HISTORIAS DE VIDA Y ASPECTOS ECOLÓGICOS DE ALGUNAS ESPECIES DE IMPORTANCIA COMERCIAL

Clave del proyecto: 20070370
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Descripción de Actividades Realizadas

Los peces de distintos ecosistemas han sido objeto de estudio por mucho tiempo, encontrando que la variación entre los atributos de sus historias de vida puede ser enmarcada en estrategias generales. Así mismo se ha mencionado, que el éxito de la explotación sustentable de los recursos marinos, depende del conocimiento y entendimiento conjunto de la mayoría de estas variables. Para muchas especies de alto valor comercial existen varias estimaciones de algunos de estos atributos; sin embargo, en aquellas que no son objeto de la pesca o cuyo valor comercial es bajo, la información al respecto es inexistente o poco accesible. Los objetivos de esta propuesta son 1) revisar algunas variables de las historias de vida de algunas especies de importancia comercial de México; 2) Obtener, estandarizar y analizar la información de algunas variables de las historias de vida de algunas especies de importancia comercial para describir patrones de variación; 3) analizar la información relacionada a los hábitos alimentarios de algunas especies de importancia comercial en México para describir los patrones de variación relacionados.

Con la finalidad de encontrar patrones globales que incorporen la información sobre los atributos de las historias de vida se llevaron a cabo análisis de componentes principales (ACP), en el cual se compararon los efectos de todas las variables analizadas. El análisis comparativo de estos resultados permitió definir y jerarquizar atributos en estrategias generales como base general desde un punto de vista ecológico así conocimiento útil para fines de manejo.

Al a fecha se cuenta con una matriz de datos con atributos sobre las historias de vida de 68 especies de las familias Scombridae, Istiophoridae, Xiphiidae y Coryphaenidae; las variables incorporadas en la base de datos incluyen la edad a la longitud cero, longitud asintótica, longitud máxima, longevidad, peso asintótico, longitud y edad de primera madurez, ciclo de vida reproductivo, tasa de crecimiento, tasa de mortalidad e índice de crecimiento (Φ'). Los datos recopilados se analizaron a través de técnicas exploratorias y técnicas estadísticas multivariados. Previo al análisis numérico (análisis de componentes principales) se eliminaron aquellas variables correlacionadas altamente (Lmax, Linf. K, M, NT, M/K.). Las variables empleadas para el análisis fueron: longevidad, edad de primera madurez, longitud de primera madurez (Lm), Q/B, Ø´ = log10 K 2(log10 L∞), Lm/Lmax. Los dos primeres componentes del análisis explican el 74% de la variación contenida en las variables (Tabla 1) y están relacionadas con longevidad de los organismos y con el índice de crecimiento Φ'.

Variable	Eigenvalor	% Total	% Acumulado
1	2.34	39.04	39.04
2	2.12	35.4	74.44
3	0.95	15.86	90.30
4	0.57	9.5	99.79
5	0.01	0.2	99.99
6	0.00	0.01	100

Tabla 1. Resultados del análisis de componentes principales para los atributos de las historias de vida de algunas especies de peces de importancia comercial de las familias Scombridae, Istiophoridae, Xiphiidae y Coryphaenidae.

Conclusiones

Muchas estimaciones que versan sobre la dinámica de los recursos pesqueros (estimaciones de abundancias, análisis de poblaciones virtuales, modelos de flujos tróficos, entre otras) requieren de información que tienen que ver con variables de sus historias de vida, muchas de ellas se reportan en este documento y todas ellas juegan un papel importante en diversos procesos biológicos. En general, el análisis preliminar de la información recopilada permitió identificar que la mayoría de las especies analizadas pueden ser clasificadas dentro de la categoría de estrategia intermedia, es decir, especies con cambios en biomasa rápidos y de variación alta, vida relativamente larga (10-20 años), resisten periodos con condiciones ambientales desfavorables durante el reclutamiento, sus poblaciones no son tan estables dentro de periodos de régimen, tiempo generacionales cortos.

La existencia de información biológica actualizada, depurada y sistematizada de especies de importancia comercial será de utilidad para aquellos investigadores que tengan interés en la dinámica de poblaciones de peces explotadas. Como estrategia para llevar este proyecto a un final satisfactorio se continuará con la recopilación y actualización de información sobre los atributos de las variables de historia de vida una mayor cantidad de especies de importancia comercial para México.

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Analysis of the ecosystem structure of Laguna Alvarado, western Gulf of Mexico, by means of a mass balance model

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Abstract

Alvarado is one of the most productive estuary-lagoon systems in the Mexican Gulf of Mexico. It has great economic and ecological importance due to high fisheries productivity and because it serves as a nursery, feeding, and reproduction area for numerous populations of fishes and crustaceans. Because of this, extensive studies have focused on biology, ecology, fisheries (e.g. shrimp, oysters) and other biological components of the system during the last few decades. This study presents a mass-balanced trophic model for Laguna Alvarado to determine it's structure and functional form, and to compare it with similar coastal systems of the Gulf of Mexico and Mexican Pacific coast. The model, based on the software Ecopath with Ecosim, consists of eighteen fish groups, seven invertebrate groups, and one group each of sharks and rays, marine mammals, phytoplankton, sea grasses and detritus. The acceptability of the model is indicated by the pedigree index (0.5) which range from 0 to 1 based on the quality of input data. The highest trophic level was 3.6 for marine mammals and snappers. Total system throughput reached 2680 t km^{-2} year^{-1}, of which total consumption made up 47%, respiratory flows made up 37% and flows to detritus made up 16%. The total system production was higher than consumption, and net primary production higher than respiration. The mean transfer efficiency was 13.8%. The mean trophic level of the catch was 2.3 and the primary production required to sustain the catch was estimated in 31 t km^{-2} yr^{-1}. Ecosystem overhead was 2.4 times the ascendancy. Results suggest a balance between primary production and consumption. In contrast with other Mexican coastal lagoons, Laguna Alvarado differs strongly in relation to the primary source of energy; here the primary producers (seagrasses) are more important than detritus pathways. This fact can be interpreted a response to mangrove deforest, overfishing, etc. Future work might include the compilation of fishing and biomass time trends to develop historical verification and fitting of temporal simulations.

Keywords: energy flows; trophic structure; Ecopath model; coastal lagoon; Mexico; Alvarado Lagoon

1. Introduction

Coastal lagoons are recognized as highly productive ecosystems that are used by numerous organisms for feeding, growth, reproduction and refuge (Allen and Horn, 1975; Day and Yáñez-Arancibia, 1982; Day et al., 1989). These ecosystems benefit humans in terms of food production (i.e. fisheries), transportation and recreation (NOAA, 1990). The annual economic value of coastal fisheries in the U.S. Gulf of Mexico stands around 650 million U.S. dollars (NOAA, 1990). The complexity of the oceanographic conditions that characterize coastal lagoons, as well as their multiple uses and biological diversity, necessitates a holistic approach to assess and manage their living resources.

In highly dynamic ecosystem, the resilience of the food web depends on how energy flows through the system (Hunter and Price, 1992). Many coastal lagoon food webs appear to be highly resilient, as they remain generally intact despite the challenges of an extremely dynamic environment (Day et al., 1989). Understanding how ecosystems react and recover from perturbations is a fundamental goal of ecology (Cottingham and Schindler, 2000). There are two approaches

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with inorganic and organic nutrients often attributed to freshwater runoff). Despite, very few attempts have been made to quantify the transfer of seagrass production into coastal food webs (Livingston, 1982, 1984; Luczkovich et al., 2002), or to determine the importance of seagrass production to primary production generated by other major plant groups (phytoplankton, macroalgae, benthic microalgae, mangroves).

The mixed trophic impact matrix indicated that groups in Laguna Alvarado are closely interconnected. In general, an increase in the biomass of a given group had a direct negative impact on its prey groups and an indirect negative impact on groups competing for the same food resource. Furthermore, a biomass increase in a group had a direct positive impact on the predators of that group, and an indirect positive impact on groups feeding, in turn, on those predators. Therefore, we hypothesize that any significant impact on wigeongrass abundance and distribution has the potential for cascade effect, particularly on wigeongrass-associated functional groups (crabs, shrimp, halfbreaks, pinfish, needlefish, infauna), and could create a situation that is difficult, if not impossible, to reverse.

On other hand, the omnivory index (0.25) of Laguna Alvarado was close with to those calculated for other coastal ecosystems (Table 5) such as the Huizache-Caimanero and Mandinga (0.25–0.24), and was higher than for Celestún, Tamiahua, Términos, and Tampamachoco (0.13–0.18) ecosystems. The larger index in our model than others models appears to be due to a difference in the species and diet compositions of benthic epifauna, whose diet in our model comprises a lower proportion of detritus than in other models. Moreover, the structure of the model can influence results and therefore comparison, so further work would imply to perform comparison with standardized models (Moloney et al., 2005; Coll et al., 2006b).

Laguna Alvarado has a relatively low ascendancy when compared with other systems (Abarca-Arenas and Valero-Pacheco, 1993; de la Cruz-Agüero, 1993; Rosado-Solórzano and Guzmán del Proo, 1998; Manichkand-Heileman et al., 2000; Vega-Cendejas and Arreguín-Sánchez, 2001; Zetina-Rejón et al., 2003). The system overhead is approximately 60–65% and ascendancy is approximately 30–35%. This suggests that Laguna Alvarado ecosystem has significant 'strength in reserve'. Unfortunately, it is unclear whether strength in reserve means resilience or resistance. That is, the system may either be resistant to perturbations, or it may be resilient and 'bounce back' quickly. It might even have a combination of both qualities.

The system omnivory index is also one of the highest, but the connectance index is close to average. This suggests that while the complexity of the ecosystem is close to that of other lagoons in Mexico, there is a greater variety in food links. The mean trophic level of catches in Laguna Alvarado (2.3) is the lowest of all the ecosystems shown in Table 5, reflecting the trophic level of shrimp which constitutes 60% of the system total catch. The low TLc in addition to relatively low PPR would probably be related with a high risk of ecosystem overfishing. *Sensu* Tudela et al. (2005) overfished ecosystems have a wider TLc range of 2.2–3.9 and %PPR of 2.8–89.5.

From the present study, it is clear that Ecopath is a useful tool for illuminating fundamental processes involved in trophic interactions and energy fluxes in coastal ecosystems. Future work could include the compilation of fishing and biomass time trends to develop historical simulations and future projections using Ecosim and Ecospace software.

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The Role of Predation in the Shrimp Stock Collapse in the Southern Gulf of Mexico

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Abstract.—The Campeche Sound, in the southern Gulf of Mexico, has historically been an important area for the exploitation of shrimp. Highest yields were obtained in the early 1970s with nearly 25,000 metric tons (mt) per year. However, catches declined 50% by 1980 and 90% by the late 1990s. Currently yields amount to around 1,500 mt. Several hypotheses have been suggested to explain the stock decline, including high fishing intensity, environmental changes, impact of the oil industry, and degradation of coastal areas. In this contribution, we explore the influence of predation in the shrimp stock collapse. The approach is based on a new trophic model using Ecopath for the period of 1978–1981, previous to the drastic decline in shrimp yields. The model considers explicitly the interaction of two interdependent ecosystems, the Terminos Lagoon and the adjacent continental shelf. Shrimp life history was partitioned to juveniles living in the lagoon and adults on the continental shelf. They are linked through a stock–recruitment relationship. The model provides the starting point for dynamic simulations using Ecosim. Simulations were calibrated using the historical exploitation pattern. Several scenarios show how shrimp is vulnerable to predators assuming bottom up, top down, and mixed control. When bottom up control is assumed, the model does not simulate the historical stock depletion. Under top down control, depletion was higher than recorded by the fishery. Mixed control scenario was closest to historical data trend. Results suggest that predation has an important role in the shrimp stock depletion.

Introduction

The continental shelf off Campeche Sound, in the southwestern Gulf of Mexico (Figure 1), constitutes an ecosystem in which several human activities occur, among the most important of which are the fishing and oil industries. In this area, the oil industry extracts around 70% Mexico's total oil and natural gas production. Before the oil industry was established in the early 1980s, fishing, particularly for shrimp, was the base of the regional economy. However, this fishery has collapsed (Figure 2); annual harvests have fallen from 27,000 metric tons (mt) during the early 1970s, to 3,000 mt or less in recent years (Arreguín-Sánchez et al. 1997). The main problem in the area is the decline of the pink shrimp *Farfantepenaeus duorarum* stock, which constituted in the past almost 90% of the total catch. Several hypotheses have been proposed to explain the decline in the shrimp stock (Arreguín-Sánchez et al. 1997a, 1999); one frequently argued by the public is the

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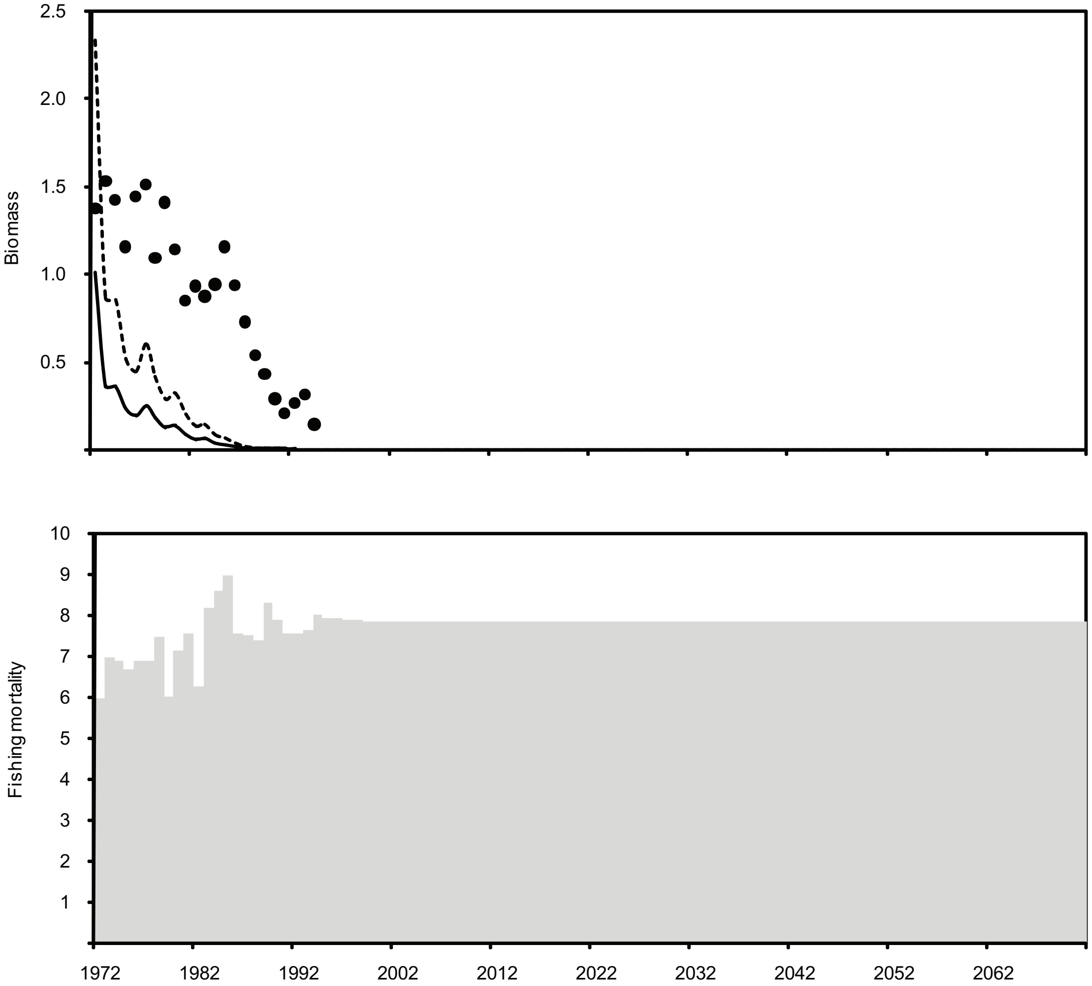

Figure 8. Top down scenario using historic fishing mortality from 1972 to 1994 and last 3 years average fishing mortality for the rest of simulation. Solid line is the simulated adult biomass and dash line is the juvenile biomass (dots = observed value and line = simulated values).

simulated data, however fishermen argue that increase of abundance of some predators could impact shrimp stock, particularly in coastal waters. The next step is to meet and incorporate evidence of predators' roles in the ecosystem and on the processes behind the pink shrimp stock collapse.

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Scientific Name	Family	Max. length (Lmax) cm	L infinity (Linf) cm	K / year	to _year_	Natural mortality (M)/year	Life span (approx.) year	Generation time year	Age at first maturity (tm) year	L maturity (Lm) cm	L max. yield (Lopt) cm	Length-weight cm	Nitrogen & Protein (g)	Reproductive guild	Fecundity	Relative Yield per Recruit (Y'/R)	Resilience / Productivity	Intrinsic rate of increase (rm)/ year	Main food	Trophic level	Food consumption (Q/B)
Acanthocybium solandri	Scombridae	250.0 TL	253.4	0.13	(-0.73)	0.23	22.3	7.8	4.2	120.4	170.1	253.4	116435	nonguarders: open water/ substratum egg scatterers		0.0344	Low; decline threshold	0.76	nekton mainly animals	4.4 +/- s.e. 0.77	8.3
Allothunnus fallai	Scombridae	105.0 FL	107.9	0.26	(-0.45)		11.1	3.6	2.4	55.9	69.9	107.9	116435				Medium; decline threshold		nekton mainly animals	3.7 +/- s.e. 0.59	2.9
Auxis rochei eudorax	Scombridae	36.5 FL	38.1	0.68	(-0.22)		4.2	1.2	1.0	22.0	23.6	38.1	16				High; decline threshold				0.0
Auxis rochei rochei	Scombridae	50.0 FL	47.2	0.40	(-0.37)	0.65	7.2	2.3	1.7	26.6	30.6	47.2	1937	nonguarders: open water/ substratum egg scatterers		0.0392	High; decline threshold	2.04	nekton mainly animals	4.1 +/- s.e. 0.61	13.2
Auxis thazard brachydorax	Scombridae	40.0 FL	41.7	0.62	(-0.24)		4.6	1.3	1.1	23.8	26.0	41.7	16				High; decline threshold				0.0
Auxis thazard thazard	Scombridae	65.0 FL	51.5	1.00	(-0.14)	1.52	2.9	1.0	0.7	28.8	34.2	51.5	2280	nonguarders: open water/ substratum egg scatterers	523,450	0.0433	High; decline threshold	4.76	nekton mainly animals	4.3 +/- s.e. 0.68	6.9
Cybiosarda elegans	Scombridae	45.0 FL	46.9	0.56	(-0.26)		5.1	1.5	1.2	26.5	29.3	46.9	1653				High; decline threshold				7.4
Euthynnus affinis	Scombridae	100.0 FL	90.0	0.44	(-0.27)	0.68	6.5	2.2	1.4	47.5	59.4	90.0	14587	nonguarders: open water/ substratum egg scatterers	377,889	0.0423	High; decline threshold	2.12	nekton mainly animals	4.5 +/- s.e. 0.79	9.3
Euthynnus alletteratus	Scombridae	122.0 TL	115.0	0.19	(-0.62)	0.29	15.2	5.1	3.2	59.2	76.2	115.0	24790	nonguarders: open water/ substratum egg scatterers	395,221	0.0430	Medium; decline threshold	0.92	nekton mainly animals	4.5 +/- s.e. 0.8	2.6
Euthynnus lineatus	Scombridae	84.0 FL	86.6	0.31	(-0.40)		9.3	2.9	2.0	45.9	55.6	86.6	17031				High; decline threshold		nekton mainly animals	3.8+/- s. e. 0.6	4.2
Gasterochisma melampus	Scombridae	164.0 FL	167.4	0.17	(-0.62)		17.0	5.7	3.4	83.0	110.5	167.4	49029				Medium; decline threshold		mainly animals	4.4+/- s. e. 0.57	2.2

Grammatorcynus bicarinatus	Scombridae	112.0 FL	115.0	0.24	(-0.48)		12.0	3.9	2.5	59.2	74.7	115.0	49029				Medium; decline threshold		nekton mainly animals	4.5+/- s. e. 0.8	2.8
Grammatorcynus bilineatus	Scombridae	100.0 FL	102.8	0.27	(-0.44)		10.7	3.4	2.3	53.5	66.5	102.8	49029				Medium; decline threshold		nekton mainly animals	4.2+/- s. e. 0.69	3.0
Gymnosarda unicolor	Scombridae	248.0 FL	251.4	0.12	(-0.80)		24.2	8.5	4.6	119.5	168.7	251.4	238951				Low; decline threshold		nekton mainly animals	4.5+/- s. e. 0.75	2.4
Katsuwonus pelamis	Scombridae	108.0 FL	79.1	0.64	(-0.19)	0.80	4.5	1.7	1.0	42.3	55.8	79.1	6861	nonguarders: open water/ substratum egg scatterers	400,000	0.0570	High; decline threshold	2.30	nekton mainly animals	4.4 +/- s.e. 0.76	32.6
Orcynopsis unicolor	Scombridae	130.0 FL	133.1	0.21	(-0.53)		13.8	4.5	2.8	67.5	87.0	133.1	238951				Medium; decline threshold		nekton mainly animals	4.5+/- s. e. 0.8	2.6
Rastrelliger brachysoma	Scombridae	34.5 FL	27.6	1.60	(-0.10)	2.60	1.8	0.6	0.5	16.4	17.9	27.6	549	nonguarders: open water/ substratum egg scatterers		0.0392	High; decline threshold	8.14	zooplankton plants/ detritus +animals	2.7+/- s. e. 0.31	34.1
Rastrelliger faughni	Scombridae	20.0 FL	25.9	1.45	(-0.11)	2.47	2.0	0.6	0.5	15.5	16.5	25.9	549			0.0365	High; decline threshold	8.06	zooplankton mainly animals	3.4+/- s. e. 0.45	12.8
Rastrelliger kanagurta	Scombridae	35.0 FL	25.5	1.50	(-0.11)	2.44	1.9	0.6	0.5	15.3	16.5	25.5	187	nonguarders: open water/ substratum egg scatterers		0.0391	High; decline threshold	7.64	nekton mainly animals	3.2+/- s. e. 0.38	11.6
Sarda australis	Scombridae	180.0 FL	183.4	0.16	(-0.65)		18.1	6.1	3.6	90.0	121.5	183.4	238951				Medium; decline threshold		nekton mainly animals	4.5+/- s. e. 0.8	2.1
Sarda chiliensis chiliensis	Scombridae	102.0 TL	76.0	0.46	(-0.28)	0.63	6.3	2.3	1.4	40.8	52.2	76.0	5849	nonguarders: open water/ substratum egg scatterers		0.0503	High; decline threshold	1.88	nekton mainly animals	4.5 +/- s.e. 0.78	29.5
Sarda chiliensis lineolata	Scombridae	102.0 FL	77.0	0.62	(-0.20)	0.79	4.6	1.8	1.0	41.3	54.0	77.0	2822			0.0556	High; decline threshold	2.26			9.5
Sarda orientalis	Scombridae	102.0 FL	104.9	0.26	(-0.46)		11.1	3.5	2.4	54.5	67.9	104.9	13680	nonguarders: open water/ substratum egg scatterers			Medium; decline threshold		nekton mainly animals	4.2+/- s. e. 0.69	2.6
Sarda sarda	Scombridae	91.4 FL	64.0	0.69	(-0.19)	0.88	4.1	1.6	1.0	35.0	44.9	64.0	2826	nonguarders: open water/ substratum egg scatterers		0.0555	High; decline threshold	2.54	nekton mainly animals	4.5 +/- s.e. 0.74	7.5
Scomber australasicus	Scombridae	44.0 FL	44.1	0.24	(-0.63)	0.41	11.9	3.6	2.9	25.0	28.1	44.1	1180			0.0363	Medium; decline threshold	1.36	nekton mainly animals	4.2 +/- s.e. 0.74	4.2
Scomber colias	Scombridae	0.0	1.1	0.47	(-0.86)		5.5	3.4	2.8	0.9	0.6	1.1	16				High; decline threshold		mainly animals	3.9+/- s. e. 0.63	32.8

Scomber japonicus	Scombridae	64.0 TL	44.5	0.32	(-0.47)	0.42	8.9	3.3	2.1	25.2	31.0	44.5	1497	nonguarders: open water/ substratum egg scatterers	401,291	0.0534	High; decline threshold	1.20	zooplankton mainly animals	3.1 +/- s.e. 0.43	5.1
Scomber scombrus	Scombridae	60.0 FL	44.5	0.27	(-0.56)	0.40	10.6	3.5	2.5	25.2	29.8	44.5	743	nonguarders: open water/ substratum egg scatterers	629,285	0.0450	Medium; decline threshold	1.20	zooplankton mainly animals	3.6 +/- s.e. 0.56	4.4
Scomberomorus brasiliensis	Scombridae	125.0 FL	93.8	0.18	(-0.71)	0.36	16.3	5.2	3.4	49.3	60.4	93.8	6139	nonguarders: open water/ substratum egg scatterers		0.0282	Medium; decline threshold	1.28	nekton mainly animals	4.4+/- s. e. 0.76	5.7
Scomberomorus cavalla	Scombridae	184.0 TL	142.0	0.14	(-0.82)	0.26	21.2	7.0	4.2	71.6	93.0	142.0	20482	nonguarders: open water/ substratum egg scatterers	919,510	0.0318	Low; decline threshold	0.88	nekton mainly animals	4.5 +/- s.e. 0.8	4.0
Scomberomorus commerson	Scombridae	240.0 FL	182.0	0.30	(-0.34)	0.45	9.7	3.3	1.9	89.4	121.3	182.0	46009	nonguarders: open water/ substratum egg scatterers	692,820	0.0442	Medium; decline threshold	1.36	nekton mainly animals	4.5 +/- s.e. 0.8	3.8
Scomberomorus concolor	Scombridae	77.0 FL	79.5	0.34	(-0.37)		8.5	2.6	1.9	42.5	50.8	79.5	13680				High; decline threshold				3.5
Scomberomorus guttatus	Scombridae	76.0 FL	78.5	0.34	(-0.37)		8.5	2.6	1.9	42.0	50.2	78.5	4685	nonguarders: open water/ substratum egg scatterers	650,769		High; decline threshold		nekton mainly animals	4.3+/- s. e. 0.67	2.8
Scomberomorus koreanus	Scombridae	150.0 FL	153.3	0.18	(-0.60)		16.1	5.4	3.3	76.7	100.8	153.3	4685				Medium; decline threshold		nekton mainly animals	4.2+/- s. e. 0.74	3.6
Scomberomorus lineolatus	Scombridae	80.0 FL	82.6	0.33	(-0.33)	0.42	8.8	2.8	2.0	44.0	52.9	82.6	2874	nonguarders: open water/ substratum egg scatterers	1,094,503	0.0557	High; decline threshold	1.22	mainly animals	4.5+/- s. e. 0.8	0.0
Scomberomorus maculatus	Scombridae	91.0 FL	73.9	0.33	(-0.39)	0.60	8.7	2.7	2.0	39.8	47.1	73.9	3259	nonguarders: open water/ substratum egg scatterers	459,674	0.0329	High; decline threshold	2.02	nekton mainly animals	4.5 +/- s.e. 0.74	6.1
Scomberomorus multiradiatus	Scombridae	35.0 FL	36.6	0.71	(-0.21)		4.0	1.2	1.0	21.2	22.7	36.6	4685				High; decline threshold				8.6
Scomberomorus munroi	Scombridae	104.0 FL	84.9	0.46	(-0.27)	0.75	6.3	2.0	1.4	45.1	55.0	84.9	3259	nonguarders: open water/ substratum egg scatterers		0.0390	High; decline threshold	2.34	nekton mainly animals	4.3+/- s. e. 0.76	5.5

Scomberomorus niphonius	Scombridae	100.0 FL	80.4	0.91	(-0.13)	0.96	3.2	1.3	0.7	42.9	59.5	80.4	3259	nonguarders: open water/ substratum egg scatterers	691,737	0.0712	High; decline threshold	2.66	nekton mainly animals	4.5+/- s. e. 0.8	3.1
Scomberomorus plurilineatus	Scombridae	120.0 FL	93.5	0.58	(-0.20)	0.84	4.9	1.7	1.1	49.2	63.1	93.5	7844	nonguarders: open water/ substratum egg scatterers		0.0465	High; decline threshold	2.52	nekton mainly animals	4.2+/- s. e. 0.77	4.9
Scomberomorus queenslandicus	Scombridae	100.0 FL	78.2	0.29	(-0.45)	0.54	10.0	3.1	2.2	41.9	50.0	78.2	7844			0.0317	Medium; decline threshold	1.82	nekton mainly animals	4.5 +/- s.e. 0.79	5.8
Scomberomorus regalis	Scombridae	183.0 TL	186.4	0.17	(-0.61)	0.30	17.0	5.8	3.4	91.4	123.5	186.4	45983	nonguarders: open water/ substratum egg scatterers	597,863	0.0345	Medium; decline threshold	0.98	nekton mainly animals	4.5 +/- s.e. 0.79	3.8
Scomberomorus semifasciatus	Scombridae	120.0 FL	94.4	0.60	(-0.20)	0.88	4.8	1.7	1.0	49.6	63.4	94.4	7844			0.0456	High; decline threshold	2.64	nekton mainly animals	4.5 +/- s.e. 0.8	5.2
Scomberomorus sierra	Scombridae	99.0 FL	101.8	0.27	(-0.44)		10.7	3.4	2.3	53.1	65.8	101.8	45983				Medium; decline threshold		nekton mainly animals	4.5 +/- s.e. 0.8	4.6
Scomberomorus sinensis	Scombridae	218.0 FL	221.4	0.13	(-0.76)		22.3	7.7	4.3	106.6	147.8	221.4	45983				Low; decline threshold		mainly animals	4.5+/- s. e. 0.8	1.9
Scomberomorus tritor	Scombridae	100.0 TL	100.0	0.31	(-0.38)	0.55	9.3	3.0	2.0	52.2	64.6	100.0	13040	nonguarders: open water/ substratum egg scatterers	1,000,000	0.0342	High; decline threshold	1.80	nekton mainly animals	4.3+/- s. e. 0.74	5.1
Thunnus alalunga	Scombridae	140.0 FL	141.0	0.15	(-0.77)	0.22	19.8	6.8	3.9	71.1	94.7	141.0	28339	nonguarders: open water/ substratum egg scatterers	2,449,490	0.0456	Low; decline threshold	0.64	nekton mainly animals	4.3 +/- s.e. 0.73	2.2
Thunnus albacares	Scombridae	239.0 FL	190.0	0.33	(-0.30)	0.45	8.8	3.2	1.7	92.9	130.6	190.0	133395	nonguarders: open water/ substratum egg scatterers	1,148,913	0.0506	High; decline threshold	1.34	nekton mainly animals	4.3 +/- s.e. 0.71	11.6
Thunnus atlanticus	Scombridae	107.9 FL	78.0	0.33	(-0.39)	0.59	8.7	2.7	1.9	41.8	49.8	78.0	9527	nonguarders: open water/ substratum egg scatterers		0.0338	High; decline threshold	2.00	nekton mainly animals	4.1 +/- s.e. 0.7	4.9
Thunnus maccoyii	Scombridae	245.0 FL	220.0	0.15	(-0.65)	0.21	19.2	7.0	3.7	106.0	150.0	220.0	245770	nonguarders: open water/ substratum egg scatterers	14,491,377	0.0488	Low; decline threshold	0.62	zoobenthos mainly animals	3.9+/- s. e. 0.53	1.6

Thunnus obesus	**Scombridae**	**250.0 TL**	**236.0**	**0.13**	**(-0.78)**	**0.16**	**23.2**	**8.9**	**4.6**	**112.9**	**163.4**	**236.0**	**135477**	**nonguarders: open water/ substratum egg scatterers**	**4,274,342**	**0.0522**	**Low; decline threshold**	**0.46**	**nekton mainly animals**	**4.5 +/- s.e. 0.75**	**4.6**
Thunnus orientalis	**Scombridae**	**300.0 FL**	**303.2**	**0.10**	**(-0.92)**		**29.1**	**10.4**	**5.4**	**141.4**	**205.1**	**303.2**	**187**				**Low; decline threshold**		**nekton mainly animals**	**4.2 +/- s.e. 0.55**	**1.6**
Thunnus thynnus	**Scombridae**	**458.0 TL**	**419.0**	**0.06**	**(-1.53)**	**0.07**	**52.0**	**19.7**	**8.5**	**189.1**	**301.7**	**419.0**	**1113523**	**nonguarders: Open water/ substratum egg scatterers**		**0.0626**	**Low; decline threshold**	**0.22**	**nekton mainly animals**	**4.4 +/- s.e. 0.78**	**3.9**
Thunnus tonggol	**Scombridae**	**145.0 FL**	**110.0**	**0.32**	**(-0.36)**	**0.55**	**8.9**	**2.9**	**1.9**	**56.9**	**71.3**	**110.0**	**1113523**			**0.0360**	**High; decline threshold**	**1.78**	**nekton mainly animals**	**4.5 +/- s.e. 0.77**	**4.8**

Back to Search **Back to Top**

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