instance, rather hyperbolically argues that “moving from chemically processed grain to discrete electronic pixels…[may make digital photography] as distinct from its predecessor…as the automobile was from the horse-drawn carriage” (1999, p. xii). Much of the popular discourse about the impact of digital photography tends to focus on the embedded features in the technology itself; Meyer (2005b), for instance, reports that 32% of themes in a sample of articles in popular press sources from 2000-2004 dealt with technological features of digital cameras.[22] It is easy to argue that the proponents of digital photography have been remarkably successful in selling their product to consumers: in 2003, sales of digital cameras surpassed those of film cameras and in 2004, consumers purchased 48% more digital cameras (15.7 million) than film cameras (10.6 million) (Gleeson, 2004). Clearly, a great many people have been able to legitimate their investment in digital camera equipment.

One interesting side note of the new digital “revolution” in photography was that it came at a time when the film photography industry was experiencing economic difficulties (Frangos, 1993; Swasy, 1997). It remains to be seen what the long-term effect the change to digital will have on the industry. While companies such as Kodak, Polaroid, Fuji and others have dropped or severely curtailed their production of film, Kodak has also repositioned itself as a leader in digital photography camera sales, and other companies such as Casio have entered the field. In some ways, particularly at this

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[22] Cass & Lauer (2003) argue that although digital camera technology has no particular technological requirement to have basic looks and functions that are similar to familiar film-based cameras, these familiar design features are skeumorphs, or attributes that refer to familiar functional features of previous technology, that serve to temper the social and psychological impacts of innovation.

stage, digital cameras are changing so rapidly in capabilities and features, one can casually observe that photographers are now replacing cameras more like computer aficionados replace computer equipment. We have anecdotally observed that rather than acquiring a core set of equipment and purchasing lenses and accessories, which is what people appeared to do in the seventies and eighties, people now regularly upgrade their core cameras, software and other equipment. If this is true, it could actually signal a new period of sustained economic growth through planned obsolescence for the photography industry that parallels that of the computer hardware and software industry. This possibility merits further study.

A techno-centric perspective emphasizes the extent to which new technologies can alter the processes of photography, such as allowing arbitrary image manipulation or the rapid access to vast digital corpuses; it focuses on the features of the technology and on the technical skills required to use the technology. While this individualistic and technologically-centered perspective has value, it does not address broader questions of social change related to the new technology. This is not to say that scholars have not yet begun to study digital photography from an academic perspective, for they have. The majority of serious literature[23] on digital photography falls into three main categories: debates on the impact of easy digital manipulation of photographs, discussions of digital photography's role in photojournalism, and studies of personal photography. The following section briefly outlines some of this research.

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[23] Excluding the literature solely interested in the artistic aspects of digital photography, which is well outside the scope of the topics being discussed here.

3.2 Photography Domains

Cameras are used by a wide variety of people for an equally wide variety of purposes. Photography is an egalitarian art form. Unlike painting or sculpture which generally require relatively extensive skills and training before the amateur is able to produce a piece that recognizably represents reality, the camera allows even the rankest of amateurs to produce an image that allows easy identification of its subject. While additional training and practice can help distinguish gifted photographers from the masses, the fact that automatic exposure and focusing allows anyone at all to produce a decent image makes photography unusual. This democratizing nature of photography has been recognized since the medium's earliest days.

The result of this ease of use is that cameras have become ubiquitous in much of the world. Masses of people armed with cameras and camera phones stand ready to document people, places and events at a moment's notice. Given this fact, how can one even attempt to come to some understanding of such a widespread phenomenon?

Faced with such a daunting task, it is helpful to break down various types of photographers using a simple but ultimately helpful typology as shown in Table 2.

Table 2: Types of people using photography and examples of each

	Photographers	Use photography
	I	II
Professional	Photojournalists Wedding/events Sports Advertising	Scientists (biology, medicine, astronomy, archaeology, ecology, etc.) Police/courtroom
	III	IV
Amateur	Hobbyists Photography clubs Citizen journalists	Personal snapshots Family photographs Scrap bookers

In this simple 2x2 table, people who use photography are divided along two axes. The left dimension distinguishes between professional and amateur photographers. While in reality the difference between vocational (professional) and avocational (amateur) approaches to photography may lie more on a continuum instead of two discrete categories, this simplification serves well here. Evidence suggests that professionals and amateurs view photography differently, and use photography in different ways. This observation is based on the author's own research and on other literature about differences between professionals and amateurs. (See Star & Griesemer (1989) for a discussion of differences between professionals and amateurs in science and Stebbins (1992) for a thorough discussion of the complex relationship between professionals and amateurs in general).

It is important to note that there is no value judgment implied here: amateurs are not less important, or necessarily less knowledgeable, than professionals. Certainly, an amateur photographer may be far more knowledgeable about the specifics of camera equipment than a professional scientist using photography as a scientific tool. Nevertheless, besides the obvious financial difference between amateurs and professionals, there are undeniable differences in the ways amateurs and professionals are viewed by the public, and these differences have meaningful consequences.

The top dimension represents another aspect of identity: whether the person using a camera is a self-identified *photographer*, or whether they have another more important role, in a symbolic interactionist sense (Mead, 1934), to which their practice of photography is secondary. In this sense, they *use photography*, but are not primarily a *photographer*. So a professional sports photographer falls in quadrant I, whereas a scientist who uses photographic techniques falls in quadrant II. The sports photographer has *photographer* as a primary role and an important part of their personal and professional identity. The research with scientists described in this dissertation, on the other hand, suggests that marine mammal scientists generally do not view themselves as photographers, but as scientists, and that cameras and photography are simply scientific tools no different from a microscope or mass spectrometer. *Photographer* is generally not a role they identify with in their professional career, or when it is, it is a smaller, secondary role to their major role as a scientist.

The difference between these two quadrants is significant. Professional photographers have to engage photography daily as the main driving force behind their work. Professionals who *use* photography but are not primarily photographers, on the other hand, are often less engaged in debates about photography but are no less significantly affected by changes in technology. Their level of engagement reflects that they have other more central roles to which their practice of photography is secondary.

Likewise for amateurs, an amateur photographer connotes someone actively engaged in the hobby of photography (quadrant III). Again, *photographer* is a major role, in this case an avocational role rather than a professional role. Compare this to college students going to a party and sending casual snapshots via their camera phones. Without any particular interest in photography *per se*, it is still possible to own and effectively to use photographic equipment, but in this case the person is using photography to fulfill other needs and desires such as social interaction and as a tool for memory (quadrant IV).

The four categories here are related to people's social roles, and thus may be situation-specific. For instance, a scientist who photographs microscopic specimens in her professional role may also be a hobbyist photographer on the weekends. Unless she is framing her scientific specimens and entering them in her photography club's exhibitions alongside scenic views of lakes and rivers, these two roles are separate and situation-specific.

We argue here that people occupying roles in the different quadrants of this table view and use photography and digital photography differently and have different expectations for, and understandings of, photographic technology. Whereas a quadrant III amateur photographer may be very interested in detailed technical differences between image production techniques, quadrant IV scrap bookers are generally going to be more interested in whether a particular shot is representative of the event they are trying to memorialize.

Examples of types of people using digital photography are also listed in the table above. The fields with some current research available to review include photojournalists (in quadrant I) and scientists, medical researchers, and police forensic photographers (in quadrant II). This dissertation mainly studies QII, a somewhat unusual and very understudied quadrant, even though there are (undocumented) assertions that "the largest area of actual employment for photographers is almost certainly in the scientific areas, where most photographers have staff positions with regular hours and regular salaries" (Marshall, 2006). While there have been studies of QI and QIV which will be discussed below, studies of QII and QIII are very limited. We suggest that the lack of research on these two quadrants is not because they are inherently uninteresting, but because they have generally been overlooked. Scientists who use photography for their work are tied to technological advances driven by markets dominated by QI, III, and IV but may have requirements that are not of interest in the other quadrants. While in some sense this means that this research is studying secondary role patterns of scientists, in the case of scientists who rely on photographic data to make scientific advances, we argue that it is a key secondary role, and one which can shed some light on the other quadrants as well. In the long term beyond this dissertation, future research is planned to collect data representative of all four quadrants to compare more comprehensively their similarities and differences.

3.3 Uses of digital photography

When considering digital photography as a socio-technical phenomenon, the table discussed above helps us to focus on domains where the computerization of photography has had the most impact on communication processes. We will look at examples from each of the four quadrants in turn. Quadrants I and II are of most relevance to this work on the professional uses of CMCs, but quadrants III and IV are also help illuminate our understanding of the topic.

3.3.1 Photojournalism

Photojournalists are an interesting case because of the tight coupling between their work behavior and the technology associated with photography. These quadrant I professional photographers have a professional identity that is inextricable from their role as photographers. In addition, the communication aspect of their use of information technologies is central to their work communicating news stories to the public. Evidence suggests that the shift to digital photography for news organizations has led to tensions within the work system. According to Mitchell, “Their unconventional channels of distribution conspire to make [digital images] very difficult to pin down…There is an erosion of traditional boundaries between artist or photographer, editor, archivist, publisher, republisher, or viewer” (2001, p. 53).

These tensions may be particularly acute due to a conservative attitude among news employees toward change in the workplace and work practices noted by Daniels & Hollifield (2002) in their study of organizational change in newsrooms. For example, the comparative ease with which digital cameras may be used may lead news organizations to send out a reporter armed with a digital camera instead of sending an accompanying professional photographer (Lowrey & Becker, 2001; Menaker, 2004). Tensions also arise between generations of employees: as new journalism school graduates enter the workforce, they are being differentially selected for having technological skills (Hansen, Paul, & Neibergall, 2003). Existing senior employees, however, may view these skills as unimportant compared to their better developed conceptual skills. Reporters, photographers and editors must adjust to new information-processing tools and behavior patterns (Fahmy & Smith, 2003). Employment will be in jeopardy for lab technicians and others previously involved in developing, printing, cataloging and storing photographs unless they find a role to play working with new digital systems.

The ability to delete photographs on location using digital cameras affords photojournalists greater control over their images as they decide what to keep or delete, but that this in turn leads to a tension with their editors (Fahmy & Smith, 2003). Some research estimates that one quarter of all digital images are deleted by photojournalists by differentially choosing images or through censorship (Puente, 2005). War photographer Peter Howe commented that “the problem with digital cameras is, I think, they will radically reduce the amount of images available. If these field commanders are allowed to censor images before they're transmitted, and they don't like a particular image, they can just say, ‘Delete it’” (Baker, 2003, p. 7).

There have been several recent studies examining changes in photo departments once digital methods are adopted. Russial (2000) examined changes in photo departments once digital imaging was adopted by a newspaper. Zavoina & Reichert (2000) report a tension between photo staffs responsible for print versus online editions of newspapers, with online editions having fewer staff but with a higher proportion of the staff members holding decision-making authority. Other issues include the dependence of field photographers on a ready supply of electrical power for computers and batteries for cameras, which changes their work patterns (Meyer, 2003), as well as the ongoing tension over digital manipulation of photographs, particularly how this possibility may affect the public’s view of the truthfulness of news photographs. Another notable study done by Boczkowski (2004a) doesn’t focus on digital photography *per se* but offers a social informatics view of the overall digitization of the newsroom, particularly web editions of newspapers.

3.3.2 Scientific photography

Scientific digital photography is an interesting but understudied area. Photography is an integral part of many scientific projects. Certainly, technocentric manuals are available (Ray, 1999), various specialized journals (e.g., *Journal Of Ophthalmic Photography*), plus any number of more artistic books showing the beauty possible in scientific imagery. Archaeologists use cameras to document excavations, wildlife biologists use photographs to identify and track animals from whales to elephants, microbiologists record images of microscopic specimens, and astronomers record optical and radio images of distant stars and galaxies. Medical research and clinical medicine rely on photographs for brain imaging, documentation of dermatological disorders, plastic surgery documentation and follow-up, mammography, and a myriad of other uses for data collection and patient care. However, even with the widespread use of photography in the sciences, most of the publications in this area are limited either to "how to" manuals and journals that focus on specific equipment and techniques or to art books showing the beauty of the scientific world. To date, very little research has examined the consequences of using photography (digital or otherwise) in science.

Several studies are available discussing the role of the image in scientific practice, from scientific illustrations influencing the practice of enlightenment science and the public perception of the scientific endeavor (Ford, 1992; Shea, 2000) to the role of scientific imagery in gender and power discourses by feminist science studies researchers (Treichler, Cartwright, & Penley, 1998). Mitman (1999) discusses the role of nature films in shaping Americans' relationships with nature and wildlife. However, to the best of our knowledge, the research described in this dissertation represents the first work on digital photography from either an information science or science and technology studies (S&TS) perspective.

3.3.3 Photography in the legal system

Another domain of quadrant II professionals is that of law-enforcement personnel who use photography in their work with the police and in courtrooms. Digital photography is involved in the legal system in several ways. Forensic teams take photographs of crime scenes; police use automatic cameras to photograph license plate numbers of cars speeding, running red lights, and driving in restricted areas; the wounds of assault and abuse victims are documented with photographs; and citizens' photographs of crimes and of inappropriate or illegal behavior by the police themselves are used to identify and potentially to prosecute or reprimand perpetrators.

Digital photography is allowing police to prosecute certain types of crimes more aggressively, including domestic abuse cases. Whereas blurry snapshots used to take weeks to wend their way through processing labs and to find their way to the courtroom, digital photographs of bruises and wounds can be immediately sent electronically to judges and prosecutors who can use the evidence to prosecute abuse cases even without the victim's consent (Kershaw, 2002). Domestic abuse victims are often unwilling to press charges against their abusers, but prosecutors have pushed for "mandatory prosecution" policies that allow prosecution without the cooperation of victims. The ready availability of digital photographic evidence of abuse to present to the court has increased the ability of prosecutors to hold and charge abusers who formerly would have been released due to uncooperative victims and lack of convincing evidence to present in court.

Police departments and the courts are computerizing all aspects of the legal system, and photographs play a part in a variety of systems. Police use in-car databases that can pull up photographs of suspects and computerized mug shot databases. Courts use case management systems that allow efficient tracking of cases throughout the justice system. Forensic scientists use digital photographs to document evidence of crimes, and can use image analysis tools to examine digital photographs and videos for evidence.

Forensic science is an interesting example of how advancing technology can have unexpected and unforeseen social consequences. A recent concern among legal experts is the so-called “CSI Effect.” Not limited to digital photography, the CSI Effect refers to the changing expectations of juries who expect high-tech, definitive evidence based on what they have seen on the popular television show *CSI: Crime Scene Investigation* and its offshoots. The speed of analysis, ability to use computers to enhance digital images, and highly automated systems that forensic scientists are portrayed using on these popular television shows has caused concerns that juries come to the courtroom with unrealistic expectations of what forensic science is able to accomplish. While forensic scientists have far more tools at their disposal than in the past, the flashy television version moves well into the realm of science fiction and can cause juries to be wary of evidence that is not as impressive as what they have seen on television.

Despite some early concerns about the potential easy manipulation of digital images, digital photography has been widely adopted by police agencies and courts. The concerns expressed about maintaining the chain of evidence required for admissibility into evidence have been addressed in several ways. Software programs designed to verify the authenticity of digital photographs have been developed, and police departments have established procedures for transmitting and storing digital images. Crime scene technicians can also be called to testify that the digital images represent what they saw at the crime scene. In short, if the images are a "fair and reasonably accurate representation" of what photographers observed with their eyes, the evidence is considered admissible (Parke, 2003).

Digital cameras are also influencing policing due to the growing ubiquity of small digital cameras, video cams and camera phones that people routinely carry. There have been a number of high-profile instances of citizens using digital cameras and camera phones to snap pictures of crimes in progress. In addition, there are growing numbers of cases of citizens recording still or video images of police allegedly abusing suspected perpetrators that are regularly surfacing in the media and on the Internet. Websites have been set up to track incidents of alleged police brutality and misconduct. Thus, digital photography has the consequence of increasing both the likelihood of catching criminals, and of catching inappropriate police conduct.

Digital surveillance is another key issue in the legal system. Surveillance cameras are increasing in quantity, particularly in urban areas. The United Kingdom has been among the most aggressive at establishing a "surveillance society," installing digital CCTV cameras throughout public spaces in London and the rest of the UK. Other countries, including the United States, have been less aggressive in monitoring public spaces, but concerns over crime and terrorism are causing law enforcement personnel to consider increased monitoring. Increased public surveillance raises a number of issues, including concerns over balancing the privacy rights of citizens against public desires for reducing crime and increasing safety (Norris, McCahill, & Wood, 2004).

3.3.4 Other professional domains

The number of other studies of digital photography is limited, but at least one additional area is worth noting, since the findings in the study may have some impact on this research. Frosh (2003) studied mass produced advertising images, specifically those produced and distributed through the stock photography industry. Frosh refers to the visual content industry as a “regime of signification” (p. 8), and argues that a range of changes in the stock photography industry related to new technologies, changing markets, and shifting economic realities are all operating to fundamentally alter the regime in which stock photographers operate. Both the approach and the notion of regimes (see below) reflect many of the same issues that this research raises, and will potentially provide a very useful contrasting study in a different domain than that studied here.

3.3.5 Amateur photography: Snapshots, camera phones and Web 2.0

While much of the discussion of photography so far has been on professional uses of photography, it would be remiss to discuss digital photography without mentioning the growing research into people’s personal uses of digital images. A prominent researcher in this area is Van House (Van House & Davis, 2005; Van House et al., 2004). Van House’s work examines the social meanings people place on photographic images. Much of the related research in this area is from a Human-Computer Interaction (HCI) design perspective. HCI strives to understand the interfaces designed to facilitate the use of images, and of image capture and storage devices.

Research in this area has examined how casual photographers use and want to use digital photographic technologies. Frohlich et al. (2002) suggests that users have the same difficulties in organizing their digital photos as they did when faced with piles of photo albums and shoeboxes stuffed with prints. They have a desire for new ways of sharing, sending, indexing and annotating photographs for their personal use. Unfortunately, this desire is mostly unsatisfied for now. In fact, several studies have found that only two features of indexing software were desired or used regularly: date-based sorting and showing lots of thumbnails on the screen. In software with more complex indexing and annotation features, these advanced features were not used after initial experimentation (Graham, Garcia-Molina, Paepcke, & Winograd, 2002; Rodden & Wood, 2003). Camera phone users, in fact, have been shown to be uninterested in the wide variety of options for annotating photos, and mainly want to be able to attach either a short personal comment or a witty remark to their images (Wilhelm, Takhteyev, Sarvas, Van House, & Davis, 2004).

Studies of camera phone users (Van House & Davis, 2005) and photobloggers (Cohen, 2005) both suggest that digital photography changes people’s definitions of what is worthy of being photographed. Due to the essentially zero per-shot cost of taking a photograph, users are more likely to take pictures of mundane or ‘silly’ things, and in fact, Cohen argues that photobloggers are often motivated by a desire to share their particular view of the world, especially of mundane objects in the world. Cohen also notes that photobloggers use their photoblogs to motivate them to take and post new photographs more regularly than they may have in the past, consistent with Rodden & Wood's argument that users took far more photographs (an increase of between 20% and 200% for their subjects) once they began to use digital equipment (Rodden & Wood, 2003).

Photoblogging is part of the so-called Web 2.0 phenomenon. In general, photoblogging is seen as a social networking activity on the internet, enabled by sites that allow easy posting of photographs to share with others. The range of activity of photobloggers tends to fall into two types which are consistent with quadrants III and IV of Table 1, according to Meyer, Hara, & Rosenbaum (2005). The quadrant III photobloggers are amateur photographers, who regularly post artistic photographs, often to their own dedicated websites. The quadrant IV photobloggers, who are more engaged in photo sharing than photoblogging, are posting snapshots of events, friends, family, and travel. These photo-sharers often use popular mass market sites such as Flickr rather than dedicated personal websites.

3.4 Digital image manipulation

It is important here to discuss one of the more contentious issues regarding the computerization of photography: the increasing ease with which images can be altered. Image manipulation is, of course, nothing new in the field of photography. Even though photography has been widely seen as a tool for recording objective reality, all photographs other than ones taken by totally automatic processes involve some degree of manipulation. The position where the photographer stands in relation to the scene, the instant at which the exposure is made, the choice of camera, lens, shutter speed and aperture, and the selection of which photographs among many to print and publish can all be considered manipulations of reality. In addition, traditional photographic techniques allow for a broad range of manipulations between the moments when the shutter is pressed and the final print is displayed. Film may be over- or under-developed to compensate for exposure issues during developing, and prints may be dodged, burned, developed in various chemicals and using various papers, and retouched. Ritchin notes in his influential book on photography's digital revolution that digital techniques themselves did not create the possibility of leading and mis-leading through photography: "Photographs have long been used to illustrate preconceptions. They have long been decontextualized, misdirected, cynically relied up to confirm certain values by those who control their use" (1999, p. 125). Electronic technology, he argues, just allows it to be done better and more easily than before and is forcing those involved to re-examine their understanding of photographic meaning. Mitchell (2001) agrees with Ritchin that photographs have long been manipulated in a variety of ways both technical and non-technical but remarks that:

> The growing circulation of the new graphic currency that digital imaging technology mints is relentlessly destabilizing the old photographic orthodoxy, denaturing the established rules of graphic communication, and disrupting the familiar practices of image production and exchange. This conditions demands, with increasing urgency, a fundamental critical reappraisal of the uses to which we put graphic artifacts, the values we therefore assign to them, and the ethical principles that guide our transactions with them. (2001, p. 223)

This concern for the possible negative effects of digital manipulation is echoed in a number of articles including Gross et al.'s (2003) introduction to the volume that includes Bousé (2003) examining wildlife photography and Soar (2003) discussing advertising photography. Chapnick worried at the beginning of the digital era that photojournalism was "on the brink of widespread abuses of [its electronic capabilities]" (1994, p. 349). One possible outcome, according to Ritchin, is that the authorship of images will be reinforced: by claiming responsibility for the content and representation within images, photographers can assume a role of vouching for their images to prevent their viewers from becoming skeptical of the content shown.

Not all digital manipulation is viewed in the same ways, however. In certain photographic fields, such as journalism, manipulation can result in serious consequences, including ending a photographer's career. In advertising photography, on the other hand, digital manipulation is considered one of the essential skills photographers need to have in their arsenal today.[24]

The introduction of computer mediation of photographic communication raises the potential for manipulation to new levels. Altering an image is much easier with Photoshop or comparable programs used to alter images digitally and is harder to detect in many cases. "Here, photography and digital imaging diverge strikingly, for the stored array of integers has none of the fragility and recalcitrance of the photograph's emulsion

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[24] For examples see Stucker (2007a) showing the extensive computer retouching and compositing required for an automotive advertisement, and Stucker (2007b) for examples of some of the world's most sought after electronic retouching and digital editing services.

coated surface…The essential characteristic of digital information is that it *can* be manipulated easily and very rapidly by computer" (Mitchell, 2001, p. 7). Changes to the array of pixels in a digital image can be made to the original image, and in skilled hands can be done undetectably. Compared to developing photographs in darkroom, the editing tools of digital photography allow anyone with a computer and appropriate software to manipulate photographs without the involvement of a skilled technician.

Photojournalism in particular has taken a strong stance against the manipulation or alteration of photographs. Two leading professional organizations for photojournalists, the American Society of Media Photographers and the National Press Photographers Association, both have strong statements in their codes of ethics against electronically altering photographs. The following is representative of the view maintained by these professional societies:

> As journalists, we believe that credibility is our greatest asset. In documentary photojournalism, it is wrong to alter the content of a photograph in any way (electronically or in the darkroom) that deceives the public. We believe the guidelines for fair and accurate reporting should be the criteria for judging what may be done electronically to a photograph. (National Press Photographers Association, 2003)

With such a strong position, one might conclude that photojournalists never engage in manipulation of photographs and have the strongest possible incentives to avoid the temptation of such manipulation. In practice, however, a variety of manipulations clearly occur, and the reaction in most instances when such alterations are discovered has been swift and decisive. Public apologies and firings have resulted from such seemingly insignificant alterations as digitally erasing the name of a competing newspaper from a player’s uniform in a sports photo, or digitally placing a tennis ball in a shot of a tennis serve. The fact that even these apparently unimportant alterations have been dealt with decisively underscores the magnitude of the fear that allowing any sort of digital manipulation of news photographs will result in widespread public distrust of photojournalism. The easy manipulation of digital photographs will require that organizations place additional emphasis on the reputation of photographers, editors and publications as a means of reassuring viewers that images are not intentionally misleading: “As it becomes easier to tamper with the evidence of the photograph, all those involved in the process of publishing photographs will personally have to vouch for the content of the image” (Ritchin, 1999, p. 98).

3.5 Conclusion

Scholarly research into digital photography as a form of information technology is only recently receiving serious attention. While there is great deal of literature on the topic of photography, relatively little of this deals with the role of photography as a technology that has social consequences. Only with the recent advent of digital photography and the computerization of the whole photographic process has photography come to the attention of information and communication technology researchers. The ubiquity of digital photography tools, however, will almost certainly lead to a growing number of studies in this area.

This chapter has discussed various domains that use digital photography as a socio-technical phenomenon. By distinguishing between professionals and amateurs, and between self-identified photographers and those who use photography mainly as a tool for other purposes such as scientific data collection or maintaining personal relationships, this chapter has offered an entrée into a large and complex set of socio-technical relationships. Several examples have been used to illustrate the range of issues that arise once photography moves from a communication technology to a computer mediated technology. These examples are by no means exhaustive of the ways in which photography is used, but they represent good illustrations of the issues arising for each of the various types of people who use photography.

A number of tendencies and tensions arise when individuals and organizations begin to use digital cameras and other digital photography tools. Digital cameras are generally viewed as easier to use and simpler than film cameras, but they actually require a much more complex computerized technology package to use to their fullest. Film cameras required the purchase of a camera, possibly a detachable lens, and film which could be sent for developing. Darkrooms were entirely optional, and relatively rare. Digital cameras require the purchase of a camera which is often more expensive than comparable film cameras, possibly a lens, memory cards to store images, a computer to retrieve images from the camera, software to manage and manipulate the images, a color printer, and possibly online access fees. While some of these elements are optional, this complete package is a much more common setup than private darkrooms were to past generations. While it is possible to take one's digital camera to the drugstore to print out a single copy of a shot before deleting it, this practice is not the norm.

Besides purchasing this complex assemblage, those wishing to make photographs must also learn to use all these tools. As we will see below, scientists keeping catalogs of whale tail photographs cannot just maintain a folder of slides on a shelf. Now they must learn to work with databases and various computer hardware and software packages or hire additional staff to do this work for them. Photojournalists no longer send their film to the lab for developing but must instead travel with computers with network connections (possibly via satellite in remote locations) and manage their photo collections on-site. The advantage in speed comes at a cost of increased complexity.

Other contrasts are apparent as well: people take more photographs, but they tend to print fewer of them. More photos are deleted, but more are shared through e-mail or websites. Fewer chemicals are required, but computers have their own embodied environmental cost. Ongoing costs are lower, but equipment may initially be more expensive. In addition, digital cameras, software and computer systems all experience relatively rapid obsolescence and are replaced much more quickly than film cameras traditionally have been. Photo manipulation software allows users to easily correct errors in exposure and framing but also sets the stage for potential distrust of photographs by allowing for easy manipulation of files to create images that misrepresent reality.

A wide variety of amateurs and professionals have adopted digital photography for both personal and work-related uses. For both groups, those who identify as photographers and those who simply use photography as a tool, there are important consequences to adopting this technology. However, there has been a paucity of scholarly research that has sought to understand the implications of this new form of computerized photography. While social informatics and human computer interaction researchers have started to study digital photography, additional attention needs to be paid to the social and organizational impacts of new photographic technologies. Digital photography is undeniably here to stay, at least until it is replaced by a newer technology. As a widespread technology with the ability to shape public opinion, scientific understanding, and personal relationships, digital photography and related technologies are worthy of far more scholarly attention, and the hope is that more academics will take up this call to study digital photography from a variety of disciplinary and interdisciplinary perspectives.

CHAPTER 4: RESEARCH PROCESS AND METHODS

This thesis has shown that there is a well-developed theoretical literature arguing that technology is socially constructed, particularly within the SCOT and ANT traditions, less so for the STIN approach. When designing this project, it was argued in the proposal that an approach using the elements of the theoretical approaches discussed above (SCOT/ANT/STIN) might benefit from the addition of the concept of communication regimes as to investigate a new area of study, digital photography. The argument was that since digital photography encompasses such a wide variety of possible activities, it was necessary to have a way of establishing boundaries that would limit the scope of this research. Communication regimes offered a potential way to do this by limiting the research to organizational settings as opposed to informal and personal uses of photography. The degree to which this assertion proved to be supported by the data will be discussed in the results and discussion chapters. In short, the general social construction / STIN approach proved very valuable in uncovering significant aspects of the socio-technical nature of scientific photography, but the notion of there being relatively stable rules and systems (communication regimes) guiding scientific practices proved problematic. However, even were there no refinements to theory offered by this research, the lack of empirical and theoretically-grounded research into digital photography, which is becoming a nearly ubiquitous feature of modern life, represents a major gap in the literature that the work reported here seeks to bridge.

This chapter employs a fairly traditional organization for a discussion of methods. However, the reader should note that in the appendices, there is an extended reflexive discussion of the nature of the research written in more personal terms. In a dissertation attempting, in part, to uncover ordinary scientific practices that often disappear behind cleaned and sanitized publications, it would seem slightly dishonest to translate the very real and human dimensions of this research itself into a truthful but, by necessity, formalized methods chapter without also including the more human side of the research. The goal in including this additional section is to provide transparency about the real practices engaged in during the research and to be forthright about its successes and failures from a methodological perspective.

4.1 Preliminary work

The author of this project has engaged in research into STINs and into various aspects of the socio-technical nature of digital photography since this research began in 2003[25]. Prior to the defense of the proposal for this dissertation, the author also engaged in preliminary work with marine mammal researchers to determine the feasibility of the study to gauge the interest among the scientists in participating, to identify key players,

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[25] Peer-reviewed conference presentations based on reviews of full papers have been presented on communication regimes (Meyer, 2005a), and on the development of media frames about digital photography (Meyer, 2005b)[25]. Other conference presentations were made on the general topic of digital photography and include research on manipulation of photographs (Meyer & Kling, 2003) and on photoblogging on the Internet (Meyer et al., 2005). A version of the section of this paper examining and critiquing the STIN strategy was published and presented at the International Human Choice & Computers (HCC7) conference in Maribor, Slovenia (Meyer, 2006). Finally, the reflexive methods discussion in the Appendix I was presented and discussed extensively at an international workshop on studying scientists in action held in Fribourg, Switzerland in 2007 (Meyer, 2007b).

and to identify likely research sites. In December 2005, the author attended the biennial meeting of the Society for Marine Mammalogy (SMM) in San Diego, California. The SMM is the main professional organization for scientists studying marine mammals.[26] At this meeting, he attended every paper, panel and poster session for which the abstract indicated any involvement with photo-identification and spoke with the author(s) if they were available. In these approximately 45-50 conversations, he described this research project, asked researchers some general details about their project's involvement with photo-identification, digital photography, the size of their group, and the location of their work and field sites. He also asked the researchers who else he should be meeting, and gained a number of valuable personal introductions this way.

While these contacts were preliminary and did not involve formal interviews, he was able to gain valuable initial insights into this field, some of which are reported above in the background section. The author also identified many of the key players in the field and was able to obtain agreement from scientists at a number of research sites who agreed to participate in this research; these sites are identified below. Overall, the scientists who were approached were very interested in this work, open to participating in it, and very interested in the results as a way to continue to improve their own research and technology choices in the future. Attending this meeting proved to have been a vital first step in ensuring the success of this project.

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[26] Every scientist interviewed (n=41) belonged to the Society for Marine Mammalogy, and many identified it as their most important professional affiliation.

4.2 General methodological approach

Studying digital photography use by scientists could be approached in a number of possible ways, but an appropriate strategy for answering the research questions laid out above (p. 7) is case study research. Marine mammal researchers operate within a bounded system of scientists, which makes them amenable to the case study approach (Stake, 1998). Furthermore, the reason for studying this multi-site case (Creswell, 1998; Nadai & Maeder, 2005) was to develop an instrumental case study that helps to pursue an external interest of refining theory, as opposed to developing an intrinsic case study designed primarily to understand the phenomenology of a particular case (Stake, 1998). Multiple sites, which can also be thought of as specific sub-cases of the main case, were selected not in an attempt to make statistical generalizations about a population, but to develop analytic generalizations about theory because "if two or more cases[27] are shown to support the same theory, replication may be claimed" (Yin, 2003, p. 38). Case study research, which may use either positivist or interpretive approaches, is also a commonly accepted tool in information systems research (Myers, 1997), particularly for research that "investigates a contemporary phenomenon in a real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used" (Yin, 2003, p. 23).

This study involved qualitative research, including 41 semi-structured interviews at 13 sites (visiting nine in person and four by telephone), and one period of observation

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[27] Or, as is used here, sub-cases (sites) contributing to the larger case (marine mammal scientists using photo-identification methods).

of marine mammal scientists on boats in the field at the Atlantic Dolphin Research Institute. Originally, we had hoped to include 2-3 periods of observation of the boat-based activities of the scientists. The main reason why very little observation of the scientists in the field was included is that much of the marine mammal research is done on small boats in remote and sometimes sensitive locations, and accommodating an observer proved not to be physically possible or geographically feasible in most cases. In addition, it became clear that many of the most interesting things about marine mammal photo-id work from a socio-technical perspective occur after the photographs have been collected in the field and are organized and processed back on shore. These are discussed in detail in the results chapter.

4.2.1 Sample

The research sites selected for this study were identified through a purposive method involving an examination of recent research articles in marine mammalogy using photo-identification methods, by talking with every available scientist presenting a paper or poster using photo-identification methods at the 2005 Society of Marine Mammalogy biennial meeting, and by asking them to recommend others who might participate in this project. While this sort of purposive sample has limitations, particularly with regard to being able to generalize from a small sample to a large population, in a small field such as the subject of this study it can be the most efficient way to gain access to “information rich” participants in the domain (Patton (1990) cited in Morse (1998)). Marine mammal researchers are located in a variety of public, private and educational institutions around the world, and there is no specific organization[28] or special interest group dedicated to photo-identification methods. Thus, there was no practical way to establish a population from which to draw interview subjects randomly. In addition, since the author traveled to the laboratory locations, some limitations of logistics had to be taken into account. However, the researchers and research sites chosen were often referred to, unprompted, during interviews at other, unrelated sites, indicating that they are part of a shared network of scientists. Many have been involved in this work for a considerable period of time[29]. We are confident that this sample does not misrepresent ordinary scientific practice in the marine mammal photo-identification subfield.

4.2.2 Field sites

Table 3 summarizes the participating research sites in this project. The sites chosen demonstrate some of the variety in the types of organizations involved in marine research. Non-profit organizations ranged from very small institutes with just a few employees in an out-of-the-way location to large campuses with multiple buildings and hundreds of employees. Some of the facilities were closed to the public, while others had public outreach facilities such as museums, aquariums, and boat trips. The colleges and

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[28] While the Society for Marine Mammalogy (SMM) is the major professional affiliation for the scientists in this study, the Society itself also has many more members not engaged in photo-related work. Other common techniques include genetics research, acoustics, and invasive health assessments. With no way to reliably identify which SMM members used which technique, drawing a representative sample would have had its own inherent limitations.

[29] Most of the sites included are shown in a table of photo-identification projects listed in a 1988 report on a symposium convened to bring photo-identification researchers together for the first and apparently only time (Hammond, Mizroch, & Donovan, 1990); (Mizroch, personal communication, Dec. 2005).

universities were on campuses familiar to anyone in higher education, and the facilities housing the scientists were typical university office and laboratory spaces. The government facilities tended to be large campuses with multiple large buildings housing hundreds of employees, but the animal research programs share these campuses with many other marine biology and oceanographic research programs. Several of the sites are described in much greater detail in the results chapter.

Table 3: Research sites and number of participants

Site Name[30]	Acronym	Type of organization	# of scientists*	# interviews	Type of interviews
Atlantic Coast Marine Center	ACMC	Large non-profit	6-20	1	Telephone
Atlantic Dolphin Research Institute	ADRI	Large non-profit	21-100	4	In-person
Canadian Science Center	CSC	Government agency	6-20	1	Telephone
Coast College	CC	Liberal arts college	<5	2	In-person
Dolphin Bay Center	DBC	Small non-profit	<5	2	In-person
Federal Marine Agency	FMA	Government agency	100+	4	In-person
Gulf Coast Research Institute	GCRI	Large non-profit	21-100	4	In-person
Northern Pacific University	NPU	Teaching university	6-20	1	Telephone
Pacific Whale Project	PWP	Mid-sized non-profit	6-20	8	In-person
Southern Gulf University	SGU	Research university	6-20	9	In-person
South European Dolphin Center	SEDC	Small non-profit	<5	1	In-person
U.S. Marine Agency	USMA	Government agency	6-20	3	In-person
Whale Canada	WC	Small non-profit	<5	1	Telephone
Total sites = 13				41	

* Includes only scientists involved in marine mammal research. Some of the groups are part of much larger organizations that support a wide variety of marine research activities and, in some cases, public outreach such as education programs and aquariums. All numbers are estimations based on participant-provided information.

While a non-representative case study could have been produced by visiting just one site, by comparing and contrasting what occurs at the different research centers, this study is able to reach some general conclusions about the field of marine mammal photo-id research. This is preferable to being able only to consider what happens at a single,

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[30] All names of research sites and of the participating scientists have been replaced with non-identifying pseudonyms. The pseudonyms for participants were generated using a random name generator available on the Internet at [http://www.kleimo.com/random/name.cfm].

possibly idiosyncratic, location. In fact, it will be shown below that the sometimes idiosyncratic nature of ordinary scientific action is one of the key findings of this research. The multi-site method of creating a case study from a number of sub-cases provides a higher degree of certainty that this research is accurate and representative of this sub-field.

4.2.3 Site visits

Site visits were planned primarily via e-mail messages and telephone calls with the primary contact at each site.[31] In some cases, the primary contacts arranged interview times with their colleagues; in other cases, they provided contact information and the author was then able to work out individual schedules with each participant prior to arrival.

During the site visits, participants were generally interviewed in their offices or laboratories. In most cases, they were near their computers and could demonstrate examples of their work on their computer screens. They were also asked to show how they did their work, and at many sites it was possible to observe various stages of the photo-ID process, including data collection on the water and photo matching from both paper-based[32] and computer-based catalogs (see Figure 1).

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[31] For much more detailed information on the challenges of planning site visits, see Appendix 1.

[32] The results chapter includes a more detailed discussion of using paper-based catalogs to match digital photos, which at first glance may appear somewhat anachronistic to a technologist looking at this field.

Figure 1: Typical computerized and paper-based catalogs

For this research project, the site visits were relatively brief, ranging from 1-3 days each, depending on the number of people being interviewed. While short visits of this nature are not ideal compared to extended interactions, the relatively large number of interviews done during multiple site visits mitigates some of the weaknesses of this data collection strategy.

4.2.4 Additional telephone interviews

A small number (n=5) of additional researchers were interviewed by telephone after all the site visits had been completed. Most of these interviews were with scientists working in locations that made interviewing them in person not feasible due to the cost of traveling a long distance for just one or two interviews. Four of these five scientists interviewed by telephone were selected using similar purposive methods as that for the selection of sites visited in person. The fifth was an additional subject from one of the previously visited sites who was in the field at the time of the site visit. While telephone interviews do not allow an appreciation of the local context in the same way that in-person visits do, by doing the telephone interviews at the end of the project after visiting a wide variety of sites allowed the author to have a ready appreciation for the descriptions provided by the scientists being interviewed.

Table 4: Research schedule

Year	Month	Activity
2006	July	Successfully defended proposal
	October	Visited 1 research site
	November	Visited 1 research site
	December	Visited 4 research sites
2007	January	Visited 2 research sites
	February	Visited 1 research site
	March-May	Did telephone interviews at 4 research sites Updated research database with document evidence Polished theory and background portions of dissertation
	June	Final updates to research database Final analysis Wrote results section and remaining dissertation text
	August	Defend dissertation
	After project ends	Publish results in peer-reviewed journals and present data at a variety of conferences in information science, social studies of science and technology, and marine mammal research.

4.3 Specific methods of data collection

4.3.1 Semi-structured interviews

One challenge for the qualitative analyst is to ensure that the data collected from a semi-structured interview (Bernard, 1995) will be something more than simply reporting emic, or insider, versions of events. One of the goals of those studying technology through a social lens is not just to understand and relate the narratives told about technology by the users:

> [Analysts] must be able to pack concepts as well as unpack them, to deconstruct narratives, and then to reconstruct more credible and reflexive alternative narratives. They must be able to make knowledge claims about technologies and their role in the social order, not just simply be commentators about others' claims. (Kling, 1992a, p. 355)

Levy and Hollan (1998) describe the person-centered interview approach, which is particularly useful for examining "the nature of the relations…between individual members of the community and their historical and current socio-cultural and material contexts. How are community members *constituted* by their contexts?" [emphasis original] (p. 333). To do this, it is important to understand the difference between an informant and a respondent, and to direct interviews skillfully toward eliciting the types of information available from both of these perspectives. An example of the type of question that would use the interviewee as an informant is: 'Could you describe for me how digital photography came to be adopted within this organization?' The question encourages the interviewee to answer as an expert witness of sorts, which tends to result in the types of answers that reflect local cultural expectations of how things are meant to be, regardless of how they are in practice. Asking questions that treat the interviewee as a respondent, on the other hand, are more likely to result in more personal information that may reveal significant differences from the culturally expected answer. For instance, 'Can you tell me about your first digital camera?' followed by 'How did you learn to use it?' and 'Did it change your work in any way?' are all geared toward the personal, but in a way that illuminates an understanding of the social. "Person-centered interviewing moves back and forth between the informant and respondent modes" (Levy & Hollan, 1998, p. 336) and helps to uncover the tensions between social and cultural expectations and individual experience of events, a goal of the research reported here. Thus, the interview schedule incorporated person-centered interview techniques.

The questions in the interview schedule were derived from discussions held with marine mammal researchers at the Society for Marine Mammalogy meeting in December 2005, combined with Kling's methods for studying STINs and the research questions enumerated above. The interview was not formally pre-tested with a non-participating scientist. While this had been the intention, a series of appointments made shortly after the acceptance of the proposal were cancelled by potential pre-test subjects at the last minute. As a result, time ran out before the first interview had to be done, at a location that coincided with the author's conference travel. Because of the inelasticity of the interview date and the fact that the first site was a very small one, it was decided that this first site would constitute both the test of the instrument and the first set of interviews. Had the instrument needed to be changed in substantive ways, these first interviews would have been excluded from the study. As it turned out, the first interviewees were interviewed and also de-briefed, and no major modifications were found to be necessary in the range, type, or wording of questions. Thus, these interviews were included in the study, and the same research instrument was used throughout the interviews.

All interviews were recorded using a small digital audio recorder that saves files in WMA format. Each interview was copied to both a laptop computer and a backup external hard drive each evening during the research trips.

Notes about each interview and site visit were recorded in the research database for the study as soon as possible after each interview, usually the same evening after returning to a hotel. This timeliness is important, so that observations will be fresh in the researcher's mind (Wolcott, 1990).

Table 5: Number and length of interviews

	Total	Mean	Range
Interviews	**41**		
Length of interviews (in hours:minutes)	**54:00**	**1:19**	**0:33 – 3:13**
Length of transcripts (in pages)	1,132	28	12 – 63
Words in transcripts (in thousands)	480 K	12 K	5 – 27 K

All the interviews were transcribed by a distributed team[33] of transcribers, who all followed a similar format for transcription. The audio files were delivered either by registered mail or by password-protected and encrypted HTTPS secure download using utilities provided by Indiana University.[34] Table 5 provides details of the number and length of the transcribed interviews. In all, the 41 interviews comprised 54 hours of audio. The transcriptions totaled 1,132 pages, and took less than seven workdays to transcribe using this distributed method. While some consistency was sacrificed by this approach, the overall speed with which the transcribing was completed at a reasonable cost could not be matched by other methods.

4.3.2 Document analysis

One of the strengths of person-centered interviews is that it helps to uncover competing versions of events. Another method for understanding the relationships and tensions between official accounts and concrete practice is by examining both internal and external documents generated within and about the scientist's organization. This

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[33] See Appendix I for the whole story behind the team of distributed transcribers who worked on this study.

[34] The Slashtmp service (https://www.slashtmp.iu.edu) provided by Indiana University's UITS (University Information Technology Services) department allows for secure, password protected downloads with a uniquely generated URL for each file and no directory browsing capability. A sample download URL (https://www.slashtmp.iu.edu/public/download.php?FILE=etmeyer/92655WNWzuq) demonstrates how this services differs from posting a list of files on a non-secure website, or on an FTP-server with easily guessed file name patterns.

documentation can include memos, agendas, minutes, announcements, proposals, progress reports, and news articles. In practical terms, the types of documents obtained for this research tended to fall into several categories: procedures manuals, websites, photographs, news reports, newsletters, and written output such as reports, journal articles, and research manuscripts including master's theses. In all, 115 documents totaling 1,098 pages were included in the research database, as were 405 photographs (246 taken in the course of the research, and 159 provided by participants) (see Table 6). These external documents are in addition to the 41 interview transcripts, totaling 1,132 pages. The entire database had 561 items totaling 2,635 pages.

Table 6: Research database summary

Source documents	# of items	Total pages
Interviews	**41**	**1132**
Photographs	**405**	**405**
Taken during research	246	246
Provided by research subjects	159	159
Documents	**115**	**1098**
Internal communications (manuals, memos, reports, etc.)	24	280
External communications (articles, newsletters, websites, etc.)	92	818
Total	**561**	**2635**

As Yin points out, "these and other types of documents are useful even though they are not always accurate and may not be lacking in bias …the most important use of documents is to corroborate and augments evidence from other sources" (Yin, 2003, p. 87). In other words, documentation helps the analyst triangulate accounts of events using multiple sources of evidence.

4.3.3 Field observations

Another type of evidence was collected through direct observation of scientists in their work settings. During a field visit, the case study researcher can record observations of environmental conditions and social behaviors. As Yin points out, “if a case study is about a new technology, for instance, observations of the technology at work are invaluable aids for understanding the actual uses of the technology or potential problems being encountered” (2003, p. 92). While observing may seem like a natural and somewhat passive activity, a researcher must plan carefully to avoid being either marginalized or influencing the observation setting too greatly. Creswell (1998) identifies a series of steps for observing social environments. These include identifying gatekeepers and key informants for access into the observational setting; recording notes in the field of both a descriptive and a reflective nature; recording details about individual behaviors, the physical setting, events and activities as well as one’s own reaction to these details (pp. 125-126). These procedures were followed by this study and documented in the case study database.

Writing up field notes of observations is essential and is another area where anthropologists have developed reliable tools for ensuring the accuracy and usefulness of field notes. Bernard (1995) advocates planning to spend 2-3 hours per day in the field working on writing field notes and never sleeping on one’s notes: “You’ll forget a lot of what you would like to have in your notes if you don’t write them up in the afternoon or the evening each day” (p. 191). Following this advice, notes were written each evening after returning from a day’s interviews and observations. Bernard’s advice to keep many small notes organized chronologically rather than a long running commentary was followed. He recommends this both to facilitate organization and to allow easier analysis in programs such as NVivo, which assist with coding and analysis, creating part of the case study database.

4.3.4 Coding

All interviews, photographs, and other supporting documents were double coded using NVivo 7. The first coding for each interview took between 40-60 minutes, on average, depending on the length of the interview and the density of pertinent information provided by the respondent. After all the interviews were coded once, a second, quicker coding on each document using the stable coding tree was done to make sure that codes added inductively while coding later transcripts were also coded in earlier transcripts. Documents and field notes, which were generally more specific and of shorter length, were coded once each. In most cases, there is a great deal of additional information available for further research that could be re-coded and re-analyzed in the future.

The coding categories (see appendix, p. 314) were a combination of pre-designed codes based on the research questions for the project and codes that were inductively discovered from the data (Strauss, 1993). The coding structure was somewhat fluid during the early coding stages, but quickly stabilized after coding just a few interviews; later interviews added only a handful of additional codes.

4.3.5 Multiple methods

Using multiple methods with careful attention to the compilation of a case study database addresses some of the shortcomings that occur too frequently in qualitative research. The use of triangulation, or multiple methods, reflects an attempt to secure an in-depth understanding of the phenomenon in question, since objective reality may be difficult or impossible to capture (Denzin & Lincoln, 2000, p. 2). The multiple methods in this case involved personal interviews, observations in the lab and in the field, and the examination of documents. Case studies generally use triangulation as a way to clarify meaning through both verifying that an observation is replicable and, conversely, identifying ways the phenomenon is seen differently by different actors (Stake, 1998).

4.4 Data analysis

Field notes and transcribed interviews were maintained in NVivo. NVivo 7, while limited in many ways, does help with organization of qualitative research data and permits easy accessibility when mapping the data to the research questions for the study (Bong, 2002; Bourdon, 2002). The interviews, field notes, and other materials were all coded to assist with analysis (Creswell, 1998; Emerson, Fretz, & Shaw, 1995; Strauss, 1993). Even though computerized organization of qualitative data can be useful in generating some automatic data, such as numbers of codes, the actual winnowing of the data into useful themes for writing the narrative involves extensive manual involvement with the data (Creswell, 1998; Lincoln & Guba, 1985). As Yin notes, “the analysis of case study evidence is one of the least developed and most difficult aspects of doing case studies” (2003, p. 109). Yin goes on to note a strong preference for analyzing case study data by starting from theoretical propositions which are laid out as a series of research questions. The research questions identified above and the general principals of the STIN strategy allowed for this approach. Thus, the qualitative data was coded, examined and analyzed for evidence to answer each research question, and also for evidence that the research question was incorrectly posed due to a misunderstanding of the domain.[35] Special attention was paid to describing accurately the social contexts inhabited by marine mammal scientists, keeping an open mind to alternative interpretations and maintaining healthy suspicions of the narratives of insiders (Klein & Myers, 1999).

Levels of interest for the data analysis stage included the individual scientists, the research sites, the research specialties (i.e., species studied), and the actual case, the overall field of marine mammalogy photo-identification. Each level contributed to a better understanding of the socio-technical system, and allowed for the creation of a more complete STIN model.

4.5 Assessing quality in qualitative research

In qualitative research of this nature, the positivist notions and measures of validity, reliability, and generalization are somewhat problematic (Kvale, 1995). That is not to say, however, that the analyst is immune from addressing potential concerns about the quality of the research. Polkinghorne suggests that "validating knowledge claims is not a mechanical process but, instead, is an argumentative process…to convince readers

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[35] NVivo itself, however, proved in many ways to be far less useful than hoped. See the reflexive fieldwork account in the appendix for a more complete discussion of the shortcomings identified in NVivo.

of the likelihood that the support for the claim is strong enough that the claim can serve as a basis for understanding of and action in the human realm" (2007, p. 476). Such techniques used to support the argumentative claims made in the course of the research included employing complete discussions of the methods used and problems encountered during the research (in this chapter and in the appendix), keeping and documenting a research database showing the types and quantity of data collected, using multiple methods and multiple sources of evidence to triangulate claims, and collecting data from a variety of research participants at a variety of research locales. In addition, techniques such as member checking were used to enhance the reliability of the research. Member checking involves clarifying statements made by the research participant during the course of a conversation or interview and also reporting back to participants to get their feedback on what was written about them (Lincoln & Guba, 1985). The former was done in all cases, the latter in selected cases. While none of these techniques alone assure acceptable quality, taken together they strengthen the researcher's ability to make claims about the domain being studied.

Social informatics (SI) is an odd field with regard to methods. Part of this stems from the fact that SI is not, in fact, a coherent field of study, but instead is a set of loosely connected researchers studying similar problems that ask the analyst to problematize socio-technical interactions. Since those who self-identify as SI researchers come from a wide variety of disciplinary backgrounds, they bring with them a variety of disciplinary biases about how research is to be carried out. The most important thing for many SI researchers, however, is to choose a method appropriate to studying the question at hand that will yield reliable and/or trustworthy empirical data. Whether those data are collected in a quantifiable format or in a qualitative format matters less than matching the methods to the question.

This study was exploratory in many ways. The study focused on a little studied field (albeit within the much-studied general area of ‘scientific behavior’) that uses an understudied technology (photography). The STIN approach to asking research questions has not been widely tested. Because of the uncertainties underlying such a situation, it was not possible to design a formal survey, or administer a standardized instrument and to expect to yield meaningful information about the socio-technical realities of marine mammal scientists. However, this research did not precisely follow a grounded theory (Strauss, 1993) approach, either. Grounded theory advocates primarily coding up from the data in an inductive way to determine categories found in the evidence collected. The STIN approach is a hybrid – some coding is done inductively, generating new categories based on the evidence in the data. However, the STIN approach did allow going into the field with an extensive list of pre-defined categories, reflected in the nine research questions guiding this study. These research questions are similar to a more positivist approach to data collection, with the exception that they were not framed as hypotheses that could be falsified but as working propositions from which to launch the questioning, coding, and analysis.

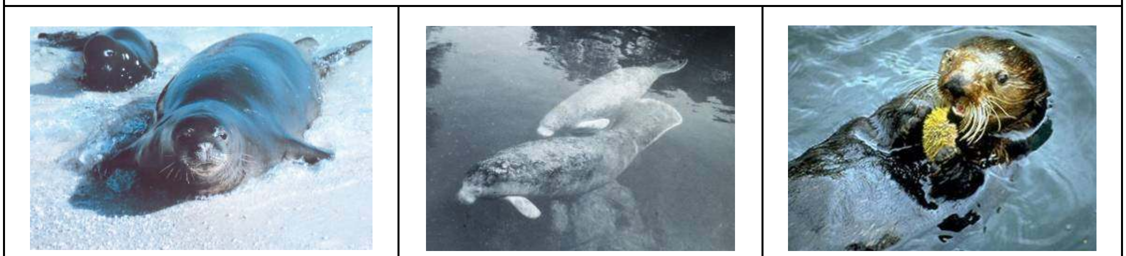
4.6 Conclusion

Brower (2000) makes four recommendations for improving qualitative research: 1) push description to explanation, 2) improve the quality and quantity of data, 3) develop theoretical sensitivity, and 4) develop sensitivity for the backstage. The STIN approach addresses points 1 and 3, by attempting to explain socio-technical phenomena rather than simply offering descriptive accounts and by linking these explanations to the theoretical underpinnings described above. The case study approach and ethnographic methods described above all were chosen to improve the quality and the quantity of data that were collected. Finally, the overall argument that technology is part of a process of mutual shaping and social construction addressed the analytic depth required to understand the backstage activities of scientists while the triangulation methods described provided tools for documenting how this backstage activity influences behavior and plays a role in creating social change.

CHAPTER 5: MARINE BIOLOGY AND PHOTO-ID

While the central questions guiding this research pertain to the computerization of photography and the ways in which the switch to digital photography has had an impact on the ordinary practices of marine mammal scientists, to understand this change we must first understand how photography came to be incorporated into marine mammal science and the role that image technology has played in advancing the field's scientific agenda. By looking at the development of this technique, which for some researchers provides the bulk of their scientific data, we will see that there have been socio-technical considerations linked to photo-identification from the beginning.

Cetaceans



Pinnipeds Manatees Sea otters

Figure 2: Marine mammals[36]

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[36] Photo credits: All photos are public domain NOAA photos, identified below.
1) Humpback whale breaching image: Image ID: sanc0605, NOAA's Sanctuaries Collection. Available online: [http://www.photolib.noaa.gov/htmls/sanc0605.htm]

5.1 Marine mammals and public controversy

Marine mammal science includes the study of whales & dolphins (order *Cetacea*), seals, sea lions & walruses (order *Carnivora*, superfamily *pinnipedia*), manatees (order *Sirenia*), and sea otters (order *Carnivora*, family *mustelidae*, genus *enhydra*) (see Figure 2). Many marine mammal species have been the subject of intense debate as various groups have sought to negotiate the tensions among a variety of stakeholders. The first half of the 20th century coincided with a growing scientific interest in field biology and the naturalistic study of animal behavior. Prior to this period, most professional scientists working on animal studies were confined to laboratories, and field-based observations were considered the realm of amateurs. Between the two world wars, however, an important shift took place in the academic study of wildlife that resulted in much more emphasis on the collection of data in the field and the observation of the natural social organization and relations of animals (Mitman & Burkhardt, 1991).

Along with this change in scientific practice was a growing understanding of the relationship between human activities and the world's ecosystems. Whaling, for instance,

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2) Three dolphins bow riding image: Image ID: anim0860, NOAA's Ark – Animals Collection, Photographer: Commander Grady Tuell, NOAA Corps. Available online: [http://www.photolib.noaa.gov/htmls/anim0860.htm]
3) Killer whale in ice: Image ID: anim0840, NOAA's Ark – Animals Collection. Available online: [http://www.photolib.noaa.gov/htmls/anim0840.htm]
4) Hawaiian monk seal image: Image ID: anim0293, NOAA's Ark – Animals Collection, Photographer: Dr. James P. McVey, NOAA Sea Grant Program. Available online: [http://www.photolib.noaa.gov/htmls/anim0293.htm]
5) Manatee cow and calf image: Image ID: line1147, NOAA's America's Coastlines Collection. Available online: [http://www.photolib.noaa.gov/htmls/line1147.htm]
6) Sea otter image: Image ID: nerr0875, NOAA's Estuarine Research Reserve Collection. Available online: [http://www.photolib.noaa.gov/htmls/nerr0875.htm]

has been the subject of controversy and negotiation since the impacts of centuries of whaling became clearly evident in the first half of the 20th century. In 1946, the International Whaling Commission (IWC) was established to “try to put a brake on the decimation of the whale populations in the Southern Ocean” (Hammond, 2006, p. 54) but was not able to establish a moratorium on commercial whaling until 1986. Other actors such as the Save the Whale campaign (founded in 1977) have worked in a highly visible way to raise public awareness of threats to the world’s whales, including “killings, captures, bombings, and pollution” (Save the Whales, 2007). Meanwhile, stakeholders from the whaling industry (including most notably Japan, but also 30 other pro-whaling countries) continue to push for the end of the temporary 1986 moratorium on whaling put in place by the IWC (Kyodo News Service, 2007), and indigenous populations already have limited exemptions to the ban.

Other marine mammals have also been central players in controversies about hunting, habitat, and the environment. The infamous news videos of the Canadian seal industry produced in 1964 touched off the ‘Seal Wars’ as various environmental organizations sent protesters to try to stop the clubbing of baby harp seals (Lee, 1989), and the controversies over the annual seal hunt continue to this day (BBC News, 2004). Stakeholders in this controversy include scientists, Canada’s government, the governments of other nations controlling imports of fur, the fur industry, consumers, environmental organizations, animal rights groups, and, if one extends the concept of actants to non-human players, arguably the seals themselves.

Other controversies include the dolphin-safe tuna consumer labeling movement aimed at limiting the number of dolphins taken during the fishing of yellow-fin tuna, conflicts between local fishing industries and shellfish-eating sea otters, and disagreements over harbor seals that have taken up residence in spots inconvenient to some humans, such as the famous La Jolla Children's Pool resident colony. The fishing industry, in particular, has repeatedly called for culling various marine mammal species which compete for fish stocks:

> Science will never put an end to calls for culling marine mammals. There will always be segments of society that will, because of their values, attitudes or objectives, continue to call for culls of marine mammal populations. In some of these cases, culling proposals will arise out of a genuine belief that there is a real conflict. In many others, marine mammals will continue to be used as scapegoats for failures in fishery management. In still other situations, calls for culling marine mammals will simply be part of a political strategy to promote commercial consumptive use of marine mammals, including both seals and whales. (Lavigne, 2003, p. 42)

Whales, seals, otters, dolphins, and a host of other marine mammals have been and continue to be at the center of controversies over the environment, resource use, animal rights, the economy, and human-animal interaction.

Popular entertainments also contribute to the ongoing public relations battle being waged in these controversies, as evidenced by movies such as *Free Willy* and *Whale Rider* and a whole host of animal themed television programs on specialty cable networks like the Discovery channel. These shows and movies carry on the tradition started by earlier influential television programs of the 1960s such as *Flipper*, *Mutual of Omaha's Wild Kingdom*, and the animal episodes of *The Wonderful World of Disney*:

> One cannot underestimate the benefits science and environmentalism have accrued from the interest in wildlife and nature stimulated by film. For many of my generation, *Flipper*, *Sea Hunt*, and *The Undersea World of Jacques Cousteau*, along with family summer vacations spent in America's national parks, were decisive childhood influences in shaping our aspirations to become more deeply involved with animals and nature. By eliciting an emotional relationship with wildlife on screen (who among us did not long for a pet dolphin just like Flipper?), film strengthened my desire to make intimate contact with animals in the wild. And by encouraging a sense of wonder and intrigue, natural history film instilled a passion for biology and the natural environment that motivates me to this day. (Mitman, 1999, p. 207)

In addition to these films and videos, books,[37] magazine articles and news articles continue to cover the activities of marine mammal scientists. Nexis, for example, shows that major newspapers published nearly 750 news articles in 2006 containing the phrase "marine mammals," and searching for "whales" or "dolphins"[38] each yields more than the Nexis search limit of 3000 results. Marine parks such as Sea World continue to draw large numbers of visitors,[39] and eco-tourism is a growing industry (Tsui, 2006). One segment of the eco-tourism industry that has drawn particular interest from scholars is whale watching, which is viewed by many as a relatively benign way to allow people to see wild whales and dolphins on the open water. Corkeron notes that "whale watching is one of the most rapidly growing forms of nature-based commercial tourism in the world today" (Corkeron, 2006, p. 162) but also cautions that this growth can also represent a threat to marine species. Lusseau (2004), for instance, shows that having commercial tour boats near dolphins with less than 68 minutes between dolphin-boat interactions is too

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[37] For example, see Hand's (1994) *Gone Whaling* and Whitehead's (1990) *Voyage to the Whales*.

[38] For the dolphin search, also included AND NOT football, to exclude the Miami Dolphins football team.

[39] See Davis (1997) for a in-depth examination of the operation and corporate culture of Sea World.

energy costly for the animals, reducing the overall time the animals spend resting and causing them to avoid the area. Nevertheless, the relation between commercial marine mammal watching and scientists is generally a good one. In one study of whale watching in the Vancouver Island and San Juan Island area, it was noted that "the commercial whale watchers and the research community have excellent relations, exchanging information on the whereabouts of the whales, on their behavior, and on the well-being of particular members of the whale population" (Lawrence, Phillips, & Hardy, 1999, p. 484).

The intersection of this public interest combined with the highly public controversies such as those mentioned above are pertinent to this discussion because the presence of such controversies also fuels interest in scientific research (Martin & Richards, 1995). Furthermore, a controversy over scientific methods helped spur the development of photo-identification methods. Previous scientific methods included the capture and release of biological specimens, radio tagging, biopsy sampling, branding or tagging individual animals, or the even more controversial killing and dissection of wild animals for scientific research. According to Weinrich (1987), "most [whale] research was conducted using the carcasses of dead whales before the 1970s." A growing number of researchers, however, were interested in developing new techniques that were non-lethal, and non-invasive compared to the techniques described above (Hammond et al., 1990). According to one early pioneer in dolphin photo-identification:

> The original seed of the idea [to use photography for identification]…came from talking around the campfire… It was one of these fun things where ideas come to fruition independently due to synergism and the overall status of the sciences. In the 50s, I don't think anyone would have really come up with that idea... I

> remember telling [a prominent scientist in 1971] about this idea of photo-identifying, and he said, ‘Don’t do it. It is not worthwhile. You’re barking up the wrong tree. You can’t do it, you’ll be disappointed. The only way to do it is to catch them and brand them.’ But, of course, they use photo-identification now very successfully. (Interview with Dr. Gerald Lemoine[40])

The idea of using natural markings to identify individual animals did not originate among marine mammal researchers. Würsig and Jefferson (1990) cite sources showing that biologists studying honeybees, graylag geese, zebras, black rhinoceroses, giraffes, and others all pre-dated the efforts by marine mammal researchers to use naturally occurring markings instead of the more common practice of artificial marking and tagging used widely during the 1950s and 1960s. Non-systematic use of natural markings to identify individual marine mammals, however, had been practiced as early as the 19th century by whalers and fishermen, although this tended to be limited to small numbers of particularly distinctive animals (Würsig & Jefferson, 1990).

Another important impetus for the development of non-invasive techniques in the early 1970s was the passage of the Marine Mammal Protection Act (MMPA) by the U.S. Congress. The MMPA issues prohibitions (with certain exceptions) “for any person subject to the jurisdiction of the United States or any vessel or other conveyance subject to the jurisdiction of the United States to take any marine mammal on the high seas” ("Marine Mammal Protection Act," 1972). The act also prohibits the importation or possession of marine mammals or products made from them. While scientific research was one allowable reason for a permit that would allow takings, the act clearly stated that

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[40] All names of people interviewed for this research have been replaced with pseudonyms in this manuscript.

lethal permits (‘level A harassment’) would only be issued in cases where nonlethal methods were not feasible. Even ‘level B’ harassment (such as getting close to the animals with boats to take their photographs) requires a permit.

By the early 1970s, there was a perfect storm for developing new methods of studying marine mammals. The public was interested in saving wild animals and the environment, political forces had passed the MMPA, young scientists were looking for less invasive methods for studying marine mammals, and the camera industry had recently developed relatively affordable SLR (single-lens reflex) cameras with interchangeable lenses allowing photographs to be easily made of distant subjects by using telephoto or zoom lenses[41]. These forces in the socio-technical world of marine mammal research helped lead to the development of photo-identification as a viable and valuable tool for scientific research.

5.2 Photo-identification methods

Photo-identification methods for marine mammal research involve recording natural markings using a camera, and then matching those photographs to catalogs from previous seasons and/or locations to find matching images of the same individual. These methods were initially developed (in the early 1970s) to study population dynamics of marine mammals (Würsig & Jefferson, 1990). When a set of individual animals have

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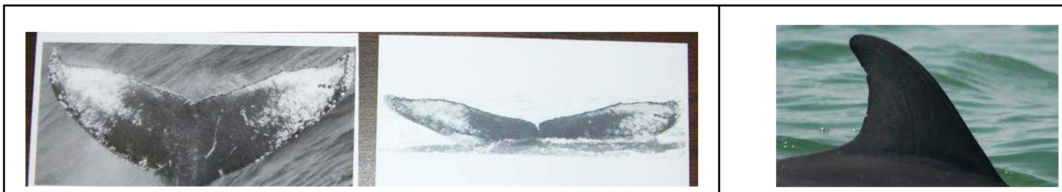
[41] While the earliest SLR cameras date back to the Nikon F, introduced in 1959, the 1960s were a period of development and change in the photographic industry (Canon, 2007). By 1971, however, Nikon had introduced the F2, and the Canon F1 system with a wide array of lenses was introduced with much fanfare. The growing functionality and maturity of these products helped transition the SLR from a professional photographer’s tool to a commodity, at least for what would later be called the “pro-sumer” market, serious amateurs willing to pay higher than average prices for advanced photographic equipment.

been photographed, matched, and correlated over time, the scientists can then use the collected data to estimate population parameters, including population size, survival rates, reproductive rates, and ages at first reproduction (Hammond et al., 1990). While early photo-identification work focused mainly on whales and dolphins, researchers of other species including seals, sea lions, manatees, and others have more recently begun to adopt photo-identification in their work (Harting, Baker, & Becker, 2004; McConkey, 1999). Nutch argues that “the use of photographic identification dramatically changed what scientists, as well as the public, know about cetacea” (Nutch, 2006, p. 153).

Besides photo-identification, other major techniques for studying marine mammals include acoustics, genetics, telemetry, anatomy, and toxicology. A combination of these techniques may be used by any given research project.



Humpback whale ID photos

Bottlenose dolphin ID photo

Figure 3: Sample identification photos

Photo-identification in practice involves taking photographs of animals in the field; the preferred angle and part of the body is dependent upon the species (see Figure 3). Humpback whales, for instance, are identified using fluke (tail) photographs that capture the outline of the fluke’s shape, any notches or bite marks in the fluke, and, most importantly, the coloration pattern on the fluke. Dolphin identification relies on the shape and pattern of nicks and notches in the dorsal fin, while seal identification relies on scars and general pelage pattern on the body. The images are then added to a catalog either manually by a knowledgeable researcher familiar with the population's members, or with the assistance of automated identification software. The image data are also associated with other data collected on the animal, including GPS readings for sightings, genetic information gathered through biopsies, and other research information. As will be seen in the next chapter, however, there do not appear to be any standardized databases currently for this work, so many of the systems in use are custom, locally developed applications.

Most marine mammal scientists contacted in the course of this research reported that they began to switch to digital photography only in the last 3-4 years. This shift corresponds with a major workshop on digital photography techniques convened at the 2003 biennial meeting of the Society for Marine Mammalogy. The change has not been wholly uncontroversial; one example is a published exchange between Markowitz et al. (2003a; 2003b) and Mizroch (2003) debating whether digital photography was of sufficiently high quality for photo-identification work compared with the standard of fine-grained black-and-white film. There are also current technical controversies including differences over various photographic file standards, such as lossy JPEG versus RAW or TIFF formats as a storage format. Tensions in the field such as these will be discussed again in the following chapters.

5.3 The social organization of a scientific field

Marine mammal science is in some respects a very public scientific field. While the public doesn't consume technical publications on the population parameters and social behaviors of whales, the public most certainly continues to express a deep and abiding interest in all manner of marine mammal species. As the president of the World

Wildlife Fund (WWF) noted, “few species stir human emotions as deeply as the great whales: indeed, so pervasive is worldwide public concern about saving these leviathans that whale conservation seems almost a cliché” (Fuller, 1995). Dolphins, seals, otters, and other marine mammals likewise continue to attract public interest, philanthropy, and tourist dollars. This public interest has in turn helped to support the field of marine mammal science. Donations, income from aquariums, and funds from eco-volunteer experiences all contribute to the advancement of scientific knowledge.

The scientists have a vested interest in keeping their work in the public eye. Working with species that can attract public interest, donations, and research funds helps advance the field’s scientific goals in ways scientists studying less popular subjects do not have available to them. As one scientist interviewed for this research observed:

> But the [species] project—they are a dime a dozen. They are not endangered at all. I believe it’s important to also study animals who are not endangered and look at robustness of species, in other words. But we can never use the argument that, “Wow, you know, they’re almost gone. We’ve got to get funding for these creatures.” So there’s less pressure there, and that’s why I think that’s a particularly difficult [situation]. (Interview with Dr. Gerald Lemoine)

As will be seen in the following chapter, some researchers rely heavily on private giving and fees paid by eco-volunteers to cover their day-to-day field operating expenses. So, while the public controversies discussed in this chapter involve cases in which the species studied by the scientists are under threat, these very threats and controversies also have the unintended consequence of increasing the resources available to advance scientific knowledge.

CHAPTER 6: RESEARCH RESULTS

In this research, we are ‘following a thing’ using multi-sited research, as suggested by Marcus (1995). This approach is opposed to more common sociological approaches involving following a social group or pursuing a theory. By focusing on a single technology being used in multiple settings, we hope to shed light onto the ways in which a seemingly simple technology can be socially constructed. The ‘thing’ we are following is digital photography[42]. The place to which we have followed it is the field of marine mammal science and the scientific technique of photo-identification.

Before answering the specific research questions posed in this study, it is important first to understand more about the participating scientists, the studies in which they work, and what they do in the field and in the lab. In the previous chapter, we discussed some of the ways that this technique became an important tool for marine mammal research, and gave an overview of some of the general methods and uses of photo-identification. This chapter begins by looking at the various stages of the photo-identification process in marine mammal science in greater detail and then turns to a consideration of the specific research questions.

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[42] Of course, digital photography is actually an assemblage of things, including cameras, lenses, printers, software packages, computer interfaces, GPS devices, and so forth. For the purposes here, though, it will suffice to treat the entire assemblage as one thing being used in a variety of different settings.

6.1 The photo-identification process

As we will see throughout this chapter, there is not a single process for dealing with photo-identification of marine mammals, but instead a number of variations on a general theme. While many of the main steps are similar from study to study, there are often significant differences in the actual methods employed from site to site. This section will look at both the general theme and at some of the specific variations that will help the reader understand the overall workflow with regarding to digital photographs.

6.1.1 Taking photographs in the field

Figure 4: Dolphins in the field[43]

Capturing photo-identification images in the field involves a complex set of skills, including the ability to use the photographic equipment, but also a wide range of other

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[43] All photographs of animals were provided by research participants and taken under appropriate permits. No photographs of animals being approached under permits were taken by the researcher during this study.

skills related to understanding animal behavior, weather patterns, boats, and the other scientists on the team (see Figure 4 for sample dolphins recorded in the wild). The method of finding animals depends on the study. Some scientists follow specific predetermined patterns (transects), other engage in more opportunistic sightings, going to spots where they expect to encounter individuals. Emma Hatcher provides an overview of a typical day gathering photo-identification data at the Atlantic Dolphin Research Institute:

> Emma Hatcher: We plan for the best weather day as possible; as with any research, the longer the better. You get all your gear and everything together. It's a very combined effort. You've got people. You've got boats. You've got logistics. You've got time frames. So, we try to pick the optimal days that we can stay out the longest, and being in [location] with our lovely weather and rain and lightning, summers are usually filled with rain and running from lightning, and winters are usually dodging cold fronts and wind. So, we check the weather, we plan on things, and the next morning, we double check because as we found out in the past…we would just go out and look nice in the morning…[and] come noon you'd be running off the water…. Sometimes you can't even use that research if you don't get very far, so you've wasted a day that you could've spent in the labs.
>
> EH cont.: …Next is we made it to a certain timeframe, usually early morning, and I guess I'd load everything on the boat. We try to survey one-way as animals, you know, move. They're not stationary. So moving one direction upon a group, we take a second to visualize what's going on and make an assessment of what the animals are doing, where they're going, how many there are, are there calves, what other obstacles are in the way, is it a high boat area – there's a lot of things that within a few seconds you have to determine their way. They're a lot more in tuned to us than we are of them. We may see them 400 feet off, they're aware of us before that. So, any move that you make with your vessel, they're going to be reacting to - whether they choose to not react to it or directly react to it. They're still aware of it. So, that's our optimal time of engaging is that second, when we view then, we see them so you have to kind of do it quickly, decide what you're going to do in kind of a quick manner. So we approach whenever we deem necessary. However, we figure that would be easiest way to approach them, take an image of the dorsal fin in a perpendicular angle…which is our fingerprint…. I think it takes a lot of experience coming back and analyzing your own photographs knowing what distance is okay and what distance is not okay to

> shoot at, so a lot of this is back and forth…. You take as many images as necessary until the photographer feels that they are sure the image is crisp, that it's clear, it's within distance and it's at the appropriate perpendicular angle. If the photographer cannot identify those three features, then you continue to stay on animals until the photographer says yes. It's a lot of communication between the driver and the photographer, as the driver's responsibility is to know how many animals are in the area and to communicate with the photographer. I'm saying if they separate in a group, "Are you sure you have the animals on the right, can you identify them to me? Okay then, we'll move to the animals on the left." And the photographer's responsibility is to be able to communicate to the driver. "Yes, I've got a tip-neck, a mom and calf on the right. You can leave them. Let's go to the next step."

Taking ID photos of dolphins

Logging encounter data

Figure 5: Field data collection

Once the encounter has been completed, the photographer stows the camera back in the waterproof casing and proceeds to log the data for the encounter (see Figure 5). The log sheets vary by site but include the same general information: location information from the GPS unit, environmental information, information identifying the scientists on the boat, information about the number of animals and behavioral information about them, general notes, and a log of the images that were taken during the encounter (see Figure 6). Some sites reported changing their logging habits in the field after switching to digital:

> Leah Tull: With the slides we were a lot better [about logging our data]. With the slides, I would call out every picture I took. I would say left dorsal, right dorsal, and if possible the animal and if I wouldn't know the animal I would say A1 or C1 or whatever just to indicate it's the first adult…. [A volunteer] would definitely hang on my lips and write [everything] down. We also did this because we couldn't develop the film ourselves but we had to send it away and they often had problems with the development, so with this technique we could also check out…the films…. Unfortunately, now we don't still do that…it's nice that you don't have to call out anymore because you're taking way too many pictures. I'm trying to go back to figure out a way how we can do this because I don't think you can do it with digital. It's so quick and you don't have to pay for the developing…. I [don't know if] it is worthwhile calling out every picture, but I think we should have a mind check, what's going on and I haven't figured out how to do that yet.

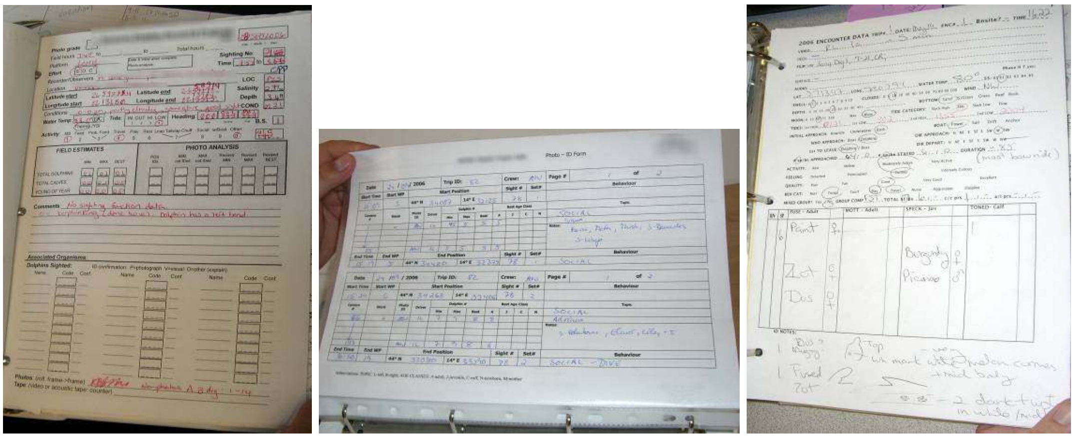

Figure 6: Sample encounter logs

Depending on the scientific questions, other protocols than the one described above can also be followed with regard to animal encounters:

> Holly Kershaw: My work is all observational so we do what are called focal follows. It's a pretty widely used practice…it's where you basically pick a focal group or individual and you follow them in the boat and you try to maintain a close enough distance that you can keep track of them and take photos; but not so close that you're disturbing them. So I follow groups because it's really hard to

> keep track of individual dolphins because they're zooming around. It's hard to keep track of their fins. So we follow them. My protocol was to follow one group for an hour and every two minutes I would take a point sample. It's called instantaneous point sampling. So I had a stop watch that was set to beep every two minutes. So it beeps, counts up to two minutes then beeps again so it's always beeping. So at the beep I would record the group size, the group behavior, and the group spread so how far apart. So what was the greatest distant between two individuals in the group.

One of the Pacific Whale Project technicians described their methods this way:

> Sheri Wine: [Our encounters are] usually opportunistic. The survey that's… just off the coast here, there's actually a route that you take. It's kind of a big triangle and so you always go the same way. And if you find animals or if you see some off in the distance, you'll stray from your course and then come back. But, for the most part, like grey whales [in location], we always know where they're feeding. So we can go to the same spot every year and they're there. So it's pretty simple.

Different species can also make different demands on the researcher. Protocols are, of course, tailored to match the behaviors of the target species. A researcher at Southern Gulf University describes her research protocol:

> Mattie Conner: Territorial male [sea otters] are a little bit less sketchy than moms and pops. Moms and pops tend to flee pretty quickly when the boat's coming around. The territorial males - they're much more approachable and easier to get a photograph of…. If they are a male, then I get to follow them for awhile and there's a good chance that they are a transitional male, meaning that they're not going to establish a territorial area and then I'll never see them again. So I take photographs of them and I log it away in a folder in the computer and then if I see them again, I can match up those matches. Yeah, okay, this guy was here before…plot it out on the map, he was in the same general area before. Okay, great, so he's probably going to stick around for a while. So, then there's the ones that I never see again, sometimes I see twice and then they're gone. They got kicked out of their territory by someone else or sometimes if I'm really lucky, I get to see them three or four times and that means they have established a territory.

In all of the above cases, the research protocol is driven by the scientific research questions. Population parameters are more easily measured using systematic surveys, whereas association and behavioral data require longer encounters with a group of animals to record their behaviors and relationships to one another. In some cases, it is possible for later researchers to go back and re-mine a collection of photographs to ask different questions, such as at the Gulf Coast Research Institute, where a researcher interested in mother-calf associations went back through data and images that had been collected primarily for population estimate purposes and found images that would help answer her questions about mothers and calves.

6.1.2 Processing and organizing data

The next step after collecting the images and associated log data in the field is to download the data onto computers, back everything up, and then start to process the images and record the data into a database.[44] This step is one that has shifted from the film era to the digital era. With film, the images would not be ready until much later, sometimes at the end of the field season altogether. Digital images are available immediately, which means in most studies, people start working on organizing them right away, even if they are in field locations distant from their labs.

> Dr. Rita Price: So we get back and usually what we do is we have all these images. And what happens with the digital? You take more pictures. There's more data to go through. [laughs]…I'd think at least twice as much… [slight groan] because we don't delete things in the field. We don't do that…What we do is we try to go through…those digital files and we try to pick the best picture of an individual and put them in the best folders for that encounter. So when you come home, there are the five whales that were in the best photo of each one. Usually we don't get that done because we're just really tired.

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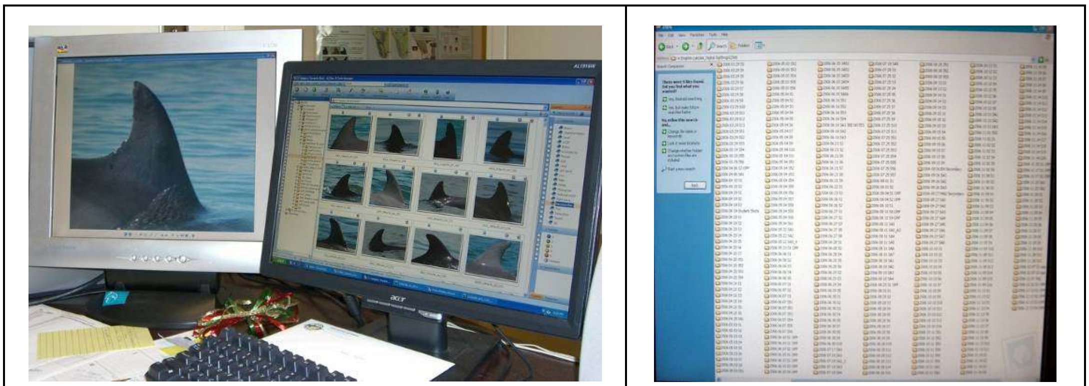
[44] The expertise and personnel required to construct the databases is discussed in detail later in this chapter.

> RP cont.: But the other thing we do, years ago when we first started the digital stuff, I'd get an external hard drive and we'd back everything up on the external hard drive. Plus, we'd make CDs of everything. So, the problem was, you know, before all I had to do was make a label and put it around the film. Now, I'm processing and batching and renaming and trying to find all these, okay now it's 07CA001 (for roll "1"), 'D' for digital, 00 for Orcinus Orca, 001 for frame 1; and it's just like, "Oh my god." And me being not raised up with computers and stuff…I mean it was a cool tool and everything like that; I loved it. But all of a sudden when we got back to the ship we're processing all this stuff and you're looking at a couple hours worth of work…. And all of a sudden my computer that I had initially was [working] all night long [on] the batch rename or converting to .tiffs or something; I can't remember which one it was. It took forever, you know? I'd wake up in the middle of the night and I'd see the thing flashing that it got stuck, and I'd have to…oh god! [laughing] So anyway. That's kind of the deal with the digitals.

One of the Atlantic Dolphin Research Institute technicians described how ADRI researchers deal with their data at the end of a day on the water:

> Emma Hatcher: We come back in immediately because it takes several hours to download those four gigs of images usually. We'll drop the card on the hard drive, we'll go clean the boat, and we'll pull off all the data sheets and start entering the data sheets. Somebody will clean, somebody will enter, and usually it's enough of a timeframe that you get in that late at night in the dark, so we'll leave the card, we'll drop and leave the card then lock everything down. In the morning, we'll compare the card to what was dropped to make sure it's equal. We won't use that card the next day to make sure that it gets backed up, but overnight technically at 11 o'clock everything should be backed up.

Different projects use different software to maintain their databases of images. The most commonly encountered software is ACDSee, a commercially-available photograph organizing system. Many of the respondents reported choosing ACDSee because of its batch-renaming capabilities and because it allows easy access to and editing of EXIF metadata embedded in the photographs. However, other programs such as Photoshop are also in use, and a number of projects essentially use the Windows file structure to make a "database" of their photographs simply by storing them in a tree of folders that are hierarchically organized to reflect their categorization system (see Figure 7).



Sample ACDSee database

Sample folder-based 'database'

Figure 7: Sample photo databases

A separate database is generally maintained for all the textual information – sighting data from the log sheets, tracking information for workflow, data connecting matches to previous sightings, etc. The most common software for building these databases is Microsoft Access,[45] and most will look familiar to anyone who uses Access databases (Figure 8).

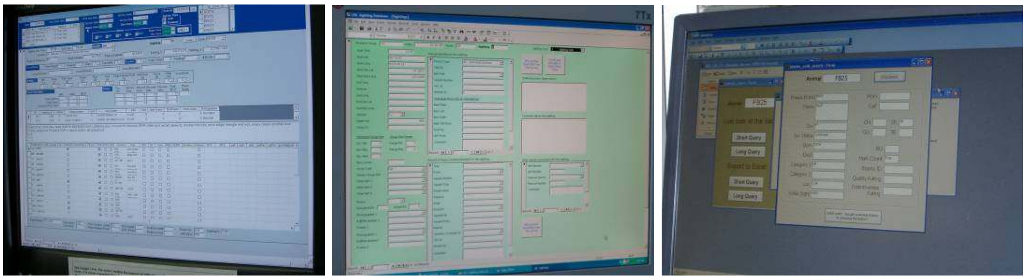


Figure 8: Sample information tracking databases

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[45] See discussion of expertise on page 209 for an understanding of how these databases are designed and maintained.

These databases provide the ability to work with the longitudinal data collected by these centers, some with catalogs and databases going back several decades:

> Sara Prentice: All of our data is stored in our Access database. It's a front-end / back-end system…We can easily list the sightings for an animal. So like this one we've seen many times…you can just sort by the date and see every time she's been seen from 1984 all the way to 2006. And we've seen her since August but we haven't updated our database yet since then. So she's been seen over 567 times. You can also look at the master code list which is for each animal; this is the basic information that I have as well in the digital catalog. That's the name, the freeze brand if it has a freeze brand, the sex, if the sex has been confirmed or if it's presumed, when it was born if we know that, when it died, the fin categories and sometimes there's two fin categories, the location code. Within each study area we break up the area into smaller areas called location codes. And so that's usually the location code where that animal was first seen, just as a general way of looking at where they hang out. What year or in some cases the exact date that animal was first seen, initial sighting, if they're a mom of anybody,…who their calves are…birth order,…biopsy, ID, quality and distinctiveness.

Maintaining such a large collection of data can be a challenge:

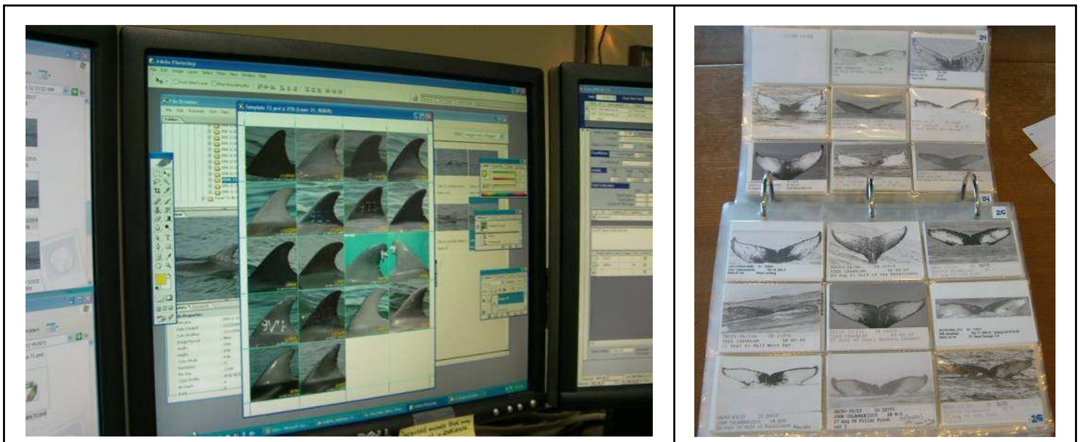
> Dr. Gary Lewin: Well, hopefully they've stressed the things that are important to us, and that is quality, making sure that we maintain the highest level of rigor in terms of examining the photographs and determining the identifications of the individuals. We've learned the hard way that you need to be very careful from the start and make sure that your identifications are as accurate as possible from the beginning. In the 70's, our photographs weren't as good as they are now. In the 80's our photographs weren't as good as they are now. And, we weren't as familiar with the process…There wasn't anybody out there to show us how to do it. We had to do it ourselves and over time we keep challenging original identifications. Every once in a while we find a match that was incorrect from 20 years ago, but it's only with better photographs now and with better ability, new eyes to look at those things, that they come out…[The process] has to be defensible…. It came about because we wanted to be able to publish our findings and we had to be sure of the data and unless we're going to send all of our images out with every paper in a table, you've got to be able to demonstrate to people that you've got a system that works so that they can feel confident about the identification data.

The work put into processing the images in ACDSee or other programs, entering and maintaining data in databases, and tracking the large amounts of both text and image information was a considerable task for all the scientific projects in this study. Most researchers and technicians, and some investigators, spent at least a portion of their time doing the manual work that ensured that their work in the field was translated into usable scientific data.

6.1.3 Matching images

Beyond organizing the data about sightings, another large task for most of these projects is matching images to find a positive identification for new sightings. In projects that are focused on small populations of 100-200 animals, the investigators and other personnel often know many of the animals on sight, so matching does not take up inordinate amounts of their time. Other projects' catalogs of individual animals, however, can contain thousands or even tens of thousands of identified individuals, and it is in these projects where matching becomes a on-going major part of their operations.

For different species, the specific features of the animal used for matching vary. Dolphins, for instance, are identified primarily by the shape and location of nicks and notches in their dorsal fins, along with the overall shape of the fin. Humpback whales are identified by the coloration of their flukes (tails), along with other fluke features such as cuts and shark bites. Gray whales are identified by mottled coloration patterns on their sides as they surface. Other species all have different features that make them identifiable.



Screen-based matching

Print matching

Figure 9: Photo matching techniques

In Figure 9, some sample setups for matching animals is shown (also see Figure 1 on p. 117). In the image on the left, a screen-based matching system at the Atlantic Dolphin Research Institute (ADRI) is shown, and on the right is a print-based matching system from the Pacific Whale Project (PWP). These two projects will be used to illustrate the different approaches to matching.

The techniques for making these matches are site-specific. ADRI, for instance, has three computer monitors on each workstation. The matcher brings up the image to be matched on one computer monitor, and then brings up the appropriate sub-catalog on another screen. The sub-catalogs are grouped based on a major characteristic, again dependent on species. ADRI's dolphins are grouped by the location of the most defining mark on the fin, such as the upper-third of the leading edge, or the lower half of the trailing edge. The matcher then uses the keyboard to flip through previously identified images in the catalog looking for a match.

> Amy Kirkwood: Then once we do that, you'll take their representative shot – the best shot that we chose – and it'll go into their code folder. So this is their representative shot from this day, and I chose 22…. If I didn't know who this animal was, we have our dolphins separated out by where their nicks and notches are. So it kind of narrows down your search if you don't know who it is. So he looks like he's an 'entire' because he's got marks in each portion of his fin on the trailing edge…. You would just scroll through these pictures until we found a… a positive match…. So, there he is. You know, this picture could actually be replaced by this picture, because I think it's crisper. So we would eventually replace it. What I'd probably do is just do it now. Or do it when we analyze just to keep it up to date. Otherwise, your list of things to do gets huge…. We always put the pictures in here facing left. But, with this guy, we got a better picture of the freeze brand on the right, so it's in there as a right. But if it's a right-side picture, that's best. We'll rotate it, and put it in there and just mark it like this, as a left or right shot. So we know what we're looking at…. What I would do is I would crop the picture and give him a new code shot. And we make them little two-by-twos.

The tracking database with information about the animal being matched is shown on a third screen. The two matchers at ADRI also go into the field to collect data, and perform the majority of data management and coordination tasks between them.

Contrast this to the matching method used by one of the humpback whale projects, the Pacific Whale Project (PWP), that is dealing with a population of animals in the thousands. At PWP, all their photographs are also taken and stored digitally, but the matching is done via 2" tall by 5" wide ink-jet prints. The matchers in this case work from books which are grouped by year, location, and overall degree of white versus dark coloration on the fluke. When they have a new image to match, they open the three-ring binder containing the photographs from a given year and location, and hold the picture up to the nine images on each binder page one at a time looking for a match. They work their way through the likely color category and the two adjacent categories.

> Rhonda Storey: My next whale would be this guy. And I…go into the different categories that the whales are broken up into, which are marked here. And they

> start with the number one being all white. Including all white through the middle. The midline. To 2A, where you have a dark line through the middle. So, even this one is still a 1, because there's a white spot. So when you're matching, say, a 2C whale, we are directed to match in this catalogue, if I had 41, I would match through 2B, the category before 2C, and then 3A the category after. So, you get one ahead, one below. We have discretion, though, if we think that it needs to go further one way or the other. So some of these fluke, I matched a whale that was in a 4C, so I'm supposed to go to 4B, and 5M. But I thought, "Well, maybe I should take it through the next one over here," or two below it, just in case. Once you start getting into a lot of the darks from 4C on, where there are just the last touches of white, we've realized that we could - in the past - have missed a lot of matches. So when you get to this, you go through 4C and all the other categories below it.

Once they have worked through one batch for that location and year, they will start over again at the beginning for all un-matched images working with a different location and year. Four full-time employees spend 40 hours per week doing this task.

> Rhonda Storey: I think Pacific Whale has done a really great job in creating categories, and over the years had a pretty confident way of creating those color categories so that you don't have to take a single whale through 500 other whales. You can you can pretty well narrow it down to maybe 75. So that's a time saver…. It's very labor-intensive and time-consuming…. It's pretty straightforward, but it's, um… it's pretty boring. [laughs]… [To deal with the boredom] I park my car in two-hour limits. So every two hours I have to get up and move the car. And take a walk.

To add to the difficulty of doing this work, more than one matcher reported that hours or even days could pass without a successful match.

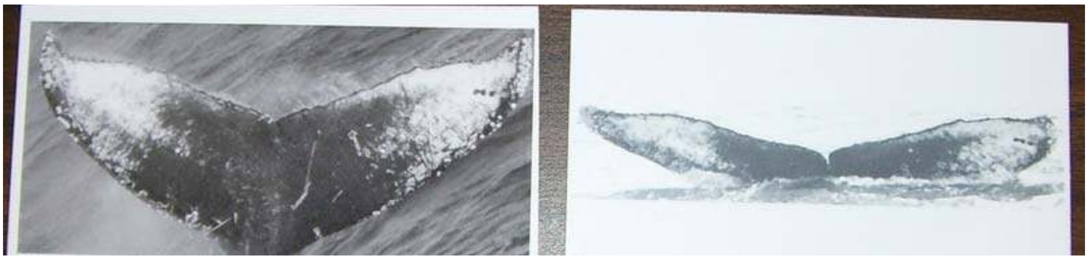
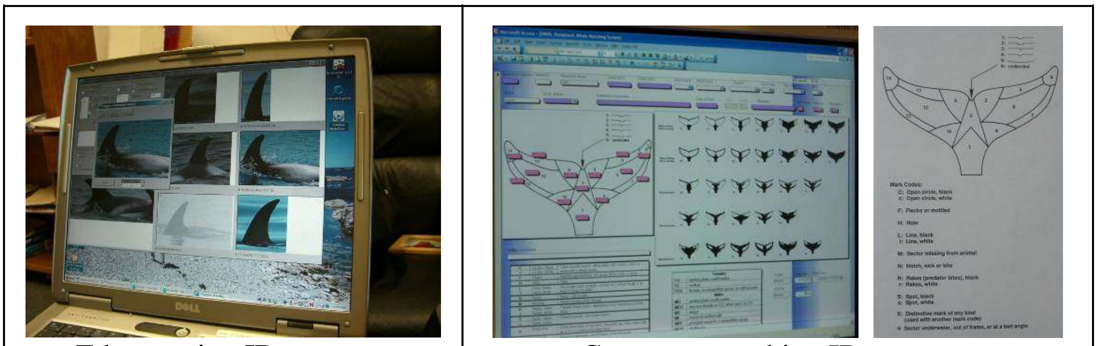


Figure 10: Example of a matched humpback whale image

Figure 10 illustrates the how difficult matching individuals can be to untrained eyes. The two images shown here are of the same whale, but there are not many clues to someone unfamiliar with the animals that that is the case. The photos were taken at slightly different angles, the tail is at a different angle relative to the water in each, some of the tail is obscured by water in the right-hand image, and the exposure is different in the two images. The skilled matcher, however, notices the pattern of coloration in light and dark and the other markings on the tail. In this case, there are three distinctive dots on the far right-hand portion of the tail that help confirm that this is a match.

The projects all had different methods for actually doing the matching, but ADRI and PWP illustrate the range of variability. From an entirely digital, screen-based matching system to a completely print-based, three-ring binder based system, clearly the digital features of the photography do not dictate the specific methods used to work with the photographs, even while the features of the technology influence the range of methods used in different settings.

6.1.4 Automated matching



Edge-tracing ID program

Category-matching ID program

Figure 11: Approaches to automated matching

One of the ways that marine mammal researchers have hoped to deal with the time, expense, and tedium of matching large populations is through automated matching systems. A number of systems have been built over the years, and most participants in this study had used or tried using at least one of the systems. Some of the more well-known systems are FinScan, DARWIN, EUROPHLUKES, and DIGITS, although there are a number of others. The method used for automating the matching process varies considerably. Some programs attempt to do edge-tracing (either automatically or manually) to get an outline of the nicks and notches in a dolphin fin, for instance, and then use an algorithm to find a set of potential matches for a human matcher to examine (see left-hand side of Figure 11). Others use a technique called 'landmarking,' where categories are assigned to different features of the animal and a set of rules is created for tagging each image with these categories (see right-hand side of Figure 11). These coded images then are used to select potential matches algorithmically. The following is a description from a user of one of the automated programs:

> Dr. Lynne Shoop: What it does is it's… [for] computer-assisted matching. And so what it tries to do is reorganize your catalog so that it shuffles it so there, the most likely matches at the top, and the least likely matches at the bottom. What I always did was go all the way through the list and…even if I thought it was a match, I would write it down as a possible match and then go all the way through. What I found that was valuable for was, A, I would make sure—I would catch a lot of internal matches that, it really looks like that one, but if I went through, oh, it's also that one…. The other thing is sometimes what it did is when it reorganizes them, I would see two together that weren't the dolphin I was looking for, but I could see were clearly the same animal.

There have been several problems with more widespread adoption of these programs, including perceptions of difficult to use interfaces or lack of accuracy. One of the biggest barriers, however, is related to the fact that marine mammal scientists studying different species use very different types of features to make their positive identifications. No single program has been flexible enough to would work with bottlenose dolphin fins, humpback tails, overhead views of bowhead whales, and scratches on otter noses. The methods that may work for one project may not work for another. As a result, some of the efforts to design automated programs have withered on the vine as the initiators of the attempt find relatively little outside interest in working in the way the program would require. In the interviews for this project, better automated matching systems were one of the most wished for technological innovations. We will return to this issue in Research question 9: Technological alternatives.

6.1.5 Summary

In this first section, we have walked through the general process of photo-identification, from taking photographs in the field, to processing and storing the images, to matching the images with previously identified individuals in the catalog. Next we will turn to the specific research questions posed by this research in an attempt to understand how digital photography plays a role in the social behaviors of marine mammal scientists.

6.2 Answering the research questions

When this research was proposed, nine interrelated research questions were developed using the STIN strategy taken from social informatics, as described above. Throughout the research, these research questions have proven to be excellent guides for maintaining the focus of the research, and for probing into the nature of the socio-technical systems of which digital photo-identification is a part. For the rest of this chapter, each research question will be addressed in turn, discussing the evidence from the study that helps us answer the research questions and presenting examples from the research to illustrate each.

Table 7: Research questions

1. Who are the relevant actors within the systems supporting photo-identification research, and what are the core groups both related and unrelated to photography to which these actors belong?
2. What are the pressures/incentives or impediments to adopting digital techniques?
3. How is knowledge about how to use digital photography technology obtained (e.g., is it formal or informal, what role do other researchers play, who in the scientist's networks participate in the learning)?
4. What are the resource flows (e.g., to pay for equipment, staff, field work, new specialists in digital technology, etc.) that the scientists have mobilized to pay for their photo-identification work?
5. Who becomes involved in the photo-id process for the first time when scientists adopt digital photography; which formerly involved actors and technologies are excluded; and how are peripheral actors affected?
6. What conflicts arise over the digital photography computing package in routine use, and what are the biggest benefits of digital photography in routine use?
7. How are the data shared with other scientists?
8. What are the architectural choice points for the system (e.g., what choices are made over time that influence the current configuration of the computing package), and what are the rejected alternatives? What are the other elements of the total computing package (e.g., databases, GPS, etc.) used to support photo-identification? Have these changed?
9. What technological alternatives would be desirable to improve the existing system (e.g., if one were not limited to existing technology, what sort of system could respondents imagine that would make their research more effective)?

6.2.1 Research question 1: Relevant actors and core groups

1. *Who are the relevant actors within the systems supporting photo-identification research, and what are the core groups both related and unrelated to photography to which these actors belong?*

6.2.1.1 Human actors

Identifying the relevant actors and relevant social groups among marine mammal photo-identification scientists yields an interesting list of actors and actants participating in the system. Some are obvious, others less so.

Among the more obvious participants are the investigators, researchers, technicians, field personnel and support staff involved in gathering and using the scientific data to identify and track various marine mammals. Investigators are the primary leaders of the scientific projects, exercising autonomy in decision-making and acting as leaders in generating research and funding. Investigators are generally senior scientists who oversee the operations of their studies, although they may delegate specific day-to-day decisions to trusted others. The involvement of an investigator in hands-on research depends on the study. The researchers, on the other hand, are less senior scientists and are nearly always heavily involved in the day-to-day science but are less responsible for organizational issues than the investigators. Technicians are often less well-credentialed (often holding undergraduate degrees) and are in many cases younger participants in the scientific projects. For instance, the average age for technicians in this study was 28, compared with 34 years old for researchers, and 56 for investigators.[46] Technicians are generally much less autonomous with regard to their work assignments. Finally, field personnel and support staff have the least autonomy but also contribute to the scientific endeavor in important ways that are described below.

Even though the fact that a research scientist is an actor in a system of scientific knowledge production is wholly unsurprising, the investigators are actually quite surprising in a number of ways. First, a naïve assumption held prior to doing this research

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[46] Technicians (n=13), mean age=27.5, range=20-35, s.d.=4.1
Researchers (n=14), mean age=33.7, range=27-45, s.d.=6.2
Investigators (n=14), mean age=55.6, range=50-62, s.d.=4.0

was that most of the leaders of the scientific projects studied would be Ph.D.-holding academics. In fact, however, this was true only of the participants at universities and government agencies. At projects centered in colleges or universities (n=3), four Ph.D.-level scientists were part of the study, representing all of the principal investigators (PIs) and one-third of all participants at those sites. Likewise, at government agencies (n=3), Ph.D. scientists led four of the five projects, and made up one-half of the participants at the sites. At non-profit organizations, however, something very different emerged. For non-profits, Ph.D. scientists led the projects at only two of the seven sites studied, representing only one-tenth of the participants at non-profit organizations. Indeed, several of the scientists had relatively little formal academic training, holding a bachelor's degree or less.

When asked about whether the lack of formal credentials had caused difficulty in gaining acceptance from their scientific peers, one felt that it likely had.

> *Interviewer: You mentioned, when you were thinking of publishing [about your photo-id system], that your colleague had concerns you didn't have 'luggage' after your name and concerns about publishing too soon. Has that been an impediment at all to the kind of things you're trying to do when you're talking to the scientific colleagues?*
>
> Alan Crane: Well, yes. I think that there's a reticence for well-educated people sometimes to listen to people that perhaps are very well educated in what they know or what they do through life experience and there may be a natural…reason for that. I mean, somebody that goes to college for 12 years and is narrowed in on this particular specialty might not see a peripheral side of things.
>
> AC cont.: And believe me, when I'm having open heart surgery, I want somebody with that narrow focus. I don't want somebody like me who has sat in on a lot of heart operations, knows a lot about hearts, read a lot of books and has a lot of heart. I don't want him operating on me. I want somebody that absolutely has done nothing, but live, eat and breathe and sleep cardiology since they were born.

> They were made to do that, but in the real world, sometimes when somebody in our field comes out with a great idea or something, it has to be in a published form before it has any kind of acceptance, otherwise, what may happen is, you go over to somebody and you go, "hey look, I've got digital cameras and I figured this whole thing out and here's how it works and here's the equipment, and here's how much it costs, here's where you get it and here's the data sheets we use", and the next thing you know, you're reading somebody else's publication about what you did telling you what <u>they</u> did and that happens a lot.

Another project leader, however, had a different perspective:

> Jacob Tipton: Things started to be steady and our reputation was getting solid enough that we could apply and compete against other universities or other things. All of us having Bachelor's degrees didn't make the most impressive credentials until we had a little bit more of a track record and publications. I was able to get a few things published as an undergraduate, so that kind of helped… But there was also a little bit of a way that it was a benefit, too, because it was unusual and in some ways it played a part in our [success] – it's like we were the strange group and we didn't have advanced degrees, but we did good work. You sort of carved out this little different niche and it played a positive role. And, for a long time we hadn't had anyone with a Ph.D. even work here.

The fact that relatively few Ph.D.s were working at the non-profits, however, should not be confused with a lack of scientific rigor at these programs. Some of the most impressive systems of documentation, data management, quality control, and overall organization encountered during this research were at non-profit organizations. In all the cases where people in leadership roles lacked academic credentials, they made up for it in two ways. First, they had extensive field experience with the animals, and second, they had personal charisma. As Jacob Tipton noted above, becoming known for good work was a ticket into the field, at least at the time he was gaining entrée, in the late 1970s and early 1980s. Alan Crane felt that entering the field and being taken seriously had become less possible without advanced degrees, however:

> Alan Crane: I mean, there's no question, you have to go to college today if you're going to -- you have to have at minimum a Master's degree. If you don't have a Ph.D. to go with it, then you're really going to be, you know, just at a certain level. You'll never get that way, so getting Ph.D., I mean, if I was starting out now, I would definitely be attentive to getting a Ph.D. and going directly for the throat.

The path of entry into many of the non-profit organizations, however, is still somewhat informal. While most of the technicians who participated in this research held Bachelor's degrees in a biology-related subject, getting hired to work with marine mammals in many cases involved a somewhat circuitous route. The following three examples illustrate this point:

> Anna Hawes: I started here [at Pacific Whale] as an intern. I interned for two quarters, volunteered for two quarters, and now I'm a paid employee.
>
> Amy Kirkwood: Came to Atlantic Dolphin in 2002, I believe. Started out as a volunteer, and then got hired. Began volunteering and then I was hired as (name)'s admin assistant. And with all my other experience I was eventually able to move over to photo ID.
>
> Kathryn Stamps: I went from my internship right to my part time job with the state just to pay the bills basically, because I volunteered here for some time before they could pay me.

Many of the younger technicians at the non-profit organizations reported similar stories of creatively finding ways to gain leverage into an organization through internships, volunteering, and holding a variety of low-paid, temporary jobs either in or out of science to be able to pay their bills. Most, however, either had plans to get their Master's degree, or were actively enrolled in a Master's program, as they learned by experience the truth of Alan Crane's observation above that "you have to have at minimum a Master's degree." Many of the students interviewed at the universities involved in this study had done work in the field before returning to get their Master's or Ph.D. degrees:

> Cynthia Conlin: I traveled a fair bit and then I got a job as a research assistant…studying nesting sea turtles and I did that for about seven months and then got the job in New Zealand basically starting as a volunteer research assistant and through that got to know Gerald [Lemoine, the investigator at her current project].

So while solid experience was once a ticket into marine mammal science, particularly when it was a younger field, today the experience must, in most cases, be combined with formal academic credentials in order to advance in the field.

One characteristic shared by nearly all of the people who led projects at non-profit organizations was an obvious personal charisma. It is difficult to operationalize the concept of charisma,[47] since it is one of those qualities that is easy to recognize in those that have it, but can be difficult to document. Analyzing the scientific and organizational leadership styles of the scientific projects represented here would be another whole study, but it is worth mentioning the observation that personal charisma appears to have played a role in the scientific success of many of the leaders in this study. Pursuing this observation in a more systematic way could very well be a later study that grows out of this current research.

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[47] While the business literature has studied leadership and management styles (see House & Aditya (1997) for a review), and the political science literature has looked extensively at charisma and political leadership (see Van Wart (2003) for a review), the science studies literature has largely ignored the role of leadership in scientific endeavors outside of some scientific biographies, such as the many biographies of Robert Oppenheimer (e.g., Bird & Sherwin (2005)).

In addition to the primary investigators / study leaders and technicians at each site, there is generally another category of scientist involved, referred to here as researchers. These scientists in almost all the cases observed hold a Master's degree, and can be distinguished from investigators and technicians in several ways. First, unlike the investigators, they do not generally lead multiple projects nor do they represent the organization in an official capacity to outside actors or groups. They may be the lead investigator for a specific project, and may have obtained funding largely on their own to pursue that project, or they may primarily be working in a leadership role on some aspect of a project initiated by the investigator. Unlike technicians, however, the researchers are generally somewhat autonomous with regard to specific job duties and expectations. So while a technician is generally assigned to a project where his or her help is needed, the researchers are more likely to be partners in deciding what projects they will take on. For instance:

> *Interviewer: How do you decide what new projects to take on? I mean, is it assigned by the lab or is it just based on what you're interested in?*
>
> Holly Kershaw: Yeah, just basically what I'm interested in. Because when I approached [investigator] about wanting to work with these…dolphins, I told him what I was interested in and he said [location] would be a good site for me to work at and then from there I developed my own research questions.

This however is variable by site. At another research site, one researcher described the process of new project initiation in this way:

> Faye Hampton: Probably our two senior scientists will confer if they've got something interesting and discuss it. I will tell them if we've got the data and if that's available and how systematic the collection was or how we could contribute to it.

So while these researchers are important contributors in shaping the ordinary scientific practices, they do not have as much autonomy as investigators / project leaders. They tend, however, to have greater longevity at any given site than the technicians, many of whom had participated in a number of projects for short periods ranging from several months to several years, and were often in positions that were heavily contingent on the availability of continuing funding.

Other important actors related to the performance of the ordinary scientific activities in these organizations are the support personnel. Describing the number of people required to keep one research vessel operating during their field season, a researcher said this:

> Jennifer Daggett: Well, we have [the investigator]. It's usually [the investigator in charge] but things have been changing a bit. I've taken over for her on trips that she has off, so it's say a research director…, the research assistant…, the captain…, and the first mate, which varies with whoever we get for the summer. Those are the four main crew. Then, we usually have a volunteer cook who comes out and then we have, that's five, then we have the rest of them are paying participants or colleagues that we bring out from Hawaii or Greece or whoever comes out.

The boat operators can be a captain, in the case of larger sea-going research vessels, or a driver in the case of smaller projects operating from a base on shore. The driver in those cases may be one of the researchers, or may be a dedicated driver. Driving a boat when interacting with ocean mammals can be tricky. The level of harassment of the animals that is allowed is limited by the permits under which these projects operate, and a skilled driver needs to be good at predicting the behavior of the animals and anticipating the needs of the photographer, biopsy dart operator, or other scientist on the boat.

> Mattie Conner: But driving you have to always be looking, so…I could easily call out things to mark on the behavioral sheet as well as rely on my photographer to get the photos and position them using the boat in a way that they could take photos.

A technician at ADRI illustrates the complexity of interacting with wild animals:

> Amy Kirkwood: First and foremost is what they're doing, because your approach is different if they're engaged in social activity, or if they're just traveling in a straight line. Traveling in a straight line's wonderful. But you always need to get the same type of shot…you either need to be parallel with the dolphin, so you can get their picture, you know, parallel to the [boat], or perpendicular…to the viewfinder. And then, you also need [the right] distance. Well, with our lenses, fortunately, we don't need to be as close. I'd say…within 50 feet. Sometimes they make it easy for you, and they'll come closer, or they'll come and investigate the boat, and you're able to get your picture real quick. We try and get on them and off them as fast as we can so we're not disturbing them so much.

Once the photographs are collected in the field, one of the chores upon returning to shore is to download the digital images from memory cards to hard-drive storage which will later be transferred to computers and/or servers back at the lab. This is obviously a change from the period when the field was film-based, and represents both a new set of activities and a new set of actors, the information technology (IT) support personnel. Whether IT support is just another role played by a researcher or technician or whether there are staff dedicated to this role depends partly on the size of the study. If there are dedicated IT staff members, they are unlikely to be in the field at the time data is downloaded and backed up, but they will have helped set up procedures for dealing with technical aspects of storing and backing up data. Several of the larger projects had very detailed procedures manuals with specifications for each step of this process. Others appointed someone who seemed to have an affinity for data management to overseeing the IT work:

> John Maze: I studied Marine Science, concentration in Marine Biology… [and now I] I basically manage the data collection, train people that are in the field, like the new grad students and research assistants. I schedule all the field work, who the captains are going to be, who the observers are going to be. Just manage the computers, the space, intern acquisition and placements, just all that jazz.

So to recap, the analysis thus far includes a list so far of some of the more obvious actors in the system of marine mammal photo-identification. Investigators, researchers and technicians all fall within the overall category of *scientists*, while field support and IT support personnel may or may not also fall into that category. What about some less obvious actors in this socio-technical system?

Volunteer workers play several important roles on many of these scientific projects. As mentioned above, some students and recent graduates volunteer for research organizations with an eye toward eventually being hired into full-time staff positions. However, another type of volunteer is also an important actor in this system, the eco-volunteer. Eco-volunteers sign up to participate in research during their vacations and provide both labor and participation fees. While the most well-known institution organizing eco-volunteer trips is Earthwatch, some of the projects recruited volunteers through other organizations or even recruited volunteers directly.

Many of the projects encourage the participation of eco-volunteers on their field research trips and gain several valuable things from this interaction. First, they have additional hands available on the boat to handle activities such as logging data and serving as spotters for animals in the water.

> Cynthia Conlin: So generally, my setup was that I was drive, because it was just a little boat, like a five and a half meter boat. I would be driving the boat, I would have a photographer and I would have maybe two or three volunteers who would basically record data that I would call out. And I found that system worked really well for me to be able to always keep my eye on the dolphins at all times. Because often, you know, you can't do everything.

Depending on the project, the expectations for the eco-volunteers can vary:

> Paul Dawkins: We really try to minimize whale watching. We really make it clear to people that they're coming with a research team. And, that we're not going to cater to tourism. So if they have any doubts about coming out with us, don't. [Laughs]

The volunteer contribution is not limited to labor, however, as the following pair of comments by research investigators illustrates:

> Dr. Gerald Lemoine: Each volunteer needs to pay Earthwatch; I think it's now $2100 or $2200 to be with us for two weeks. And they help, it's variable, depending on their background and capabilities and interests. But some are of tremendous help, intellectually and physically. But they help financially, for sure, all of them.

> Dr. Gary Lewin: Earthwatch has been a sustaining source of support for us. It's somewhat less so now than it used to be. We're down to half as many teams now as we used to have. But, we've been working with them since 1982 and it's been a source of support, as well.

This financial component of the volunteer experience will be discussed again below in the section for Research question 4: Resource flows.

Who are these volunteers? There doesn't appear to be a single type, as comments from two of the researchers illustrate:

> John Maze: Oh, all kinds. There are a few types [of volunteers]. There's the high school student who's interested in doing science type, there's the high school student who got it as a gift type, there's older people that just want a vacation, sort of alone and away from anything. And then there are single people and married people that just, it sounds terrible to say, but it's not really, if they want a break from their jobs, from their kids, from their house, from their friends, just want to get away and do something for themselves. I get a lot of those people. I get people that are biologists, that want to come and study different biology, different sorts of things. Every once in awhile we get college undergraduates that are interested in the field, but we generally steer them towards internships. It's a full length internship just because they can get more out of that. It's more designed for them, but sometimes they can't with their schedule, so it's better for them to come [as volunteers].

> Holly Kershaw: I'd say the most common would be middle aged single women, so maybe in their early 40's or late 30's. We get a lot of teachers because teachers can get grants through Earthwatch to come so they have their way paid to come on the trip. Then they have to create a lesson plan out of what they learned and bring it back to the classroom. So we usually have at least one teacher on every trip but it's mostly women that come in that 40-year-old range I'd say.

One downside to volunteer labor is that when dealing with complex systems, volunteers often do not participate long enough to be able to contribute:

> Amy Kirkwood: We have volunteers that have gone out on boats with us, and that have helped us with little things in the lab, but generally there's such a high turnover with volunteers, that it would take them too long to teach them how to use all of this.

Another issue is the time that the care and feeding of short-term volunteers takes the researchers and technicians during their field season:

> *Interviewer: What are some of the costs and benefits?*

> Holly Kershaw: Well, the benefit of course is that you get money. Also you're hopefully educating some of these people so they'll go and spread the conservation message basically to others. The cost is that it does take away from the research sometimes because some of these people, a lot of them are there on vacation and things. We're there trying to get our research done, but you have to spend more time training. You get more individuals in, more teams in every two

> weeks so you have to start over with training and spend more time with that. Then also we have a lot of bad weather days due to high winds and then you have to [entertain them], especially if we’re in a remote place. [In this remote location], you know, you can’t go to a movie or to the pub so you have to find activities to keep them happy and all that. So it’s more work than if you didn’t have them but we couldn’t be there unless we had them so...

The decision about how much to rely on volunteer labor, both on the water and back in the lab, depends not only on the preferences of the project personnel, then, but also on the complexity of the tasks that need to be performed. At least one organization used to use volunteers more extensively during the film era than they do now that they have transitioned to digital photography. The Pacific Whale Project used to rely on volunteers to use their darkroom and print out black and white prints of the photographs that would be used for identification. Now that they have transitioned to digital photography, however, they turned their darkroom into a room for other uses and no longer use as many volunteers. Instead, full-time staff handled most of the steps in organizing and processing the digital images. We will return to this phenomenon when we discuss excluded actors below.

One last category of actors also plays a supportive financial role in marine mammal science: individual philanthropists and donors. This group of actors plays a much bigger role for non-profit organizations than for universities or government agencies, which get more of their funding from grants and the operating accounts of their parent organizations. For non-profits, however, private giving can account for an important source of continuing funding. The need to keep donors interested and engaged is one of the reasons many of the non-profits produce regular newsletters for their supporters. These newsletters report on current research projects, announce important events for the study population ("among the milestones was the birth of a calf defining a span of five generations of resident dolphins living in [the study area]" (GCRI newsletter)), contain profiles of scientists and staff members, highlight challenges facing the species that the project studies, and in general report information that will keep supporters interested in maintaining their level of giving.

6.2.1.2 Non-human actants

While there are certainly other actors involved in the socio-technical networks of marine mammal photo-identification scientists, the ones identified here represent some of the more important actors in the system. But what about non-human actants? Setting aside the question of whether non-human actants can be participants in the system by exercising agency, they are without doubt influential parts of the socio-technical network by their mere presence. Even for those non-human actants without the ability to direct their influence, their roles in the system influence the range of actions of other actors and actants.

Among the non-human actants of interest for this study are the digital photography technology package, other information and computing systems, the animals that are the subjects of study, the ecosystems in which these animals live, governmental organizations and their regulations pertaining to research on wild animals, non-governmental organizations, and funding sources.

One of the strengths of social informatics research, and one characteristic that separates it from much of sociology, is its attention to technology and willingness to foreground technology. The most obvious technology that plays an important part in digital photo-identification is the digital photography technology. Photography is not limited to just cameras. It also encompasses the other elements that are required to translate photons into useable documentation and data that can contribute to scientific knowledge. The total computing package of photography will be discussed in greater detail below (Research question 8: Choice points and the total computing package, p. 238). However, several aspects of photographic technology are better discussed here since they impact the other actors in this system in material ways.

The selection of a particular photographic system is one that has long-lasting implications for a scientific program. When buying a professional-level SLR camera, a scientific program is also making a long term commitment to purchasing additional equipment that has compatible lenses, memory cards, and other accessories. Of the sites participating in this research, there was a nearly even division between sites using Canon equipment and those using Nikon equipment. Only one site had large investments in both brands of camera; most used either Nikon or Canon. The decision about which system to use was often made many years before the switch to digital, as research projects acquired not only camera bodies but also expensive lenses. When beginning to contemplate switching to digital photography, even if one brand of camera had offered advantages over the other, throwing away large investments in both camera bodies <u>and</u> lenses would have been much more costly than switching existing professional lenses (which can cost thousands of dollars each) to the new digital bodies. Instead, programs watched developments by the camera manufacturer they had already invested in, and purchased test equipment once it appeared that the cost had come down enough for it to be affordable and offered the features they anticipated needing in the field (fast focusing, little shutter lag, good light sensitivity, and most importantly, good enough resolution to identify animals in the shots. Thus, the camera brand, and by extension, the camera manufacturers, become actants influencing the timing for a program to enter the digital photography arena.

Specific features of the cameras also have an impact on the practice of science. Shutter lag, for instance, was a problem that had to be eliminated by the camera manufacturers before marine mammal researchers even considered using digital cameras. In the earliest days of digital photography, cameras had noticeable shutter lag, the time that elapsed between depressing the shutter release and the actual exposure being recorded by the sensor. Shutter lag has always been particularly pronounced in inexpensive consumer models, but even professional cameras were plagued by shutter lag issues until models such as the Nikon D1 and Canon EOS-1D were released in 1999 and 2001, respectively. The shutter lag issue was a major problem for scientists studying marine mammals. Dolphins are fast swimming creatures, and the difference between a clear shot of a fin and a shot of open water can be a fraction of a second. Even with humpback whales, which are relatively slow moving, pressing a lagging shutter when the animal is at the perfect angle will result in a less-than-perfect shot with portions of the tail at an incorrect angle or obscured by water. Whales do not stop to pose for the camera.

> Dr. Walter Bent (Describing aerial photography from the belly of an airplane flying over bowhead whales in the Arctic): The digital is not turning over quite as fast and has this delay. You fire, it pauses, and then it clicks. And I have not been in the field and worked with this, but we gave a camera to a guy who went up there to do digital alongside film, and that was the issue: and in the end he had no

> photographs. Because of that delay "3, 2, 1, fire" and he just has a photo of where the whale had been, whereas the film cameras caught it.

Another important camera feature is the sturdiness of the cameras and their ability to survive in a sometimes harsh marine environment.

> Jacob Tipton: [Salt water is] a big problem. You want to keep them in a pelican case and protect them as much as possible, but at the end of the day we probably take most cameras in for professional servicing on almost an annual basis to get them cleaned up for that reason. And again, it's not just the salt water environment but the fact that we're operating in an open boat. There's no protection from spray or fog so they are constantly being exposed to the elements.

For the investigators responsible not only for the overall conduct of the research, but also for paying the bills incurred, these concerns can be particularly acute:

> Gerald Lemoine: I'm now going around and telling the folks I work with that they should treat every bit of camera and electronic gear as if it were sort of a newborn baby. Don't just throw it in somewhere and forget about it, or let it heat up in a car, or let it get salt spray on it; it just will inhibit you from getting the kind of data that you need.

Note in both quotations above that a feature of the cameras (perceived fragility) is prompting action on the part of actors within the system. This is why the cameras can be considered to be actants within the socio-technical system rather than mere artifacts: they are differentially (if passively) influencing actions and behaviors of other actors. Understanding this does not require one to accept technological determinism, the widely rejected notion that technology "causes" actors to behave in certain ways. Shutter lag or fragility does not force scientists to wait for better technology, or to take extra care with their equipment. It does however influence the actions and interactions of participants in the system by limiting the range of potential uses of the technology.

Some of the features of digital photography are open to interpretive flexibility (as discussed above on p. 33). The sensitivity of the sensors in digital cameras is one:

> Cynthia Conlin: Light was sometimes a pain in the butt. I don't know if it was - I guess just a better camera…but that was something that was really hard sometimes because when you're out at the crack of dawn or near dusk, and you have all these dolphins and they have fins, but you're not getting quite enough light - that's something that I'm sure as cameras get better, you'll get more of a range.

Others had a different interpretation:

> Jacob Tipton: The fact that [digital] was more flexible in terms of the color, black and white, also I would say things like low light. In film days in low light the only way I could shoot in low light is to either put a different film in my camera and decide to push the film and it could be a different roll, in digital I can change that on the fly much more able to take photographs in compromised situations more easily. So I'm more likely to take photos in those settings. So I think those are kind of the main ways, the fact that it adds color, the ease of shooting in many settings and removed some of the appearance of expense in the photographs, we're more willing to use it in low light settings.

An investigator with the Federal Marine Agency also sees the advantages of digital cameras when operating in low-light situations:

> Maureen Colvin: I came back from aerial surveys [of harbor seals]…where I was supposed to shoot film but I brought the digital camera as a backup, the D1X… The guy who was in charge of it, a guy here, liked digital, but they hadn't really explored it much. And I had all these rolls of film…we basically fly over harbor seals haul-outs of the lowest of the tides. And the first lowest of the tides was very early in the morning, and so I just shot digital because it was much too ridiculously low light levels. And at the end of that day when I was looking at the photos on the computer, I called…the guy in charge of the project…and said, "Hey, my digitals are looking real good. Can I just keep shooting?" And he goes, "Yeah."

This interpretive flexibility reflects the way in which different actors can look at the same feature of an artifact and interpret it in different ways. Whereas Conlin felt that digital cameras were difficult to use in low light, Tipton and Colvin both thought just the opposite. So competing interpretations (‘poor low-light tool’ and ‘good low-light tool’) are played out in discussions, formal and informal, as other actors are enrolled in the system. A new participant will be influenced by the interpretation made by those they encounter in the domain. More areas of interpretive flexibility will be discussed below in the section on architectural choice points for the system (p. 238).

A second non-human actant is the information system required to use the digital photographs collected in the field in a meaningful and useful way. When film photographs of marine mammals were collected in the field, it was not necessary to involve computing technology in any way. Film was developed in darkrooms or at professional labs; slides or prints were stored in binders and files, and matching could be done by hand and recorded in paper-based systems. Prior to the advent of digital photography, databases were becoming more widely used to record, store and query data about photographs and other encounter information, but the photographs and the computers remained disconnected from one another. Once projects began to switch to digital photography, though, it was no longer viable not also to develop much more elaborate computer systems to deal with organizing digital data, organizing and editing digital photos, backing up data, locating digital files, and assisting in the matching process. Software became much more connected with the performance of photo-identification. Among the more commonly used software packages for dealing with digital photographs and their related data are ACDSee, Microsoft Access, Microsoft Excel, and Photoshop. However, as many as 25 other less common programs are also in regular use at various sites to deal with the digital photographs. Hardware also became more elaborate, as projects installed networked servers to store and share their growing collections of digital images.

One of the unintended consequences of all this new computer hardware and software is an increasing need for experts to deal with the information technology aspects of the science:

> Sara Prentice: We have all of our images on a central server with each computer accessing the images on that central server and I've…installed ACDSee separately on each computer and put a database on each computer using ACDSee telling them where all the images are and giving all the information about their names and their known information and their categories and everything. Sometimes when I'm doing my updates – when I do updates, nobody else can use ACDSee at the same time that I'm doing an update when I'm changing out photos or adding information that we know about animals. So I often have to come in on the weekends to do that when nobody else is going to be on the computer.

Much more information about aspects of the computer technology being used to work with photo-identification is included below. Here, the main point to establish is that the computer technology is more than a mere artifact, and is in many cases better analyzed as an actant since its features and limitations influence the range of possible actions of actors within the system.

Let us consider a completely different sort of non-human actant now, as we turn our attention to the animals studied by the marine mammal scientists. Dolphins, whales, manatees, seals, sea otters, and so forth are important actants within this socio-technical system.

Once the notion outlined in Chapter 5 is accepted that studying marine mammals in a non-invasive fashion is preferable to invasive methods, the animals become more important actants in the system. Instead of creatures that are killed and turned into objects (carcasses) for studying in the laboratory, the living animals now have much more influence on the practice of science. Dolphins, whales, sea otters – all swim where they choose and are protected from excessive harassment by federal law and international agreements. Whales in particular can spend 90 percent of their time underwater, whereas most of the photo-identification projects are done on the surface of the water. The scientists must spend a lot of time anticipating the surface appearances of the whales they are studying. Likewise, dolphin scientists must anticipate the diving and surfacing of the animals, sometimes in large groups. A dolphin can appear to be heading in one direction after a dive and then surface someplace else entirely.

Again, one does not need to engage in debates about whether the animals' behavior towards human scientists is purposive or not or struggle with issues raised by animal-rights groups to acknowledge that the activities of the marine mammals are influencing the behaviors of the scientists. We have already mentioned one way in which aspects of the animals' behavior interacts with the technology in this socio-technical system: being fast swimmers, the animals force scientists to wait until their cameras are able to capture that motion. As another example, the dolphins in one of the projects in this research had skin coloration that was quite similar to the water color in the area where they lived, making it difficult for auto-focus cameras to focus reliably on the fin instead of the surrounding water. Is this purposive? Of course not, but it does influence socio-technical choices made by actors in the system.

Once the animals are seen as important actants in this socio-technical system, the next step is to argue that the ecosystems in which they live are also actants influencing socio-technical choices and social behavior. Bowhead whales live in the Arctic region, an environment that is fairly inhospitable to humans. As a result, the bowhead whales are commonly studied using aerial photography. The following is an example of the difficulty in gathering identification and photogrammetric information on these animals:

> Dr. Walter Bent: Meanwhile a third camera was held over a belly board, it could be as much as a meter across. So you are looking through this glass right down on top of the whale and with this handheld camera you had better chances of adjusting towards the angle. The left right component is done by the pilot, so from the rear I may tell the pilot "We've got a whale at 11 o'clock, out two miles." So I talk him into it saying "just in the next hole over" and he says "okay, I see it." So then he's adjusting that alignment and someone in the plane would look out of a bubble window—the windows stick out several inches—and look down there is a plumb line and so as the whale position passes under they do a countdown "three, two, one, now." And at that all the cameras fire, and if I'm holding the camera over the belly port, a second or two prior to that the whale starts to come into view and I can fire several shots.

The interaction between the perceived fragility of the cameras and the realities of the harsh marine environment in which marine mammals live has been noted above. Furthermore, the remoteness of many of the locations plays an important role in how science is done. If a project has to go out on a self-contained vessel for weeks at a time, different socio-technical allowances must be made (in terms of ensuring power for electronic devices, adequate storage for the data collected, extra equipment in case of failure, etc.) than if a project is operating near a populated area in well-traveled waters.

What other non-human actants have important influences on the ordinary science of marine mammal photo-ID? One important actant that was discussed in chapter 5 is the

Marine Mammal Protection Act (MMPA), and other pertinent governmental regulations and regulatory bodies. As was described earlier, the limitations placed on takings and harassment of marine mammals was an important actant that influenced the development of photo-identification as a scientific tool and that continues to influence the performance of scientific activities today. Along with the MMPA are the regulatory agencies, such as the International Whaling Commission (IWC), the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (FWS), the U.S. Marine Mammal Commission (MMC), Fisheries and Oceans Canada (DFO), and similar organizations in other countries. In the United States, there is a complex division of responsibilities among several agencies:

> Authority to manage marine mammals was divided between the Department of the Interior (delegated to the Fish and Wildlife Service) and the Department of Commerce (delegated to the National Oceanic and Atmospheric Administration). A third Federal agency, the Marine Mammal Commission (MMC), was later established to review and make recommendations on the policies and actions of the Service and NOAA related to their implementation of the MMPA. Coordination among these agencies is necessary in order to provide the best management practices for marine mammals. The Service was given authority to implement the MMPA for the conservation and management of sea and marine otters, walrus, polar bear, 3 species of manatees, and dugong. The Service's regulations for implementation of the MMPA can be found at 50 CFR Part 18. The National Marine Fisheries Service (NOAA-Fisheries) was given the responsibility to conserve and manage pinnepeds other than walruses (i.e., seals and sea lions) and cetaceans (whales and dolphins). (U.S. Fish & Wildlife Service, 2007)

This complexity adds work and expertise requirements for scientists wishing to pursue marine mammal research. Organizations such as the International Whaling Commission also have an important role to play in terms of negotiating the extent to which whales are protected or harvested. As an organization, the IWC can be considered a non-human actant in the system of marine mammal photo-identification, but it is also its own very complex actor-network, made of up both conservation-minded voices and pro-whaling groups: “It's amazing that people continue to go there every year, because what you have is two voices that are talking past one another. You have the whalers and the anti-whalers” (Japan’s deputy whaling commissioner Joji Morishita, quoted in Black (2007)). Beyond its role as a negotiating platform for issues regarding the protection and harvesting of whales, the IWC also serves an informational role for whale scientists; one of few publications specifically aimed at documenting photo-identification methods was published by the IWC based on the papers presented at a symposium sponsored by the IWC (Hammond et al., 1990).

A number of non-governmental organizations (NGOs) are also influential actants in the study of marine mammals. Organizations such as Earthwatch have already been mentioned as providing volunteers and financial support for field science, but there is also a wide range of other environmental and conservation organizations that maintain a focus on marine mammal protection, conservation, and scientific study. From large international organizations such as the World Wildlife Fund and the Natural Resources Defense Council to the literally thousands of smaller NGOs operating around the world, the NGOs influence policies towards marine mammals, both nationally and internationally, provide education resources to maintain public interest in marine mammal science, arrange travel for tourists to observe wild animals and to participate in science as eco-volunteers, and are a source of funding both for specific scientific projects and for ongoing operating expenses of scientific organizations.

This brings us to the final non-human actant: funding organizations. There is some overlap here with both governmental and non-governmental organizations, since research funds often flow from these sources. The funding aspect of science, however, is an important enough actant in the system to merit its own discussion. Funding issues will be discussed in more detail below (Research question 4: Resource flows, p. 203), but it is important to note that without continuing sources of grant funding, much of the marine mammal photo-identification would have a difficult time continuing. First, a researcher at the Canadian Science Center, a government run facility, reported that:

> Robert Newton: It is mostly funded through the [Canadian] Species at Risk Act… It is where the bulk of our funding…comes from. For many years there was no funding at all. It was just on our holidays and weekends (laughs).

Next, a researcher at Dolphin Bay Center, a small non-profit offers this:

> Jennifer Daggett: For the most part, I mean we are completely dependent on grants so we're completely non-profit or other donations. So for most of them we would put money in towards a specific grant and most of the grants that we applied for they need to have you know they are not just general money, you have to have a specific thing for it, so we put in for different grants for the camera, and computers, and other cameras and things like that.

The investigator on the same project at Dolphin Bay had this to say:

> Dr. Carole Pepin: We work mostly with family foundations…many give us just general operating funds, but a few of them like target a project, so would send in a request, for example, this equipment upgrade, which, in the $5,000 to $10,000 range, it's pretty easy to do for some of the foundations…Wildlife, environment, sometimes specific marine animals foundations…a lot of them are long term funders for us actually, just every year they expect a grant [application] from us. Which is nice.

The non-human actants discussed in this section, photographic systems, information systems, animals, ecosystems, governmental and non-governmental organizations, and funding agencies, all play important roles in influencing science and the socio-technical system of marine mammal photo-identification. A less radical view of actants has been taken here than some actor-network theorists have adopted when they argue that non-human actants can exercise agency. In our usage, we avoid the question of agency and instead prefer to discuss the influential roles filled by these actants no matter whether that influence is purposive or not. For the purposes of understanding how these socio-technical systems function, the resulting effects are more important than any potential motivations of non-human actants.

6.2.1.3 Core groups

What are the core groups to which marine mammal scientists using photo-identification belong? Certainly, as scientists a major core group is their primary professional affiliation. In nearly all cases in the research, when asked to name the most important group for them professional, the response was the Society for Marine Mammalogy (SMM). The SMM has approximately 1600 members[48] world-wide, and the biennial conference is a large, well-attended event. The SMM encompasses all sorts of research into marine mammals, using a variety of techniques including photo-identification, acoustics, genetics, and other methods. At the 2005 biennial meeting in San Diego, California, there were over 900 posters presented (2 days of poster sessions, with 42 display bays of 8-12 posters each). While only a small number of the posters had

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[48] As listed in the Membership Directory at http://www.marinemammalogy.org/members/directory.cfm, access by subscription only. Last accessed June 22, 2007.

photo-identification in their title or abstract (approximately 30), other posters identified photo-identification as one of the tools used in the research. Informal estimates by several prominent researchers who use photo-identification was that about 500 scientists use some form of photo-identification in their work, or about one-third of the Society. At the 2003 biennial meeting held in Greensboro, South Carolina, a special workshop on digital photo-identification techniques was held; at the 2007 meeting in Cape Town, South Africa, another workshop on "Recent advances in digital techniques" is planned. Thus, the SMM provides both an important professional affiliation, and a source of continuing sharing of knowledge about photo-identification techniques and results.

The SMM is also an important publication outlet, as the publisher of *Marine Mammal Science*, an important journal for the field. Since the founding of the journal in 1985, 219 articles have been published that mention photographic evidence. Through the publishing activities and the selection of posters and talks at the biennial meetings, the SMM also performs an important regulatory role, ensuring through peer-review that research is of a quality acceptable to their scientific community.

Beyond their membership in the SMM and other societies, marine mammal scientists are also members of two other types of core groups based on their professional affiliations and personal networks: trans-species and species-specific communities of practice. For our purposes, we will follow Hara's definition of communities of practice: "informal networks that support professional practitioners to develop a shared meaning and engage in knowledge building among the members" (Hara, 2006, pp. 76-77). Thus, communities of practice can be considered core groups for their members because of their role in transmitting and sharing knowledge about their scientific endeavors.

The trans-species communities of practice are those that transcend the study of a particular species or genus. People who use photo-identification as a scientific technique, we suggest, form one of those communities of practice. While there are subtleties that come into play when comparing photo-identification techniques for bottlenose dolphins, humpback whales, blue whales, and sea otters, much of the general knowledge about how to do photo-identification is shared by researchers working with different species of animals, across the marine mammal spectrum. In the 1990 IWC symposium, for instance, presentations were weighted toward cetaceans (whales and dolphins), but also included presentations on other animals such as gray seals and harbor seals. Among cetacean researchers at the workshop, there were examples from a wide variety of species: bottlenose dolphins, right whales, sperm whales, killer whales, minke whales, fin whales, humpback whales, and a number of others. There appears to be much less collaboration with scientists outside of the field of marine mammalogy, however, even though terrestrial scientists also use photographic identification techniques with animals such as elephants.

There are also species-specific communities of practice, which can range from very large communities of scientists for a widespread species such as humpback whales, to very small communities studying rarer or more inaccessible populations of animals and/or using very specific techniques with population of animals:

> Dr. Carole Pepin (discussing the technique of using underwater photography to identify dolphins): I'd say a handful. It's a handful. Yeah, I mean there's only

> three places in the world where we've really got consistent, you know, use of that…I can think of 1, 2, 3, 4 - yeah, probably literally half a dozen.

These species-specific communities of practice can also include non-scientists interested in the species. Some of these non-scientists who are interested in the science contribute photographs to the scientific catalogs. Here is a description of one such person:

> Anna Hawes: He runs a vessel that is a whale watching vessel, and so he is doing everything all at once. He is the captaining the boat. He is driving, he is taking pictures, he is the announcer, he is the naturalist, he is writing everything down.

The ability to identify other members in these small communities of practice readily was apparent. At the end of each interview, subjects were asked to identify other scientists who might be appropriate subjects for this research project. Not only were the first responses primarily scientists studying the same species as themselves, but there was also a considerable degree of consistency when the question was asked of the other scientists. So, for example, if scientist A identified colleagues B, C, D, and E as good sources of information, a later visit with colleague D tended to yield a similar list (possibly A, B, E, and F, omitting C but adding an additional case F).

Another important set of core groups for this study are the organizations for which the scientists work, their employers. As mentioned before, this research included projects centered in colleges and universities, at government facilities, and at non-profit organizations. Compare how a government employee and a non-profit director describe obtaining funds for their research. Dr. Bent works at the Federal Marine Agency (FMA):

> Dr. Walter Bent: There was a while they discouraged us from seeking reimbursable funds is what we call going outside, and so for many years if we did

> a project it's because [the agency] directed the money. I would write the proposals and present why we should do it.

In contrast, recall the statement above by Dr. Pepin, who heads her own small non-profit organization, that family foundations are an important source of operating and project-specific funds. The general atmosphere is also different at the different types of organizations (see the discussion "In the field" (p. 293) in the appendix for a full description of some of the different types of sites visited). The government facilities were large, with rows of offices lined up along corridors and were difficult to gain entrée to and to get commitments from potential participants. The non-profits were in a variety of types of facilities, and interestingly provided some of the easiest access because they had the most reliable schedules overall: they opened at a certain time, and a large proportion of their employees were then present on site throughout the work day. Scientists at colleges and universities, on the other hand, were sometimes difficult to schedule for interviews because of a laid-back attitude toward working on-site. Many of the participants indicated that their regular work was often done at home or elsewhere. These different organizational norms and expectations influence how works gets done, who chooses to work in that type of setting, and how much collaboration occurs within an organization.

One final type of core group that is slightly different from the communities of practice mentioned above is the peer networks and collaborations among scientists. The peer networks are networks of other scientists at a similar level in the knowledge hierarchy. In other words, the investigators discussed above share network connections with other investigators but rarely with graduate students other than those with whom they work. Likewise, graduate students often had large networks both within their universities and with peers at other universities at a similar level whom they had met during field experiences, at conferences, or during previous schooling. One could identify large numbers of these peer networks (heads of non-profits, government contractors, government employees, etc.), and some will be mentioned later below.

One of the most important types of peer networks are large scientific collaborations. The SPLASH collaboration, for instance, stands for “Structure of Populations, Levels of Abundance, and Status of Humpbacks” and is a collaborative three-year project involving over 150 researchers in ten countries designed to determine the population levels of North Pacific humpback whales and other scientific questions about the animals’ health and behavior (Chadwick, 2007; The Hawaii Association for Marine Education and Research, 2007). While SPLASH is one of the largest collaborations among marine mammal researchers in recent years, other smaller collaborations form an important way for scientists studying wide ranging populations to gather data on their populations.

The likelihood of engaging in collaborative research seems to be at least partly linked to the behavior of the animals (which are actants in the system, as described above). Small populations that stay in a relatively small area, such as many dolphin species, are often studied by just one scientific group, or by a small number of researchers:

> *Interviewer: Do you know if any other researchers are studying the same dolphins?*

> Holly Kershaw: No I don’t think there are. Well, take that back. The New Zealand department of conservation. We’ve worked with them in the past and we have shared photos with them and they’ve shared photos with us. That’s the only group I can think of and they’re in New Zealand.

Humpback whales, on the other hand, swim thousands of miles during their annual migrations, and collaborating with scientists working at other geographic locations can help a scientist track down information about the movements and behaviors of long-ranging animals.

Table 8: Actors, actants, and core groups

Actors	Non-human actants	Core groups
Investigators	Photography systems	Professional societies
Researchers	Information systems	Trans-species communities of practice
Technicians	Animals	
Field support personnel	Ecosystems	Species-specific communities of practice
IT Staff	Governmental organizations	
Volunteers	Non-governmental organizations	Organizations / Employers
Philanthropists	Funding agencies	Peer networks / collaborations

A large number of actors, non-human actants and core groups have been identified that are relevant to marine mammal scientists and their use of photo-identification as a scientific method. These are summarized in Table 8 above. These key players will re-appear in the following sections as we discuss the rest of the research questions.

6.2.2 Research question 2: Incentives and impediments

2. *What are the pressures/incentives or impediments to adopting digital techniques?*

An important concern for the scientists when it came to switching from film-based photography to digital photography was to identify the costs and benefits. Some of the costs and benefits were apparent during the decision process; others emerged only after projects had started using the digital equipment. In this section, the most important incentives and impediments early in the adoption process will be discussed. A consideration of the emergent benefits, conflicts, and unintended consequences will be left for Research question 6: Benefits and conflicts on p. 216.

During the 1990s, camera manufacturers were framing digital photography as an inevitable replacement for film (Meyer, 2007a). Anybody using photography equipment in a serious way would have been hard-pressed to ignore the growing trend toward digital cameras and the corresponding retreat from film photography. Marine mammal scientists were no exception, and many reported wanting to try early experiments with digital equipment but were impeded by concerns about their ability to perform at the level required by their science.

> Dr. Gerald Lemoine: Well, ever since about—I don't know the exact year, but I'd say about '93 or '94, I was looking at the very professional cameras that were costing $30,000 at that time and wondering whether we could get anything that we could at all remotely afford that would have a fast enough shot rate. And it just wasn't there, at least not what we could find and/or could afford. It was not doable. And in, I think it was '97 that [name] was out in the field…and he emailed me and he said, "Hey Gerald, we've talked about [digital cameras] before…There's this new Nikon Coolpix out." And it was the one…where you rotate it like that. It was a monstrosity. It was a horrible thing. And I looked at it. I went to a camera place and looked at it. And it still wasn't fast enough. At least that one, that model. And I said, "No, I'm not willing to buy it. Let's wait." Well, the next year, I'm pretty sure it was the next year, the D1…the first one. We still have it, by the way, and it's still working. It's been a wonderful workhorse. And that was it. The world changed. It was $7,000 when we got it…and we had the lenses, so we didn't need anything but the body…. And that was it…again, we had been talking about it. I was interested in it, of course. But [name] was the one who was really on top of it when he said, "Can we buy this Coolpix?" And I nixed that. And the next year, we did get the [Nikon]—I'm pretty sure it was…maybe even less than a year later that that lovely machine came out.

Lemoine's worries about the performance of digital cameras were also reflected in the following recollections of the discussions about switching to digital cameras:

> Denise Conway: We were worried about "are [digital images] really as good slides?" What was the archivability? We were really concerned about archivability. We wanted to know, you know, it just seems like the technology to be able to store data digitally changes like every year. I mean we used to have SyQuest drives, you know, way back when. And then it was Zip drives, and now you don't even have Zip drives…Now it's all USB and back-up USB drives. I mean, what's it going to be [next]?

> Ellen Batton: Those conversations and those issues all took place before anybody ever had a digital camera. Pretty much once somebody got a digital camera, they stopped having [concerns]. That was amazing because I remember beforehand, [people saying], "these cameras are going to be too sensitive, and they're not going to hold up to the abuse of being in the environment." Just nobody was quite convinced that they were good enough. It was around that year when the SLR digitals became some combination of affordable enough for us to get our hands on a good one and widely available…You know, I think the main issues were mostly just people worried about the cameras not being robust enough to handle field work.

Batton's observation that many of the concerns were alleviated once scientists actually got to try out a digital camera in the field were reflected in comments throughout many of the interviews. Nearly all the scientists who were already using digital equipment[49] indicated that they would never choose to go back to film, and were very glad overall that they had decided to switch to digital.

Another impediment to adopting digital technology was actors who preferred to maintain the status quo for a variety of reasons:

> Maureen Colvin: And I wanted to switch to digital two years before I was allowed to. And it was really unfortunate, but it was my direct supervisor, and it was like, we'd already been doing this sort of [work]…And it was, "No. For consistency, we want to make another video disc." And I ended up wasting hours of [name] and [name]'s time putting things on a video disc. And unfortunately, by the time I

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[49] A small number of scientists who have not switched to digital cameras but continue to use film were also included in this study.

> got approval, budget-wise, because I didn’t have a budget at the time to do it, they weren’t pressing video discs anymore. So it was a debacle.

One researcher indicated that the learning curve for digital cameras was steeper than she would have wished for:

> Leah Tull: Oh, yes. I was very afraid to use the digital in the beginning because we did not know what the best settings are, and we still sometimes have to meddle around…and with the slide camera I knew exactly what I would get because I have so much experience.

For those who were more cautious about jumping into digital, there were costs associated with caution as well:

> Dr. Rita Price: He wanted to completely switch over like that [snaps fingers]. It’s like “Oh my god!” You know, I’m just freaking out because here’s 25 years of data and I’m thinking, “[gasp] It’s not going to be comparable. And we’re going to lose all the survivorship stuff. And population trends.” And, I was just…you know, I’m not against it, but I was just worried. Like, how are we going merge all this together? And, so for a couple years there we did film and digital. [laughs]…My god. It was a rough couple of years. You know, because what would happen is, some images would be captured on the digital and some on film. Not all whales were captured on both formats.

Note that in all the situations described by Colvin and Price, trying to maintain parallel systems or to continue to use obsolete technology in the long term caused a great deal of stress and wasted resources, in terms of time and money. This is not to say, however, that scientists who were most successful had leapt in to the digital world without being systematic about the move from film to digital.

> John Maze: That sort of what was happening during 2003. We got one digital camera, and it went out. It went alongside the slide camera, we all got a chance to test it out, to use it, and I think….let me check my pictures, I think [name]…used it in December and [name] took it out for her July team, and she had been doing the monthly monitoring for over a decade here. So, we had everyone try it out, and I think they found that the pictures were good enough, the affordability was

> certainly there. And so we once realized that given all the other plusses, the actual data will be as good as or better than film, we felt right making the transition, but the decision making process was pretty much driven by [the investigator] with lots of input by the few people that were around him all the time.

Others were more confident that the transition was just a matter of time:

> Alan Crane: So there was a lot of discussion. It's not if we were going to use the digital technology, but how we were going to transition it and when. And, you know, Photoshop was like rev 2.1, you know, so it was in its infancy stage.

Among scientists who paid any attention to the photographic equipment trends, there definitely appeared to be a general air of inevitability about the transition to digital photography. Beyond the incentive of simply keeping up with current technology, however, as early adopters of the technology began to share their successes through their communities of practice and their peer networks, some of the advantages that the scientists were seeing began to influence others.

> Denise Conway: I think, for me, it was having seen other colleagues, particularly [name], stuff that I was just like… I was pretty wowed by it, the digital. Of course they had the top of the line cameras. They got them donated from Canon…and, I mean, they were ten thousand dollar cameras at the time I saw it and I was like "whoa". And I think that was some of the initial resistance here: "Oh, that's too expensive and we don't know if that stuffs going to be a fad"…So I think that's why, initially, when I came back with this excitement about it, it just got squashed...

Another investigator also commented on the connections that influence technology adoption:

> Dr. Janet Bostick: Those groups aren't totally separate, so I think they've influenced one another, but they do have autonomy, and so I would say that good ideas spread and people take along the good ideas that they find and do some things differently if they find that that works better for the project that they're in.

Knowledge about the incentives for switching to digital spread both through personal networks and communities of practice, as described above, and through more formal routes, such as the 2003 SMM workshop on digital techniques for marine mammalogy. Several publications also appeared in the scientific literature assessing the use of digital images for photo-identification. One well-known exchange took place between Markowitz et al. (2003a) and Mizroch (2003), with a reply by Markowitz et al. (2003b) in the journal *Marine Mammal Science*. In this exchange, Markowitz et al. made a case that digital photography increased efficiency in photo-identification, arguing that "digital photography holds promise as a seamless interface between the collection of photo-identification data and the latest computer-based analysis techniques" (2003a, p. 218). They went on to state that based on their tests, their "results indicate that digitally acquired images not only performed up to the slide film standard, but actually surpassed film on all measures examined" (2003a, p. 219). They also argued that:

> In addition to improved image quality, increased range in optimal conditions, and maintained computer resolution, digital photography saves time, resulting in fewer "missed opportunities" in the field and increased analysis speed. Digital images allow for near-instant feedback after data acquisition in the field, unlike the days to weeks that development of silver-halide emulsions can take. Therefore, we learned to recognize certain individuals more rapidly, allowing us to examine social cohesion more efficiently. (Markowitz et al., 2003a, p. 221)

Mizroch, however, replied that the jury was still out on the quality of digital images, and that Markowitz's comparisons were not applicable to all projects:

> I agree that digital photography is very promising for photo-ID studies, but until more side-by-side film versus digital camera tests are conducted, digital images cannot be considered superior to film. The film used in Markowitz et al. (2003) is not considered adequate for our photo-ID studies, and the scanner they used is not as technologically advanced as those that are available currently. In my

> experience, images taken with the Nikon D1X are demonstrably better than scanned images of Kodachrome or Ektachrome color slides, so I agree with Markowitz et al. (2003) that digital may be a better choice for them. However, in terms of absolute image quality, a properly exposed, processed, and scanned high-speed black-and-white film image would have as many, if not more, subtle details as a well-exposed digital image. (Mizroch, 2003, p. 613)

Markowitz et. al replied:

> We had much the same skepticism prior to using the Nikon Dl digital system in the field. After three years of using digital photography in the field, we can confidently say that we have not only found it to greatly increase the efficiency of our dolphin identification efforts, but also that it consistently outperforms film photography in the proportion of images of suitable quality for analysis. Were this not the case, and digital photography performed just on par with film photography, the logistical advantages of digital photography would still be considerable. For example, long-term storage of multiple copies of photographs in digital format is inexpensive (about 5,000 images before cropping can be saved on a single compact disk), and takes up very little space compared to storage of slide film or prints. Multiple copies of photo-identification catalogs are good insurance against cataclysmic stochastic events, and storage on compact disks allows for easy transport between research field and lab sites, and for collaboration between research laboratories. (Markowitz et al., 2003b, p. 610)

This public exchange of ideas was mentioned by a number of scientists interviewed during this research as having influenced them to consider the advantages and disadvantages of moving from their film-based data collection to a digital system. Less than two years later, however, the author spoke informally with Mizroch[50] at the 2005 SMM biennial conference in San Diego, and by that time technology had advanced to the point where Markowitz and Mizroch were largely in agreement with one another: digital photography's technology had become sufficiently advanced, its cost had come down to

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[50] This conversation at a professional conference was outside of the data collection for this research and were not protected by confidentiality agreements. Thus, pseudonyms have not been used, and Mizroch consented for this exchange to be reported in publication.

reasonable levels, and overall its advantages were such that there was little reason remaining to stay with film. Mizroch was using digital photography in her scientific work by that point.[51]

The incentives for and impediments to adopting digital photography discussed in this section illustrate the interpretive flexibility around the artifact of digital cameras. This one piece of technology was interpreted as efficient, impressive, and practical on the one hand, and as fragile, difficult and inadequate. To reach what SCOT theorists would call stabilization required not just changes in the technology, but also interactions between and among scientists operating within their communities of practice and peer networks to establish effective protocols for implementing the technology. This process can be classified as one of enrollment, as actors seek to convince others of the value of following a similar course and adding to their actor-network.

Once this had happened, the shift to digital occurred fairly rapidly. While there is no hard data to know how widely film is still used, most respondents felt that nearly all U.S. and European projects had switched to digital, and that projects in the developing world were lagging behind mainly due to cost issues, as the following two examples illustrate:

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[51] There is one interesting side note on the effect of publishing one's opinions in a well-read journal. As mentioned in the text, a number of participants in this research mentioned the Markowitz/Mizroch exchange without prompting. These interviews were done in 2006 and 2007; however, some perceived Mizroch as still being "anti-digital" even though she herself had switched to digital after this exchange once her concerns were reduced as the technology matured. This illustrates the longevity of the written word, and how scholarly publishing can affect how one is perceived by her colleagues.

> Denise Conway: I would say the majority of people that I know have all switched…with the exception of people in maybe Third World countries that maybe don't have the money to purchase the equipment yet. They're still using slides or photographs…. One of my colleagues…only had a slide camera and she's working in Columbia and was talking about having to send slide…rolls back and forth to get developed and all that stuff. And I said, "you know, you should have a digital camera", but she said "I just can't afford it."… [So] I went out and bought her a camera, and she did pay me back over time and I just said you need to have this. And she was so thankful. She said it made all the difference; she could look at her photos right away.

> Holly Kershaw: I read papers every once in awhile that come from [someplace] like Latin America. I'm always surprised; they say they're still using film. Like I read papers on both dolphins and otters. The marine otter [researchers there in]…a lot of those countries still use film but it's probably because they don't have the resources.

For this research, however, a small number of scientists were contacted who were not currently using digital and preferred to remain with film. Their comments will be discussed further in Research question 6: Benefits and conflicts (starting on p. 216).

6.2.3 Research question 3: Knowledge transmission

3. *How is knowledge about how to use digital photography technology obtained (e.g., is it formal or informal, what role do other researchers play, who in the scientist's networks participate in the learning)?*

Nutch has observed that many marine mammal scientists are what he calls "gadget-scientists[, who] love to tinker and fiddle with gadgets gizmos, equipment, and instruments…[and by doing so] are involving themselves in a mode of handling local conditions by utilizing…resources…" (Nutch, 1996, p. 218). This predilection is apparent in the approach nearly all the scientists in this study took in learning to use digital cameras and to apply them to their work: they got their hands on one and started playing with it. Few reported taking a class or learning initially from a workshop or publication. Instead, they started using one:

> Leah Tull: We're trying pictures, we're trying different lights, different shutter speeds…and programs for example on clouds or on sun or on just white balance… And then we are looking at…different ISO film 400, 800, 200, etc., and then look at it, download it, and compare it and check how with the different light conditions, what is the best…We basically have been teaching ourselves.

Even scientists who may have initially been inspired through a more formal method such as a conference or paper eventually turned to hands-on learning:

> Jennifer Daggett: Well, we had gone to some conferences and they had done…a talk on switching to digital and which cameras are better, which ones are worse, you know, and they published it in a journal. So we read that. We looked at what other people were using. When we actually got the camera that was basically just sitting down and going through the manual and getting all the little outs and ins and everything. And then taking what we usually use on the old camera, the settings and stuff, and finding those on there and doing that.

A few reported having some help from a peer or mentor:

> Dr Rita Price: [Name] kind of helped me with it. He would make a little cheat sheet for me, what type of settings and stuff like that. But you know we encounter problems sometimes up there and we're not sure how to really fix it, you know? Like what setting and…there's usually one of the four of us that's really savvier, actually reads the instruction booklet. Like, "No! You're supposed to…" "Oh! Okay." We, we tend to work it out. Yeah, it's a little stressful once in a while, but we tend to kind of figure things out. If not we just call [back to the facility] and, you know, "What do we do? We're having problems with this." Or, if people have experienced problems…we have little instruction books: "If this happens, do this," or "we found that in the Bering Sea that this has been happening to us; make sure to do this." So, we just talk amongst ourselves. It seems to work out okay.

It is possible that this predilection for hands-on learning was at least partly influenced by the scientists' existing comfort with film cameras. Digital cameras, in their basic operation, are not all that different from film cameras. They have similar dials and buttons, they look about the same in the case of SLR cameras, and the act of framing and capturing a shot is not all that different. Many of the differences arise at a later stage, when dealing with digital images instead of strips of film, as will be discussed later. The cameras themselves, though, are not all that different.

To understand better whether it was more likely that the scientists' experimentation with digital equipment was based on familiarity with film or whether it could be explained by their characterization as 'gadget-scientists', respondents were asked about how newcomers to this field were taught to collect photographic information in the field. They explained that the method for teaching new people to do photo-identification (digital or not) is just as hands-on. Here is the perspective from both an investigator who has trained others (Colvin), and from two technicians who were recently trained in photo-identification (Hawes and Stamps):

> Maureen Colvin: And so, again, I do that on a one-on-one, because…I like to push people a little bit. But I have done side-by-sides, and when I'm working with students or interns or whatever who are learning, I basically give them a camera and send them off to the dog park and say, "Frame and focus, and just find the right moment to shoot." And so it's just, for me, from my perspective, it's a confidence thing. You know, if you think—if you really talk to yourself, humpbacks are very slow and very predictable. And if you practice, you will get it at the right moment, and it will be better. And you will have less photos to deal with.

The perspective of a technician can be somewhat different:

> Anna Hawes: The adjustments are already made like on the ISO and all that other equipment, but you still have to be able to know like when the whale is coming up. You have to know what part of the whale to take a picture of and so they kind of gave about a 3 minute tutorial before you got in the car to go on the boat….So I jumped into the "we are going on a boat. There are a couple of whales. We need to photograph them really quickly and this is how you're going to do it." But I

> feel like if you know anything about cameras or you've ever taken a picture with the digital camera, you kind of get the idea really quickly.
>
> Kathryn Stamps (explaining how she was taught to take identification photographs): It's "here you go, here's what you want to look at, here's what you want to do, let's go."

This indicates that the hands-on approach extended beyond those who already know how to use a film camera and are transitioning to digital, and to the scientists in general. This would support Nutch's notion that marine mammal science has a tendency to attract and reward those who are comfortable fiddling with gadgets. At least one senior investigator, however, believed that this orientation may be disappearing in the latest generation of new scientists:

> Dr. Gerald Lemoine: I spent a lot of my time being involved with making things work, keeping them working. Radio tracking, oh my goodness, you can't imagine the kind of gyrations I went through to keep that equipment going. And, nowadays, I sometimes, in my older age, have to sort of stop myself and say, "Wait, it's different, and they know other things, and they pay attention to other things." But when I have a student and they don't really know the difference between DC and AC, and what to plug in where, and how to make this work, or know how to develop something, or know how to really get from one place to the other, it's sometimes very frustrating, because I think as a field biologist, one should be able to do all those things. And that it gives one a better, a deeper appreciation of what can and cannot be done, maybe. But then, on the other hand, one shouldn't be so smug about it. If I hadn't learned all of that practical stuff, I probably would've been a better thinker. I would've spent more time on the philosophical. You know, so, it really doesn't terribly much matter, I suppose. It's just different… And the kind of emails I get back from people in the field… they're very kind, and so forth, they always tell me what's wrong, and how it was solved. Usually by calling somebody from town, you know, to solve it. An electronics, or electric, or mechanical person. Which is fine, because it's available, although it gets expensive. But they tell me these things and I think, "Oh my goodness. How come—" I sort of blame myself. "How come I didn't tell them how to do that before it went wrong?" So it's a different way of life. It's a different way of viewing things, and I think I'm noticing that it's not just me, but that there is less involvement by more people in that fashion.

If these observations are valid, if there really is a large scale shift away from tinkerers, it will be interesting to see if this has any impact on the practice of field biology in the long term. Will research projects require extra personnel in the form of equipment specialists just to keep operating? Will the types of research be constrained by an inability to solve problems independently in the field? Only time will tell, and it will be interesting to watch for evidence in the future.

Some of the skills needed for photo-identification field work are taught to newcomers in a more systematic way. The following quotation comes from a researcher working at a well-established, well-run photo-identification program at the Atlantic Dolphin Research Institute (ADRI). Of the projects included in this study, ADRI had one of the most well-documented and thoroughly thought-out protocols for gathering, processing, and handling digital data. ADRI's thoroughness is reflected in the following passage:

> Faye Hampton: We require that you photograph every dolphin and every sighting. The photographer learns to identity the dolphin through the lens just to know who they shot and who they didn't shoot. We have fifteen or twenty dolphins and we have to keep track. You don't know who you shot and you have certain dolphins that are boat friendly and pop up all the time and other ones that are boat shy that won't come near the boat. You can't be shooting the same dolphin over and over consecutively. That is one of the things that we teach in the field. You have to look through the lens to discern where the dolphin is, and not by name, it's just like a quick note like, that one has a white mark on the leading edge and that one has an upper cut. It doesn't matter but we write it down and we check it off as soon as we get the shot on it. That is a skill set that is very difficult in the field to acquire because they move so fast and learning to focus on that trailing edge is very difficult.

As Hampton indicated, at ADRI the research protocol requires that every dolphin in a sighting be identifiably recorded on film, or the sighting doesn't count as a valid encounter. This raises the stakes compared to a research protocol that tolerates less than complete coverage due to different scientific goals and could thus tolerate less training in field methods before sending a newcomer out to gather data.

Another type of knowledge transmission takes place within organizations as they learn from their own mistakes:

> Denise Conway: Why are we more meticulous? I think just because we've learned from mistakes of people missing identifications and stuff like that. And I think other places…just might not have as much staff time dedication to it. But also, in another sense, I think it really slows us up and it puts us behind, although we've been making huge leaps and strides to catch up.

In this situation, the members of the scientific project acted as an ongoing repository of knowledge and experiences, and then used that knowledge to avoid repeating their mistakes. This learned knowledge can either be formally documented, such as in the 62-page field manual used at the Gulf Coast Research Institute (GCRI), or informally embedded in the memories and shared experiences of participating scientists. Either way, this institutional memory plays a part in determining how the *next* technology or methodological innovation will be approached in the future. Did the organization struggle by being early adopters? Then the investigators may display more reluctance to be at the cutting edge next time. On the other hand, was the organization being left behind, as their peers and colleagues advanced? That perception may influence earlier adoption of the next innovation.

All of the examples of learning and knowledge transmission in this section indicate that the answer to research question 3 is that knowledge about photography, digital photography, and other technological innovations is primarily obtained informally, by self-experimentation and through shared-experimentation with peers and colleagues. This informality reflects an independent streak that was non-systematically observed in a number of the participants in this research. This independence is likely an important survival trait in a scientific field that relies on spending extensive time on boats, sometimes in remote and/or inhospitable locations, and working with less-than-ideal levels of personal comfort. Thus, it is not too surprising that signs of strong independence appear at multiple points in this research, including patterns of learning and knowledge sharing.

6.2.4 Research question 4: Resource flows

4. *What are the resource flows (e.g., to pay for equipment, staff, field work, new specialists in digital technology, etc.) that the scientists have mobilized to pay for their photo-identification work?*

Science costs money. Fields like marine mammal science have considerable expenses including equipment (cameras, computers, GPS units, acoustics equipment, genetics equipment, and navigation equipment), boats, boat fuel, travel to field sites, accommodations at field locations, personnel costs, expenses for lab space, and regular operating expenses for their organizations. In addition to money, other resources such as expertise are necessary to achieve an investigator's scientific goals. This section examines some of the resources that scientists have mobilized to assure access to needed equipment and personnel, and to keep their operations running.

6.2.4.1 Equipment

Purchasing the initial digital camera equipment was one of the major hurdles to transitioning to digital photo-identification for most of the projects in this research. Professional cameras in the late 1990s were very expensive pieces of equipment, such as the Kodak Pro DCS 520, a 2.0 megapixel model that cost $10-12,000 in 1998. Even if a $12,000 camera had been ideally suited to the needs of marine mammal scientists, the likelihood of obtaining this much funding for a single piece of equipment would have been fairly low. As the prices dropped, however, the equipment moved into the range that scientists could consider as a possibility. The first model of camera adopted by a number of the projects discussed here was the Nikon D1, a 2.7 megapixel camera that debuted in 1999 for $5,850 and had dropped to approximately $4,000 by 2001. This still represented a significant expenditure but was much closer to the range that scientific projects could request from funding sources and have a pretty good chance of approval. Most of the projects reported submitting special equipment proposals to make their initial purchases of digital cameras, and now try to put additional photographic equipment into research grant proposals when they can. The initial switch for larger projects, however, could entail considerable cost if they needed to outfit several boats worth of scientists with digital equipment all at once.

> Jacob Tipton: Most of the projects the funding came through and [we discussed] what can we afford to do. [Switching entirely to digital] was a little bit more, so again it was very much something discussed among all the people here. I think it seemed big enough that we even brought our board of directors in at some point to decide, “Okay, is it worth spending $45,000 at this one time and making the jump conversion?” And, we also benefited by the fact that we did have a donor

> that actually gave us our first digital camera. It was a donation. He actually gave us the camera, so that helped.

At least one non-profit organization (ADRI) was able to use the contacts and charisma of the director to get considerable amounts of photographic equipment in exchange for the public relations advantage to the camera company:

> Alan Crane: He said every year, Compaq chooses three companies who are using their technologies for solutions…and you're doing something with animals and technology that's very interesting [so we'd like to film what you do]. Well of course, I didn't have any digital cameras. I had a little tiny crappy computer that Compaq gave me and I had this dream of getting these cameras donated from Canon. So I was wringing my hands and I had a little bit of this relationship with Canon started and the only people on the planet that had the digital cameras were the three technicians…[who] provided technical support to Canon users…
>
> AC continued: So I was able to convince the Canon guy to send me his stuff and talk to me over the phone how to use it. What button to push; two buttons at the same time and then flip the switch. It sounded very difficult. Then I had the film producer call me and there was a hurricane coming in and he was going to say yes or no and I was hoping he'd say no, and he said yes, we're going to do it. So all of a sudden, all the stuff that I had been telling him; oh we've got digital technologies, so I'm changing the world and everything. Suddenly he was going to come here and film something that I didn't have and he was going to be here in about a week. So, we have an IT Department here and so instantly I started building the fastest computer on campus. It had more slots in it, it had the slot for the little Compaq flashcard or the micro drive. It had, you know, RS232 ports for the different monitors, it had everything - - they built this thing for me and as they were just putting the last screw in, this big box arrives from Canon with this guy's phone number and they start pulling out these cameras and stuff going uh-oh and the software and these twain drivers and everything and all of a sudden, I open the door and there's [the person] from the production company and he's got his director, his cinematographer, his key grip, his sound guy, his script person - - there's eight people standing out of the office and I'm like, oh, hi, this is serious. And I had a couple of boats, I needed a platform for them to be on, and this hurricane was approaching. [This video I'm about to show you]…is what we did in three days after he knocked on my door. That's the story of how this all came about.

After this initial foray into digital photography it was still several years before ADRI actually implemented regular field use of digital photo-identification, but this initial experiment established digital as a goal and also started a good relationship with the Canon camera company that would help ADRI stay at the leading edge of digital photo-identification:

> Alan Crane: I mean, that first camera body, the D2000 in 1996 or 97, was $17,000 for a camera that shot three frames a second on a micro drive at 2.1 effective megapixels. $17,000! How do you justify that acquisition? Well, I took the cost of the film, the developing, the FedEx, the sleeves, the fire-proof safe, the time of analyzing with soft dollars, but I took the hard dollars and just for our little initial study, it was a savings of $20,000 a year. Not to mention time, that's a soft dollar saving. Time on the dolphin. Bang, did you get it? I got it, man, full frame, it's sharp! We've got these dolphins, lets move on.

As Crane indicates, some of the early adopters justified the cost of the equipment by taking into account their savings on film, developing, and other related costs. At least one participant, however, felt that the cost was artificially inflated:

> Paul Dawkins: Well I think that their cameras are more like toys. I mean, somehow, these camera companies have decided that they're going to charge $8000 for cameras that the film equivalent was a thousand, eight-hundred. I think that's nonsense, but you know, they're going to do it as long as they can get away with it. So, they put out the prosumer ones, which I never would have bought before for my work, but I can't afford the other ones. But they work alright. You know, we have just got to be more careful with them around whale spouts, and stuff.

Of course, buying a digital camera involves more than just purchasing a new camera body and no longer purchasing film and processing. For these scientific projects, it involved purchasing computers (desktops for the lab and laptops for the field), external storage media, software such as ACDSee and Photoshop, network file servers in some cases, and then committing to upgrading this computer equipment as newer versions of operating systems and software are released. In fact, this increase in the complexity and expense of computer information systems is one of the unintended consequences of the change to digital photography. This and other unintended consequences are discussed in more detail in Research question 6: Benefits and conflicts (p. 216).

6.2.4.2 Operating and staffing expenses

One of the unintended consequences of switching to digital photography for many of the projects has been an increase in permanent staff:

> Jacob Tipton: Certainly there's been one interesting move is that the handling of the photos once they get back to the office here looks very different. And, it's been certainly a move that's towards greater efficiency, but it also has one down side is that it's also moved us a little bit away from the use of untrained volunteer interns that in the film days we tended to have a lot of training on interns that would work on printing in the dark room, doing dark room work formatting photos, attaching labels, writing in data and now that's more an integrated step. It's done more efficiently time wise but it also tends to be a little bit more demanding in that it's done by staff rather than a volunteer… We still have [volunteers] very much involved in them trying to do some of the matching, but they're much less involved in the photo processing, photo printing, labeling; that's all handled by staff, and I think it's been better, more efficiently over all, but it does involve more staff.

And of course, having more paid staff requires additional resources to pay them. In order to meet these ongoing staff expenses, many of the non-profits cobbled together resources from a variety of sources:

> Jacob Tipton: And work that's identified by a government agency that needs something done and we view it's either close enough to our purpose or it helps pay the bills and keeps things funded. So, there's sort of a mixture. Not everything is kind of carefully chosen. Sometimes we do because it employs people and we need to do it. But still, within the overall over-arching goals and meeting our larger objectives.

As mentioned earlier, eco-volunteers are an important source of funds for a number of projects in both the non-profit and the education sector. The first comment is from a researcher at the South European Dolphin Center:

> Leah Tull: In between June and September, we're going out very regularly because we have eco-volunteers who pay to participate in this project and then basically, you know, they have right to go out… The research as such is 80% or 90%, I think about 90% funded by eco-volunteers…our field house and food and gasoline and the repairs to the boat…. What's not funded is buying new equipment. It's not funded. This office is funded by the city. The city, we had a very big sponsorship in 2003, …the city sponsored us for 20 years, and so we could rebuild [the building] and get some equipment…. Now, we still get a certain amount from the city which covers the electricity and things like that.

Southern Gulf University also runs programs for eco-volunteers, and one of their researchers commented:

> Holly Kershaw: [The eco-volunteers are] our main funding source for the project. They pay a certain amount to the [eco-volunteer] organization…and then we get a portion of the amount that they pay. That goes directly towards our research…. It is a pretty stable, reliable source of funding because funding is so volatile these days. You know, you can't predict it and NSF, I don't know but their percentage of grants is really low. So, it is, I mean it has costs and benefits to it but it's a pretty good source… The cost is that it's a lot of extra work and stress to have to run kind of this tourist research but then again we don't have to find our own funding. And the facilities are set up so it's good overall.

However, the investigator on Kershaw's project had a slightly different perspective, as he admitted that he made personal contributions to cover the shortfall in field expenses:

> Kershaw's PI: I always contribute something. This year, a lot, to the project, because I've got so many grad students working [there]. We didn't break even at all. But without [the eco-volunteer money], we couldn't have done any of the work, actually…but over half of that goes for the feeding…and other stuff, extra travel and so forth. Over half of it goes to that. So it's about $20,000 to $25,000 that's available for the research from [the eco-volunteer money].

For researchers working in government agencies, the actual field expenses could be relatively easy to pay for if the project was piggybacking the research onto a larger research cruise:

> Dr. Shawn Moore: It's an oceanographic research ship. But they only have ranges of about 3-4 weeks, so we have to come into shore to get food, fuel, and stuff like that. They are designed for about a month at a time…Most of the time, [our projects] are smaller scale things within the bigger project that we are already doing, so basically you don't need the money or you may only need minor new money for that because you are already going out there and you just need to buy more film or memory or to do just a little more this or that.

In general, there isn't a single source of funding for ongoing operating and staff expenses. Funds from government grants and contracts, donors, eco-volunteers, in-kind donations, and private foundation money all contribute in varying degrees. While employees at government agencies or universities have some additional security in terms of these operating expenses, several of the investigators at non-profit agencies indicated that the freedom to pursue their interests without lots of outside involvement made the trade-off in job security worthwhile.

6.2.4.3 Expertise

Besides the additional photo-identification staff mentioned above, many of the projects also invested in either dedicated or shared information technology (IT) experts. Database design, network server administration, and computer support all require specialized skills. In some cases, computer experts were brought in, and in others existing staff with a talent for working with a program like Microsoft Access had part of their time devoted to designing databases. The following excerpt describes a complex database project that was initiated at the Atlantic Coast Marine Center (ACMC):

> Brandon Lindell: I actually have been working with a programmer for quite a few years on and off. We used to have all of our data in dBASE and then I sort of envisioned a much more flexible and user-friendly environment, so we moved into Access. So, he helped us with that and we had a little matching program that folks from [a funding organization] helped set up and he helped sort of finish off. So, I've been working with him for years and he actually helped write some of the technical aspects of the grant, but unfortunately once we got the grant he was no longer available to work on it. He basically didn't have a whole lot of hope that it would work out and, you know he had to pay the bills and stuff. So, anyways, that was a fairly disturbing turn of events. And he had actually even started a little prototype of what we're moving towards. So then we had to put it out to bid and that was pretty difficult because this guy I've been working with, he really understood the database and he'd been working with it in a lot of different ways and understood how we worked because a lot of computer programmers really don't get it. They're used to people who are not as computer-adept and, you know they're used to financial stuff or healthcare systems primarily…. So, I basically sat down with all of the people I worked with and designed every single interface that we would ever need with our data…you know, every screen we would need and every field in our database and it was pretty detailed and I think both exciting to the people who have been on it and a little overwhelming because there was so much information.

ACMC provided the details of this project that was put out to bid, and the prototype interface was laid out in Excel spreadsheets, using the cells as a grid to simulate a screen and included information on required fields and the behavior of each field. A total of 53 Excel documents were required to specify the design that the biologists needed from the computer programmers. When the project was awarded, "they said, 'Yup, we can have it done in six months.' And two years later, they had it done" (Brandon Lindell). Here is a similar experience at Whale Canada:

> Paul Dawkins: We had a specially designed database for us on the Mac. We have all the data for that animal's sightings over the years, all the details, associated animals, any new scars, things of that nature, the depth, the atmospherics…we can

> get everything from that day. And the photographs are linked to that. We're working on a new thing right now because of all these new pictures coming in; it's a little scary because, you know, before we had contact sheets and all that. Things were more tangible. And so because there's so many different people working on this we have a thing we call [name] that we've created with some software developers. And we're hoping to have that in place this year so that we have a much more standardized way of putting the pictures in, after each day. So it's not just so much of a mess. You know, it can get quite messy on computers if each person's putting their files and stuff. We've had a little…it's been a little slower getting that up and going than we'd hoped because the software guys didn't quite click on what needed to be done. But, I think, we might be getting there.

The Atlantic Dolphin Research Institute (ADRI) also used expert help to design their databases and talked about the length of time required to build a system:

> *Interviewer: How about the database that they showed me? They tell me you designed that? Did you also do the programming part of it?*
>
> Faye Hampton: No, I worked with a programmer here… That has been ongoing. It took a year or more and we still tweak it.

Coming up with a database to track information about the photographs and about the other data collected in the field has been a major issue for most of the projects. Some projects took a different approach from ACMC or ADRI, and chose to have biologists working on the project pick up database skills:

> Ellen Batton: Would you like to see our in-house database…? [This] is the first database that I designed and from there things have kind of grown from it… What users see typically when they open the database is ….I think it's about five different tables. First tier of data being effort, so you have one record per day, general information about that day. You know, who, which boat, where, how long were you out? Keeps a log of events throughout the day and a log of conditions throughout the day. So from here, if you enter this, you can have several options of where to go from here and one is…to add sightings to this particular survey, so it will automatically build a link to this day… You can also filter sightings, so you can view sightings from the survey…, the next here is sighting information and each sighting is given a unique number and this is all the… forms…for

> information: lat, longs, start, end times, species, number of animals, behavior, you know, various permit information. All pretty big.

Regardless of whether projects chose to use in-house staff or to bring in outside experts, a common theme throughout the sites was that the information systems required to track all of their digital information had grown far more complex than they had originally envisioned and that maintaining the systems and upgrading their features had become a growing task for all the projects. The expertise to build and maintain these systems, then, is a resource that the marine mammal scientists have had to enlist either by hiring experts or by developing the skills of scientists.

6.2.5 Research question 5: Included and excluded actors

5. *Who becomes involved in the photo-id process for the first time when scientists adopt digital photography; which formerly involved actors and technologies are excluded; and how are peripheral actors affected?*

One of the questions that distinguishes the STIN strategy from SCOT or ANT approaches to understanding socio-technical systems is that both newly included and newly excluded actors is included in the analysis. The inclusion of new actors such as information technology (IT) experts was discussed in the previous section of this paper, so it will not be revisited here. Some of the excluded actors are fairly obvious (film-processing laboratories, film manufacturers, companies to ship the film), and not really terribly interesting from our analytic perspective since they were primary external participants in the system. Another study examining the techno-economic forces operating in the film processing industry would find them to be important actors, but most of the participants in this research were mainly glad to be free of the expense, time, and environmental costs associated with film processing.

It is, however, worth discussing the most mentioned change in human participants at marine mammal labs: the shift from volunteer labor to paid staff positions throughout the photo-identification process. This shift has resulted in a linked pair of included and excluded actors: the paid staff are newly included, and some, but not all, of the roles played by volunteers are newly excluded. The costs and benefits of this change to the practice of marine mammal science will be briefly examined.

This logging of data on the boat is an important role volunteers play in many of the projects:

> Christine Showers: I guess the primary help [the eco-volunteers provided for] my research was to record data. So, we had data sheets that we recorded surface data, like environmental data or the different behaviors or numbers, so it's good because typically, one researcher will need to watch the dolphins to call out the behavior accurately, so it's helpful if you have a volunteer that's actually recording that data while you watch the dolphins. I guess they also help in terms of maintaining equipment and cleaning equipment up at the end of the day and they actually helped quite a bit this last season in terms of analyzing data on the computer.

However, earlier in this chapter (see p. 145) a trend was noted that had been discussed by a South European Dolphin Center researcher toward changing habits in the field regarding logging data about photographic images. Part of the earlier quotation is reproduced here:

> Leah Tull: With the slides, I would call out every picture I took. I would say left dorsal, right dorsal, and if possible the animal and if I wouldn't know the animal I would say A1 or C1 or whatever just to indicate it's the first adult…. [A volunteer] would definitely hang on my lips and write [everything] down…. Unfortunately, now we don't still do that.

Several people commented that the involvement of eco-volunteers in the field was highly variable, and some believed that as the equipment got more complex, there were fewer tasks that they could trust volunteer outsiders to do accurately. The real shift, however, was noted at some of the sites that previously used local volunteer to do a number of the tasks related to maintaining the office, keeping track of data, processing images, and matching images. Recall Jacob Tipton's quotation above, in which he noted that the move away from volunteer interns and toward permanent staff is more efficient, but also more costly. One of the researchers on the same project described it this way:

> Ellen Batton: I think that it's very different. I mean, our interns come in and they're handed stock photos and this is a humpback whale, that's the catalog, go look for it. And it's changed so much in the last few years, because when it was still in film, the other thing that interns did as they came in - they didn't actually develop the film, but the negatives would need to be printed and it would be like here's a list. One of the staff would review the list to be printed and matched and we'd show them how to use the darkroom and then they would spend days and days and days in the darkroom printing photos. So that was a little bit more of a hands-on approach, but this system has taken the place of the interns, basically, so now you can't really have an intern. You will need to have somebody who's got some skill be married to the program and that's a shift that we're still dealing with that we just don't have the - - we used to really need a lot of unskilled labor and now we struggle for finding things for unskilled labor to do.

The costs of this change are obvious from the point of view of the volunteers and interns who want to work with an organization that was struggling to find things for them to do. Many interns go to non-profits to enhance their education in biology, and also to increase their ability to get hired later, either by the same organization or by another one. Recall the discussion above (see p. 162) that profiled the technicians who are actors in this system. Many of the current technicians occupying paid staff positions had gained entrée to the organization as unpaid interns or volunteers. If there are fewer opportunities for interested people to make meaningful contributions and demonstrate their commitment to marine biology, this narrows one opportunity for long term participation in marine mammal science. It is somewhat ironic that the flip side of this trend is that some of the same organizations are hiring full-time staff (either permanently or on temporary contracts) to do the more complex and technical work that unskilled interns and volunteers used to do. Open questions remain as to whether those interns are finding their way into these paid positions without having the requisite experience, and if so, how are they doing so?

The benefits from this change accrued to two different parties. First, newly employed paid employees benefited financially, particularly if their other option would have been to either do the same work for free or work in another organization about which they may not have the same passionate interest. Second, the organization benefited from having a well-trained, stable workforce over which they have more control that they would over unpaid workers. As Tipton noted above, the current system which relied on paid staff was more efficient, especially in terms of time, which helps advance the organization's scientific agenda. The opposing cost from the organization's point of view was economic – staff needed to be paid regularly, and that meant the organization would have to ensure a continuing flow of money or risk watching their scientific program grind to a halt.

As for non-human actants in the system, the evidence indicated that one system has been exchanged for another. Digital cameras replaced film cameras, memory cards replaced film, and computers and databases replaced paper catalogs. While all these changes have had important repercussions for resources (discussed above) and various benefits and conflicts (discussed in the next section), they mostly represent exchanging one form of the actant for another, rather than truly newly involved or newly excluded actants. Even computers, which were not strictly required for film-based photo-identification, were nevertheless in increasing use for information management in the years prior to their widespread use in digital photography. As such, those changes will not be discussed in this section; what will follow instead will be a discussion of the main benefits and conflicts related to the switch to digital photo-identification.

6.2.6 Research question 6: Benefits and conflicts

6. *What conflicts arise over the digital photography computing package in routine use, and what are the biggest benefits of digital photography in routine use?*

Every participant in this study had opinions about the biggest benefits that had accrued and costs they had incurred by switching from film to digital photography. In this section, evidence will be presented that some aspects of the change are viewed as clearly beneficial, some are open to debate, and at least one is a clearly unwanted cost. We will take a look at each of these in turn.

6.2.6.1 Benefit: Efficiency

Somewhat unsurprisingly, there was fairly wide agreement that using digital cameras had increased the efficiency and productivity of the scientists, as these two comments illustrate:

> Dr. Marcia Parrett: I think just efficiency - my efficiency has just increased tremendously.

> Dr. Walter Bent: You have a camera, you aim it at a whale and push the trigger, you can see the image, you captured date, time, lat, long—all the data you need is now captured by the press of a single button. So that is already there. And so I can hearken back to times where every time you had a sighting you wrote down the date, the hour, the minute, the second, the latitude—degree, minute, second—the longitude—degree, minute, second—and then how many whales and so on. It was tedious. And then you have transfer errors when they get written into something else. So I really appreciate the efficiency of capturing such long streams of data with the single push of a button.

Being able to work with the data during times when the weather was bad or the scientist was stuck and not able to gather data for some other reason also increased efficiency:

> Dr. Carole Pepin: Now we can process it on the boat, so that becomes a saving of time in the lab, so on the downtime of bad weather or no dolphins around, they just knock it out on the boat, you know, go through the photos and label them….

Some of the scientists were also beginning to take advantage of elements of the digital photography package that were previously unavailable with film, such as the presence of EXIF metadata that is embedded in the photo itself:

> Maureen Colvin: You know, [name] had already written up exporting metadata. So we're already sucking in date and time. And I was just standing in the crow's nest doing a watch and thought, "We can start putting stuff in the metadata." So pretty much I led that one, which is really fun. And when I was out with the folks again, this past year, I actually was telling them that, because it was a lot of the same students. And I was going, "Do you realize that we invented that?", which is cool…. Metadata…is incredibly important…. It's really more accurate, because you're basically looking at the photo, putting your data sheets into the photo. And the portability of it, like if I have to send a photo out to somebody, what do I do, photocopy it? Scan it? Whatever. I can just embed whatever I want them to know in the metadata and boom it out to them.

Time after time, participants agreed that they thought they were more efficient and more productive using digital cameras than they ever had been with film cameras. Of course, not everyone agreed:

> Robert Newton: People look at it as a time saving, money saving issue and I would argue that's not the case at all. In fact, the real cost is to take everyone's time into account for doing the backups and filing all this stuff properly, renaming files. It's very time consuming.

6.2.6.2 Benefit: Ongoing costs

Of course, the savings in regular operating expenses with digital is pretty clear if one only takes consumables such as film, paper and chemicals into account. Although we will later see that the situation is less clear when taking into account elements such as the cost of time and personnel, the material costs do seem to be considerably lower. Unlike film, the marginal cost in materials when taking an additional photo is close to zero. Storage is relatively cheap, so even if a project keeps many more photos, the material costs of doing so are not huge compared with the costs of processing and storing an equivalent number of prints, negatives, or slides. According to an investigator at Northern Pacific University:

> Dr. Marcia Parrett: If you take something bad, you can just delete it right there. I think it saves a lot of money in terms of film processing.

And one of the government investigators had this to say:

> Dr. Shawn Moore: We can collect data on dolphin schools that basically we couldn't before because it just wasn't worth it to take that many photos. So we are getting new kinds of information.

A technician at ADRI also agreed:

> Amy Kirkwood: I’m sure it saves a lot of money. Because you can analyze faster, you can delete pictures you don’t want, you’re not using all that film. You don’t have to be as—as—judicial with your film. You know, you can take a lot more pictures with digital and not worry about it, without breaking the bank. Um, you know, the cameras are expensive, but I think in the long run, you get your money’s worth out of them.

The ongoing money savings from using re-useable digital media compared to the expense of buying and developing film was repeated many times, and appeared to be one of the more tangible benefits of switching to digital photography.

6.2.6.3 Benefit: Immediate feedback

Digital cameras have almost universally incorporated small LCD viewing screens on the back of the camera since the earliest models. As it turns out, this feature has proven to be one of the bigger advantages that digital has offered over film as far the experience of using cameras in field settings to collect photographs of difficult to photograph animals. When shooting film or slides, a scientist only had his or her experience to tell them whether they had gotten the shot they needed. While more experienced photographers reported having had few problems with missing shots on that account, newcomers to the field often had difficulty learning to anticipate the animals’ movements and then being able to know for sure that they had captured the crucial image. With digital cameras, however, immediate feedback is available in the form of the LCD playback screen. A number of participants commented favorably about the ability to verify instantly whether a photograph contained the necessary information to identify an animal:

> Dr. Marcia Parrett: I mean your learning curve is so easy, you see a photograph. You can just see what you've taken and if you need to spend more time…to get a better photograph, you can and if you got it you go away…. It's just the immediate response.

> Sheri Wine: I think that just being able to know that you've got the photo that you want, just from being able to take the photo, that is a big benefit. Knowing that you've left a sighting knowing you've got at least close to what you needed, it is really, really helpful.

> Denise Conway: We were able to see right then and there we got the picture. We got a usable picture. Whereas with the slides, you think you get a usable picture, you get it back, and you've only gotten half the fin. So it grades out…. We really like that with digital.

> Alan Crane: I think the greatest benefit, really, in the digital technology field is that you have that instant gratification or verification.

One of the participants, however, was much more skeptical that this feature of digital cameras was truly a clear benefit:

> Robert Newton: And that's the instant gratification. People, I know that they love to look and see immediately, look at their pictures. So a lot of the time they're sitting there looking at the back of their camera rather than getting a better shot. Chimping, as they call it.

Newton commented that people were spending too much time examining the previous shot, rather than continuing to monitor the animals in the water, and thus potentially missing the opportunity for a better image.

Overall, however, many of the scientists reported that the ability to review a shot on site was one of the most important features of digital cameras as far as their usability in a field setting. As mentioned, this appeared to be particularly true when training novices to take identification photos of marine mammals. The immediate feedback of seeing the images on the preview screen and also being able to review the day's shots at the end of the day on a computer screen allowed the novices to sharpen their skills and get much quicker and better feedback as they learned.

6.2.6.4 Benefit: Workplace ergonomic issues

One somewhat unexpected benefit of digital photography was the positive physical effects reported by several of the participants who had previously worked with slide film and light tables:

> Brandon Lindell: I guess I'll just quickly throw in one other thing, which is definitely, before we used to lean over hot light tables all day, and I think…it seems much better sitting upright and being able to zoom in with the button… [Better than] being down, head down.
>
> Faye Hampton: Well, it's better on your back. Being hunched over the light tables for hours. That's for starters. It's better on your eyes and on your posture.
>
> Holly Kershaw: It was a small project but it's just harder on your eyes especially. You're just sitting over this light board with a little magnifying glass looking at these fins. Yeah, I mean it's just harder physically and it's hard to keep track of which fins are matches and you have to keep a really good filing system or else things can get mixed up and all that. So overall, it's just a longer, harder process [with slides] I think.

Likewise, several of the scientists who used to have to work with toxic darkroom chemicals reported being happy at not having to work in that environment any longer:

> Kathryn Stamps: The dark room was really hard to deal with. I mean you had to cut paper in the dark and you had to deal with chemicals. I mean, there's issues that come up with all that; then there's storing the chemicals and disposing of the chemicals and all that's been eliminated because now it's toner cartridges and paper.

These ergonomic benefits are a good example of the unintended consequences that technology can have. Not all unintended consequences are negative. Certainly, it would be surprising if any scientist said to herself, “My back hurts, maybe a digital camera will make things better.” The net effect, however, of switching from a work production system with certain technological features that were physically demanding (light tables that encouraged bad posture, darkrooms that required hazardous chemicals) to a work production system with less physical demands (comfortable workstations[52] and file sharing networks) is that the health of the scientists experienced a change for the better.

6.2.6.5 Conflict: Shooting habits

The first four consequences of digital photography identified by the scientists were largely positive. The next three changes, however, are slightly more contentious. In each of the three areas of conflict identified here, some participants viewed the change offered by digital photography in a positive light, while others had a decidedly more dim view of the change.

Nearly everyone agreed that they took more photographs in the field with digital cameras compared with film cameras. Estimates made by the participants ranged anywhere from three times to ten times as many photographs were being collected in the field. For some photographers, this was a clear benefit:

> Mattie Conner: The biggest benefit is the fact that it’s very - what’s the word…I don’t have the skills to just - I don’t have [name’s] skill…and I don’t have the patience. I can’t just sit there and be like wait, go for it, I miss it, crap. So I have

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[52] Of course, carpal tunnel syndrome or any of the other potentially negative health effects that can occur with extensive computer use become new risks.

> the rapid fire on there, and [then I'm] obviously getting rid of the majority of the photos that I take. If I used film, that's a lot of film wasting. With digital photography, we've got two memory cards and we just be click, click, click all day. Download it in a computer, erase the card, they're already in the computer, we get to reuse that card the next day. It's very cut and dry.

One of the technicians saw it this way:

> Suzanne Younts: Personally, I think the biggest benefit so far is the fact that it almost feels like an unlimited resource. As long as you have battery power and you can consistently load your pictures on to a computer. You don't have to worry about running out of film and then once you've actually collected your data and you're not limited in terms of data collection, you can manipulate your data more easily. You don't have to worry about how the lab is going to fix it up or if the pictures are going to get treated nicely or not.

Note that both of the above participants were younger technicians and had much less experience in the field. Some of the more experienced researchers and investigators, however, had a more mixed view of the ease with which low per-shot costs and fast motor drives allow collecting lots of photographs in a short time.

> Denise Conway: I think, one, we were taking more pictures because it's like, whoa, it's free, it's digital. We weren't being conservative.
>
> John Maze: It can, we were a lot less shutter happy when we used slides. We were conscious of what it costs, and if we needed to take the film to get the data, I've shot 12 rolls of film in one sighting before. But, we didn't burn as much film as we do now. We take a lot more pictures than we used to. A lot more pictures.

The number of photographs collected in the field could quickly add up to a staggering amount of information, as this comment illustrates:

> Dr. Lynne Shoop: We can end up with seven or eight hundred on a good day. I think we've gone over 1,000 one day. But when we get groups of the white-sided dolphins, we can have upwards of 70, 80 animals in a group. So particularly when we just keep taking throughout and we're there for 4 or 5 hours, it's not hard to

> start building up those numbers. On occasion, we've run out of card space, but not too often with that.

Of course, taking more photographs also means more work down the road, as the either the photographer or someone else on the project has to store, process, document, and match those additional photographs:

> Ellen Batton: It's having to go through and review all those pictures, having to store all those pictures, very few of which you'll ever actually use in your data…. I do think it's pretty unnecessary to take as many as people do. Like two or three is cool, but…I think it's another one of those disconnects between when you have one person taking pictures in the field and somebody else processing pictures that maybe doesn't like to do that. How much of my time is going into your work? Two seconds on the trigger.

Some of the most experienced photographers also commented that this easy motor-driven shooting style inspired a less careful and less scientific approach to data gathering.

> Maureen Colvin: He was one of these "ch-ch-ch-ch-ch" kind of guys [holding down the shutter to fire off shots]. And so I usually stay with them when I'm over there, and…in the evening [we were] working up our photos on the computer, and I say, "Okay, [name], pick your best photo out of your set of 12, and I'm going to pick my best photo." And they're always the same. Or sometimes his camera hasn't even caught focus. And so mine is actually better because mine is in focus.

> Robert Newton: One of the problems I see with digital, well, number one, people shoot a hell of a lot more pictures now. They're not concerned about running out of film so first, you get an awful lot more garbage. People are shooting when, normally, you would've really waited for the proper ID shot, rather than just blaze off stuff. So I see thousands of photographs in digital that you never would have pushed a button if it were film. When you've only got thirty-six shots, you tend to be really careful how you use them. I know that's how I work and certainly from the product I see coming out, I can see that the people are just not paying attention to getting the ideal photograph of killer whales. They're just blazing off a shot.

This particular conflict appears likely to continue, particularly in cases where the photographers are not necessarily those who have to then deal with all the photographs later. If they are, they report starting to self-correct over time as they learn more about animal behavior, and learn how much of the time back at the lab is taken up dealing with a profligate shooting style in the field. There will always be novices entering the field, however, and it is likely that using the motor-drive and large capacities of digital SLRs to compensate for inexperience will continue. It would be interesting to watch as the switch to digital recedes into the past, to observe whether there remains a persistent difference between scientists who had once worked with film and those who have only worked with digital. Do the ones who started digital moderate their shooting style with age and experience, or will never having had to deal with the limitations and expense of film make them permanently less careful photographers than their predecessors? Or will the concept of "careful photographers" be defined differently?

6.2.6.6 Conflict: Time demands in the field

Respondents reported above that being able to work with the photographs during down-times allowed scientists to increase their efficiency and productivity. Is there a downside, though, to having ready access to the images and computers in the field?

> Dr. Marcia Parrett: But it's also a lot more work when you come in from a boat trip, you just can't put the rolls of film away in a zip lock. You've got to deal with the data right then and there.

One of the government researchers had particularly strong opinions on this issue:

> Robert Newton: When I come back [with film], I just want to make sure my labels are right on my film and send it off to someone that does that. And it comes back

> and I stick it in the binder and that's it. With digital, first of all, at the end of the day when I'm out on a boat, I have to find a place to anchor and I have to cook a meal and all this stuff. Then, I have to make sure that all those flashcards are downloaded and burned onto some safe backup file. Now I've just made myself, you know, a whole bunch more work to do at the end of a day that I don't feel I really should be doing, you know?

The practice of starting to work with information immediately in the field was nearly universal among participants in this study. This is partly due to the scientists' enthusiasm for starting to work with their data, but it is also connected to a design element of digital cameras: they use memory cards that hold only a limited number of photographs. Any given project has a certain number of memory cards, and they generally seemed to carry about 2-3 times as much memory capacity as they anticipated needing for a day's work. In a field season of several months, scientists must regularly deal with downloading the photographs and re-formatting the memory cards to allow for continued data collection. Even if memory cards were relatively cheap, buying lots of cards and treating them like film would seem an unlikely choice, since that would tend to negate many of the advantages of digital photographs. Thus, this is another conflict that doesn't appear to have a solution; as long as digital photographs need to be regularly and manually stored, backed up, and organized, scientists are going to continue to spend time dealing with this aspect of digital photography while in the field.

6.2.6.7 Conflict: Speed of technological change

One concern expressed by some participants, particularly those who were responsible for finding and administering funding, was that photography was becoming more like personal computing in terms of the expectation of frequent upgrades and quick technological obsolescence. This is particularly noticeable to scientists who may have used one set of film equipment for many years.

> Richard Summerlin: One of the downsides I find with digital is that they are constantly coming out with new tech and it's pretty expensive when it first comes out, and then about six months later, it's really not that expensive at all.

Robert Newton (who referred to himself more than once during the interview as "a fossil") had strong opinions about this chase toward new technologies. Note that although Newton was something of a skeptic about new technology and digital photography in general, this skepticism did not stem from either technophobia or a lack of understanding of the issues technology posed. In fact, he often appeared to understand the abilities and costs of technology better than many of his peers.

> Robert Newton: One of my pet peeves…again relates to the speed at which technology is changing. I see people getting the latest camera and that was justified earlier on, I think, because the resolution was improving so rapidly. But now it tends to be features and metering and all sorts of other stuff and, what I see is a lot of people constantly on the steep part of the learning curve for new equipment. And, to me, I think you're more likely to lose information, lose opportunity, you know, screw up the encounter or not get the shots because you were not familiar with the equipment. Because there's so many settings that can be changed, and if you have to take the time before every encounter to go through and make sure you're on the right menu and you're choosing shutter and aperture, or you're interested in light meter readings or, you know, what ASA you've got the camera set at, how large a file you're using, on and on and on. And each camera is different. I see people sitting there staring at them and swizzling dials and pushing buttons and trying to make sure they're programmed properly. And I'm a real believer in, you know, first of all you buy quality equipment, especially lenses. But then you just become intimate with that camera and don't change it every six months because there is a new technology out there.

> RN cont.: More problems stem from a lack of familiarity. You should be able to use that camera in the dark, you know? With my film camera, I rarely have to take a light reading. I know what my ASA is. I know what shutter speed I want to be at and I know when I start squinting at F11. So it makes life very simple and I very

> seldom have screwed up exposures. But on digital I see them using exposure compensation and the cameras don't go to zero when you turn them off. So next time you turn it on and you've got plus a stop or a stop and a half of compensation and it hasn't been removed and you don't notice it until after your encounter and on and on it goes, so. There's a million ways to screw up and I would argue, if you don't get familiar and use a piece of equipment long enough to be comfortable with it and do it automatically and know when to check that it definitely causes a lot of problems.

This conflict may or may not be mitigated with time. If digital camera features and capabilities stabilize, the temptation to replace functional equipment will decrease. It is possible that this time is already here, as the race to increase the resolution of professional cameras in terms of megapixels has already slowed or stopped. However, if digital cameras continue to follow a PC-like replacement pattern, the issues expressed by Newton may continue to have an impact on scientific data collection.

6.2.6.8 Cost: Information organization

Finally, there is one subject that nearly everyone agreed was a large and mostly unexpected negative consequence of moving to digital photography for the marine mammal photo-ID collections. Information organization, in terms of creating systems for organizing and documenting digital photographs and their accompanying data, has proven to be a difficult, time-consuming, and expensive endeavor across the sites. The large amounts of data generated in this scientific field must be organized and accessible, or it becomes scientifically useless.

The response to this challenge, however, has been variable and highly idiosyncratic. There have not been any field-wide efforts to implement any cyber infrastructure projects that would establish tools and standards for dealing with digital photo-identification data. The few efforts to become somewhat more consistent beyond the specifics of a single lab or facility have been limited to scientists working with a particular species, such as the SPLASH humpback whale collaborative mentioned earlier. Even these projects, however, appear to be struggling to find the best ways to implement information systems that are simultaneously rigorous yet flexible enough for varied scientific goals.

Some of the organizations in this research have instituted well-documented and thorough procedures for filing, organizing, archiving, and moving photographs, while others haven taken a much more *ad hoc* approach. One of the projects even permitted the several people working on different parts of a larger research project to invent unique systems for organizing their data, and there was little consistency among them. The sophistication of the data management system was directly tied to whether the project had someone with good organizational and often database design skills.

As scientists discussed the fragility of their information systems, their comments expressed concern about this problem. At the most prosaic level, having insecurities about whether information systems were robust enough for the long term were expressed by the following participants. First, a lab manager and researcher commented:

> John Maze: Are there any downsides. I worry a lot about losing the data. It seems to me because it's so intangible that it's easy. Its hard to lose a binder full of slides, it seems a lot easier to me to lose a computer file, or to lose a CD, or to have that CD get scratched. And so, we make slides, you have the one copy. We find digital we are making many more multiple copies. And, it's easy to do, I guess it just something that you always have to think about is how seemingly easy it is to lose the data because they are so intangible.

Next, a lab manager and researcher at a different project expressed similar concerns:

> Sheri Wine: I think one of the drawbacks ias storage. Which we are finding. All the photos that we have on our server system, we have already come close to running out of space. I think that is one of the things that we're finding it difficult to deal with, and I think that just being able to take more photos is nice because it is a little bit, you get more of the information you need when you take more photos, and when you get good photos.

Newton wanted to be sure to sound a warning about the long-term data retrieval issues of digital data:

> Robert Newton: And I would argue that for small research groups, or people without the resources to have someone constantly backing this stuff up, uh, you know, right now I'm sure everyone is burning them onto DVDs, CDs. But I'll bet you anything that in ten years they're going to be hard-pressed to find something to read them with.

Beyond these concerns about the fragility of the information system was the more important problem of simply inventing ways to organize and classify these growing collections of digital information. Interestingly, few had enlisted the aid of trained database programmers; others had found a biologist who was able to learn database skills to design their data systems. None had tried to involve someone with cataloging or information organization education, and most had no awareness that such academic fields even existed. Several mentioned during casual conversation following their interviews that they hoped there was some possibility that this research might interest some information science students who could help some of the marine biologists develop better systems of information organization and classification.

Newton expressed the opinion that there should be a move towards standardization, at least, even if not a full-blown e-Science approach.

> Robert Newton: And if you don’t have a really good filing system standardized, that doesn’t change every time someone thinks it might be better done a different way. So I’m kind of waiting, I guess, to see it really stabilize with a naming protocol and a filing protocol that is not going to wander every time someone comes up with a new software for digital pictures. That happens frequently and you’ll get, people send us pictures off a camera and they’ll be in files maybe a Canon software, or a Nikon one. And you can convert them all to jpegs and fart around with them but, basically, I don’t want to be a film processor.

This area of information organization represents a huge challenge for marine mammal scientists and an opportunity to build some inter-disciplinary connections between their scientific field and information science in the future. Both would likely benefit from such collaborations, as will be discussed in the final chapter below.

In this section, a number of areas of benefits have been identified that have accrued from the switch to digital photography, areas of ongoing conflict and discussion within the area of marine mammal photo-identification, and at least one major area that is a clearly problematic aspect of the computerization of the field’s photo-identification efforts. Many of these costs and benefits were unintended consequences, both positive and negative, that sprang from the decision by scientists to make the apparently simple switch from one type of camera body to another. This illustrates some of the complexity that must be untangled when trying to understand complex socio-technical systems.

6.2.7 Research question 7: Data sharing

7. *How are the data shared with other scientists?*

Data sharing can take multiple forms in marine mammal photo-identification projects. The most obvious form of sharing, providing one’s catalog and/or data to other researchers working in overlapping areas, appears to be relatively uncommon. There are a number of reasons for this. First, as in any scientific field, considerable time and effort go into collecting and maintaining research datasets, and there is a natural reluctance to give those efforts away and allow others to benefit from one's work without them making a contribution to it.

> John Maze: It's, what's the phrase, the proprietary nature of data. So, we've worked very hard to assemble this catalog, and manage it and use it, and so [the investigator] determines those things, and he sets those priorities and he knows if it goes to somebody, who and why and where. He often, I think this is common, people would say, "I need all of this," and he'll say "Okay, what are you doing? Why are you doing it? So you don't need all of it, you need this small piece of it, and if we're going to work with you, then we would be happy to chunk this and give you the smaller piece of it." But, and you're in the field, you know, people can just take what you're doing and publish it behind your back.

Tipton also described a situation where the data were being treated as proprietary, but only for a limited time while the initial researchers had an opportunity to publish. This model is similar to one used by many collaborative projects in areas like medical research and genetics, with the original collectors of a dataset being protected for a year or so while they prepare and submit their manuscripts for publication. After that embargo period, other scientists are given access to the data and allowed to publish their own findings.

> Jacob Tipton: We're only completed matching the first three seasons and a little over halfway through the fourth season. So there's still a little ways to go to complete that. And then there will be a period of time where we'll try to get out the key publications and the reports on the findings and then really shortly after that we'll make that accessible to outside…as well.

Within these collaborations, there were also negotiations that must take place as multiple users work with shared data, as well.

> *Interviewer: Do you share [the photographs and databases] very widely outside the collaborators that you've got?*
>
> Maureen Colvin: I can't. You know, when people send all their data in to me, they have to trust. And so I really can't start a paper without making sure everybody's on board. Like, there have been 3 major papers—well, 2 plus one that's in progress—directly out of [this study]. And we had to have a workshop and we gave assignments. You know, so [name] was doing calf mortality, I was doing adult survival, and [name] was doing birth interval. And that was a planned project with a huge amount of data with the matching scheme, that was the females matching. And so, we have to be very cautious. Like, there's this long-term survival, long-term whale scene. The way it's going to work is, we will see how many people will be involved, and then I have an idea that [name], who took the photos starting in the 60's, should be the senior author even if he doesn't write it. And also, [name] from [location]…and I will work on it together, so we'll figure out whether [name] will be first or last, or [name] will be first or last. But that will be a negotiation…And so, if I plunge into something new, I can't just kind of take the data—or anybody else.

Issues beyond the standard issues of scientific collaboration, scholarly publishing, and assigning credit also appear to be at play, however. Another researcher at the same facility as Maze interpreted the lack of sharing having more to do with issues related to the range of animals:

> Denise Conway: Other people, they come in and look at our catalog and we make sure we didn't do duplicate stuff. In addition, I just got a catalog from people that are doing surveys down in [an area south of here] and they sent us print-out pictures of their animals and I wanted to contact them and see if I could get digital images and compare because I think there might be a few animals in there that are the same. I haven't had the time to look, but that's on my list of things to do…. But as far as [our study area], we're like the sole group studying it…. There's not really a need to share our catalog.

Lemoine also suggested that two characteristics preventing more sharing were simply logistics and a lack of overlap in study areas:

> Dr. Gerald Lemoine: As I say, there are no secrets. And what I'd really like to do is have somebody compare the photos of bottlenose dolphins in the [location] to

> the bottlenose dolphins that we've been studying here and to the south. But it hasn't been done. There's been nobody to put those two together. So we have not shared with [name] or any of his students. But that's not—both he and I are willing to do that, and we're hoping for some student to look at that. We haven't had anybody working north of here…so there is quite a bit gap. Otherwise, I think we'd have found greater pressure to work already together. But it still would be lovely. Still would be interesting to try.

If Conway and Lemoine's observations are correct, the lack of sharing may be tied to the fact that other scientists are not studying the same population of animals; if so, then there should be evidence that scientists studying farther-ranging and overlapping populations have engaged in more sharing of data and catalogs. In fact, there are efforts among researchers studying animals like humpback whales, which migrate thousands of miles each year, to cooperate more and share their information. For instance, the SPLASH collaboration, which was mentioned earlier, is a large, funded project designed specifically to combine contributions from hundreds of scientists into a large dataset and catalog that will cover the population and movements of humpbacks throughout the Pacific. It appears from SPLASH documents, however, that while the concept of sharing the data has been embraced, the operational issues of exactly how to share those data with the hundreds of researchers and others once it has been centrally combined are still being worked out. It will be interesting to watch developments in the SPLASH project to see if it develops into a full-blown e-Science infrastructure for collaboratively studying humpback whales.

Of course, interpersonal issues can also play a part in the likelihood of sharing data:

> Leah Tull [Asked if they share data with other scientists]: Well, there's another project down south. Unfortunately, they don't cooperate and we know we have seen some pictures in the internet, we know that at least one dolphin that was the same or seems to be the same but it's…it's not really working.

Many investigators and researchers, however, saw a clear benefit in the potential of sharing, although, again, there are likely to be difficulties as they try to work out the details of how that might be accomplished.

> Dr. Gerald Lemoine: There have been some real problems of some researchers not sharing with others and so forth, in the large whale business as well, as you probably know. But I don't think there's been any of that kind of worry in these dolphins. I think it can only benefit us if we share our catalog with somebody who's working a couple hundred kilometers down the line, see their potential matches, et cetera. And that is becoming so much easier now. I mean, you can just send a diskette or DVD or something, for heaven's sake.

April Warfield agreed that the digital technology made the logistics of sharing much easier, at least on a small scale as scientists share data at the individual level.

> April Warfield: Editing and sharing are really easy, we don't have to worry about mailing expensive prints or sharing your negatives, and what could happen. You make copies and you send them. Some of the things with [name's] long-term project is people send their negatives to you and then they want them back, and you have to get them back in a timely fashion.

Price also commented on how digital photographs had eased some of the tensions that had arisen over the issue of sharing negatives which were not easily copied:

> Dr. Rita Price: Sometimes they get possessive about their photographs. They want to see their photographs. They want a contact sheet with their photographs to, in some cases, to provide feedback so they can get better at photo ids. So, that's expensive. You're making contact sheets for them and, and if you're sharing data people really like the real photo-ID-ers in the early years, like the negatives better than the contact sheets. They look at them through microscopes, light scopes and stuff like that, and change the lighting and look at the scars and the saddles and everything else. They weren't happy if you just send them a contact sheet because they wanted the negatives but we didn't want to send the negatives. [groans,

> exasperated]….But, with the digital stuff it's kind of cool because we can just send them images. Copy the whole thing. Send on a CD or send it over e-mail. So that's cool.

It is important to distinguish between sharing photographs, which are a type of raw data in this field, sharing catalogs, which are organized sets of all identified animals from a study, and sharing databases, which contains all the other associated information. Sharing a photograph can be as easy as e-mailing it to a colleague, but sharing a database of information can be considerably more complicated.

> Dr. Marcia Parrett: It just it's complicated – so, right now I have two data bases; one on my older data from 2003 back, which was all of the data collected on film, and now I have a new…database that's all the data collected on digital.. So, this spring, I'm actually going to [location]…and we have a collaborative agreement where we share data back and forth and we'd kept it pretty much in the same format except we need to get more on the same page and we're going to work with their computer guy up there at the end of May and really get our databases uniform. Maybe then, it won't be all…the data won't be the same but they'll be the same format.

The issues of sharing databases, even when scientists are interested and willing to do so, is one that plagues many different kinds of science. Scientists create databases for research projects, and tailor them to their specific needs without necessarily giving a lot of thought to whether the data are stored in a common format or whether the field names are easily translated to other projects, and so on. As mentioned earlier, many of the databases were designed by an outside computer person, who may not have sufficient domain knowledge to anticipate such issues adequately, or by a biologist who has picked up some Access skills, and may not understand the data management issues inherent in maintaining a portable dataset. This has resulted in highly idiosyncratic databases evolving for different projects (or even within the same project over time), and then the issue of merging those datasets becomes problematic.

Another type of sharing that should be mentioned here is the sharing of images between scientists and the public. For some of the species that are in the public eye, such as killer whales, the members of the public are often interested in sending in a photograph they have made of an individual animal or a pod they have seen. This also happens between scientists – a scientist studying one species may happen to get a good ID shot of an individual of another species in the course of their field work and will often send that photograph to someone they know is working with the other species.

> Robert Newton: With digital cameras, people are more inclined to send them to you because they can e-mail them, you know, and they don't have to remember to put it in the mail. So for public contributions, I guess you could call it, or even contributions from other researchers, I think the digital has improved that. You know, I think you're more likely to get follow-through on a promise to send you pictures. [laughing] Because it's so much simpler to do.

Scientists can also share images with the public, through websites or through printed catalogs. Some killer whale researchers, for instance, involve Alaskan villages in their work by getting information to residents that will help them identify, and by extension appreciate, the killer whale populations in their area.

> Dr. Rita Price: But, what we want to do now is do a digital catalog so that if we get an updated picture, we can immediately replace it. And, I don't know if we're going to put it on web or what. I've talked to quite a bunch of schools in southeast Alaska and all the little villages up there, and what we were planning on doing was doing a CD, and having a CD available…. Now we're struggling with do we put all the animals on those CDs? What's the purpose of this? The purpose of this is just to get communities involved, like, "Hey you can tell your different animals. And they come around near Petersburg all the time." But, do they really need to have a little calf, or maybe just the distinctive animals that they can call and let us know, "Hey we saw that whale!" You know, that'd be kind of cool.

Clearly data sharing is still an area of flux in marine mammal photo-identification. While sharing between individual scientists and projects has gotten easier with the advent of digital tools, the organizational and technical skills needed to share photographs, catalogs, and databases more widely are clearly an impediment to new developments in this area. It appears likely that more studies will attempt to overcome these obstacles, and the success or failure of the early adopters will influence how later potential adopters calculate the costs versus the benefits of building scientific infrastructures for sharing data amongst themselves and with others.

6.2.8 Research question 8: Choice points and the total computing package

8. *What are the architectural choice points for the system (e.g., what choices are made over time that influence the current configuration of the computing package), and what are the rejected alternatives? What are the other elements of the total computing package (e.g., databases, GPS, etc.) used to support photo-identification? Have these changed?*

We have already discussed many of the other elements of the total computing package of photo-identification and will therefore review them here. GPS (global positioning systems) devices are important and ubiquitous tools in this field. All boats are equipped with them, and they are used to record the location of animal encounters and the tracks followed during a line transect survey. Very few projects, however, have set up systems to integrate the GPS data automatically with the photographic data. Some have experimented with commercially available camera attachments that write GPS readings into the EXIF metadata, and others have worked with storing the GPS data stream in computer files and then merging those data with their photographic databases. Both of these approaches were rare, however, among the participants in this study. Easily the most common mode of recording and storing GPS data was to record it on a paper log kept on the boat during a survey. Since many of the researchers seemed comfortable with this approach, we suspect that few will go to the trouble to add GPS devices to their cameras or work with combining disparate GPS and photo databases unless manufacturers were to incorporate this technology into the cameras. If that were the case, and reading GPS stamps from a photo’s EXIF data was as easy as it is to read time and date information, there would be a widespread move toward using this automated GPS information.

Other elements of the total computing package have been discussed in depth: databases, computers, backup systems, networks, storage media such as CDs and DVDs, memory cards, batteries, photo-editing software, statistical software, and all the other technology required to gather, store, and use digital photographs. It should be noted that while converting to digital photography requires users to also adopt these computer systems as well, there are also many other forces encouraging the adoption of many of the computing elements whether photography is involved or not. The projects here had already been adopting computer and networking technology, and digital photography’s introduction mainly required extensions and elaborations of existing computing systems. This is pointed out so that it is clear that digital photography does not *cause* the computerization of science, but does *require* that the computerization of science either be in place or be enhanced for those wishing to work with this new technology.

The main architectural choice points were encountered as projects made the decision to adopt digital photography and extend their computing environments to accommodate this change. These choice points were primarily comprised of short periods of debate, side-by-side testing, and then adoption. The following observations were typical:

> Denise Conway: This was back in like 2002-2003 when we were first testing it out. Winter of 2003, I remember, we did the side-by-side tests at [location] and we thought my project would have been the good one to do it because it's very photo-ID…a lot of the animals up here [near the lab] are very well known, so you could get an angled crappy picture and you know who it is. Whereas down there [at this researcher's study site], it was really… and that's why, because we were doing the grading thing, we really wanted to see.

> John Maze: That sort of what was happening during 2003. We got one digital camera, and it went out. It went alongside the slide camera; we all got a chance to test it out, to use it…. So, we had everyone try it out, and I think they found that the pictures were good enough, the affordability was certainly there. And so once we realized that given all the other pluses, the actual data will be as good as, or better than film, we felt right making the transition, but the decision-making process was pretty much driven by [the investigator] with lots of input by the few people that were around him all the time. (quote also cited above on p. 192)

In nearly all cases, these initial tests convinced the scientists that digital photography was as good as or better than the film photography they had been using. They have had little reason overall to reconsider this, as a commonly repeated phrase among participants was "I would never go back". Even given some of the conflicts and costs identified above, for most respondents there was very little to regret about this change, and most were quite firm in arguing that not only have their scientific methods been made easier once they adopted digital cameras, but that overall their ability to do science had been enhanced as well.

6.2.9 Research question 9: Technological alternatives

9. *What technological alternatives would be desirable to improve the existing system (e.g., if one were not limited to existing technology, what sort of system could respondents imagine that would make their research more effective)?*

So, if digital photography has been a solid success so far among marine mammal scientists, what improvements or enhancements would they like to see to make the technology work even better? There was fairly wide agreement about the most commonly wished for change: more automation for tedious tasks.

> Holly Kershaw: One of the things that would be cool is if you could somehow automatically crop your image when you are taking the photo. Just crop it on the fin I mean that would save a lot of time… If you could have your image just as it is and could somehow set it to just crop the fin. Because sometimes you do want the whole image if they do have some cut marks on their back later on or something. That would save a ton of time. Anything else? And if there was some way just with FinScan, it is kind of cumbersome with having to do all of that tracing before you actually match it so somehow it would automatically trace the fins for you. That would save a lot of time. Yeah, just something to cut down with photo work because you know that is very time consuming so anything that would cut down the time with processing. That would be good… And if there could be an integrated program. That would be nice if it didn't have any glitches in it.

Time and again, participants wished for ways to free themselves from the more tedious aspects of dealing with all these photographs, data, and the chore of matching animals manually. As was mentioned before, there have been a number of attempts at automated matching using various approaches such as edge-tracing and category-based typologies, but there appeared to be a widespread belief that these programs were not mature yet, that they did not quite do what people were hoping for.

> Dr. Marcia Parrett: Yes, [I'd like] a really, really topnotch matching system that would be easy to use and works – fool-proof, low error rate.

Others agreed that automated matching programs were essential, but extended their potential abilities even further than desktop-based systems residing in the lab:

> Alan Crane: The real component that's missing is a very evolved identification system….I would probably hire somebody from [a company that does] fingerprint identification for the FBI… [and get them to] develop the…image recognition software. I mean, they can spot an Israeli tank or an Afghani tank or whatever behind a box of rocks, you know, within 50 miles…The image recognition software really needs to evolve and take another step. Once that's done, specifically for photo-ID, then something like that could spin very quickly. So you could be on a boat and just have them talk to you, like GPS.

Crane referred at the end this quotation to his vision of having an entirely integrated, wireless, boat-based system for photo-identification. Several times in the course of the interview, he described the type of technological system that he thought was possible but had not yet been adequately researched or funded. In this scenario, a scientist armed with a digital camera would take an image of a dolphin or whale or other animal and that image would be immediately wirelessly transmitted to a boat-based computer. The computer would also be receiving GPS location data and environmental readings, and integrating all the data together on the fly. At the same time, the image would be automatically analyzed by pattern recognition software, and the most likely match(es) for that animal would pop up on the screen for a human operator to accept or reject. If the match were to be made, the database would be updated with that information, a backup would be sent to the mainland via satellite, and the scientists could go in search of the next group of animals. They could also continue to collect additional information such as biopsies from the now-identified animal based on what is already known about the animal in the database. Crane was not alone in hoping for a system of this sort:

> Dr. Lynne Shoop: One thing [I'd like to see] is if you could actually better-synch all the stuff on the boat together. I had a friend who I know synched in a camera and a GPS so that in the EXIF file, his GPS was recording. But that required him running cables from the camera to the GPS and all kinds of stuff. And that was not feasible for my kind of work. He didn't stay doing that. So automating some of those things, the way to feed all the data in…together.

Of course, a system like this would be expensive, particularly for the first adopters who would be developing it, and may be considered overkill for some of the scientific projects. Nevertheless, much of the technology to make such a system work is either currently available or likely to be developed in the near future. The biggest barriers to such a system, however, are some of the same barriers already mentioned when it comes to automated software: different species have different identification features and different types of projects collect different types of information. Making a system that is both powerful enough to operate as Crane described but *also* flexible enough to be adapted to a variety of scientific contexts is the real challenge, and one that goes beyond simple computer programming and technology integration.

The final innovation is the possibility of building better scientific cyber infrastructure to allow more and better sharing of data and collaboration among scientists. Whether this happens depends heavily on funding. Cyber infrastructure, or e-Science, projects are expensive and require the involvement of large multidisciplinary teams for successful implementation. Whether a relatively small field of biologists can attract the money and attention to build such a project is open to question. Compared with huge collaborations being built for the study of human genetics, particle physics, environmental science, and other 'big' science questions, marine mammal biology remains a field of relatively small projects operating largely independently of one another. As one participant pointed out, “you’ve got to go where the animals are,” and this field-based aspect of marine mammal science makes it likely that the field will continue to reward those best suited to highly independent work. On the other hand, if a field such as this one were to be successful in building structures for information sharing and collaboration, the lesson could be extremely valuable for other scientific fields and organizations that operate primarily in small, independent, self-sufficient units.

6.3 Summary

This chapter has summarized and discussed the major findings of this research. After summarizing the main steps in the process of photo-identification followed by the sites participating in this study, each of the nine research questions forming the basis for this project was addressed in turn. By doing so, there is now a fairly complete picture of the process of digital photo-identification among marine mammal scientists, how the scientists have changed these processes to deal with the features and limitations inherent in digital photography technology, and what some of the most important socio-technical consequences, positive and negative, intended and unintended, of this change have been.

The following two figures (Figure 12 and Figure 13) show simplified diagrams of the work processes for film-based photo-identification and for digital photo-identification.

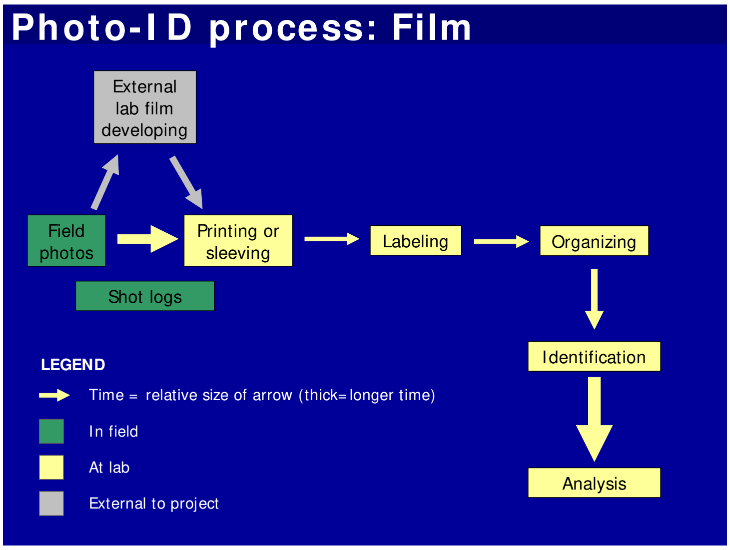

Photo-ID process: Film

External lab film developing

Field photos

Printing or sleeving

Labeling

Organizing

Shot logs

Identification

Analysis

LEGEND

→ Time = relative size of arrow (thick=longer time)

🟩 In field

🟨 At lab

⬜ External to project

Figure 12: Photo-ID process: Film

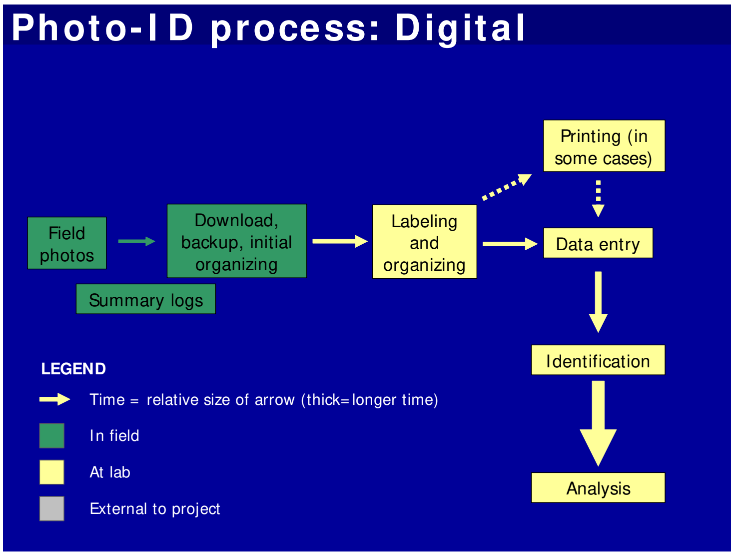

Photo-ID process: Digital

Printing (in some cases)

Field photos

Download, backup, initial organizing

Labeling and organizing

Data entry

Summary logs

Identification

Analysis

LEGEND

→ Time = relative size of arrow (thick=longer time)

🟩 In field

🟨 At lab

⬜ External to project

Figure 13: Photo-ID process: Digital

Note that while the number of steps in the process has stayed relatively constant, there have been changes in the locus of work, the types of work, and the time between some of the stages of the process. In Figure 12, we can see some of the major steps involved in doing photo-identification using film. Starting in the field (indicated by green boxes), photos are made of the animals, and generally detailed shot logs are kept to facilitate matching individual frames up to log data when the researchers get their slides or prints to work with, often not until they return from the field several months later. The film is sent to a lab (generally external to the project, as indicated by the gray box), usually in batches. Once the scientists have returned from the field, they will make black and white prints, or else sleeve and organize the color slides; they may also be assisted by volunteers. In a few cases, identification is made directly from black and white negatives using microscopes to view the images. Next, the photos or slides are labeled, put into binders, and logged for later identification. Once the photographs are manually matched and identified (using prints, light tables, or microscopes), the resulting data is entered into some sort of database system such as an Excel spreadsheet or statistics program for analysis.

Figure 13 shows the generic process followed for digital photo-identification, and highlights some of the procedural changes that have taken place. Note that more of the work is now done in the field, as indicated by the green boxes. Whereas film required relatively little work at the end of the day (labeling it and preparing it for shipping), digital images require downloading and storing at the minimum, but in many cases scientists also start to work on organizing and processing the photographs. Note the decreased size of the arrow indicating the time lag between acquisition and initial sorting and classification of the images once a project has switched to digital photography.

The logs of the photographs tend to be somewhat less detailed, listing a range of exposures for an encounter (e.g., “Start frame: 214, End Frame: 231”) rather than a shot-by-shot listing. Most external processes are eliminated in this model, as the digital data are essentially contained within the project. Labeling and organizing still take place in the lab, even when some of the initial sorting took place in the field, and there is a new step of data entry into more complex databases (designed with relational database software such as Access) than were used previously. Finally, identification and analysis still is mostly done manually, but often using computer screens instead of light boxes or microscopes, although some still print digital images and match from the prints.

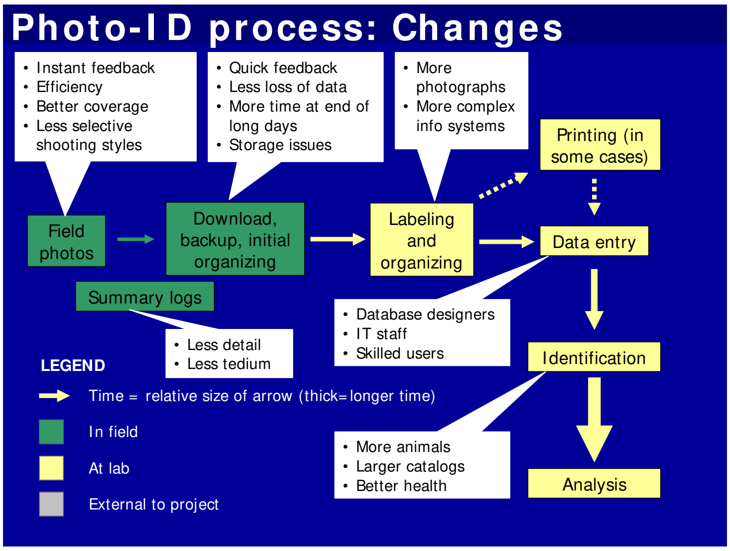

Photo-ID process: Changes

- Instant feedback
- Efficiency
- Better coverage
- Less selective shooting styles

- Quick feedback
- Less loss of data
- More time at end of long days
- Storage issues

- More photographs
- More complex info systems

Printing (in some cases)

Field photos

Download, backup, initial organizing

Labeling and organizing

Data entry

Summary logs

- Less detail
- Less tedium

- Database designers
- IT staff
- Skilled users

Identification

- More animals
- Larger catalogs
- Better health

Analysis

LEGEND

→ Time = relative size of arrow (thick=longer time)

🟩 In field

🟨 At lab

⬜ External to project

Figure 14: Changes in the photo-ID process

In Figure 14, we have added boxes summarizing the consequences of many of the changes identified in this chapter. The consequences that are generally thought to be positive (instant feedback, increased efficiency, better coverage, less loss of data) are clustered in the fieldwork portion of the diagram. Some of the controversial changes (less selective shooting, additional time demands in the field, storage issues) are also clustered in the same fieldwork portion of the diagram. Back in the lab, however, more of the controversial and generally negative consequences are apparent (increasing complexity of managing information systems, increasing needs for specialized computer staff and skilled scientific staff, greater time spent working with the increased numbers of images collected in the field, maintaining larger catalogs).

This diagram helps to illustrate the far-reaching impact that a single technology can have on a work domain. Detaching a camera lens from one three-pound piece of equipment loaded with film and attaching it to another similar-looking three-pound piece of equipment containing a light sensor and computer memory has been shown to have many consequences for marine mammal science. There are consequences for behavior in the field, on methods of organizing information, on tasks required on returning from the field, on personnel requirements and work assignments, and, in the end, on the scientific output.

While this study does not argue that these findings are necessarily generalizable, the story about technology that emerged from multiple sites in this case study leads to a preliminary conclusion that these patterns are representative of this one, small scientific field. Whether they are applicable in other domains, however, must wait for future research.

CHAPTER 7: DISCUSSION

In this dissertation, we have examined the ways that choosing to implement a new technology in a scientific field has resulted in a variety of intended and unintended consequences. At this point, it is worthwhile to re-examine the theoretical positions that formed the original basis for this research and ask how well they have helped explain the data collected in this case study. In this chapter, we will look at the concept of communication regimes and at the STIN strategy in light of the findings reported in the last chapter. We will also briefly re-examine the SCOT and ANT approaches, and discuss whether they offer additional understanding of this case. Finally, we will end with a discussion of some of the major lessons to come out of this research from the point of view of the field of information science, and discuss the future of this research project.

7.1 A communication regime, or not?

In Chapter 2, the concept of “communication regimes” was proposed as a way to frame this research and establish boundaries between professional uses of photography and amateur photography (see p. 15 above). The question to address here, then, is how well does this conceptual framework describe marine mammal photo-identification? A second question is whether the conceptual framework served its intended purpose, that of clearly establishing the boundary between scientific photography and other types of photography. In short, the answer to the former is “not very well,” and to the latter, “not really.” It is worth taking some time, however, to examine how and why this conceptual framework did not prove to be as useful or as descriptive as was originally hoped. In doing so, it will be clear that the failure of the conceptual framework to describe adequately the behaviors of the scientists in this study actually leads to a much more interesting conclusion than would have been reached if everything had gone as originally expected.

In Table 1 (p. 16), the five elements that comprise the definition of a communication regime were identified. Let us consider each element in turn in light of the data from this research. Element 1 reads as follows: *A communication regime is a loosely coupled social network in which the communication and the work system are highly coupled.* It is fairly clear from the data that marine mammal scientists fulfill the first criterion, that of constituting a loosely coupled social network. The scientists in this study all reported belonging to and regularly attending the meetings of the same professional society, often mentioned names from a relatively small network of researchers that comprises their specialties (both trans-species and within-species), and have often attended graduate school, workshops, and conferences together, or even have shared field experiences with other members of their social network. However, it is a loosely coupled network because these contacts are, by and large, sporadic and limited to relatively short interactions on widely spaced occasions.

Where the first element falls apart is in the high coupling between the communication and the work system. The work system includes all the elements of photo-identification that have been described above – capturing the images in the field, processing them, identifying animals, and so forth. However, the main communication of this information is by journal papers and conference papers/posters, as is true for most scientific research. Between the work system and the communication outputs there is a disconnect, as follows: while photographs, GPS data, and other information are gathered in the field and require considerable effort to process and maintain, by the time most research has been published, these artifacts (photographs, database entries) have been translated as “data” and recede into the background in the publication or disappear almost entirely. While some publications may include a sample photograph or two, by and large the photographs are not published with the research findings. Instead, new data have been generated from the original collection of photographs, and it is these new data that are the primary source for the publications. For instance, if a researcher is publishing a paper on associations between animals, each encounter that has been successfully identified using the photographic evidence described above becomes a single row of data: animal X was seen at location Y on date Z in these conditions. If animal A was also seen at location Y on date Z, the statistical analysis programs then turn these data into a correlation between animals X and A, along with the thousands of others in the dataset; these correlations are the data that are reported. Here is how one participant described it:

> Dr. Lynne Shoop: A lot of people do spend so much time and energy on the photos and collecting this database—this photo catalog. And then have no ability or ways to go about analyzing it. I think that’s something that’s been a drawback with particularly a lot of marine mammal researchers doing this photo-ID is that everything is about collecting the catalog, but the catalog is not an answer. The catalog doesn’t tell you anything. It’s the analysis of it [that counts].

At least one level of abstraction occurs as photographs are translated from images of animals into data that can be successfully analyzed. Element 1 doesn’t appear to offer a very accurate portrayal in this case.

In fact, element 1 may need considerable re-thinking to apply to any system involving the scientific production of knowledge, since almost all scientific data are translated and/or transformed prior to publication. In the original examples Kling, Spector & Fortuna (2004) and Hilgartner (1995) used to propose the conceptual framework of communication regimes, they considered the coupling between the production of scientific manuscripts and the electronic publication of those manuscripts. This study, however, attempted to examine steps earlier in the production of scientific knowledge than the manuscript production phase by looking at the scientific data collection phase. In doing so, it was shown that the data are less highly coupled to the manuscripts, due to translation and transformation, than the manuscripts are coupled to the journals in which they are published.

What about the next element? Element 2 states: *A communication regime is a system with a set of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge.* Again, there is trouble trying to apply this to the behavior of marine biologists if the case is the field of marine mammal photo-identification. At the level of the local study, certainly there are both implicit and explicit principles, norms, rules and decision-making procedures, often centered on the primary investigator of the project and radiating to the researchers and technicians involved in the research. Some of the evidence for this was discussed above when we examined the roles of investigators, researchers and technicians working on these scientific projects. Also, many of the rules and procedures are documented in operations manuals and other forms of documentation that can be highly detailed or very simple, depending on the norms of the study.

At the case level, however, this is much less true. Are there scientific norms pertaining to generally accepted scientific practices? Of course, and they are enforced through the process of peer-review. However, there are not, by and large, established rules that determine how those general norms of scientific behavior are operationalized by scientists performing their work. One of the notable findings about the various sites involved in this research was how very different their actual practices were from one another. While following some general principles, the actual day-to-day practices of collecting, organizing and analyzing data were highly variable and idiosyncratic. Ways of handling data, rules for keeping or discarding images, and procedures for identifying matches in the animal catalog were all very different at different sites. This is why consolidating data and working more collaboratively has proven to be difficult – each scientific project is doing something slightly differently from their colleagues working on different projects, even when those projects overlap in some way. Thus, unlike photojournalism, where central authorities have considerable influence over certain daily practices like the digital manipulation of photographs, in science the control is much more diffuse and only likely to be exercised when the most egregious of violations occurs. Whereas any evidence of publication of a doctored news photo yields immediate response, unless a scientist is found to have falsified his or her data, it is unlikely that there would be any attempt at regulation of specific data collection and management practices. The downside of not having institutional frameworks to support shared rules and procedures is that there are also not institutions that can help support the desire of scientists to share data with each other and to engage in collaborations with their fellow scientists.

Element 3 reads as follows: *A communication regime is a system in which the types of communication are tightly coupled to the production system in which they are embedded.* Again, the evidence does not support this element. Referring to the discussion of element 1, the production of scientific facts involves a system where there is a disconnect at the analytical level between the considerable time and effort spent dealing with photographs and associated data and the main communication outputs of scholarly articles. These communications do not, by and large, include the photographs central to the system of data production. In these articles, the specific elements of the production system have disappeared in a way that is not true of a system like advertising photography, where the production of photographic information is tightly tied to the output of publishing those same photographs after they have been processed (re-touched, assembled in montages, etc.). There is, however, evidence that in conference presentations, the scientists are more likely to include photographs as data to support their explanations are arguments:

> Richard Summerlin: I find [photographs] an enjoyed relief from kind of typical backgrounds of Powerpoints. But I also find that they're really, I can't…you know picture says thousands words, right? Because that's what they say and it's true. When do you put up a photograph and very easily describe something…without having to go and try painfully to describe it to them in words. Especially instrumentation set ups…. When I was using my theodolite, you know it's easier for me to describe the theodolite sitting on this tripod, attached to a computer over on the cliff side, overlooking the water by photo and simply describe what the different items are than to try and describe that visually to somebody shouldn't be a lot more challenging. You know, what you see from

> different angles can also be very easily done. Particular behaviors of dolphins, when you try and describe…head-first reentry or head-over-tail leap, or surging, or scattering, or different types of distribution…you know that when they're tightly together or they're more spread out or what do you mean by that is easy to show representative photos to compare the two different categories, especially when you're categorizing things, because people want to know what was dense for you or what was scattered for you, and you can show that visually quite easily with photographs…. So it will be very, very easy plus also I think it's just a little bit more enjoyable, it's more of a break, especially in PowerPoint, from reading the slide to being able to just visualize and understand it, if your photos are good.

At this level, the communication is most often to members of the presenter's community of practice, and the photographs appear to contribute more strongly to at least this element of a communication regime in conference settings.

Elements 4 and 5 can be dealt with together. Element 4 states: *A communication regime is a system with institutions which help to support and to regulate the regime*, and element 5 adds: *A communication regime is a system within which there are conflicts over control, over who enforces standards, over who bears the costs of change and who reaps the benefits of change.* Again, because of the distributed nature of the production of scientific facts, while there are institutions such as universities, government agencies, and non-profits operating in this domain in important ways, they do not generally regulate those aspects of the scientific endeavor involved with the production of scientific facts. These institutions may influence funding for new equipment and for field expenses, but they do not, by and large, exert much pressure on the actual practice of science. There seems to be an attitude of "leave the science to the experts," an attitude that on reflection is probably the best way to ensure that scientists are able to pursue goals they find both interesting and scientifically important.

So, digital photography use by marine mammal scientists turned out not to be a very good example of a communication regime, but in fact, it is more interesting that it was not. The failure of the communication regime concept to help understand the practice of science in this case underscores the idiosyncratic nature both of the practice of science, and of the site-specific approaches to technology implementation and use. Furthermore, the somewhat fractured nature of the field of marine mammal science is underscored; recall the discussion on the difficulty of establishing cyber infrastructure in a field populated with scientists who primarily work remotely and independently. Finally, this finding suggests that even if one were so misguided as to try to apply a top-down approach to managing change in this field, the effort would likely be doomed to failure. There are no institutions with enough influence to effect field-wide change. Instead, if change is going to happen, it will be bottom-up and the result of collegial communication between scientists operating within their peer networks and communities of practice.

7.2 Assessing the STIN strategy

When this research proposed using the STIN strategy, the following claim was made: “It is fairly clear that STIN does not reach the level of theory, nor is it a proper methodology. STIN is really an analytic strategy” (p. 72 above). Also recall that if this is not the first study to use STIN from inception rather than as a *post-hoc* analytic tool, it is at least certainly among the first to do so. As such, we should assess whether the STIN strategy was successful for this research, and if so, what it can offer to other social informatics researchers.

The STIN strategy was used to help frame the questions in this research, and to set up a series of research questions that were designed to probe the socio-technical nature of a system designed for the production of scientific knowledge. By privileging neither the social nor the technical and approaching the research as if both potentially contribute to the nature of the system in meaningful ways, the STIN approach has proven to be an extremely valuable tool for translating the sometimes vague concepts in the social informatics literature into more concrete, researchable questions.

In this sense, one could think of the STIN strategy as a theoretical lens into understanding socio-technical systems from a social informatics (SI) viewpoint. In a recent volume on social informatics (Kling et al., 2005), while there are extensive discussions of SI concepts and how to teach and communicate those concepts, there is relatively little discussion of how one actually goes about researching and uncovering these concepts. This makes social informatics research questions particularly difficult to frame adequately; lacking appropriate robust theories and methods, most SI researchers must draw on other disciplines for their approaches that they hope will yield results of interest to a social informatics audience. As discussed earlier, SI researchers traditionally come to SI from a variety of disciplines, and bring their theories and methods with them; the problem is translating these disparate approaches into something coherent enough to contribute scholarship meaningful to other researchers in SI. This problem is particularly acute for new researchers wanting to enter this field who may be daunted by the wide variety of disciplinary approaches that are brought to bear by SI researchers and the large literature that must be mastered to make sense of these approaches.

As an approach to the type of research reported here, however, the STIN strategy proved both extremely helpful and fruitful. As was seen in Chapter 6, each of the nine research questions which were modeled on Kling’s (2003) original description of the STIN approach yielded information that contributed to a fuller understanding of the consequences of a particular ICT in a system for the scientific production of knowledge (see Figure 14: Changes in the photo-ID process on p. 247 above). This contribution to understanding how new technologies are used in normal, everyday settings is one of the features that distinguishes social informatics research from much of the science and technology studies (STS) literature. The STS approaches such as SCOT and ANT are more commonly used to understand how new technologies are socially constructed during their creation, and relatively infrequently focus on their subsequent regular use. Marine mammal scientists using photo-identification, however, are not creating digital cameras. They are consumers of the technology. The cameras may well have been socially constructed during their design and implementation at companies such as Canon and Nikon, but marine biologists were not actors in that particular actor-network. They come to the game later, once the camera technology has reached sufficiently advanced levels and dropped to reasonably affordable prices, and then they shape how this technology comes to be interpreted and understood in regular use within their domain. If this study had been an attempt to understand the social construction of the camera, the SCOT or ANT approaches may have been preferable; since the focus was on the social construction of digital photo-identification of marine mammals, the STIN strategy’s focus on the ordinary uses of technology proved most useful.

Many STIN studies use the strategy of the ‘standard model’ to help readers understand what the commonly held assumptions about a technology are, which in turn draws the social informatics knowledge about the technology into sharper focus. If one were to identify a standard model for digital photography, in this case it is likely the notion that digital cameras and film cameras are essentially the same, and that digital cameras are just a better version of camera technology. Many of the marine mammal scientists had a typical response when they were first approached about this work: “Digital photography? It’s great. I love everything about it.” This research has shown that a statement like this can be an accurate reflection of their attitudes, but that there is more complexity underlying their actual interactions with the technology. During interviews, a number of participants commented that once they started thinking about the issues raised in the questions, they began to see some of the complexity in a technology that they had not taken the time to think about previously. This demonstrates how a standard model – ‘Digital cameras are like film cameras, but better” – can be uncritically accepted by users with considerable domain knowledge who have not had reason to consider more nuanced aspects of their relationship with technology.

In summary, in the case of this research, the STIN strategy has proven to be an effective tool for prying open a socio-technical system and for helping to understand how a successful technological innovation nevertheless has unintended consequences for the system. Some of these unintended consequences will benefit actors in the system, some will work to their detriment, but in either case, understanding them will help to address better existing consequences and to anticipate future consequences.

7.3 Do SCOT or ANT answer?

As has been mentioned several times, the STIN/social informatics approach to understanding socio-technical systems is more moderate on several points than are SCOT or ANT. SI researchers are generally less willing to attribute agency to non-human actants, are more interested in regular use, try to include examinations of excluded actors and actants, and are particularly attuned to identifying and understanding the unintended consequences of technological change. While SCOT and ANT have often been used to understand the creation of new technologies and the enrollment of additional actants into a network, marine mammal scientists are primarily consumers of the general technology of digital photography rather than technology innovators.

However, as has been pointed out earlier, there are still a number of areas in which SI is in general agreement with SCOT and ANT, and it is worth reviewing the concepts that have been incorporated in this research and are reflected in the results. From the Social Construction of Technology (SCOT) literature, the general concept of social construction, the notion that technology cannot be considered an autonomous force that ‘causes’ changes in society, underlies much of this research. Digital cameras, even though they were created outside of the domain being studied in this case, are still artifacts that undergo a process of social construction as actors build mental models of their socio-technical worlds that in turn influence the actions of the scientists and their peers. This concept is often expressed in SI research in terms of the configurational nature of technology, which is a way of understanding that technology assemblages can take on different configurations in different social settings, and the notion that technology design continues in use.

Other central concepts from SCOT have played an important part in this research. Relevant social groups in the socio-technical system were identified in the section answering research question 1. Interpretive flexibility was present in some elements of the technology package: recall the discussion of the low-light capabilities of digital cameras being interpreted as both problematic and as a highly useful feature by different actors. Likewise, the ability to generate many frames of digital images in rapid bursts had multiple interpretations: the less-skilled photographers who felt it helped them get the necessary shots, and the more-skilled photographers who viewed it as displaying a lack of carefulness. Other SCOT concepts, however, such as technological frames, closure and stabilization seem less useful in this case study, since there were few domain-level conflicts that required resolution. A different analysis of this same case from an alternative perspective might find these concepts more useful.

Actor-network theory (ANT) also has offered some tools used in this research. The concept of translation is certainly relevant, particularly when considering how marine mammal science translated photographs and data collected in the field into non-photographic data that formed the basis of many research questions. The photographs themselves receded into the background once they had been translated from a random image of a wild animal into evidence that a specific identified animal can be documented to have been at a certain location at a certain time.

The concept of black-boxed technology is also relevant to this case. The digital cameras were a prime example of a black-boxed phenomenon, accepted uncritically by those both within and outside of the domain. This entire project has been an act of opening that particular black-box, looking inside, and sharing what the analyst has seen there. Some of the observations made by opening the black-box may seem familiar to those within the domain; others are less so. It will be interesting after the publication of this research to learn if there is any reaction, positive or negative, from the marine mammal science community. Will they agree with what has been found in the box?

One ANT concept that appears less relevant to this case is that of enrollment. There appears to have been relatively little effort by scientists actively to enroll their colleagues into switching to digital photography. While there have been workshops and articles designed to communicate knowledge learned about the methods that can be applied with this new technology, the purpose of those events and publications appeared to be more about sharing domain knowledge within a community of practice than about trying to enroll additional participants. With some exceptions such as the Markowitz/Mizroch exchange discussed above, few of the scientists reported any evidence of either actively enrolling others, or having been enrolled by others, into switching from film to digital photography. The process was much less directed than how enrollment describes it in the ANT literature.

Overall, while both SCOT and ANT have informed aspects of this research, had they been used as the sole basis for forming the research questions and guiding the research, the results would have been less satisfying. The current hybrid approach, using the STIN strategy as informed by SCOT and ANT, however, has allowed us to gain a solid understanding of this case, and also hopefully to contribute to a general understanding of the ways in which technology use can be domain specific and socially shaped.

7.4 Issues in this research from an information science perspective

The implications of this research that are most likely to interest traditional information science audiences are the observations pertaining to information organization, the building and maintenance of digital collections and catalogues, and the idiosyncratic nature of the approaches to information management within a scientific field. Information organization issues appeared several times in the transcripts, and figuring out ways to handle the increasing volume and complexity of information is clearly an on-going issue for this field. There was little awareness, however, that information science even exists and certainly no understanding that some of the expertise available in this field might help these scientists come to terms with some of their information problems. Library and information science schools still appear to be connected in the scientists' mind with an out-dated notion of the small town librarian, and we have not done enough to educate scientists in fields like marine biology about the skills and knowledge that information scientists may be able to offer them. There is real potential here for increased collaboration in the future, and both fields should try to start building connections to the other.

Information scientists studying digital collections can also learn something about the highly variable nature of what constitutes a digital library from this research. While many of the digital collections were organized on fairly sound organizational principles, others used somewhat haphazard and confusing schemes to organize their digital collections of photographs. In other cases, the "digital collection" can take surprising forms, as illustrated in Figure 15.

Figure 15: A digital collection

This image depicts a collection of digital images of blue whales combined with existing analog images. A technologist might look at this picture and argue that it isn't a digital collection at all, just a box lid full of photographs rubber-banded together in groups. One approach to combining analog and digital data would be to scan existing photographs and build a computerized collection. In this case, however, the project had a system for organizing and maintaining its blue whale catalog that was working well for them. The system just happens to involve beat-up box lids and little stacks of blue whale photographs with the best image rubber-banded on top. When deciding to integrate digital photography into this system, the scientists learned that, at least for the moment, it was most efficient to simply print little color photographs from the digital image using their ink-jet printer and add the print to the appropriate rubber-banded stack. This was a perfectly logical and legitimate decision, and one that arguably constitutes a portion of a digital system. (The original images are also archived on computers, but all the matching and storage is done with these boxes.) Information scientists can learn from this example not to presume what constitutes the elements of a digital collection.

Finally, another lesson for information scientists is that in ordinary scientific practice, approaches to technology, to designing information systems and databases, and to dealing with digital collections are highly idiosyncratic. Much of science is done on a relatively small scale and involves lots of independent scientists creating lots of systems for managing and organizing their information. This idiosyncrasy comes about neither by design nor because the scientists want it to be this way, but because there exist few information systems that are flexible enough to work in multiple, highly specialized settings yet are robust enough to perform adequately. This is a challenge that information scientists could do well to address. The need for flexible yet powerful systems runs throughout this field, and throughout other scientific fields with which the author has been involved. Without tools of this sort, scientific studies will continue to spend precious time and resources inventing new information systems each time a scientist starts a new project with different requirements or when a new project emerges to undertake specialized scientific research.

7.5 Lessons learned

Several important lessons came out of this study. First, it is important to underscore the importance of making this research project a multi-site study of sufficient size to observe the variability present in the area of marine mammal photo-identification.

The highly variable practices for working with digital photographs, for organizing and working with the images, and the idiosyncratic nature of many of the information systems would not have been apparent had this study been a single-site study. Starting from a base of essentially identical photographic equipment (either Canon or Nikon bodies with pro-quality zoom lenses in the 300 mm range), the specific projects all made very different decisions about how to use the digital images that were acquired, how to organize the information, and how to constitute the total digital photography computing package. Visiting nine sites, doing 41 interviews, and collecting numerous additional supporting documents for analysis were all time-consuming. They proved necessary, however. Had only one or two sites been included in this study, even making each of the site visits last considerably longer and making the study more ethnographic in nature would have likely yielded research that gave a very skewed and one-sided picture of digital photography technology in this domain.

The other major lesson to come out of this research is that the STIN strategy proved to be a very useful tool for doing a study of this nature. In cases where the domain is essentially unknown, and the research needs to explore the nature of the connections between the social and the technical while making sense of the other elements of the domain, the STIN strategy provides one useful way of prying open the black-box enough to peek inside. In this case, using the STIN strategy as a framework was far superior than the more commonly used technique for qualitatively examining an unknown domain, grounded theory. Grounded theory, in our view, can hamper research by encouraging it to be not well conceived before the research begins, as some researchers expect to enter a domain and wait for the patterns of behavior and social interaction to emerge through a series of interviews, observations, and lots of coding with qualitative software tools. This does not have to be true, but too often is. By using the STIN approach, on the other hand, certain domain knowledge emerges during the course of the research, as with grounded theory, but there is also a clear framework for approaching the fieldwork that helps guide the questioning and the observations in a way that makes finding socio-technical connections more likely. The risk, of course, is that these pre-conceptions influence the outcome of the research too strongly. In this case, however, there is evidence that the research design produced a compelling and highly plausible description of the consequences of the shift to digital photography in marine mammal science. In addition, we have demonstrated that the preconceptions used to develop the research questions did not overly influence the research, as evidenced by the rejection of one of the major elements of the original conceptual framework, communication regimes, based on the evidence in the study.

In the introduction, three key themes present in much of social informatics research were discussed: embeddedness, configuration, and duality. In this research, examples of each of these themes have been explored in the findings. Digital photography is clearly embedded with marine mammal science. Digital cameras and the photographs they help to create are present throughout the process of field work, in the work that must be done on returning from the field, on the day to day practices of information organization and categorization in the lab, and in the data that form the basis for the advancement of scientific knowledge and understanding. Digital photography is also configurational in this domain: the different configurations that the total computing package of digital photography has taken in the various labs participating in this study have been evident throughout the narrative. Time and again, the idiosyncratic nature of technology, and how science invents many ways to work with the same cameras and information systems have become apparent. Finally, the duality of digital photography—its enabling and constraining effects—has been visible throughout the discussion of the findings. In looking at the benefits, conflicts, and costs related to digital photography, we have seen that digital photography both enables new behaviors, and also places constraints within the system. In short, marine mammal photo-identification has been an excellent case for understanding more about socio-technical systems from a social informatics perspective.

7.6 Limitations of the research

As with any research project, there are a number of limitations to this research. The limitations of the topic, the case, the research sites, the respondents, the theoretical approach, and the methodological approach used in this research have been mentioned in various places throughout this thesis; this section will reiterate and underscore the limitations in these areas.

The main topic of this study, digital photography, has not been widely researched from a socio-technical perspective. As a result, much of this research is by necessity exploratory and must be considered preliminary until additional studies can be done to either support or contest the findings reported here. As with any preliminary study, the inability to triangulate research findings with previous research is an unavoidable limitation. The risk is that digital photography has been mischaracterized by this research but that the lack of sufficient comparable research will allow the mischaracterization to go undetected. To minimize this limitation, considerable effort was put into studying existing research on photography, both digital and film-based, from non-socio-technical perspectives. Fields drawn on for this effort included scholarly sources in journalism, art history, art criticism, and social history along with practitioner literature aimed at the professional and amateur photography markets. This background research was designed to understand the variety of ways photography has influenced the social world; this research was discussed in detail in Chapter 3. Nothing in this background research suggested that the findings of this study were so incongruous with previous understandings of photography as to suggest that the findings should be called into serious question.

The case selected for this research, marine mammal scientists, is also a limitation of this study. As discussed elsewhere, marine mammal science is a relatively small scientific field. Even though considerable care was taken in selecting the case for this study based on a heavy dependence on photography and a relatively recent switch from film to digital, there is always the risk that this case is a highly unusual outlier that reflects neither general scientific behavior, nor scientific and professional uses of photography. Again, due to the preliminary nature of this research, this is a limitation that can only be adequately addressed in future research. Since the field of marine mammal science has not been extensively studied from a social perspective, this research cannot offer the assurances available to studies of more well-studied scientific fields.

The factors minimizing this risk include the fact that marine mammal scientists are in the mainstream of science; most respondents in this study were trained at respected colleges and universities in biology, marine biology and oceanography departments. Their research is published in major scientific journals, and there was no evidence collected during this study that the scientific practices used in this field were anything less than rigorous. Nevertheless, an important step to follow this study would be to pursue similar research in a different scientific field and look for evidence that would indicate alternate interpretations of the data presented here.

The research sites selected for a multi-site case study can potentially mischaracterize the main case to which they are contributing understanding. To address this limitation, respondents at a relatively large number of sites were either visited in person (nine sites) or interviewed via telephone (four sites). This thesis has discussed some of the variety present among these sites. Over the course of the project, however, a generally coherent pattern of scientific practice with local variations emerged. Had the study been limited to a small number of sites, it would have been quite possible that the overall picture would have been distorted. However, by the end of the data collection, the information and patterns of scientific behavior emerging during site visits had stabilized, and few new sources of variation emerged from the last several sites visited in the course of the research.

The respondents for this study were selected opportunistically rather than systematically. This could result in selecting respondents who represent too narrow of a range of views on the topic under study. To minimize this limitation, a relatively large number of respondents (n=41) were included in the research; these respondents represented a broad cross-section of potential respondents in terms of scientific roles (investigators, researchers, and technicians), age, gender, educational level, and years of experience. A number of differences between the perspectives offered by respondents in these various categories was discussed above. Overall, having this variety represented makes it less likely that the responses of any single type of scientist have dominated the research reported here.

The theoretical approach used for this study is another potential limitation. While both social informatics research and social studies of science are by now relatively well established in academia, both remain young fields. Social informatics as a discrete area of research dates back only a decade, and social studies of science date back less than 40 years. Thus, many of the tools used in these fields are still being developed. The STIN strategy, in particular, has not been used extensively before, and whether it will become more widely accepted in the future remains to be seen. This is one reason that more established theories such as SCOT and ANT were also drawn on during this research. If future research draws the utility of the STIN strategy into serious question, the choice to use it here will potentially weaken the claims made in the findings and discussion.

Finally, the methods have limitations that are discussed extensively throughout Appendix 1. A key limitation was the choice to use relatively short site visits to many sites rather than longer visits to fewer sites. There were tradeoffs inherent in this choice. By choosing to visit multiple sites, concerns about whether a particular site was representative of the field were minimized. However, this choice prevented any given site from being treated with the richness of detail that would be possible if individual sites had been subjected to full ethnographic scrutiny. While it would have been preferable to have multiple, thickly descriptive, ethnographically detailed site reports, time and money limitations prevented that luxury. To minimize this limitation as much as possible, the findings reported above have included extensive details transcribed from the words of the respondents to provide the reader with as rich an experience as possible of how marine mammal scientists are using photography in their scientific work. Additional operational problems encountered in the research are also discussed in detail in Appendix 1 (particularly in the sections starting on pages 278 and 303).

Overall, the limitations of this research identified in this section and elsewhere in this thesis as noted are not fatal limitations to the research. They do, however, limit the generalizability of the research, which is one reason that this research has not made general claims about scientific practice or about digital photography. By instead focusing on refining theory and suggesting useful avenues for future research that *would* tend collectively to increase the generalizability of this research, this study was designed to contribute to continuing developments in social informatics and other forms of socio-technical research. Like many studies using new theories and researching new technologies, this research should be viewed as a solid first step and was designed as a stepping stone to future research.

7.7 Conclusion: The future of the research

What comes next for this research? The immediate goals are obviously to transform portions of this dissertation into journal publications. In addition, the research database compiled during the course of this project is substantial, and remains largely unmined. With over one thousand pages of transcripts and another thousand pages of supporting documents, only a small portion was used here. Additional material in the database includes information about how the marine biologists in this study came to enter this scientific field, more information about the practice of photo-identification and other techniques used in studying marine mammals, data about the relationship between professional and personal uses of photography, efforts by marine biologists to establish scientific collaborations and engage in e-Science, and a number of other topics. Also, because this is a well-organized collection, it is amenable to re-analysis using alternative theoretical frameworks, particularly now that this initial analysis of the data has examined the basic structure of this field. We plan to continue to work with, and possibly to add to, this database in the future and get new and useful results from this work.

Since this thesis was among the first to use the STIN strategy as an approach to a social informatics topic, a future direction will be to use the findings presented here to suggest modifications to the STIN strategy. Among the potential modifications and enhancements are the following: first, encourage social informatics researchers to consider using the STIN strategy as a tool for designing research on socio-technical topics, rather than as a post-hoc analytic tool. The strategy used for this study proved very fruitful for generating germane data about the socio-technical nature of scientific digital photography; the strategy's success should be tested in other domains and with other research topics.

Second, encourage social informatics researchers, particularly those using the STIN strategy, to incorporate an anthropological perspective in their work. The research reported here was heavily influenced by an anthropological sensibility, and this sensibility contributed to the overall success of the project. Many of the topics social informatics researchers are pursuing include a heavy emphasis on understanding how humans interact with technology based on the research subjects' social understandings of technology and of the world. However, relatively little of the relevant anthropology literature which focuses on modern, complex societies is cited in social informatics publications.

Third, use the emergent coding scheme from this and subsequent research to modify and reshape the questions and topics that make up the STIN strategy. In a potential STIN Strategy 2.0, for instance, increased emphasis on including personal biography as a window into the work activities and technology uses of respondents would be useful. The existing STIN strategy does not specify that the roles of the individual actors in a socio-technical system are influenced by the actors' personal histories, personality traits, and interactions prior to their involvement in the socio-technical system being examined. In this research, however, adding questions about the scientists' backgrounds helped to understand the dynamics of how they worked together and how their relationships were influenced by their backgrounds. Other potential modifications also await future publication.

Finally, include and refine the use of the mutual shaping concept and other useful elements of SCOT and ANT in the STIN Strategy 2.0. While the STIN strategy was influenced by these theories, particularly ANT, there are additional elements from SCOT and ANT identified above such as interpretive flexibility, translation and black-boxing that may be able to strengthen the STIN strategy.

These are just a few of the potential modifications and extensions to the STIN strategy suggested by this research. Most will require additional research and discussion to refine sufficiently to propose a STIN Strategy 2.0, but this research may prove to be an important first step along that path.

We also hope that some of this research will find its way to a marine mammal science audience. We plan to publish a portion of this research in an appropriate journal read by marine mammalogists, and hope that it might start a dialogue that would foster more cooperation between information science and marine biology. Both fields would gain from this relationship, in our opinion. In addition, one of the unanswered questions from this research is how to determine whether technology can influence the quality of science and the production of scientific knowledge. Understanding how scientific quality is influenced, however, requires a sophisticated understanding of the scientific domain from the point of view either of an insider or a very experienced and observant outsider. Thus, it would be useful to collaborate with experienced marine biologists to assess this quality dimension of scientific practice, and to potentially begin to offer normative suggestions for how scientists can move toward the desirable technological alternatives raised in the discussion of Research Question 9 above.

Finally, one possibility for continuing this research would be to continue with a similar study in a different domain. This research has focused on one small scientific domain. It would be very informative to look next at a different domain that has adopted digital photography to better understand the ways in which the same technology can be socially shaped. Just as variability was discovered among marine mammal scientists in their use of digital photography, we would expect to find just as much or more variability if the comparison were extended to another domain. Archaeologists, for instance, have been switching to digital photography even more recently than marine mammal scientists, have different field conditions, different needs and uses of photographic information, and potentially different information organization needs. Domains outside science could also provide useful comparisons, including police forensic photographers, photojournalists, advertising photographers, or events photographers.

In the final analysis, this project has been a success beyond our initial hopes. The richness of detail collected during the interviews and reported in the results in Chapter 6 is very gratifying, and hopefully will prove useful to other social informatics and information science researchers. The success of the STIN strategy for framing research into a new socio-technical domain has suggested possibilities for future development of the strategy, and hopefully may influence its use for other social informatics projects. The documentation of the range of consequences connected with a seemingly innocuous new technology will potentially help inform additional research into the regular use of new technologies. And finally, the development of new understandings of how scientists perform their work in ordinary scientific settings can aid our understanding of scientific practice.

APPENDIX 1: Reflective Comments on Fieldwork

Many challenges face researchers interested in undertaking detailed studies of ordinary scientific activity. Many researchers have limited time available to be away from their other life and career obligations due to their roles as teachers, researchers, faculty, and members of families, thus precluding the possibility of spending months or years as an embedded, ethnographic researcher studying a laboratory or set of laboratories. Laboratories may vary widely in their willingness to accommodate the long-term presence of a researcher who doesn't have an official role within the organization as an employee or in another contributing role. Also, some scientific fields do their work in sensitive locations with limited ability to accommodate extra persons. Many of these concerns about time, funds, and access are particularly acute for doctoral students; the connection between access to resources and likelihood of completing a doctoral program is clear (Bowen & Rudenstine, 1992; Hirt & Muffo, 1998). None of these challenges, however, are an excuse for shoddy or second-rate research. Given these realities, are options available that will allow rigorous research to be conducted within these limitations? This appendix discusses how the current study of marine mammal scientists was faced with all these limitations but how I turned them to my advantage.

The major purpose of this section is to present a reflexive and personal discussion of the decisions made during this research and the practices I used during the study. The goal in doing this is to discuss the rationale for the somewhat non-traditional approach of this research, as well as to begin to assess the success of such an approach. Since this is by necessity personal, I will use the first person singular pronoun rather than the third person plural more commonly used in scholarly writing, and used elsewhere in this dissertation. This approach is consistent with Denzin and Lincoln's (2000) 'Fifth Moment' of qualitative research, and Clifford and Marcus' (1986) influential call for reflexive fieldwork accounts as an important tool for strengthening the professional culture of anthropologists and others using ethnographically-informed methods. This exercise can partly be understood as an exercise in legitimation. Marcus, however, has argued that many researchers, including those in science and technology studies, have been less willing in recent years to tell their "tales of fieldwork" at least partly because their research sites are less exotic in the traditional sense:

> Anthropological sensibility may still be strong, so to speak, in these projects, and there may be interviews and periods of sustained contact with informants, but not enough remains of traditional practices of ethnographic fieldwork to sustain the passion for telling stories of successful fieldwork, notwithstanding the need to reserve some symbolic space for this in publications. (2006, p. 115)

The process of research for this project has been a particularly interesting one, and by writing about it in some detail here, I hope that others may learn from the things I did right and the mistakes I made. In particular, future graduate students may find a frank discussion of these issues useful.

Preparing for the field: issues and opportunities

One way to study how marine mammal scientists are using digital photography in their scientific work would have been to undertake a long-term ethnographic laboratory study, with one or multiple labs. Although this approach has been the basis of many classic studies in the STS (Science and Technology Studies) literature, Lynch has argued that too many consider this as secured turf (Lynch, 2007) and that more work needs to be done to deal with the nuances of laboratory life. While I agree that there is much merit in long-term, engaged laboratory studies, in this case, such an approach was neither feasible nor particularly desirable for a number of reasons.

First of all, the research was part of my doctoral dissertation research, and funds were limited. I assembled several thousand dollars in funding from a variety of sources to support the research, but did not have the type of funding that would allow me to move to the location of a marine mammal lab and live for an extended period of time. Also, in addition to my role as a doctoral student, I have a full-time job and support a family. While my position as a data manager at a university has generous time off policies, I was still limited to approximately seven weeks of personal time per year, and generally can’t take more than two or three weeks at one time. Thus, studying one laboratory for an extended period proved to be unrealistic for this project.

Another factor played into the decision not to do a long-term laboratory study. I found that few, if any, of the marine mammal scientists I contacted were aware that scholars have an interest in studying how science operates. I sensed there was a little bemusement at being asked to be subjects of research. As such, while nearly all the labs I contacted eventually agreed to short-term visits (only four labs failed to respond after repeated attempts at contact), I believe that selling them on participating in a long-term ethnographic study would have been a much more difficult task *for this first study*.[53] To the best of my knowledge, only one other social scientist has ever studied this particular field of science (Nutch, 1996, 2006). I had no existing set of contacts that would have enabled me to gain entry, and no labs were used to accommodating the presence of a social scientist in their labs or on their boats. *In the future*, however, if I want to do additional work in this same field, I strongly believe that I could gain permission to spend extended time with at least some of the projects that participated in this dissertation research based on the sense of trust I have now developed with them. Several have actually expressed a strong interest in building future ties through such things as my potentially supplying graduate student interns to handle some of the more troublesome technical problems and problems of information organization that they have experienced.

An additional issue arises about observing these scientists in the field (as opposed to in their laboratories). For many of them, their fieldwork is carried out in remote and sometimes sensitive locations for a portion of each year. Their ability to accommodate extra personnel who are not directly contributing to their science is highly variable. For instance, one project I worked with does its fieldwork in small airplanes flying over the arctic photographing whales from overhead. These airplanes are a tight squeeze for the absolutely necessary scientists, pilots, and equipment, and there is absolutely no extra room for observers of any sort. On the other end of the scale, one study of dolphins in

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[53] Lynch (1993) mentions the difficulty in getting permission to “hang out” in labs as one of the pragmatic difficulties of laboratory studies that has influenced the shift away from observational studies of scientists in recent years.

New Zealand regularly takes untrained eco-volunteers with them for fieldwork experiences of two weeks at a time, and its members are very able and experienced at accommodating outsiders in their work. However, if I limited this research to only those projects which could accommodate an outsider both in their labs and at their field sites, many of the interesting differences between different types and scales of projects would have been obscured.

The limitations discussed here are important, and certainly have shaped the form my research took. The purpose of this discussion, however, is to argue that for the topic in question, a single in-depth ethnography would not have yielded answers to the most important questions the research sought to address. In trying to understand the new technology of digital photography, one of the underlying principles of social informatics that has guided this work is that identical or highly similar 'computing packages' (Kling & Scacchi, 1982) actually have different consequences in different settings. By doing an ethnographically-informed multi-sited study instead of a true in-depth ethnographic laboratory study, it was possible to begin to get at different ways in which scientists in one field, with similar training and similar scientific goals, are highly variable in how they use and implement a specific technology into their everyday practice. Marcus (1995; 2005) has argued that treating multiple sites "thickly" or "thinly" is a choice that must be made in the context of the research goals. In the case of marine mammal photography, while each site has been treated somewhat thinly, the overall topic of digital photography is being treated thickly, particularly in the long term. The long term goal is to create a complex ethnographic understanding of digital photography by examining its use in various contexts, rather than to develop a thick ethnography of how marine mammal scientists at one or more labs have created a specific culture of science.

Thus, instead of studying one lab in a classic ethnography, I decided to engage in shorter periods of interviews and observations with nine laboratories. The research sites are located in the southeastern U.S. Atlantic region (2 labs), southern U.S. gulf region (3 labs), western U.S. Pacific region (3 labs), and the Adriatic Sea region in southern Europe (1 lab). After all these site visits had been made, I also did telephone interviews with scientists who had agreed to be part of the research, but were working too remotely to justify the expense of a visit relative to the number of potential interviews I could perform with them. These were primarily smaller labs located in remote areas such as Alaska, Quebec, and British Columbia. Overall, I did 41 interviews (36 in person, 5 via telephone) with staff in 13 labs (9 in person, 4 via telephone) working on at least 18 different specific research projects.

Note that one factor that could limit other researchers undertaking a similar project, that of geography, was not a particular concern in this case. Namely, my base of research is located in the American Midwest, far from any ocean or center of marine research. Ocean research centers, on the other hand, tend to be located at or near coasts (Hesse, Sproull, Kiesler, & Walsh, 1993). This has actually provoked some comment from my research subjects, along the lines of “how in the world did someone from Indiana choose this as a research topic?” This actually was not a consideration when designing this project. Instead, the genesis of this project came out of my conversations with the late Rob Kling, who was my dissertation advisor until his untimely death in

2003. We shared an interest in photography and had plans to develop complementary research streams aimed at understanding the consequences of the computerization of photography in a variety of domains. Rob planned to initiate research in the area of photojournalism, while I pursued my dissertation research in another domain using digital photography, possibly a science domain since I had some background working in a scientific field through my full-time position in genetics research. After Rob died, I decided along with my new advisor, Howard Rosenbaum, to continue my portion of this research for my dissertation, and then expand it myself into additional domains after completing my dissertation.

By the fall of 2005, I had passed all of my qualifying exams and began preparing my dissertation proposal. At the time, my dissertation committee had agreed to the general structure of my research plan, and I was working on selecting the particular domain in which I would conduct the research. Obviously, studying all of scientific digital photography would be a foolhardy task, particularly for a dissertation. Instead, I began to look at the literature of a variety of different domains to determine what domains were using photography, had switched to digital photography recently enough to remember the shift but not so recently that the technology hadn’t yet settled into regular use, was somehow accessible, and was interesting to me and, ideally, to others as well. Possibilities included scientists such as archaeologists and astronomers along with other domains such as police forensic photographers, photojournalists, and advertising photographers. The discovery of marine mammal science and the presence of an active sub-field heavily engaged in photography as a major source of data collection was, quite frankly, fortuitous. I can actually remember the moment in November 2005, sitting on my couch Googling various digital photography terms, when I ran across a report of a research team in Russia using digital photography to identify whales. “Look at this,” I told my wife, “whale scientists use digital photography to identify and track specific whales. How cool is that?” She responded with more interest than usual as I described the report. At that moment, I had my first inkling that I had possibly found a domain both that would interest me and would also likely be interesting to outsiders hearing about my research.

In deciding on this field, location was not a major concern. I was prepared for the possibility of travel with any domain that met my main criteria. I must admit this is because of a bias I have as a scholar. I am always more than a little suspicious of research with a population that has apparently been chosen merely because of its proximity to the researcher. Research about a group “located in a town with a large Midwestern university,” or even worse, with classes of college sophomores, always strikes me as somewhat doubtful, particularly with regard to how well the population represents anything at all. Certainly, some very interesting projects come to a researcher’s attention because of their location, but in many cases it appears that simply the easiest route was chosen. This is particularly true if a strong case is not made for the selection of the population. So, in deciding to study the consequences of digital photography in a specific domain I could have done a simple, little study of something local like the *Indianapolis Star* newsroom or scientists at the Indiana University School of Medicine. However, I could think of no compelling reason why anyone else should be interested in those cases, nor that there was any reason to suspect that those particular stories would illuminate any more general understanding of digital photography.

Marine mammal photography, however, was quite compelling as a case study. Here was a scientific field that was certainly not terribly obscure, due to long-standing public interest in animals such as whales and dolphins, but had been little studied from a social scientific perspective. Photography plays a central role for the subset of this field which focuses on population studies and photographic mark-recapture techniques, and has been well-developed over time. The first uses of photography in marine mammal projects date back to the early 1970s, when scientists first noticed that not only could they recognize individual animals, but that they could do so using photographs taken in the field and then correlated from year to year and location to location. The 1970s also marked a period in which there was increased public interest in the welfare of whale, seals, dolphins and other marine mammals, and scientists who were using techniques that involved capturing or killing animals faced heavy pressure to come up with new techniques. The Marine Mammal Protection Act of 1972, which limited “takes” of marine mammals and set up regulated permits for scientific research of marine mammals, also had the effect of encouraging scientists to seek out non-intrusive methods for studying marine mammals. Most marine mammal scientific photography was done either with black and white negative film, from which prints were made, or color slides, which were examined on light tables. When digital photography began to supplant film in the consumer photography market between 1995 and 2005, scientists also began to look at whether they could use this new technology.

Most scientists in the field were fairly late adopters of digital cameras. Even though digital cameras had been fairly widely available since the mid-1990s and professional-grade bodies were introduced by Nikon in 1999 and Canon in 2001, most marine mammal scientists did not really switch to digital photography until sometime in the 2003-2004 timeframe, although some early innovators began experimenting much earlier than that. Between 2003 and 2005, however, a majority of projects appear to have made the switch to digital photography. This relatively recent, rapid, and thorough switch fit my needs perfectly. Plenty of scientists and staff would have been involved both in with film photography and digital photography, and could thus offer informed knowledge about differences between the two in their work; many would have been involved in the actual change. Also, since the change was recent, most would still remember the periods before, during and after the change to digital. Finally, the subfield of marine mammal photo-identification is small enough that it would be possible that my conclusions based on this research would be at least representative of this one subfield, a claim I could not hope to make if I studied photojournalists at one or two local newspapers.

Entering the field

Once I determined that marine mammal science might meet my research needs, I began to assemble additional information that I would need to finalize this choice and include in my dissertation proposal to make my case. I read websites, gathered scientific articles,[54] and began contacting some people in the field to determine the likely interest and feasibility. As it turned out, timing was on my side. One of the scientists whom I contacted both for a reprint of one of his articles and to discuss the role photography played in his work suggested that a good way to get a sense of the field and to meet some people who might be interested in helping me would be to attend their major conference. The conference drew many of the marine mammal scientists[55] and usually had several papers and a large number of posters using photo-id data. The major scientific meeting for marine mammalogists only occurs every two years, but the next meeting was coming up in less than two weeks, in San Diego, California, in December 2005.

Here is an example of needing to be able to take advantage of opportunities that come your way during research. I made a quick call to my advisor and described what I knew so far about these marine biologists. His response was also quite positive, so we decided it was worthwhile to quickly purchase a plane ticket and fly out to California for the meeting. If I missed this chance, it would not present itself again. The next meeting was not scheduled until December of 2007 and would be held in South Africa. Waiting was not an option if I was going to make this work.

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[54] Gathering scientific articles on marine mammal science topics from a library at Indiana University turned out to be more troublesome than I expected. Although just as much of the marine biology literature is available through electronic sources as in any other field, without a marine biology department, Indiana University's library has little reason to subscribe to the electronic versions of the relevant journals. Thus, I had to make a number of inter-library loan requests for articles and also contacted a number of authors directly for reprints. This also proved fortuitous, as one of the authors I contacted for a reprint is the scientist mentioned in the text who suggested I attend the upcoming scientific meetings.

[55] This assertion was later supported by my research, which found that this conference held by the Society for Marine Mammalogy was the most important professional affiliation for nearly all my research subjects, and the only professional meeting that most attended consistently.

Attending the meeting proved to be a critical decision, one that I feel set up the rest of the project for success. At the meeting I talked informally to between 45 and 50 people over three days, asking about their research, describing my project, and ascertaining the likelihood of their being interested and willing to participate in my research. I also attended any paper that discussed photo-ID data, and visited every poster that had photography anywhere in the title or abstract or had photographs on display as I went through the exhibit hall. The contacts I made after paper presentations and during the poster sessions formed the initial core of contacts I had available to me when I later begin to select sites for inclusion in the research.

On reflection, I think that going to a conference in the field one is studying early on in the research process is critical for anyone studying an academic or scientific field. I suspect this is also true for other professions that engage in regular professional conferences as well. I've never seen this advice written anywhere, though, so I had to discover this truth on my own. Graduate students are often told of the importance of attending conferences in their own fields in order to learn the ropes, but in my experience, this is not translated into advising them to do the same for a field they are studying. At the Society for Marine Mammalogy (SMM) conference, however, I not only made important contacts for my research and established my first contact with many potential subjects in-person and face-to-face, but I also learned quite a lot about the field. During the course of the conference, I attended many sessions and posters and learned about some of the current main dialogues in the field. I attended papers about results obtained using photo-ID methods, but I also attended a number of sessions about results in some of the other main areas of research, acoustics and genetics. There was also a fascinating and informative “movie night” during the conference, where research teams showed films and videos made during their field seasons. By seeing these videos, I got my first exposure to what happens in the field, how photo-ID is done, and how genetic biopsies are obtained. I saw some of the usual and unusual behavioral patterns of seals, dolphins and whales, and many other things that began to help me acclimate to the discipline.

I also think that my attending the conference and meeting people face-to-face for my first contact made me and my research seem more legitimate to the people I met. Their first contact with me wasn’t some spam-like e-mail out of the blue, or a cold telephone call interrupting their day. In fact, the few sites where I had difficulty getting a response to my initial requests for participation were those where I had not met at least one member of their project at the SMM conference.

During a conference, people expect to talk about their research. My asking questions about it fit within their expectations of how they would spend their time at the conference. They aren’t busy doing lots of other things, since they expect to be talking and networking. I also found that the people I met at this conference were very friendly, open and willing to talk, and the conference overall had an easy-going and welcoming feel to it. While not essential to the research since it is certainly no major problem to work in a more formal field, knowing that marine mammal scientists were likely to be fairly informal and easy to talk to helped me plan for my site visits. I knew better what to expect in terms of their style, and also was less likely to commit a *faux pas* such as dressing wildly inappropriately for the setting. Just as one wouldn't want to show up for an interview with a CEO wearing jeans and a t-shirt, showing up in a marine mammal lab wearing a dress suit and tie would not put the research participants at ease. Being appropriately dressed helps establish rapport with the interviewees, and also helps to establish legitimacy.

After attending the SMM conference, I was convinced that marine mammal photo-identification was the perfect case study for my dissertation. Luckily, my research committee enthusiastically agreed, and my dissertation proposal was defended and accepted without changes in July 2006.

Starting in August 2006, I began to re-contact potential interviewees about their willingness to allow me access to their facilities and their staff, primarily via e-mail. I used an e-mail message that had been approved by my campus Institutional Review Board which re-introduced myself, provided some brief detail about the project as well as a link to my website with additional information available, and contained a short questionnaire asking about their willingness to participate, the number of staff involved in photography at their site, and other researchers in their area whom I should considering contacting. In methodology-speak, I used a combination of convenience sampling and snowball sampling.

The e-mails worked fairly well, but I did find that I had a difficult time in a number of cases getting timely responses (particularly from people I hadn't met face-to-face) until I had a firm date when I would be in their area. When I sent an e-mail saying, in effect, "I'd like to come to your area, please let me know when would work best for you," the e-mail tended to languish in their inbox (they later told me). Conversely, once I had a firm date I was able to say, "I will be in [your city] in two weeks, and would like to interview you and your staff. Based on the number of people you told me about, it will probably take 2-3 days. Would it be possible to start either on Monday or Wednesday of [the week in question]?" In these cases, I almost always got a positive response.[56] The only exceptions were a small number of people who were going to be out of town (often in the field), and two facilities that just never responded, even when another of my interviewees tried to intervene on my behalf with them. The ones who were out of town all agreed to later telephone interviews when their schedule permitted if I required additional information about their lab.

The difficulty in getting sites to select dates could have been a problem if I just kept going back and forth in trying to get a specific time from the interviewees. However, the financial limitations mentioned above actually solved this particular problem for me. Since I was doing a lot of traveling, whenever possible I planned to double and triple up sites to visit based on their general geographic area. Rather than making nine individual trips, I made five longer trips and visited multiple sites on three of the trips. Additionally, I also piggy-backed four of the five trips onto conference travel for which I had partial travel funding available. So, when attending a conference in a certain large American city

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[56] Note that this is exactly opposite of advice for planning qualitative research given by Thomas, who suggests that when interviewing powerful people such as CEO's, that "executives tend to be far more generous with their schedules when you suggest a data a month or so away" (1993, p. 87). This underscores that the qualitative researcher must adapt to the norms and expectations of the domain they are studying, and must often do so with little or no advance warning of what those norms might be.

that would be on a Monday and Tuesday, I made arrangements for interviews at a research site in a nearby small ocean-front city during the previous week, stayed over the weekend and attended the conference, and then did additional interviews at a second site nearby for the remainder of the week. All told, I spent about a month actually visiting and interviewing scientists.

One of the trips was to a state with several important sites that I wanted to be sure to include because of their key role in the development of photo-ID methods in marine mammal science, but I didn't have any conference trips planned that would take me anywhere near that area. I was having a difficult time getting people to commit to dates and finally had to just pick a date two weeks out, purchase plane tickets somewhat on faith, and follow the method above of giving people options to choose from. In almost all of the cases, both for the conference-related travel and the research-only travel, I was not able to get everyone committed to dates and times until one week before my arrival. Most airplane tickets require 14 day advance purchases, and either do not allow changes or charge high fees for changes. You can see the disconnect: with airline tickets purchased 14 days out and schedules very uncertain until 5-7 days out, I had to simply go ahead and buy tickets and hope for the best. I am pleased to say that it worked out better than I could have hoped in all cases, but there were certainly some worrisome days when it appeared I would be taking a trip for a week or two and have absolutely nobody to talk to during that time.

In the field

Even though much of this section is about the challenges of getting into the field and setting up qualitative research in a scientific field, I would be remiss if I didn't take some time to discuss the organizations I studied.

When I first set out to study marine mammal scientists, I rather naively assumed that I would primarily be visiting universities. As it turns out, I visited only one university in the course of this research, because much of the activity in the field is in other sorts of organizations. Some of the predominant organizations are non-profit research foundations, both small and large, government agencies, and private contractors who often do contract work for the government. This research included two small private non-profit organizations (with 1-4 full-time employees), two medium non-profit (with approximately 10 full-time employees), three large non-profits (with hundreds of employees), three government facilities (with many hundreds of employees), one program that was part of a large university, and two programs located at smaller colleges.

Given the space limitations here, I won't describe all the sites in detail, but it is useful to have at least an overview of three representative sites. First, the Dolphin Bay Center[57] (DBC) is a small non-profit organization that regularly engages in field research for several months of the year. The main field site is not located near the lab facility; the research staff leaves its main facility in the United States and moves to an off-shore ship in the Caribbean during the field season, which lasts for 2-3 months. The project has four

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[57] All names of projects and people have been changed to respect the interviewees' anonymity.

full-time employees: a director (who is the primary scientist), another scientist (who is working on a graduate degree), an office manager, and a ship's captain. DBC also takes on graduate students regularly to contribute to their training and allow them to gather data with the dolphins studied by this project. The DBC innovates in several areas of marine photography, particularly underwater photo-ID and underwater videography. Unlike most of the researchers I interviewed who take photographs from boats, the DBC scientists get into the water with the dolphins to photograph and record video and audio. They are the only group studying the particular population of dolphins they work with and have developed trust with the relatively small population of animals over the last 22 years that they have been working with them.

DBC's facility is modest. It is located in a small office park, and has a small open area near the front door with the office manager's office off the side of that. The director's office is a moderately sized room, and beyond that is the main lab space, where the second scientist works. The lab space also contains a number of computers, files, shelves, and worktables. The majority of the work is done in this rear area, which takes up about half of the total available space.

DBC was founded by the current director, and relies on a combination of grants, private gifts, and other private sources of income to continue operations. The organization has a board of directors, but the director clearly makes most of the operational decisions. The director chose to start the organization after having worked on some other projects because she "had more flexibility for funding and project options."

She holds a PhD, but did not at the time she started the organization, when she had a master's degree.

It is worth noting that I was surprised by the level of achievement in marine mammal science overall by people who did not necessarily hold a PhD. Again, one of my preconceptions before doing this work was that I would be talking mainly to PhD-level scientists when I was speaking with project directors, and possibly master's- or bachelor's-level scientists when interviewing staff. In fact, I found people with a wide variety of education levels working at all levels of the scientific organizations I studied. Among project directors, for instance, there were certainly a number of PhDs, but also several with master's degrees, bachelor's degrees, and even one notable case of a project director with no formal education beyond high school. That particular scientist had begun working with marine mammals as a trainer at water parks such as SeaWorld and then later in several conservation roles with wild dolphins. A series of events (and, it must be noted, considerable personal charisma) had eventually led him to use his approximately 20 years of practical experience with marine animals to join a large scientific institute and start the Atlantic Dolphin Research Institute (ADRI), a project that is now large, very well funded, and highly respected. He did think that his lack of formal credentials had hampered him on occasion as far as being taken seriously as a scientist, and he did collaborate with several PhDs and scientists with master's degrees, both in running the project and in publishing results.

ADRI is part of a larger research and conservation organization. Its facilities are on a large campus that includes several hundred scientists. There is a protected harbor in the center of campus, from which vessels can sail out into the Atlantic. Arriving at the campus, one must first sign in with security at a gatehouse. The ADRI project is in two buildings. One, which houses the director and several scientific staff, also has space for meetings and is a very spacious and nicely decorated building. The second building, located near a boat dock, is where the staff who work with photo-ID data on a regular basis are housed. Beyond their photo-ID work, ADRI is also engaged in dolphin rescue work as well as necropsies. The core photo-ID staff consists of the director, another scientist, and two-full time staff. There are also a large number of other staff on the project, including a veterinarian, equipment and maintenance personnel, and a number of other scientific staff. ADRI has been very successful in getting funding, to the extent that they actually re-distribute some funding to other, smaller projects in their geographic region.

The ADRI was a perfect example of a project that was extremely hard to get to commit to a date for my visit, but once I arrived, the staff could not have been more helpful and accommodating. Even though the project only has four people involved mainly in photo-related work, I spent two full days at the facility, interviewing people, watching them work, eating with them in the facility's cafeteria, and going out on a boat with them on an opportunistic survey. Even though the weather was somewhat uncooperative during my visit, the staff knew I wanted to see them at work on the boat and were constantly monitoring the weather forecasts. When we got a several-hour window of decent weather, they took me out and I was able to observe them during several encounters with dolphins. They would not normally have gone out that day but went far out of their way to help me understand their work.

ADRI's work is done both locally, leaving from their on-site boat docks, and along a large portion of the Atlantic coast of the United States. They have arrangements with other docking facilities in their main research areas, and also can transport some of their boats and put them in closer to their target area. They have access to a number of boats, including six of various sizes at their main dock. They have smaller boats for working close to shore, larger boats for surveys on the open ocean, and specially designed boats for rescues and work that involves capturing animals for health assessments. Because much of their work is close to their facility and the animals they study are year-round residents, ADRI does boat-based surveys throughout the year. They average several days a month on the water and spend the rest of the time working with organizing and analyzing the data back at the lab. At ADRI, photo-ID teams are relatively stable, with driver/photographer pairs working pretty much exclusively together for years. They felt that this allowed the pair to get to know each other's habits, and made them very efficient at data collection in the field.

The differences in actual field collection practices between sites in this research were notable, probably none more so than differences in how teams were organized. At ADRI, as I mentioned, a driver/photographer pair might work together for a number of years. At another facility I visited, the pairs were constantly shuffled and changed. At a third, many of the staff actually went out alone and did both jobs themselves, both driving and photographing animals. Another had multiple people on each boat, with each taking turns with one driving, two to three photographing, and one recording data. Some of these differences were due to different animal behaviors, boat sizes, and local conditions, but I think there is something else going on here too.

This is purely speculative and is based on little more than my impressions, but to my eyes, each project developed scientific habits that to a certain extent reflected personality traits of the senior scientists in charge of the projects. While I'm not a psychologist and did not perform psychological tests on participants, I did get a number of clues about the personalities of the people I spoke with based on my interactions with them and on the things their staff members said about them. For instance, at the project where people went out alone, the principal investigator had a reputation as something of a loner. He was certainly the quietest and least voluble of the PIs I spoke with, and while he was willing to let me speak to his staff as long as I wanted, he did not seem over-enthusiastic about being interviewed himself. The staff were very competent and careful about their science, but were certainly overall less chummy, for lack of a better word, than many of the other projects I visited. There are many similar examples at other projects that I don't have time to discuss here. I mention it here because I think that there may be potential for someone more expert in psychology to study the extent to which PI personality influences the practice of science.

The Federal Marine Agency (FMA) is a large governmental organization that engages in a variety of projects researching various aspects of the marine world, including marine mammals, fish, oceanography, geology and other areas of science and conservation. Security at FMA is relatively high in light of increased governmental regulations about security post 9/11. The FMA is unlike the other projects I visited in that there were fewer full-time staff on-site per project. The project staffs I spoke with generally had one senior scientist and one staff scientist, who was sometimes shared among multiple projects. When they actually go out into the field to collect data, they increase the size of their teams by collaborating with external scientists and hiring contract scientists. Many of the surveys, for instance, are from large ocean-going vessels with as many as 50 people aboard carrying out various scientific projects. The relative importance of the photo-ID work depends on the overall purpose of the trip and is often pursued only after other scientific projects gather they data they require, or when the ship happens across marine mammals during its regular transect.

Most of the FMA scientists I interviewed held master's degrees and had long experience in their fields. The FMA facility overall is very large, with several large buildings. The photo-ID scientists I interviewed had small offices located along a corridor of dozens of similar offices. Space definitely appeared to be at a premium, and while the facility was in a nice waterfront location, the buildings had a decidedly institutional government feel to them – large, concrete, and drab. The FMA workspace appeared the least open and collaborative of all the projects I visited, with lots of small, private spaces instead of the open, shared spaces I saw at the other projects. The FMA scientists, notably, also had the hardest time identifying colleagues who might also be available to contribute to my research, even when it later turned out that another scientist referred me to someone not too far from their offices in the same facility.

These three examples of a small non-profit (DBC), large non-profit (ADRI), and large governmental agency (FMA) demonstrate the range of institutional arrangements that support marine mammal research. Even though many of the specific photo-ID projects are relatively small, the size of the institution in which they operate has an effect on how they are organized and ordinarily function. Small scientific institutions with limited resources result in projects with considerable personal involvement of everyone in the organization. Larger scientific organizations, on the other hand, have greater resources available but also have more layers of decision-making required before being able to innovate. Huge organizations, such as the government, have lots of resources, but also have the least flexibility in instituting change.

The actual interviews loosely followed a semi-structured instrument developed in advance to guide the conversation and to avoid neglecting important topics. The questions were often asked out of order, as I would follow up on points that the interviewees had made immediately if they touched on points that would otherwise come later in the list of questions. All of the major questions and topics were addressed to all the scientists, although specific side discussions varied from person to person. Also, some sections were skipped when irrelevant; if, for instance, the interviewee had done photography only with digital cameras, we didn't go into the differences between film and digital to any great extent. The questions included asking for their work practices in great detail, but also touched on their backgrounds as scientists, their interactions with others in their organization and in the scientific field as a whole, their professional communications, their personal involvement with photography, and their general level of comfort and competence with technology. The interviews averaged about an hour and 15 minutes each, ranging from the shortest interview of 45 minutes to the longest of nearly three hours spread over two sessions on two different days. The interviews were primarily in the scientists' offices or labs, as I requested to be where we could look at the photographs they use while we talked.[58]

One comment about the interviews should be mentioned. At the two small non-profits and one medium-sized non-profit, I interviewed everyone who was available during my visit. At the larger facilities, I interviewed everyone who was available who worked on photo-identification projects, which was usually just one or two small projects in the larger organization. This was somewhat perplexing to many of the scientists, who didn't quite understand why I wanted to talk to *everyone*. "Why do you need to interview everyone? We all do the same thing," they would say. Of course, anyone familiar with qualitative research will understand that by getting different perspectives on the same organization, I was able to triangulate on a more complete picture of the organization and its use of technology. For the scientists, however, this seemed a little odd, but they also seemed willing to accommodate this eccentricity once I assured them that I wanted to find out not just about how their specific photography system worked, but also about individual scientists and how they got involved in this work. Even though the scientists I interviewed regularly engaged in scientific inquiry, they were not usually called upon to

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[58] All the interviews were recorded with a very small Olympus WS-320M digital audio recorder with an external Sony ECM-DS30P microphone. The interviews were later transcribed by professional transcriptionists and coded using NVivo 7.

be reflective about their roles as scientists, and some mentioned quite enjoying the opportunity to reflect on some of these topics.

In general, I found that presenting the study in very honest terms served me best. I made no effort to conceal the goals of my research, and while I only described the project in general terms to people I planned to interview, much more detailed information is available on my website to anyone interested in looking. On at least three occasions, as I arrived at an interviewee’s office I noticed that my website was up on their screen and they had been looking over some of the information about my project. Several also commented that they thought the project overview sounded interesting, and that they felt the main research questions were useful and appropriate. I didn’t find that having seen more detail about the project caused them to color their answers to my questions, and in a few cases it did cause them to offer some additional detail that they felt might address some of the things I hoped to understand. I suspect that the success of this level of openness was due to the fact that my research was not seen as threatening in any way to the interviewees, so there was little reason to conceal anything about how they are using something as apparently innocuous as digital photography.

Another factor in building rapport with the interviewees was that I approached all the interviews as what Forsythe has called an “*outsider with considerable inside experience*” (1999, p. 130). I presented myself as someone from a strongly technological field, with a background in science, and with an understanding of photography seeking to understand their specific field about which I knew little. Thus, I always asked people to explain their particular field as if I knew very little about how photo-ID work was done, but didn't pretend that I didn't understand photography or computer tools. This sort of combined expert-novice dichotomy resulted in my neither 'studying up' (Nader, 1972) nor engaging in traditional subaltern studies, with the interviewer of higher status than the interviewees. Instead, I was 'studying sideways' (Hannerz, 2004). The interviews were very comfortable, both for me and apparently for those being interviewed, and I had to do very little prompting other than asking brief questions and probing comments that I wished to follow up.

Problems with the research

Since this is meant to be a reflexive summary of the research, I would be remiss if I didn't mention the one main source of trouble for the research: transcribing 50+ hours of interviews. When I first began doing the interviews, I did not have funding available to pay for professional transcription services, and tried to do it myself using Transcriber 1.5.1 shareware software. I first tried using typing, and later using Dragon Naturally Speaking to re-dictate interviews into the software, a method suggested on several qualitative research discussion lists. What I learned is that I am pitifully slow at transcription. It became very clear that I needed another way to transcribe the interviews if I hoped to ever finish the research.

As luck would have it, I gained some additional funding from my doctoral school that allowed me to pay for transcription, as long as I was able to keep the costs down. I thought I had the perfect solution when I found a site called contractedwork.com that allows people who need services such as transcription to post jobs and receive bids on the work. I got 7 bids on my job, ranging from $600-$5400. The lowest bids came from companies operating in India, and the highest from large, established companies. I choose a bid in the middle of the pack in terms of dollars but whose owner had responded to my queries quickly and efficiently.

Unfortunately, that was to be the last quick and efficient work on my behalf by this company. After my many requests for interim transcripts were met with demurral ("I'm just cleaning them up and formatting them"), I was told that all would be done by the end of a certain week. When the date came and went with no transcripts, I tried repeatedly to get in touch with the transcriptionist. To make a long story short, her computer had crashed, she had no backup, and all except one of my transcripts had been destroyed.

At that point, time was pressing, so I contacted a number of other transcription services. In the end, in order to get the large number of interviews transcribed, I doled out the work to 11 transcribers working at four different companies and was able to get everything done in fewer than 10 days. While I was forced into this situation by necessity, it was actually a fairly interesting experience once I decided to try it. I contacted approximately 15 transcription services that advertised on Craigslist Indianapolis (http://indianapolis.craigslist.org/search/bbb?query=transcription), ContractedWork.com, or had been mentioned in a recent discussion on the qual-software e-mail list (qual-software@jiscmail.ac.uk). The four services I ended up using all responded promptly to my initial query, offered reasonably affordable rates ranging from $30-65 per hour of audio transcribed, and were available for immediate work. In order to avoid finding myself in a similar situation as that which had prompted this crises, each transcriber was given only a few recordings at a time as WMA or MP3 files (depending on the needs of the transcriber), and then provided more download links to audio files through the secure Slashtmp service[59] when the previous transcripts were returned. The transcribers were all very accommodating of this non-standard approach. In the end, I had transcribers in Indiana, Wisconsin, Georgia, and Pennsylvania working on the project.

Two major lessons came out of this stressful and painful situation. First, never put all your eggs in one basket when it comes to any stage of research. Second, when outsourcing work to anyone outside your immediate control, do so in small batches that you will be able to check regularly for completion and accuracy. If I were to use a single company again in the future, I would spread the work over many months and require every transcript back in a timely fashion before giving them the next small batch. If I need it done quickly, I would again use multiple services. Hopefully others will learn from my mistake.

The other decision that I consider to be somewhat of a mistake was in using NVivo as my main tool for organizing, coding, and analyzing the data for this study. NVivo came highly recommended from a number of sources, and prior to the proposal I had downloaded trial versions of NVivo, Atlas.ti, and maxQDA for testing. Based on small samples, it appeared that NVivo would be most useful for this research. After using it more intensively during the time when I was coding all the interview transcripts, I discovered many problems with the program that had not been apparent in smaller

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[59] See footnote 34 on page 121 for more details about this service and its security features.

samples. While NVivo proved to be fairly useful for analysis, the software itself has a large number of usability problems that made its use highly inefficient from my point of view for coding large numbers of sources and long documents. The problems I encountered were not simply a matter of training or user error, since searches on the NVivo online forums found other users complaining about the same aspects of the software that bothered me, and for which there were no apparent fixes or work-arounds. In fact, while re-reading the transcripts and coding the documents was a useful exercise for organizing my thinking about how to present the arguments in this dissertation, for the actual extraction and selection of quotations to use in the narrative, the desktop-searching tool, Copernic, proved much more valuable than did NVivo. In future projects, I will explore using alternative research database systems.

Discussion

Rather than a classic ethnographic study, this research is ethnographic in the sense that it relies on a holistic view of scientists at work to understand their use of a particular technology. By focusing the work on a technology and its various manifestations, this research was seeking to understand more about the social and human dimensions of technology in scientific workplaces. Even though the project had to work within the limitations of time, budget, and overall approach described in this paper, the approach appears to have been successful at yielding the types of information necessary to answer the main research questions.

Is this ethnography? No, not at all, at least not in the Malinowskian tradition.[60] I have bachelor's and master's degrees in cultural anthropology and have done traditional ethnographic fieldwork, living for a year in a remote location among people very different from myself. This is not the same, nor does it aspire to be. However, my goals have been to approach the topic from the same holistic perspective learned from anthropology, and to try to incorporate the world-view of the marine mammal scientists into my understanding of their routine activities that have developed around the technology of digital photography. Schlecker & Hirsch suggest that "adoption of an ethnographic methodology [in STS]… reflects an increasing endeavor to incorporate ever more contexts, which seemed to constitute 'audience' and the 'contents of science'" (2001, p. 75). This research is focused on understanding the contexts in which digital photography is put to use, and thus suggested an ethnographically-informed approach. Instead of a long-term ethnography, the approach described here is consistent with the post-analytic ethnomethodological approach described by Lynch (1993) in his call for researchers studying science to spend less time talking about science and more time observing scientists engaged in their everyday behaviors.

The approach described in this appendix has demonstrated that a multi-site study of ordinary scientific practice that focuses on a single technology in different settings can succeed quite well. It has yielded a large amount of useful data that illuminate a fuller

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[60] It is worth mentioning that the Malinowskian tradition is being challenged within anthropology. Marcus (2005) discusses at length the fears that traditional Malinowskian engagement is at risk of losing its long-held position of dominance in the field.

understanding of the ordinary scientific behavior of marine mammal scientists by focusing on a key technology, digital photography, used in the science of marine mammalogy.

While the methods used in this study have proven fruitful, the research suggests a number of ways the study could be extended in the future. Given more time and resources, it would be likely that several of the nine sites where this research was carried out would now permit much longer term access now that they are more familiar with the project and the researcher. Several of the projects have volunteer field experiences that one could participate in, for the cost of the several thousand dollars required of anyone who wishes to join these projects for several weeks. Even a more Latourian approach of "following the actor" would be possible, following some of the more prominent and connected actors in this highly inter-connected network of marine mammal researchers (Latour, 1987). Note that all these approaches, however, would be better suited to answering different kinds of questions, complementary to those addressed in this research.

This project with marine mammal researchers is just one part of a longer planned study of digital photography in a variety of domains. For this stage, which forms the basis for my doctoral dissertation, getting the research done in a timely fashion was an important concern. Later stages will have somewhat more flexibility in timing, and also potentially better access to funding sources. It is possible that for future extensions of this project, I'll have much more time and money to do my research and can do a full-fledged ethnographic study. However, given the success of the approach used in this study, it may be more valuable to follow up with a similar study in a different scientific domain, such as archaeology or astronomy. This would provide additional comparative data for understanding how ordinary practices of scientists evolve as scientists adopt new technologies. The important thing is to design the research in such a way that the limitations can be made to work to the advantage of the specific project and to adapt the research methods to best fit the research questions and domain of study.

APPENDIX 2: Interview guide

The following interview guide was used for the semi-structured interviews done with subjects. The schedule of questions was not followed verbatim, and while the order was generally followed, the flow of the conversation often dictated skipping back and forth to sections pertinent to comments made during the session. Sections not pertinent to the interviewee in question were skipped (e.g., if the person was not at the organization at the time it switched from film to digital, questions about the organizational discussions surrounding the switch were skipped over). The box at the right [RQx] denotes the research question number(s) that the question was designed to contribute information to answering.

1. **Background information**
    - 1.1. Education
        - 1.1.1. Where did you go to college?
        - 1.1.2. What field did you study as an undergraduate?
        - 1.1.3. When did you graduate?
        - 1.1.4. Where did you go to graduate school (masters? Ph.D.?)
        - 1.1.5. What field(s) did you study?
        - 1.1.6. When did you graduate?
    - 1.2. How did you first become interested in marine mammals?
        - 1.2.1. Where did you grow up? Was it near an ocean?
        - 1.2.2. When did you first have experiences of any sort with marine mammals?
    - 1.3. What do you hope to achieve with your research?
    - 1.4. Work history
        - 1.4.1. Let's talk about your work history now. What was your first professional job?
        - 1.4.2. How long did you stay in that? (Repeat for all jobs in field up to current)
        - 1.4.3. How long have you been in your current position?

2. **Work processes**
    - 2.1. Description of photo-identification work
        - 2.1.1. Could you walk me though what you actually do when you work with photography in your research? (Start with a sample photo of theirs)

          Probes:
            - 2.1.1.1. Describe what you do in the field
            - 2.1.1.2. What sort of equipment do you use?
            - 2.1.1.3. How do you decide what to photograph?
            - 2.1.1.4. How many photographs do you take in a day? Week? Season? Year?
            - 2.1.1.5. How do you document what you do?
            - 2.1.1.6. What happens to the photographs in the field?
            - 2.1.1.7. What happens to the photos after a day's work? [RQ5]

   2.1.1.8. What happens to the photos after the field work ends? [RQ5]
   2.1.1.9. What do you do with the photos during the off season?
  2.1.2. For each of the above, who actually does this work? [RQ5]
  2.1.3. How do the photographs aid your research? [RQ7]
  2.1.4. Do you publish the photographs themselves in research? [RQ7]

3. **Organizational Information**
 3.1. Now, I'd like to talk a little about the organization you work for.
  3.1.1. How many people work in facility?
  3.1.2. How many are involved with photo-identification in any way? [RQ1,5]
  3.1.3. Who are they?
  3.1.4. What are those people's primary jobs? [RQ1,5]
  3.1.5. Which species do they study?
 3.2. How long has the organization been doing photo-id work?
  3.2.1. Were they at the organization when that started?
 3.3. When did they switch to digital?
  3.3.1. Were they at the organization when that switch occurred?
  3.3.2. How did the decision to switch take place?
  3.3.3. Who was involved? [RQ1]
  3.3.4. What sort of discussions took place? [RQ2,3,8]
  3.3.5. Are there any documents (e-mails, memos) from that period discussing the switch? [RQ2,3]
  3.3.6. If so, can I get copies?
 3.4. How did the switch go?
  3.4.1. How did people learn the new technology? [RQ2,3,8]
  3.4.2. What sort of big problems occurred? [RQ2,4,6,8]
  3.4.3. What little problems occurred? [RQ2,4,6,8]
  3.4.4. Were there any conflicts? [RQ6,8]
  3.4.5. What were the immediate benefits? [RQ8]
  3.4.6. What were the long-term benefits? [RQ6]
  3.4.7. How was your experience compared to other organizations you are aware of that have switched to digital photography?
 3.5. Were there any people who only started working with your photo data after you switched to digital? [RQ5]
  3.5.1. What do they do? [RQ4,5]
 3.6. Is there anyone who used to work with your photographs, but has stopped doing so since you switched to digital? [RQ5]
  3.6.1. What did they do? [RQ5]
  3.6.2. What do they do now? [RQ5]

4. **Funding**
 4.1. When the new equipment was purchased, who was involved in making that decision? [RQ4,8]
 4.2. What sort of equipment and software did you have to buy originally? [RQ8]

4.2.1. Were there additional things you had to buy later that you hadn’t thought of initially, or weren’t available at the time? [RQ8]
4.2.2. What were they, and how long afterwards did you acquire them? [RQ8]
4.2.3. How was it paid for? [RQ4]
4.3. How much did cost influence when you adopted ? [RQ2,4]
4.4. What are your main sources of funding for ongoing photo-id work? [RQ4]

5. **Personal experience with photo-id**
5.1. What year did you personally first start using any sort of photo-identification?
5.1.1. Why did you decide to use photo-identification? Did anyone influence your choices? [RQ2]
5.1.1.1. Tell me more about your relationship with those people influencing the decision. [RQ8]
5.1.2. How did you learn to do it? [RQ3]
5.1.3. Who taught you? [RQ3]
5.1.4. Can you describe the learning process for me? [RQ3]
5.2. What software packages do you use? [RQ8]
5.2.1. To manage photos? [RQ8]
5.2.2. To keep track of identifications? [RQ8]
5.2.3. To share images with other researchers? [RQ8]
5.3. What other technology do you use in conjunction with digital photography?
5.3.1. For instance: GPS? Database software? Photo-manipulation software (ACDSee, others)? Other technologies? [RQ8]

6. Routine use
6.1.1. How much of your time is spent working with photo-id data? [RQ6,8]
6.1.2. What other ways do you spend your time?
6.1.3. Make a pie chart of how much time they spend on various tasks in an average week. [RQ4]
6.1.4. What are the biggest benefits of digital photography in your opinion?
6.1.4.1. How does it affect your scientific work?
6.1.5. Are there any particular frustrations for you in working with digital photography? [RQ6]
6.1.6. What sort of things used to happen with film that no longer happen with digital photography?
6.1.7. What sort of things happen now with digital photography that never happened with film?
6.1.8. If you could change something about your digital photography total package, what would it be? [RQ6,9]
6.1.9. Are there changes you could imagine, not limited to currently technology, that would make your work better or easier or more efficient? [RQ6,9]

7. Do you do personal photography? [RQ3]
7.1.1. To what level: snapshots, artistic photography, hobbyist, pro?

        - 7.1.2. If so, does that photography seem the same or is it a different sort of activity for you? [RQ3]
        - 7.1.3. What sorts of things do you like to take photographs of?
        - 7.1.4. Which digital came first, personal or work?
            - 7.1.4.1. Do you think one influenced the other? [RQ3]
            - 7.1.4.2. If yes, in what ways? [RQ3]

8. Technology use

        - 8.1.1. How would you characterize your own level of comfort with technology? [RQ2,3,8]
        - 8.1.2. Compare this to your colleagues – do you think they are more or less tech-savvy that you? Can you give examples? [RQ3]
        - 8.1.3. Do you think your organization is technologically advanced compared to others in your field, technologically behind, or about average? Why?
        - 8.1.4. How do you learn about other new technologies (GPS, databases, etc.)? [RQ3,8]

9. Professional communication

    - 9.1. Affiliations
        - 9.1.1. What do you consider to be your most important professional affiliations? [RQ1,7]
    - 9.2. Networking [RQ1]
        - 9.2.1. Who else do you share your photographs with? [RQ7]
        - 9.2.2. How do you share them? [RQ7]
        - 9.2.3. Has this changed since you started using digital? How? [RQ7]
    - 9.3. How do you decide on what projects to take on? Are they assigned, based on grants, based on contracts, self-initiated?
    - 9.4. Do you use photographs in your publications or in your talks? [RQ7]
        - 9.4.1. How?
        - 9.4.2. Do you find that you use them either more or less frequently than you did with film images? [RQ7]
    - 9.5. Do you share the images with any non-researchers (such as on a website, in schools, or in popular publications)?
        - 9.5.1. Do you do this more or less frequently since switching to digital?

10. Other topics

    - 10.1. Are there other aspects of your work with photography that you think I've missed?

APPENDIX 3: Coding tree hierarchy

The following shows the coding tree hierarchy used as the base coding scheme in NVivo. Additional categories were added inductively from the data, but these represent the categories specifically designed to help answer the research questions for this project. Underlined portions of the concepts represent the shortcut codes used in NVivo.

Codes based on Research Questions

1. Who are the relevant actors within the systems supporting photo-identification research, and what are the core groups both related and unrelated to photography to which these actors belong?
   - 1.1. Relevant actors
   - 1.2. Non-human actants
   - 1.3. Relevant social groups
   - 1.4. Social networks
     - 1.4.1. Loosely coupled
     - 1.4.2. Tightly coupled
   - 1.5. Work systems
     - 1.5.1. Loosely coupled
     - 1.5.2. Tightly coupled
2. What are the pressures/incentives or impediments to adopting digital techniques?
   - 2.1. Pressures to adopt technology
   - 2.2. Incentives to adopt technology
   - 2.3. Impediments to adopting technology
   - 2.4. Translation
   - 2.5. Enrollment
3. How is knowledge about how to use digital photography technology obtained (e.g., is it formal or informal, what role do other researchers play, who in the scientist's networks participate in the learning)?
   - 3.1. Formal learning
   - 3.2. Informal learning
   - 3.3. Peer learning
   - 3.4. Mentor learning
   - 3.5. Technological frames
   - 3.6. Principles
   - 3.7. Norms
   - 3.8. Rules
   - 3.9. Decision-making Procedures
4. What are the resource flows (e.g., to pay for equipment, staff, field work, new specialists in digital technology, etc.) that the scientists have mobilized to pay for their photo-identification work?
   - 4.1. Regime support

- 4.2. Resource flows
  - 4.2.1. Equipment
  - 4.2.2. Staff
  - 4.2.3. Field expenses
- 4.3. Expertise

5. Who becomes involved in the photo-id process for the first time when scientists adopt digital photography, which formerly involved actors and technologies are excluded, and how are peripheral actors affected?
   - 5.1. New actants
   - 5.2. Excluded actants
6. What conflicts arise over the digital photography computing package in routine use, and what are the biggest benefits of digital photography in routine use?
   - 6.1. Technology benefits
   - 6.2. Technology costs
   - 6.3. Technology-related conflicts
   - 6.4. Control conflicts
     - 6.4.1. Regime regulation
       - 6.4.1.1.Legitimacy
7. How are the data shared with other scientists?
   - 7.1. Data sharing
   - 7.2. Data hoarding
   - 7.3. Communication and production systems
8. What are the architectural choice points for the system (e.g., what choices are made over time that influence the current configuration of the computing package), and what are the rejected alternatives? What are the other elements of the total computing package (e.g., databases, GPS, etc.) used to support photo-identification and have these changed?
   - 8.1. Choice points
   - 8.2. Social construction
   - 8.3. Interpretive flexibility
   - 8.4. Mutual shaping
   - 8.5. Closure
   - 8.6. Stabilization / converging expectations
9. What technological alternatives would be desirable to improve the existing system (e.g., if one were not limited to existing technology, what sort of system could they imagine that would make their research more effective)?
   - 9.1. Alternatives
   - 9.2. Desirable new technology

Additional Codes

10. Methods
    - 10.1. Acoustics
    - 10.2. Aerial
      - 10.2.1. Photogrammetry

    - 10.2.2. Photography
  - 10.3. Behavioral sampling
  - 10.4. Genetics
  - 10.5. Health assessments
  - 10.6. Innovations
    - 10.6.1. Idiosyncratic methods
    - 10.6.2. Unusual techniques
  - 10.7. Organizing
    - 10.7.1. Archival issues
    - 10.7.2. Databases
    - 10.7.3. General
    - 10.7.4. Metadata
    - 10.7.5. Photo databases
  - 10.8. Photo-ID
    - 10.8.1. Automated methods
    - 10.8.2. Boat-based collection
    - 10.8.3. Catalogs
      - 10.8.3.1. Digital
      - 10.8.3.2. Paper
      - 10.8.3.3. Slides
      - 10.8.3.4. Web-based
    - 10.8.4. Manual methods
      - 10.8.4.1. Conversion of old catalogs
    - 10.8.5. Matching
      - 10.8.5.1. Screen-based
      - 10.8.5.2. Paper-based
    - 10.8.6. Preparing data
    - 10.8.7. Tracking photos
  - 10.9. Strandings
  - 10.10. Tagging
- 11. Organizational Level
  - 11.1. Hiring practices
  - 11.2. Roles
    - 11.2.1. Boat operating
    - 11.2.2. Data management
    - 11.2.3. Interns
    - 11.2.4. IT Support
    - 11.2.5. Matching
    - 11.2.6. Photographer
    - 11.2.7. Spotter
    - 11.2.8. Volunteers
  - 11.3. Work context
- 12. Species
  - 12.1. Dolphins

        - 12.1.1. Bottlenose
        - 12.1.2. Dusky
        - 12.1.3. Spotted
        - 12.1.4. White-beaked
        - 12.1.5. White-sided
    - 12.2. Sea otters
    - 12.3. Whales
        - 12.3.1. Blue
        - 12.3.2. Bowhead
        - 12.3.3. Fin
        - 12.3.4. Gray
        - 12.3.5. Humpback
        - 12.3.6. Killer
        - 12.3.7. Minke
        - 12.3.8. Right
- 13. Study details
    - 13.1. Areas studied
    - 13.2. Population size
    - 13.3. Season
    - 13.4. Topics studied
- 14. Technology
    - 14.1. Hardware
        - 14.1.1. Cameras
        - 14.1.2. GPS
        - 14.1.3. Video
        - 14.1.4. Computers
    - 14.2. Levels
        - 14.2.1. Cutting edge
        - 14.2.2. Low tech
        - 14.2.3. Modern
        - 14.2.4. Modern but basic
        - 14.2.5. Superceded
    - 14.3. Software
        - 14.3.1. (Long list of specific software programs)
- 15. Free nodes
    - 15.1. e-Science
    - 15.2. Good audio for talks
    - 15.3. Good picture for talks and paper
    - 15.4. Good quote for paper
    - 15.5. MMPA
    - 15.6. Requests from participants
    - 15.7. Switching to digital

APPENDIX 4: Abbreviations

ACMC: Atlantic Coast Marine Center (pseudonym)

ADRI: Atlantic Dolphin Research Institute (pseudonym)

AEC: Atomic Energy Commission

ANT: Actor-Network Theory

CCTV: Closed Circuit Television

CD: Compact Disk (computer media, 650 megabyte standard capacity)

CoP: Community of Practice

DBC: Dolphin Bay Center (pseudonym)

DFO: Fisheries and Oceans Canada (Canadian government agency)

DVD: Digital Versatile Disk (computer media, 4.7 gigabyte standard capacity)

EDF: Electricité de France

EXIF: Exchangeable Image File (standard metadata file format for digital images)

F/OSSD: Free and Open Source Software Development

FMA: Federal Marine Agency (pseudonym)

FWS: Fish and Wildlife Service (U.S. government agency)

GCRI: Gulf Coast Research Institute (pseudonym)

GHRH: Growth Hormone Releasing Hormone

GPS: Global Positioning System

HCI: Human-Computer Interaction

ICT: Information and Communication Technology

IT: Information Technology

IWC: International Whaling Commission

JPEG: Type of image file using compression methods

LCD: Liquid Crystal Display

MMC: Marine Mammal Commission (U.S. government agency)

MMPA: Marine Mammal Protection Act of 1972

MP3: Moving Picture Experts Group Layer-3 Audio (compressed audio file format)

NGO: Non-Governmental Organization

NOAA: National Oceanic and Atmospheric Administration (U.S. government agency)

PC: Personal Computer

PDA: Personal Digital Assistant (hand-held electronic device)

Photo-ID: Photo-identification method in marine mammal science

PI: Principal Investigator

PWP: Pacific Whale Project (pseudonym)

QI, QII, QIII, QIV: Quadrants 1-4, respectively, of a two by two table

RAW: Type of image file storing all the original unprocessed camera data

SCOT: Social Construction of Technology

SI: Social Informatics

SLR: Single-Lens Reflex (a type of camera with interchangeable lenses)

SSK: Sociology of Scientific Knowledge

SMM: Society for Marine Mammalogy

SPLASH: Structure of Populations, Levels of Abundance, and Status of Humpbacks

STIN: Socio-Technical Interaction Network

STS: Science and Technology Studies

TA: Technology Assessment [Theory]

TIFF: Type of image file that stores the image uncompressed

UK: United Kingdom

VEL: A type of French electric car

WMA: Windows Media Audio

WPA: Works Progress Administration (1930s U.S. government agency)

WWF: World Wildlife Fund

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Van House, N., Davis, M., Takhteyev, Y., Good, N., Wilhelm, A., & Finn, M. (2004). *From "What?" to "Why?": The Social Uses of Personal Photos*. Paper presented at the CSCW'04, Chicago, Illinois.

Van Wart, M. (2003). Public-Sector Leadership Theory: An Assessment. *Public Administration Review, 63*(2), 214-228.

Vehovar, V. (2006). Social Informatics: An Emerging Discipline? In J. Berleur, M. I. Numinem & J. Impagliazzo (Eds.), *IFIP International Federation for Information Processing, Volume 223, Social Informatics: An Information Society for All? In Remembrance of Rob Kling* (pp. 73-85). Boston: Springer.

Wagner, J. (2004). Constructing Credible Images: Documentary Studies, Social Research, and Visual Studies. *American Behavioral Scientist, 47*(12), 1477-1506.

Walker, D. (2003). Brian Walski Discusses His Doctored Photo [Electronic Version]. *Photo District News (PDN) Online*. Retrieved Sept. 20, 2003 from http://www.pdnonline.com/pdn/search/article_display.jsp?vnu_content_id=1000456607.

Weinrich, M. (1987). Goodbye, Beltane (1980-1987). *Whalewatcher: The Journal of the American Cetacean Society, 21*(4).

Whitehead, H. (1990). *Voyage to the Whales*. Post Mills, VT: Chelsea Green Publishing Company.

Wilhelm, A., Takhteyev, Y., Sarvas, R., Van House, N., & Davis, M. (2004, April 24-29). Photo Annotation on a Camera Phone. *CHI 2004* (pp. 1403-1406), Vienna, Austria.

Williams, R., & Edge, D. (1996). The Social Shaping of Technology. *Research Policy, 25*, 856-899.

Winner, L. (1993). Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology. *Science, Technology, and Human Values, 18*(3), 362-378.

Wolcott, H. F. (1990). *Writing up Qualitative Research*. Newbury Park, CA: Sage.

Würsig, B., & Jefferson, T. A. (1990). Methods of Photo-Identification for Small Cetaceans. In P. S. Hammond, S. A. Mizroch & G. P. Donovan (Eds.), *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters (Report of the International Whaling Commission Special Issue 12)* (pp. 43-52). Cambridge, MA: International Whaling Commission.

Yin, R. K. (2003). *Case Study Research: Design and Methods* (Third ed.). Newbury Park CA: Sage.

Zavoina, S., & Reichert, T. (2000). Media convergence/management change: The evolving workflow for visual journalists. *Journal of Media Economics, 13*(2), 143-151.

CURRICULUM VITAE

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Education

Doctor of Philosophy in Information Science Indiana University, Bloomington, Indiana	2007
Master of Arts in Cultural Anthropology University of California, Santa Barbara, California	1990
Bachelor of Arts (*Summa cum laude*) in Anthropology, Minor: Photography Ohio University, Athens, Ohio	1988

Professional Experience

Research Fellow University of Oxford, Oxford Internet Institute, Oxford, UK	2007-
Data Management and Research Specialist Indiana University, Institute of Psychiatric Research, Indianapolis, Indiana	1997-2007
Adjunct Instructor Indiana University, School of Library and Information Science, Bloomington, Indiana	2006
Instructor Kellogg Community College, Social Science Department, Battle Creek, Michigan	1997
Visiting Lecturer University of Nairobi, Sociology Department, Nairobi, Kenya	1995-1996
Visiting Instructor The College of Wooster, Sociology & Anthropology Department, Wooster, Ohio	1993-1995

Professional Affiliations

American Society for Information Science & Technology (ASIS&T)
American Sociological Association (ASA)
Association of Internet Researchers (A.o.I.R.)
Association for Library & Information Science Education (ALISE)
Society for the Social Studies of Science (4S)

Honors & Awards

Student Fellow, Rob Kling Center for Social Informatics, Indiana University	1999-2007
Travel Award, School of Library & Information Science, Indiana University	2007
Travel Award, Scientific Practice as Ordinary Action: An International Workshop on Scientists at Work, University of Fribourg, Switzerland	2007
Margaret Griffin Coffin Fellowship, SLIS, Indiana University	2006-2007
Rob Kling Fellowship, Rob Kling Center for Social Informatics, Indiana U.	2006
Invitee & Travel Award, ASIS&T Doctoral Seminar on Research & Career Development, Austin, TX	2006
Invitee & Travel Award, i-Conference Doctoral Student Colloquium, Ann Arbor, MI	2006
Travel Award, School of Library & Information Science, Indiana University	2005
Travel Award, Indiana Mental Health Association	2005
Invitee & Travel Award, Workshop on Social Informatics, Beckman Center of the National Academy of Sciences and Engineering, U. of California, Irvine	2005
"Best Paper Presented", Annual Doctoral Research Forum, SLIS, Indiana U.	2004
Travel Award, Indiana Mental Health Association	2003
2nd Annual Webshop, University of Maryland, College Park, MD	2002
1st Annual Webshop, University of Maryland, College Park, MD	2001
Travel Award, Center for Social Informatics, Indiana University	2000
Travel Award, School of Library & Information Science, Indiana University	2000
Summer Research Grant, The College of Wooster	1994
TA of the Year Nominee, University of California, Santa Barbara	1990
Research Grant, University of California	1990
Graduate Study Grant, University of California	1988-1990
Regent's Fellowship, University of California	1988-1990
Outstanding Graduate Award, Dept. of Sociology and Anthropology, Ohio U.	1988
National Merit Scholar, Ohio University	1984-1988
Dean's List, Ohio University (On dean's list all terms for all four years)	1984-1988
Dean's Scholarship, Ohio University	1984-1988
Martin-Marietta Scholarship (50 awards nationally)	1984-1988

Professional Development

Teaching and Learning with Technology Conference, Purdue University	2007
Preparing Future Faculty Conference, Indiana University, Bloomington	2005
OHRP Research Community Forum: Risks and Rights in Research, Indiana U.	2004
1st Annual Webshop on Internet Research, U. of Maryland, College Park	2001
ICPSR Summer Institute for Quantitative Methods, U. of Michigan, Ann Arbor	1994
Great Lakes College Assoc. Course Design and Teaching Workshop, Kenyon, OH	1994

Service

Reviewer, AMCIS-12 Social Theory in Info Systems Minitrack, Americas Conference on Info Systems	2006
Professional Development Committee, Psychiatry Department, IUPUI	2001-2005
Cultural Events Committee, The College of Wooster	1994-1995
Student Group Advisor (two groups), The College of Wooster	1994-1995
Martin Steiglitz Memorial Lecture Series Organizer, The College of Wooster	1994

Scholarly Activity

* Peer reviewed articles marked with an asterisk (*) in listing below.

Publications: Social Informatics

*Meyer, E.T. (2008). Digital Photography. In St. Amant, K. and Kelsey, S. (Eds.), Handbook of Research on Computer Mediated Communication. Hershey, PA: Information Science Reference.

*Meyer, E. T. (2008). Framing the Photographs: Digital Photography as a Computerization Movement. In K. L. Kraemer & M. S. Elliott (Eds.), Computerization Movements and Technology Diffusion: From Mainframes to Ubiquitous Computing. Medford, NJ: Information Today, Inc.

*Meyer, E.T. (2007). Moving from small science to big science: Social and organizational impediments to large scale data sharing. e-Social Science 2007 conference, Ann Arbor, Michigan, Oct. 7-9.

*Meyer, E. T. (2006). Socio-technical Interaction Networks: A discussion of the strengths, weaknesses and future of Kling's STIN model. In IFIP International Federation for Information Processing, Volume 223, Social Informatics: An Information Society for All? In Remembrance of Rob Kling, eds. Berleur, J., Numinen, M.I., Impagliazzo, J., (Boston: Springer), 37-48. Also presented in the plenary session of the Seventh International Conference "Human Choice and Computers" (HCC7), Maribor, Slovenia, September 21-23.

*Meyer, E. T. (2005). Communication Regimes: A Conceptual Framework for Examining IT and Social Change in Organizations. In Grove, A. (Ed.) Proceedings of the 68th Annual Meeting of the American Society for Information Science & Technology (ASIST) 42, Charlotte, NC (US).

*Meyer, E. T. (2005). Framing the Photographs: Understanding Digital Photography as a Computerization Movement. Paper presented at the workshop Extending the Contributions of Professor Rob Kling to the Analysis of Computerization Movements, Irvine, CA, March 11-12. Also selected to appear as a chapter in forthcoming edited book. Available online: http://www.crito.uci.edu/si/resources/meyer.pdf.

Meyer, E. T. & Kling, R. (2002). Leveling the playing field, or expanding the bleachers? Socio-Technical Interaction Networks and arXiv.org. Available online as part of the Indiana University Center for Social Informatics Working Paper Series, No. WP-02-10, from http://www.slis.indiana.edu/csi/WP/WP02-10B.html.

*Meyer, E. T. (2000). Information Inequality and UCITA. In Kraft, D.H. (Ed.) Proceedings of the 63rd Annual Meeting of the American Society for Information Science (ASIS) 37, Chicago, IL (US).

Meyer, E. T. & Kling, R. (2000). The Research Divide: Internet Commons, Scholarly Participation and Pre-print Servers. Presented at Constituting the Commons: Crafting Sustainable Commons in the New Millenium, the Eighth Conference of the International Association for the Study of Common Property, Bloomington, Indiana, USA, May 31-June 4.

Publications: Biomedical

*Nurnberger, J. I., Kuperman, S., Flury-Wetherill, L., Meyer, E. T., Lawson, W. B., & MacKinnon, D. F. (2007). Genetics of Comorbid Mood Disorder and Alcohol Dependence. Journal of Dual Diagnosis, 3(2), 31-46.

*Hayden, E. P., Wiegand, R. E., Meyer, E. T., Bauer, L. O., O'Conner, S. J., Nurnberger, J. I., et al. (2006). Patterns of Regional Brain Activity in Alcohol-Dependent Subjects. Alcoholism: Clinical and Experimental Research, 30(12), 1986-1991.

*Nurnberger, J. I., Wiegand, R., Bucholz, K., O'Conner, S., Meyer, E. T., Reich, T., et al. (2004). A Family Study of Alcohol Dependence: Co-aggregation of Multiple Disorders in Relatives of Alcohol Dependent Probands. Archives of General Psychiatry, 61(12), 1246-1256.

*Dick, D., Foroud, T., Flury, L., Bowman, E., Miller, M., Rau, N. L., et al. (2003). Genome-wide Linkage Analyses of Bipolar Disorder: A New Sample of 250 NIMH Genetics Initiative Pedigrees. American J. of Human Genetics, 73(1), 107-114.

*McInnis, M. G., Dick, D. M., Willour, V. L., Avramopoulos, D., MacKinnon, D. F., Simpson, S. G., et al. (2003). Genome-wide scan and conditional analysis in bipolar disorder: evidence for genomic interaction in the National Institute of Mental Health genetics initiative bipolar pedigrees. Biol Psychiatry, 54(11), 1265-1273.

*Nurnberger, J. I., Jr., Foroud, T., Flury, L., Meyer, E. T., & Wiegand, R. (2002). Is there a genetic relationship between alcoholism and depression? Alcohol Res Health, 26(3), 233-240.

*Nurnberger, J. I., Jr., Foroud, T., Flury, L., Su, J., Meyer, E. T., Hu, K., et al. (2001). Evidence for a locus on chromosome 1 that influences vulnerability to alcoholism and affective disorder. Am J Psychiatry, 158(5), 718-724.

*Lawson, W., Meyer, E. T., Hu, K.-l., & Nurnberger, J. I. (2001). Substance abuse in bipolar disorder. Biol Psychiatry, 49(8), 154.

Conference Papers: Social Informatics

Meyer, E.T. Tensions between established practice and changing technologies: Marine mammal scientists and digital photography. Paper presented at 2007 Society for Social Studies of Science (4S) conference, Montreal, Canada, October 11-13.

Meyer, E.T. 2007. Enrollment into Collaborative Scientific Infrastructures: The Gravitational Model of Collaborative Scientific Infrastructure. Invited panelist for plenary panel "Enabling Communities - and Research on Communities - with Cyberinfrastructure" at the 3rd International Conference on Communities & Technologies, Lansing, Michigan, June 30.

Meyer, E.T. 2007. Organize the Whales! Marine biology and the challenges of organizing scientific digital photographs. Paper presented at workshop "Memory practices in computer-mediated communities: a research methods workshop" at the 3rd International Conference on Communities & Technologies, Lansing, Michigan, June 28.

*Meyer, E.T. (2007). Studying Scientists and their Technology: Digital photography as a lens for understanding how marine biologists use technology in their work. Paper presented at Scientific Practice as Ordinary Action: An International Workshop on Scientists at Work, University of Fribourg, Switzerland, March 22-23.

Meyer, E.T. (2007). Scientific digital photography: The case of marine mammal research. Poster presented at ALISE Doctoral Research Poster Session, ALISE Annual Conference, Seattle, WA, January 15-18.

Meyer, E.T. (2006). Digital photography use by marine mammal scientists. Paper presented at "Interrogating the social realities of information and communications systems" ASIST pre-conference workshop, Austin, TX, November 4.

Meyer, E.T. (2006). Science and digital photography. Poster presented at iSchool Conference, Ann Arbor, MI, October 15-17.

Meyer, E. T., Rosenbaum, H., & Hara, N. (2005). How Photobloggers are Framing a New Computerization Movement. Paper presented at the Association of Internet Researchers (AoIR) Annual Meeting, Chicago, IL, October 6-9.

Meyer, E.T. (2004). Digital Photography as a Computerization Movement: Communication regimes and social change. Paper presented at the Annual Doctoral Research Forum, School of Library & Information Science, Indiana University, Bloomington, IN. Won "Best Paper Presentation" award.

Meyer, E.T., & Kling, R. (2003). To Photoshop or Not to Photoshop: Digital Manipulation and the STIN Framework. Paper presented at the Association of Internet Researchers Annual Meeting, Toronto, ON.

Meyer, E.T., & Kling, R. (2003). To Photoshop or Not to Photoshop: Digital Manipulation and the STIN Framework. Paper presented at the Doctoral Research Forum, School of Library & Information Science, Indiana U., Bloomington, IN.

*Meyer, E.T., & Kling, R. (2000). Technology & Unequal Participation: Access to electronic working paper repositories and scholarly participation in elite scientific communities. Paper presented at the American Sociological Association Annual Meeting, Washington, D.C.

*Meyer, E.T. (1995). Technology, Opportunity and Race. Paper presented at the North-Central Sociological Association Annual Meeting, Pittsburgh, PA.

Meyer, E.T. (1994). Oral History in the Mountains. Paper presented at the Oral History in Ohio Annual Conference Lima, OH.

*Meyer, E.T. (1994). Economic Influences on Ethnic Identification. Paper presented at the National Association of Ethnic Studies, Kansas City, MO.

*Meyer, E.T. (1993). Communities in West Virginia: Responses to Change. Paper presented at the Appalachian Studies Association, Johnson City, TN.

*Meyer, E.T. (1993). Rural Black Communities and Economic Opportunity: The Coal Miners in Appalachia. Paper presented at the Western Political Science Association, Pasadena, CA.

Meyer, E.T. (1992). Enclave Communities: Blacks in West Virginia. Paper presented at the National Institute on Social Work and Human Services in Rural Areas, Morgantown, WV.

Meyer, E.T. (1992). Diversity in Appalachia. Paper presented at the West Virginia Human Resources Association Annual Conference, Wheeling, WV.

Conference Papers: Biomedical

Nurnberger, J. I., Wiegand, R., Bierut, L., Bucholz, K., Foroud, T., Edenberg, H., et al. (2005, December 11-15). Prediction of Alcohol Problems using a Prospective Longitudinal Design including Genotype. Paper presented at the American College of Neuropsychopharmacology (ACNP) Annual Meeting, Waikoloa, Hawaii.

Nurnberger, J. I., Wiegand, R., Bierut, L., Bucholz, K., Foroud, T., Edenberg, H., et al. (2005, June 25-29). Prediction of Alcohol Problems Using a Prospective Longitudinal Design including Genotype. Paper presented at the Research Society on Alcoholism (RSA), Santa Barbara, CA.

Nurnberger, J. I., Meyer, E. T., & Wiegand, R. (2004, September 11-12). The Vulnerability Score Algorithm: Prediction of Illness Using the NIMH Bipolar Dataset. Paper presented at the International Genetics Epidemiology Society, Nöördwijkerhout, The Netherlands.

Nurnberger, J. I., Flury, L., Edenberg, H., Bowman, E., Miller, M., Rau, N. L., et al. (2003, October 4-8). Dissecting Bipolar Affective Disorder: Linkage analysis of bipolar illness with and without alcohol dependence. Paper presented at the World Congress on Psychiatric Genetics, Quebec City, Quebec, Canada.

Nurnberger, J. I., Wiegand, R., Bucholz, K., O'Conner, S., Meyer, E. T., Reich, T., et al. (2003, June 26-July 1). Aggregation of Multipole Clinical Disorders in Relatives of Alcohol Dependent Probands. Paper presented at the Research Society on Alcoholism (RSA), Vancouver.

Nurnberger, J. I., Wiegand, R., O'Conner, S., King, L., Petti, T., Moe, P. R., et al. (2003, June 21-26). A Family Study of Alcoholism: Variation in Relative Risk as a Function of Diagnosis and Site of Ascertainment. Paper presented at the Research Society on Alcoholism, Fort Lauderdale, FL.

Nurnberger, J. I., O'Conner, S., Meyer, E. T., Reich, T., Rice, J., Schuckit, M., et al. (2002, June 28-July 3). A Family Study of Alcoholism: Diagnosing Relatives with Family History Information Alone. Paper presented at the Research Society on Alcoholism, San Francisco, CA.

Nurnberger, J. I., Foroud, T., Hu, K.-l., Castellucio, P., Edenberg, H., & Meyer, E. T. (2001, October 6-10). A Quantitative Estimate of Genetic Vulnerability for a Multifactorial Condition. Paper presented at the World Congress on Psychiatric Genetics, St. Louis, MO.

Moe, P. R., Nurnberger, J. I., Meyer, E. T., & Wildblood, R. (2001, October 6-10). Alcohol Use and Dependence in Parents and Offspring. Paper presented at the World Congress on Psychiatric Genetics, St. Louis, MO.

Nurnberger, J. I., O'Conner, S., Meyer, E. T., Reich, T., Rice, J., Schuckit, M., et al. (2001, June 23-28). A Family Study of Alcoholism: The Effect of Best-Estimate Diagnosis. Paper presented at the Research Society on Alcoholism, Montreal, Quebec, Canada.

Lawson, W., Meyer, E. T., DePaulo, J., Gershon, E. S., Reich, T., & Nurnberger, J. I. (2000, August 27-31). Family Studies of Co-Occurring Bipolar Disorder and Substance Abuse. Paper presented at the World Council on Psychiatric Genetics, Versailles, France.

Nurnberger, J. I., Foroud, T., Meyer, E. T., Hu, K.-l., Flury, L., & Su, J. (2000, August 27-31). A Quantitative Estimate of Individual Genetic Vulnerability for a Complex Trait: Application to Bipolar Illness. Paper presented at the World Congress on Psychiatric Genetics, Versailles, France.

Nurnberger, J. I., Lawson, W., Meyer, E. T., Hu, K.-l., Foroud, T., Flury, L., et al. (2000, June 24-29). Alcoholism and Mania: Is there a Genetic Relationship? Paper presented at the Research Society on Alcoholism, Denver, CO.

Nurnberger, J. I., Foroud, T., Meyer, E. T., Hu, K.-l., Flury, L., Su, J., et al. (2000, February 13-15). A Quantitative Estimate of Individual Genetic Vulnerability for a Complex Trait: Application to Bipolar Illness. Paper presented at the Molecular Psychiatry Meeting, Park City, UT.

Nurnberger, J. I., Foroud, T., Flury, L., & Meyer, E. T. (1999). Comorbidity Between Alcoholism and Depression: A Molecular Analysis. Paper presented at the Molecular Psychiatry Meeting, Park City, UT.

Nurnberger, J. I., Foroud, T., Flury, L., Meyer, E. T., Crowe, R., Hesselbrock, V., et al. (1999, October 14-18). The Relationship Between Alcoholism and Depression: A Molecular Analysis. Paper presented at the World Congress on Psychiatric Genetics, Monterey, CA.

Nurnberger, J. I., Foroud, T., Flury, L., Meyer, E. T., Edenberg, H., DePaulo, J., et al. (1999, October 14-18). New Analysis of the NIMH Bipolar Dataset. Paper presented at the World Congress on Psychiatric Genetics, Monterey, CA.

Nurnberger, J. I., Foroud, T., Meyer, E. T., Hu, K.-l., Flury, L., & Su, J. (1999, October 14-18). A Quantitative Estimate of Individual Genetic Vulnerability for a Multifactoral Condition: Application to Bipolar Illness. Paper presented at the World Congress on Psychiatric Genetics, Monterey, CA.

Software Applications - Biomedical

Meyer, E. T. (2006). Computerized K-SADS for the Tablet PC (Version 1) [MiForms/.NET application]. Indianapolis, IN: Collaboration on Adolescents at High Risk for Familial Bipolar Disorder. Available at: http://www.bipolargenes.org/hrdownloads.html.

Meyer, E. T. (2006). Predictor Database (Version 5) [Access/VB application]. Indianapolis, IN: Collaboration on Adolescents at High Risk for Familial Bipolar Disorder. Available at: http://www.bipolargenes.org/hrdownloads.html.

Meyer, E. T. (2005). Digger 4 / BP Database (Version 4) [Access/VB application]. Indianapolis, IN: Bipolar Genomics Collaboration. Available at: http://www.bipolargenes.org/downloads.html.

Public Talks

Meyer, E. T., Rosenbaum, H., & Hara, N. (2005, November 18). How photobloggers are framing a new computerization movement. SLIS Colloquium, Indiana University, Bloomington, IN.

Meyer, E.T. (2000). UCITA and Information Inequality. Doctoral Research Forum, School of Library and Information Science, Indiana University, Bloomington, IN.

Meyer, E.T. (2000). Internet and the Democratization of Information: The Case of Arxiv.org. Friday Forum, School of Library and Information Science, Indiana University, Bloomington, IN.

Meyer, E.T. (1995). USA Today Reports 63.1% of Americans Have an Opinion!: Teaching Students Skills for Assessing Statistics. Faculty Reports Series, The College of Wooster, OH.

Meyer, E.T. (1995). Population and Consumption: Too Many Kids or Too Much Stuff? International Students' Association Annual Conference, Wooster, OH.

Meyer, E.T. (1995). Living Simply...More than Simply Living. Fireside Chat, The College of Wooster, OH.

Meyer, E.T. (1994). Immigration and the United States. Nomad Club, Orrville, OH.

Meyer, E.T. (1993). From King Coal to Chemical Valley: Economics and Race Relations in Central Appalachia. Brown Bag Lecture Series, University of California, Santa Barbara, CA.

Meyer, E.T. (1993). Fire Mountain, Flood Hollow and Chemical Valley: Threats to the Environment in Appalachia. Environmental Studies Program, University of California, Santa Barbara, CA.

Meyer, E.T. (1993). African-American Communities in West Virginia. West Virginia State College, Institute, WV.

Meyer, E.T. (1992). Mining in Southern Appalachia. Ohio Univ. Dept. of Sociology & Anthropology, Athens, OH.