

Fish Consumption Patterns of Populations in Vicinities of Lake Kastoria and Lake Pamvotis, Greece

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ABSTRACT

Objectives are to establish fish consumption patterns of populations in vicinities of two lakes (Kastoria and Pamvotis) in Greece for use in the assessment of risks associated with consumption of fishes in these agriculturally impaired lakes. Parameters measured were demographics (i.e., gender, age, weight, education level, occupation, residency), freshwater fish eating frequency, species and sizes of fishes consumed, and fish consumption habits [i.e., quantity, parts, and preparation method]. All annual mean site-specific consumption rates of the four gender-age class sub-populations surveyed in vicinity of Lake Kastoria (avg. range= 0.103-0.29 kg/day) exceed those of Greece (0.066 kg/day), EU (0.068 kg/day), Spain (0.104 kg/day), Portugal (0.159 kg/day), and the USEPA default value (0.054 kg/day) with two exceptions. Female consumption rates (0.087-0.103 kg/day) of *Perca fluviatilis* were below annual consumption rates of Spain and Portugal. Similarly, annual mean site-specific consumption rates of *Anguilla anguilla* and *Cyprinus carpio* by male (0.199-0.210 kg/day) and female adults (0.096-0.157 kg/day) in vicinity of Lake Pamvotis exceeded those of Greece, EU, Spain, Portugal, and the USEPA default value. Survey results indicate better-educated Greeks to be higher consumers of fish; however, market availability appears to be a stronger determinant of food choice in comparison to health education. All populations in vicinities of both lakes preferred to eat fried fishes with one exception: grilled *C. carpio* from Lake Pamvotis was preferred by female and male adults.

Keywords: fish consumption, risk assessment, chronic daily intake, Greece

INTRODUCTION

Bioconcentration of environmental contaminants is receiving increased attention from Europe's general public, for-profit and non-profit institutions, regulatory agencies of countries in the European Community (EC), and the European Environmental Agency (EEA) (Hill, 1999; Millstone et al., 2000; Tait, 2001; Tait and Quinn, 1998; WHO, 1989; UNEP, 1999). Increased concern stems from increased public and

governmental awareness of their impacts on human health, tourism, and other economic issues that effect gross domestic markets (Braxton and Frewer, 1998; Hites et al., 2004; Miles and Frewer, 1998; World Bank, 1994). Public demand for healthful foods is causing considerable shifts in commodity markets (Millstone et al., 2000; Tait, 2001; Kafka and Alvensleben, 1997; World Bank, 1992), and demands for clean water has now become a dominant issue in the tourism industry (UNEP, 1999; World Bank, 1994).

In Greece, fish consumption has been increasing since 1995, concurrent with public awareness that seafood is healthy and can substitute for meat consumption (USDA, 2003). Per capita consumption of fisheries products in Greece is 24 kg (USDA, 2003). With the increased use and exploitation of localized fisheries comes an incremental increase in exposure to local pollution problems (Szucs and Grasselli, 2004; World Bank, 1992). The problem may be particularly acute in highly localized fisheries such as those in lakes, rivers, and natural water dependent aquaculture facilities as they tend to be located in, or impacted by, high yield agriculture areas (Stickney, 1979; Landau, 1992; Stevenson, 2004). Such is the case in Lake Kastoria, Lake Pamvotis, and Lake Vistonis in Greece. For example, we identified 10 pesticides (Atonik, Cobex, Efmethrin=Efmethren/Permethrin, Fusilade, Primextra, Ridomil, Sencor, Targa, Thimet, and Thiodan=Endosulfan) that were routinely applied prophylactically to agricultural fields draining into Lake Vistonis in 1993, where acute toxicity had been reported to decimate the population of *Cyprinus carpio* in an aquaculture facility operated by monks (Alpanezos, pers. comm.). Consumption of freshwater fishes from Lake Pamvotis has diminished in recent years because of increased public awareness of the pollution state of the lake (Filos, pers. comm., 2002). Whereas studies in the variability of fish consumption within 10 European countries, nutrient content of foods in Greece, policy analysis on food safety in Europe, and the association of cooking methods to cancer have been conducted (Boulous et al., 1996; Millstone et al., 2000; Rohrmann et al., 2002; Welch et al., 2002), there appear to be no published data on human consumption patterns of freshwater fisheries products for use in calculating risks associated with consumption of freshwater fishes in Greece.

Our objective is to establish fish consumption patterns of populations in vicinities of two lakes (Kastoria and Pamvotis) in Greece for use in assessing risks associated with consumption of fishes in these two agri-chemically impaired lakes.

STUDY AREA

Lake Kastoria (~28 km²; karst basin=304 km²; avg. depth=4 m; max. depth=8.5 m), a eutrophic lake with large concentrations of phytoplankton and mats of submerged aquatic vegetation (Aliakmon River drainage), is located in Kastoria (Macedonia Prefecture) in northwestern Greece (Skoulikidis et al., 1998). The lake, which receives runoff from agricultural operations (e.g., corn, apple orchards, livestock) and a furrier industry, has dropped ~ 1.5 m in the last 5 years, primarily through water withdrawal for agricultural operations (Filos, pers. comm.). Mean physical and nutrient concentrations in the lake are pH (8.2), total phosphorus (39 µg/l), P-PO₄ (31.3 µg/l; max=62.5), N-NO₂ (5.8 µg/l; max=19.0), N (15.8 µg/l; max=1011); N-NO₃ (22.4 µg/l), and N-NH₄ (288 µg/l) (Hadjibiros et al., 1998). Mean heavy metal concentrations for Pb (31.1 ppb), Zn (32.8-81.2 ppb), Cu (6.6-19.4 ppb), Cd (0.7 ppb), Hg (0.25 ppb) and As (11.1 ppb) have been recorded from Lake Kastoria (Hadjibiros et al., 1998). Main sources of cadmium, copper, lead, and zinc are fertilizer and pesticide residues (Hadjibiros et al., 1998).

Lake Pamvotis (22 km²; basin=330 km²; avg. depth=5.5 m; max. depth=11 m) is an eutrophic lake beside the city of Ioannina (Epiros Prefecture) in western Greece (Skoulikidis et al., 1998). Mean physical and nutrient concentrations in the lake are pH (8.4), total phosphorus (38 µg/l), P-PO₄ (31.7 µg/l; max=91), N-NO₂ (2.2 µg/l; max=65.3), N (24.1 µg/l; max=926); N-NO₃ (27.3 µg/l), and N-NH₄ (62.8 µg/l) (Hadjibiros et al., 1998). Mean heavy metal concentrations for Zn (33.1 ppb), Cu (5.2 ppb), Cd (1.6 ppb), and As (1.9 ppb) have been reported from Lake Pamvotis (Hadjibiros et al., 1998). Eutrophication is primarily a result of domestic wastewater inputs (Hadjibiros et al., 1998).

MATERIALS AND METHODS

Fish consumption patterns were determined through the use of personal interviews with 90 people selected at random in Kastoria Greece for Lake Kastoria; and 135 people in Ioannina, Greece for Lake Pamvotis. Fish consumption survey interviews, modeled after guidelines and recommendations in USEPA (1998), were conducted in Greek for Lake Kastoria on June 5, 6, 10, and 17, 2002; and in Ioannina for Lake Pamvotis, Greece on June 6, 7, 8, 9, 11, 28, 29, 30 and July 1, 2002. Variables recorded included: demographics [i.e., gender, age, weight (kg), education (0=none, 1=elementary, 2=middle school, 3=1st-2nd years of high school, 4=3rd and 4th years of high school, 5=graduate school), occupation (0=unemployed/retired; 1=student; 2=housewife; 3=agricultural worker/fisherman; 4=blue collar; 5=professional), residency (1=yes, 2=no), domicile distance from lake (m)] and eating statistics [i.e., general marine and freshwater fish eating frequency (days/year); specific freshwater species and sizes (kg) eaten (*Perca fluviatilis*, *Rutilus rutilus* for Lake Kastoria, and *Anguilla anguilla*, *Cyprinus carpio*, *Silurus aristotelis* for Lake Pamvotis), specific eating frequency (days/year) per freshwater species from each lake, and fish consumption habits [i.e., quantity (kg), parts (frequency consumption of muscle, skin, bones, head, intestine), and preparation method (fry, grill, boil, head boil, soup frequency). Selection of fish species was based on freshwater fish eating preference, species availability per lake, and ecological feeding type: food chain position (predator, prey); feeding type (i.e., carnivore, herbivore, omnivore), and feeding position (e.g. bottom) as follows: herbivorous bottom feeder=*R. rutilus* and *C. carpio*; carnivorous bottom feeder=*S. aristotelis*; carnivorous pelagic feeder: *P. fluviatilis*; and carnivorous bottom feeder=*A. anguilla*.

Four gender-age class groups (male adult ≥ 18 yo; female adult ≥ 18 yo; male youth <18 yo; female youth <18 yo) conform to those specified in USEPA (1998). Percentages and other proportional measurements were converted into arcsin equivalents to normalize variance prior to statistical tests. Spearman's correlation analysis (SAS, 2002) was used to identify significant correlations among variables per lake and species. Option NOMISS was employed to eliminate observations with missing values as pairwise correlation matrices may not be nonnegative definite, and the pattern of missing values may bias results (SAS, 2002). Analysis of variance followed by Duncan's multiple range test (SAS, 2002) was used to test differences in each variable among gender-age class groups by lake and species in order to distinguish group specific consumption patterns from overall consumption patterns.

RESULTS

Lake Kastoria demographics- Mean ages and weights of male (47.3 y; 85.9 kg) and female (48.5 y; 63.5 kg) adults were significantly greater than those of female (12 yo, 37.4 kg) and male (10.4 y; 38.6 kg) youth (Table 1). Mean grade level (1.75) of male

youth was significantly lower than those of male and female adults (range=2.7-2.8; Table 1). Occupation level of male adults (3.8) was significantly greater than those of female adults (2.8) and male and female children (Table 1). Mean eating days (126.2) of marine and freshwater fishes by male adults were significantly greater than those (range=76.9-105.8 days) of other interview groups, and negatively correlated with weight (coefficient=-0.3175; $p=0.0336$; Table 1).

Lake Kastoria Consumption Patterns by Species Consumed:

Perca fluviatilis: Annual mean consumption of *P. fluviatilis* ranged from 0.087 kg/day in female adults to 0.273 kg/day in male adults and (Table 2), and did not vary significantly among gender-age groups ($F=1.70$; $p=0.1889$). Mean fish size (range=0.32-0.50 kg) and number of days (range= 57.5-73.9) of eating *P. fluviatilis* did not vary significantly among all gender-age groups (Table 3). However, quantity ($\bar{x}=0.93$ kg) of *P. fluviatilis* consumed per meal by male adults was significantly greater than those (range $\bar{x}=0.34-0.45$ kg) consumed by other gender-age groups (Table 3).

Interviewee weight was significantly positively correlated with age ($p<0.0001$), education ($p=0.0037$), occupation ($p<0.0001$) quantity of *P. fluviatilis* consumed ($p=0.004$), and eating skin ($p=0.0072$) and bones ($p=0.0218$) of the species. Frequency of eating skin was correlated with quantity of *P. fluviatilis* consumed ($p=0.0204$). *Perca fluviatilis* consumption days were correlated positively with frequency of eating skin ($p=0.0163$) and negatively with eating heads ($p=0.0099$). Boiling heads of *P. fluviatilis* was correlated with frequency of eating bones ($p=0.0136$) and soup ($p<0.0001$). Fish size and frequency of eating fried *P. fluviatilis* were negatively correlated (coefficient=-0.4906), whereas fish size and frequency of eating grilled *P. fluviatilis* were positively correlated (coefficient=0.3580; $p=0.0376$) indicating that smaller fish were fried and larger ones grilled. Mean percents (65-67) of consumption of fried *P. fluviatilis* were significantly greater than those of grilled (\bar{x} range=27-35) and boiled (\bar{x} range=0-3) in female and male adults (Table 4).

Mean skin eating frequencies (range=82-90 %) in female and male adults were significantly greater than those (\bar{x} range=0-33 %) in female and male youth (Table 3). Mean frequencies of eating heads (60 %) and bones (40 %) by male adults were significantly greater than those (\bar{x} range=0-1 %) in female and male youth (Table 3). Mean percents (range 33-55) of consumption of fried *P. fluviatilis* were significantly greater than those of other preparation methods except by female youth (Table 3). All *P. fluviatilis* were gutted prior to consumption, regardless of preparation method.

Rutilus rutilus: Annual mean consumption of *R. rutilus* ranged from 0.185 kg/day in female adults to 0.297 kg/day in male children (Table 2), and did not vary significantly among gender-age groups ($F=1.68$; $p=0.1970$). Mean quantity ($\bar{x}=0.93$ kg) of *R. rutilus* consumed per meal by male adults was significantly greater than those (\bar{x} range=0.30-0.48 kg) consumed by other gender-age groups (Table 5). Mean fish size (range=0.10-0.12 kg) and number of days (range= 77.0-96.7) of eating *R. rutilus* did not vary significantly among all gender-age groups (Table 5).

Interviewee weight (correlation=0.5340; $p=0.0028$) and occupation (correlation=0.4178; $p=0.0269$) were significantly correlated with quantity of *R. rutilus* consumed. Age was significantly correlated with eating skin (correlation=0.36984; $p=0.0483$) and bones (correlation=0.4550; $p=0.0131$) of *R. rutilus*. Eating skin was significantly correlated with occupation (correlation=0.3908; $p=0.0398$), and eating heads (correlation=0.4761; $p=0.0090$) and bones (correlation=0.3864; $p=0.0384$), negatively correlated with grilling *R. rutilus* (correlation=-0.3864; $p=0.0384$), and

number of days per year consuming *R. rutilus* (correlation=-0.5811; $p=0.0009$).

Frequencies of eating skin, heads, and bones (fried or grilled) did not vary significantly among gender-age groups (Table 5). Percent frequencies (\bar{x} range=67-80 %) of eating fried *R. rutilus* by all gender-age groups was significantly greater than eating the species either grilled (\bar{x} range=20-33 %) or boiled (0 %)(Table 5). All *R. rutilus* were gutted prior to consumption, regardless of preparation method, and none was boiled to make soup.

Lake Pamvotis demographics (based on 135 interviews): Mean ages and weights of male (43.2 y; 81.9 kg) and female (44.6 y; 68.6 kg) adults were significantly greater than those of female (10.1 y; 40.6 kg) and male (11.3 y; 44.4 kg) youth (Table 1). Mean educational levels of female (3.8) and male (3.5) adults were significantly greater than those of male (1.4) and female (1.2) youth (Table 1). Occupation levels of female (3.7) and male (3.0) adults were significantly greater than those of female (1.1) and male youth (0.96)(Table 1). Mean distance (1270.8 m) between homes and lakes of male youth were significantly greater than those of adult females (640.2) and males (640.0; $F=2.81$; $p<0.042$). Mean eating days (\bar{x} range=40.5-60.9) of marine and freshwater fishes did not vary significantly among all gender-age groups ($F=7.86$; $p<0.0001$).

Anguilla anguilla: Annual mean consumption of *A. anguilla* ranged from 0.010 kg/day in female children to 0.199 kg/day in male adults (Table 6), and did not vary significantly among gender-age groups ($F=1.31$; $p=0.3193$). Mean number of consumption days (55) for *A. anguilla* by male adults was significantly greater than those (\bar{x} range=1-6.5) for female and male youth (Table 6).

Age (correlation=0.5360; $p=0.0001$), weight (correlation=0.3828; $p=0.0087$), and frequency of eating fried fish (correlation=0.5647; $p<0.0001$) were correlated with frequency of eating *A. anguilla*. Frequency of eating soup made from *A. anguilla* was significantly correlated with boiling heads (correlation=1.0; $p<0.0001$) eating bones (correlation=1.0; $p<0.0001$), eating heads (correlation=1.0; $p<0.0001$).

Quantity, fish size, frequency of eating skin, heads, bones by any preparation method (i.e., fried, grilled, or boiled) of *A. anguilla* did not vary significantly among gender-age groups (Table 6). Consumption of fried *A. anguilla* (63 %) was significantly greater than other preparation methods (grilled, 37 %; boiled, 0 %) in female adults (Table 7). Correspondingly, male adults ate fried (48 %) and grilled (48 %) *A. anguilla* significantly more than boiled (4 %) *A. anguilla* (Table 7). All *A. anguilla* were gutted prior to consumption, regardless of preparation method.

Cyprinus carpio: Annual mean consumption of *C. carpio* ranged from 0.056 kg/day in female children to 0.210 kg/day in male adults (Table 1), and did not vary significantly among gender-age groups ($F=1.17$; $p=0.33427$). Mean quantity (0.86 kg) of *C. carpio* consumed per meal by male adults was significantly greater than those (\bar{x} range=0.21-0.25 kg) consumed by female and male youth (Table 8).

Interviewee weight was significantly correlated with age (correlation=0.4768, $p=0.0011$), education level (correlation=0.4768, $p=0.0011$), occupation (correlation=0.05868, 0.0011), and quantity of *C. carpio* consumed (correlation=0.7959, $p<0.0001$). Occupation was correlated with eating grilled *C. carpio* (correlation=0.4041; $p=0.0406$) and negatively correlated with eating fried *C. carpio* (correlation=-0.6645; $p=0.0002$). Interviewees consuming a greater quantity of *C. carpio* were more likely to boil *C. carpio* (correlation=0.6040; $p=0.0009$), heads of *C. carpio* (correlation=0.6040; $p=0.0009$) and eat soup (correlation=0.6018; $p=0.0009$).

Eating skins of *C. carpio* was correlated with frequencies of eating heads (correlation=0.9117; $p<0.0001$), boiling *C. carpio* (correlation=0.5449; $p=0.0033$), boiling heads (correlation=0.5449; $p=0.0033$), and eating soup made from boiled flesh and heads of *C. carpio* (correlation=0.5328; $p=0.0042$). Eating heads of *C. carpio* was correlated with boiling flesh of *C. carpio* (correlation=0.5976; $p=0.0010$), heads of *C. carpio* (correlation=0.5976; $p=0.0010$), and eating soup (correlation=0.5844; $p=0.0014$). Likewise, eating bones of *C. carpio* was correlated with boiling flesh (correlation=0.5547; $p=0.0027$), boiling heads (correlation=0.5547; $p=0.0027$); and frequency of eating soup made from *C. carpio* (correlation=0.7167; $p<0.0001$). Grilling *C. carpio* was inversely correlated with frying the species (correlation=-0.5437; $p=0.0034$). Grilling was correlated with number of consumption days for *C. carpio* (correlation=0.4710; $p=0.0132$).

Percentages of eating grilled *C. carpio* in female adults (78) and male adults (63) were significantly greater than those for fried (18-28 %) and boiled (4-9 %) in female and male adults (Table 7). Fried *C. carpio* (70 %) consumed by female youth was significantly greater than that consumed boiled (0 %)(Table 7).

Silurus aristotelis: Annual mean consumption of *S. aristotelis* ranged from 0.02 kg/day in male adults to 0.042 kg/day in female adults (Table 1), and did not vary significantly among gender-age groups ($F=0.30$; $p=0.8217$).

Interviewee age was significantly correlated with quantity of *S. aristotelis* consumed (correlation=0.5546; $p=0.0258$)(Table 9). Eating skin was significantly correlated with eating heads (correlation=0.5092; $p=0.0440$), grilling (correlation=0.8783; $p<0.0001$), and number of consumption days (correlation=0.7398; $p<0.0001$) for *S. aristotelis*. Consumers living closer to Lake Pamvotis ate *S. aristotelis* on fewer days than those living further away (correlation=-0.3357; $p=0.0278$).

Mean numbers of consumption days (7.5-11.9 days), quantity (0.27-0.50 kg) and fish size (0.61-1.1 kg) of *S. aristotelis*, parts eaten [skin (38-100 %), head (0-40 %), bones (0-12 %)], and preparation methods [fry (88-100 %), grill (50-100 %)] did not vary significantly among gender-age groups (Table 9). Consumption of fried (\bar{x} range=69-70 %) *S. aristotelis* by female and male adults was significantly greater than that for grilled (\bar{x} range=30-31 %) or boiled (0) *S. aristotelis* (Table 7). There was no difference in the percent of fried (50) and grilled (50) *S. aristotelis* consumed by female or male youth (Table 7). All *S. aristotelis* were gutted prior to consumption, regardless of preparation method, and none was boiled to make soup.

DISCUSSION

This is the first published study to generate site-specific consumption rates of freshwater fishes in Greece that can be applied as chronic daily intake values (CDI) in determining carcinogenic and non-carcinogenic human health risks associated with the consumption of fish tissues. All annual mean site-specific consumption rates of gender-age populations in vicinity of Lake Kastoria (avg. range= 0.103-0.29 kg/day) exceed those of Greece (0.066 kg/day; USDA, 2003 and Welch et al., 2002), EU (0.068 kg/day; Leatherhead Food RA, 2001), Spain (0.104 kg/day; Szucs and Grasselli, 2004), Portugal (0.159 kg/day; Szucs and Grasselli, 2004), and the USEPA default value (0.054 kg/day; USEPA, 1991) with two exceptions. Female consumption rates (0.087-0.103 kg/day) of *P. fluviatilis* were below annual consumption rates of Spain and Portugal (Table 2). Similarly, annual mean site-specific consumption rates of *A. anguilla* and *C. carpio* by male (0.199-0.210 kg/day) and female adults (0.096-0.157 kg/day) in vicinity of Lake Pamvotis exceeded those Greece, EU, Spain, Portugal, and

the USEPA default value (USEPA, 1991) (Table 2). Many of our site-specific consumption rates for the two lakes rival those of Native Americans in Alaska whose annual mean consumption rate is 0.324 kg/day, six times greater the USEPA default value (TERA, 1999). As there are such high consumption rates for these two different inland populations, and as exposure varies considerably under different circumstances, we concur with the WHO (1999) which strongly encourages responsible authorities in countries to characterize risk on the basis of local measured or predicted site-specific exposure scenarios and not default values such as those available for USEPA models. To date, no default values have been issued by the EEA. Application of site-specific consumption rates as the CDI in risk assessment investigations is warranted as current consumption rates (0.066 and 0.068 kg/day) listed for Greece (USDA, 2003 and Welch et al., 2002), and the EU (Leatherhead Food RA, 2001) would underestimate effects of chronic pesticide and other contaminant exposures to local populations utilizing freshwater fishes as a protein source. For example, the EEA (2004) indicates that pesticides are the most common cause of acute and sub-chronic poisonings because of the amounts of pesticides used in comparison with other chemicals, their high toxicity, and inappropriate storage. EEA (2004) did not comment on long-term exposures to pesticides, but indicated that scientific evidence and information concerning actual exposures to chemical substances and their possible health effects is lacking in most European countries, and that the lack of data for health impact assessment poses a big problem. Further, no association between exceedances of EU standards or (WHO) guidelines for pesticides and the incidence of morbidity or mortality has been established, possibly because of the safety margin built into EU standards/WHO guidelines is considerable, and because of the scarcity of appropriate studies (EEA, 2004).

Average consumption of fishes has increased from 0.039 kg/day (Trichopoulou and Lagiou, 1998) to 0.066 kg/day in Greece from 1980-2003 (USDA, 2003 and Welch et al., 2002). The Greek Ministry of Health and Welfare (2003) states that fish and seafood can physiologically substitute meat and eggs, but culinary, practical, and economic constraints dictate a recommendation of about one serving of fish (0.060 kg) per day. Trichopoulou and Lagiou (1998) indicate that fish and seafood availability in Greece decreases with proximity to urban areas, and can be attributed to the immediate availability of sea products in rural coastal areas and islands. Our high consumption rates of fishes from both of these inland lakes, where fishes are plentiful and readily available, are consistent with the statement by Trichopoulou and Lagiou (1998) who reported that one would expect better educated Greeks to be higher consumers of fish; however, market availability appears to be a stronger determinant of food choice in comparison to health education in this case: better educated Greeks are usually residing in the urban and not the rural areas.

Consumption frequencies of fish from Pamvotis Lake were lower than those from Kastoria Lake. This is consistent with the report of Filos (pers. comm., 2002) who indicated consumption of freshwater fishes from Pamvotis Lake had decreased in recent years as public awareness of the lake's pollution had increased. The significantly lower educational levels of adults in Kastoria coupled with fewer pollution reports for Lake Kastoria (Filos, pers. comm., 2002) are probably related to higher consumption rates at this lake.

A study of consumer perceptions of food-related hazards (including pesticide residue health risks) in 16 European countries and the USA conducted by Kafka and

Alvensleben (1997) indicated the index of concern (112) for Greece was greater than the European mean (100), USA (109), and all other European countries (range=63 in Spain-103 in Norway) except Germany (143) and Austria (136). This may reflect the recent and increased frequency of reports about pesticides and environmental and human health concerns available in Greece (Braxton and Frewer, 1998; Miles and Frewer, 1998; EEA, 2003). For example, pesticides have been identified as important freshwater pollutants in Greece (Albanis, 1992; Albanis et al., 1994). Greece authorized the use of nine of the 12 hazardous pesticides on the EEA's Water Framework Directive Priority List, but does not monitor any of them (EEA, 2003), despite documented exceedances (0.2-0.6 mg/kg; limit of detection=0.05 mg/kg) of maximum residue limit (MRL) in grapes tested from Greece (Brown, 2004); presence of organochlorine pesticide residues in human breast milk associated with food consumption patterns of mothers (Schinas et al., 2000); higher than normal concentrations of pesticides in mousaka, bean soup, infant food, and feta cheese (Boulous et al., 1996); and mammogram abnormalities and malignant changes in tumors of female greenhouse workers in Crete (Dolapsakis et al., 2001).

Data on food cooking methods in the EEA and Greece are scarce, even though there is epidemiologic evidence that consumption of fried, grilled or barbecued meat and fish that are well-done or browned may be associated with an increased cancer risk (Rohrmann et al., 2002). All populations in vicinities of both lakes preferred to eat fried fishes with one exception: grilled *C. carpio* from Lake Pamvotis was preferred by female and male adults (Tables 4 and 7). Preference for fried fish may reflect the transition from traditional Mediterranean and Cretan diets (Simopoulos, 2001) to a more western style diet in Greece, a phenomenon described for younger dwellers in urban areas of the country by Costacou et al. (2003). This is in contrast to the report by Rohrmann et al. (2002) who found that frying was more often noted in northern Europe, and roasting and stir-frying were more often used in the south.

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TABLE 1. Comparison of demographic characteristics of adult and youth males and females surveyed in vicinities of Lake Kastoria and Lake Pamvotis, Greece from June-July, 2002.

	Pamvotis ♀ Child	Kastoria ♂ Child	Pamvotis ♂ Child	Kastoria ♀ Child	Pamvotis ♂ Adult	Kastoria ♀ Adult	Pamvotis ♂ Adult	Kastoria ♀ Adult	Kastoria ♂ Adult
Age (yr)	10.1	10.4	11.3	12.0	43.2	44.6	47.3	48.5	48.5
F=54.1; p<0.0001									
	Kastoria ♀ Child	Kastoria ♂ Child	Pamvotis ♀ Child	Pamvotis ♂ Child	Kastoria ♀ Adult	Kastoria ♂ Adult	Pamvotis ♂ Adult	Kastoria ♀ Adult	Kastoria ♂ Adult
Weight (kg)	37.4	38.6	40.6	44.4	63.5	68.6	81.9	85.9	85.9
F=51.1; p<0.0001									
	Pamvotis ♀ Child	Pamvotis ♂ Child	Kastoria ♂ Child	Kastoria ♀ Child	Pamvotis ♂ Adult	Kastoria ♂ Adult	Pamvotis ♂ Adult	Pamvotis ♀ Adult	Pamvotis ♂ Adult
Education ^a	1.2	1.4	1.8	2.0	2.7	2.8	3.5	3.8	3.8
F=17.5; p<0.0001									
	Pamvotis ♂ Child	Kastoria ♀ Child	Kastoria ♂ Child	Pamvotis ♀ Child	Pamvotis ♂ Adult	Kastoria ♂ Adult	Pamvotis ♀ Adult	Kastoria ♂ Adult	Kastoria ♀ Adult
Occupation ^b	1.0	1.0	1.0	1.1	2.8	3.0	3.7	3.8	3.8
F=29.8; p<0.0001									
	Pamvotis ♀ Child	Pamvotis ♂ Child	Kastoria ♀ Child	Kastoria ♂ Child	Pamvotis ♀ Adult	Kastoria ♂ Adult	Pamvotis ♂ Adult	Kastoria ♀ Adult	Kastoria ♂ Adult
Quantity consumed (kg/meal)	0.24	0.27	0.32	0.43	0.45	0.46	0.72	0.93	0.93
F=8.45; p<0.0001									
	Pamvotis ♂ Adult	Pamvotis ♀ Child	Pamvotis ♂ Child	Pamvotis ♀ Adult	Kastoria ♂ Adult	Kastoria ♀ Adult	Kastoria ♂ Child	Kastoria ♀ Child	Kastoria ♂ Child
Days of eating fish	40.5	43.4	47.2	60.9	76.9	80	105.9	126.2	126.2
F=7.86; p<0.0001									

TABLE 2. Consumption rates (kg) of *Perca fluviatilis*, *Rutilus rutilus*, *Anguilla anguilla*, *Cyprinus carpio*, and *Silurus aristotelis* by populations in vicinity of Lake Kastoria and Lake Pamvotis, Greece in 2002, and fish consumption rates of other selected populations.

Lake Kastoria		kg/day			
	♂ adult	♀ adult	♂ child	♀ child	
<i>P. fluviatilis</i>	0.273	0.087	0.172	0.103	
<i>R. rutilus</i>	0.244	0.185	0.297	0.219	
Lake Pamvotis					
<i>A. anguilla</i>	0.199	0.096	0.027	0.010	
<i>C. carpio</i>	0.210	0.157	0.079	0.056	
<i>S. aristotelis</i>	0.023	0.042	0.035	0.035	
USEPA default ¹		kg/day			
EU ²		0.054			
Greece ³		0.068			
Portugal ⁴		0.159			
Spain ⁴		0.104			
USA Subsistence fishermen		0.086			
USA MN Native Americans		0.390			

1 – USEPA, 1991a

2 – Leatherhead Food RA, 2001

3 – USDA, 2003

4 – Szucs and Grasselli, 2004

TABLE 3. Results of Duncan's Multiple Range Test of population consumption parameters for *Perca fluviatilis*. Underscored means do not differ ($p=0.05$).

Species eating frequency Mean %	Female youth 50	Male youth 67	Male adult 83	Female adult 84
F=1.32; $p=0.2814$				
No. days eating species Mean days	Female youth 57.5	Female adult 62	Male adult 71.8	Male youth 73.9
F=0.14; $p=0.9382$				
Quantity consumed/meal Mean (kg)	Female youth 0.34	Male youth 0.41	Female adult 0.45	Male adult 0.93
F=4.92; $p=0.0067$				
Fish size Mean (kg)	Male youth 0.32	Female adult 0.43	Female youth 0.5	Male adult 0.5
F=0.59; $p=0.6265$				
% skin consumption Mean %	Female youth 0	Male youth 33	Female adult 82	Male adult 90
F=7.7; $p=0.0006$				
Eating heads Mean %	Female youth 0	Male youth 10	Female adult 36	Male adult 60
F=2.75; $p=0.0598$				
Eating bones Mean %	Male youth 0	Female youth 0	Female adult 10	Male adult 40
F=2.89; $p=0.0519$				
Eating fried fish Mean %	Female youth 50	Male youth 78	Male adult 90	Female adult 91
F=1.32; $p=2859$				
Eating grilled fish Mean %	Female adult 55	Male youth 56	Male adult 60	Female youth 75
F=0.17; $p=0.9173$				
Eating boiled fish Mean %	Female youth 0	Male youth 0	Male adult 0	Female adult 10
F=0.68; $p=0.5733$				
Soup eating frequency Mean %	Female youth 0	Male youth 0	Male adult 0	Female adult 20
F=0.68; $p=0.5733$				

TABLE 4. Percent fried, grilled, and boiled *Perca fluviatilis* and *Rutilus rutilus* consumed by female and male adults and youth in vicinity of Lake Kastoria, Greece, June, 2002. Underscored means do not differ significantly ($p=0.05$).

<i>Perca fluviatilis</i>				
Female adult Mean	Boil 3.0	Grill 30.0	Fry 67.0	
F=13.91; $p<0.0001$				
Female youth Mean	Boil 0	Fry 37	Grill 63	
F=2.60; $p=0.1288$				
Male adult Mean	Boil 0	Grill 35	Fry 65	
F=13.00; $p<0.0001$				
Male youth Mean	Boil 0	Grill 33	Fry 67	
F=7.62; $p=0.0027$				
<i>Rutilus rutilus</i>				
Female adult Mean	Boil 0	Grill 20	Fry 80	
F=39.07; $p<0.0001$				
Female youth Mean	Boil 0	Grill 25	Fry 75	
F=10.53; $p=0.0044$				
Male adult Mean	Boil 0	Grill 33	Fry 67	
F=12.04; $p=0.0002$				
Male youth Mean	Boil 0	Grill 33	Fry 67	
F=15.07; $p=0.0003$				

TABLE 5. Results of Duncan's Multiple Range Test of population consumption parameters for *Rutilus rutilus*. Underscored means do not differ ($p=0.05$).

Species eating frequency Mean % F=2.01; $p=0.1339$	Male youth 67	Female adult 91	Female youth 100	Male adult 100
No. days eating species youth Mean days F=0.10; $p=0.9594$	Female adult 77	Male adult 81.1	Male youth 88	Female 96.7
Quantity consumed/meal Mean (kg) F=6.15; $p=0.0028$	Female youth 0.3	Female adult 0.45	Male youth 0.48	Male adult 0.93
Fish size Mean (kg) F=1.64; $p=0.2050$	Male youth 0.1	Female adult 0.1	Female youth 0.1	Male adult 0.12
% skin consumption adult Mean % F=1.33; $p=0.2855$	Male youth 67	Female youth 75	Male adult 89	Female 100
Eating heads adult Mean % F=0.90; $p=0.4559$	Female youth 25	Male youth 50	Male adult 67	Female 70
Eating bones Mean % F=1.75; $p=0.1821$	Male youth 17	Female youth 25	Female adult 60	Male adult 67
Eating fried fish adult Mean % F=0.72; $p=0.5504$	Female youth 89	Male youth 100	Male adult 100	Female 100
Eating grilled fish Mean % F=0.34; $p=0.7948$	Female adult 40	Female youth 50	Male adult 56	Male youth 67

TABLE 6. Results of Duncan's Multiple Range Test of population consumption parameters for *Anguilla anguilla*. Underscored means do not differ ($p=0.05$).

Species eating frequency Mean % F=3.13; $p=0.0356$	Female youth 8	Male youth 25	Female adult 31	Male adult 62
No. days eating species Total days F=2.88; $p=0.0473$	Female youth 0.9	Male youth 6.4	Female adult 35.4	Male adult 55
Quantity consumed/meal Mean (kg) F=3.02; $p=0.0754$	Female adult 0.28	Male youth 0.3	Female youth 0.35	Male adult 0.78
Fish size Mean (kg) F=0.40; $p=0.7562$	Female youth 0.3	Female adult 1.1	Male youth 1.3	Male adult 1.43
% skin consumption adult Mean % F=0.73; $p=0.5535$	Male youth 0	Female youth 0	Male adult 50	Female 50
Eating heads Mean % F=0.43; $p=0.7352$	Female youth 0	Male youth 0	Female adult 25	Male adult 38
Eating bones Mean % F=0.24; $p=0.8636$	Male youth 0	Female youth 0	Female adult 0	Male adult 17
Eating fried fish adult Mean % F=2.73; $p=0.0944$	Female youth 0	Male youth 50	Male adult 88	Female 100
Eating grilled fish youth Mean % F=0.47; $p=0.7063$	Male youth 50	Female adult 75	Male adult 88	Female 100
Eating boiled fish Mean % F=0.24; $p=0.8636$	Female youth 0	Male youth 0	Female adult 0	Male adult 12
Soup eating frequency Mean % F=0.24; $p=0.8636$	Female youth 0	Male youth 0	Female adult 0	Male adult 38

TABLE 7. Percent fried, grilled, and boiled *Anguilla anguilla*, *Cyprinus carpio*, and *Silurus aristotelis* consumed by female and male adults and youth in vicinity of Lake Pamvotis, Greece, June, 2002. Underscored means do not differ significantly ($p=0.05$).

Anguilla anguilla

Female adult	Boil	Grill	Fry
Mean	0	37	63

F=9.65; $p=0.0059$

Male Adult	Boil	Grill	Fry
Mean	4	48	48

F=9.41; $p=0.0012$

Cyprinus carpio

Female adult	Boil	Fry	Grill
Mean	4	18	78

F=9.56; $p=0.0059$

Female youth	Boil	Grill	Fry
Mean	0	30	70

F=4.63; $p=0.0323$

Male adult	Boil	Fry	Grill
Mean	9	28	63

F=6.07; $p=0.0067$

Male youth	Boil	Grill	Fry
Mean	0	50	50

F=1.50; $p=0.2953$

Silurus aristotelis

Female adult	Boil	Grill	Fry
Mean	0	30	70

F=12.38; $p=0.0012$

Female youth	Boil	Grill	Fry
Mean	0	50	50

F=99.99; $p<0.0001$

Male adult		Boil	Grill	Fry
Mean	0	31	69	

F=10.30; $p=0.0008$

Male youth	Boil	Grill	Fry
Mean	0	50	50

F=99.99; $p<0.0001$

TABLE 8. Results of Duncan's Multiple Range Test of population consumption parameters for *Cyprinus carpio*. Underscored means do not differ ($p=0.05$).

Species eating frequency	Male youth	Female youth	Male adult	Female adult
Mean %	38	42	69	77
F=1.82; $p=0.1580$				
No. days eating species	Male youth	Female youth	Male adult	Female adult
Total days	47	47.4	50.3	84
F=0.62; $p=0.6035$				
Quantity consumed/meal	Female youth	Male youth	Female adult	Male adult
Mean (kg)	0.21	0.25	0.52	0.86
F=7.17; $p=0.0014$				
Fish size	Male youth	Female adult	Female youth	Male adult
Mean (kg)	4	5.6	5.9	7.6
F=1.32; $p=0.2929$				
% skin consumption	Female youth	Female adult	Male youth	Male adult
Mean %	20	20	33	44
F=0.49; $p=0.6900$				
Eating heads	Male youth	Female adult	Female youth	Male adult
Mean %	0	20	20	44
F=0.93; $p=0.4403$				
Eating bones	Male youth	Female youth	Female adult	Male adult
Mean %	0	0	0	10
F=0.64; $p=0.5977$				
Eating fried fish	Female adult	Male adult	Female youth	Male youth
Mean %	30	33	40	67
F=0.42; $p=0.7379$				
Eating grilled fish	Male youth	Female youth	Male adult	Female adult
Mean %	67	80	89	90
F=0.36; $p=0.7841$				
Eating boiled fish	Female youth	Male youth	Female adult	Male adult
Mean %	0	0	10	22
F=0.66; $p=0.5855$				
Soup eating frequency	Female youth	Male youth	Female adult	Male adult
Mean %	0	0	20	56
F=0.76; $p=0.5302$				

TABLE 9. Results of Duncan's Multiple Range Test of population consumption parameters for *Silurus aristotelis*. Underscored means do not differ ($p=0.05$).

Species eating frequency Mean % F=0.77; p=0.5183	Female youth 17	Male youth 25	Female adult 42	Male adult 47
No. days eating species Total days F=0.15; p=0.9285	Male adult 7.5	Female youth 7.9	Female adult 10.3	Male youth 11.9
Quantity consumed/meal Mean (kg) F=0.53; p=0.6693	Female youth 0.27	Male youth 0.27	Male adult 0.5	Female adult 0.5
Fish size Mean (kg) F=1.62; p=0.2374	Male adult 0.61	Female adult 0.62	Male youth 1.1	Female youth 1.1
% skin consumption Mean % F=1.12; p=0.3789	Male adult 38	Female adult 60	Male youth 100	Female youth 100
Eating heads Mean % F=0.44; p=0.7256	Male youth 0	Female youth 0	Male adult 25	Female adult 40
Eating bones Mean % F=0.29; p=0.8348	Male youth 0	Female adult 0	Female youth 0	Male adult 12
Eating fried fish Mean % F=0.29; p=0.8348	Male adult 88	Male youth 100	Female youth 100	Female adult 100
Eating grilled fish Mean % F=0.69; p=0.5768	Male adult 50	Female adult 60	Male youth 100	Female youth 100