The following supplement accompanies the article

Potential for top-down control on tropical tunas based on size structure of predator–prey interactions

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Supplement. Sources and modeling analyses of the primary data and references for supplementary tables

Description of primary data used in study analyses. The 1955 to 1960 food habits data contain diet information for yellowfin tuna *Thunnus albacares* in the eastern tropical Pacific Ocean, taken from Frank Alverson's handwritten notebooks and coded into Access by L. Duffy. These data are published in Alverson (1963). The predator samples were taken at canneries, not at sea. The predators were captured by pole-and-line gear and in unassociated purse-seine sets, and samples were taken from wells (fish holds) that often contained multiple sets.

The 1969 to 1972 food habits records are for yellowfin tuna captured by purse seine mostly during 1970 to 1972 (a few samples were from 1969) in the eastern tropical Pacific Ocean. The samples were primarily from purse-seine sets on dolphins, with a few from unassociated and floating-object sets. These data were summarized by yellowfin tuna age class and prey family in Olson & Boggs (1986). The samples were taken at canneries, not at sea. The predators were sampled from wells that often contained multiple sets. The stomach contents analysis was started by W. Klawe and continued by R. Olson with assistance from K. Schaefer.

The 1992 to 1994 diet data are for a variety of tunas and bycatch species (including dolphins) captured by purse seine in the eastern tropical Pacific Ocean. Three set types—dolphin sets, floating-object sets and unassociated sets—are represented. The samples were taken at sea from individual purse-seine sets by IATTC observers. Stomach contents analysis was done mostly by F. Galván-Magaña (CICIMAR and IATTC), with assistance from J. Martínez (Cumaná, Venezuela).

The 2003 to 2005 food habits data are also for a variety of tunas and bycatch species captured by purse seine in the eastern Pacific Ocean. Three set types—dolphin sets, floating-object sets and unassociated sets—are represented. The samples were taken at sea by IATTC observers. Stomach contents analysis was done by N. Bocanegra-Castillo (CICIMAR), V. Alatorre (CICIMAR), J. Morales-Vera (Manta, Ecuador), M. Loor-Mera (Manta, Ecuador) and L. Cedeño (Manta, Ecuador), with supervision by F. Galván-Magaña (CICIMAR) and R. Olson.

Table S1. List of theses, reports and peer-reviewed publications from which summarized food habits data for the eastern Pacific Ocean were obtained

Common name	Study location	Study years	Source
Albacore and Pacific bluefin tunas	California	1968–1969	Pinkas et al. (1971)
Albacore tuna	California	1955–1961	Clemens & Iselin (1963)
Albacore tuna	Central/northeastern Pacific Ocean	1950–1957	Iverson (1962)
Blue marlin	Cabo San Lucas, Mexico	1987–1989	Abitia-Cárdeñas et al. (1999)
Blue marlin	Hawaii	1981	Brock (1984)
Coastal spotted and eastern spinner dolphins	Eastern Pacific Ocean	1968	Perrin et al. (1973)
Dolphinfish	Eastern Pacific Ocean	1992–1994	Olson & Galván-Magaña (2002)
Galapagos shark	Hawaii	1967–1969	Wetherbee et al. (1996)
Indo-Pacific sailfish	Mazaltán, Sinaloa, Mexico	2002–2003	Arizmendi-Rodriguez et al. (2006)
Indo-Pacific sailfish	Southern Gulf of California	1988–1991	Rosas-Alayola et al. (2002)
Scalloped hammerhead shark	Mazaltán, Sinaloa, Mexico	2000–2004	Torres-Roja (2006)
Shortfin mako shark	Baja California, Mexico	2000–2004	Velasco (2005)
Silky shark	Baja California, Mexico	2000–2002	Cabrera Chávez-Costa (2003)
Skipjack & albacore tunas, bonito	California Current	1983	Bernard et al. (1985)
Skipjack tuna	Marquesas and Tuamotu islands	1957–1959	Nakamura (1965)
Smooth hammerhead shark	Ecuador	2004	Bolaños-Martinez (2008)
Smooth hammerhead shark	Baja California, Mexico	2000–2004	Ochoa-Diaz (2006)
Striped marlin	Baja California, Mexico	1988–1989	Abitia-Cárdeñas et al. (1997)
Striped marlin	Southern Gulf of California	1994–1995	Abitia-Cárdeñas et al. (2002)
Striped marlin	San Diego, California	1950–1951	Hubbs & Wisner (1953)
Striped, blue and black marlins	Northern New Zealand	1960–1964	Baker (1966)
Swordfish	Baja, California, Mexico	1988–1996	Markaida & Hochberg (2005)
Swordfish	Baja California, Mexico	1992–1993	Markaida & Sosa-Nishizaki (1998)
Thresher shark	Ecuador	2003	Polo-Silva et al. (2007)
Tiger shark	Hawaii	1967–1969	Lowe et al. (1996)
'Tunas', 'billfishes'	Western Pacific Ocean	1949–1958	Watanabe (1960)
Yellowfin and bigeye tunas	Central Pacific Ocean	1950–1953	King & Ikehara (1956)
Yellowfin and skipjack tunas	Eastern Pacific Ocean	1957–1959	Alverson (1963)
Yellowfin and skipjack tunas, dolphinfish	Hawaii	1951–1956	Tester & Nakamura (1957)
Yellowfin tuna	Hawaii	1980–1983	Brock (1985)
Yellowfin tuna	American Samoa	1985–1989	Buckley & Miller (1994)
Yellowfin tuna	Eastern Pacific Ocean	1970–1972	Olson & Boggs (1986)
Yellowfin tuna	Near Hawaiian and Phoenix islands	1950–1956	Waldron & King (1963)
Yellowfin tuna	Western equatorial Pacific Ocean	1950–1953	Watanabe (1958)
Yellowfin, albacore and bigeye tunas, black marlin	Southern equatorial Pacific Ocean	1957	Koga (1958)
Yellowfin, skipjack and bigeye tunas	Eastern equatorial Pacific and Samoa Islands	1969–1970	Hida (1973)

Table S2. Data used to model the lifetime reproductive potential of yellowfin and skipjack tunas in the eastern tropical Pacific Ocean. For yellowfin tuna, age/length-specific estimates of fecundity, maturity and sex ratio are based on Schaefer (1998) (see Maunder 2007) and combined-sex natural mortality rates (M) are based on Maunder & Aires-da-Silva (2009). For skipjack tuna, all parameter values are borrowed from Maunder & Harley (2005). Note: sex-specific information and estimates of fecundity were not available for skipjack tuna in the Pacific Ocean. Fecundity at age for skipjack tuna in the Pacific Ocean was assumed to be proportional to weight at age

	Yellowfin tuna					Skipjack tuna			
Age (quarters)	M	Relative fecundity × maturity	Sex ratio		Age (months)	M	Maturity	Sex ratio	Weight
2	0.5000	0.0000	0.5000		9	0.5623	0.0000	0.5000	0.4743
3	0.4400	0.0000	0.5000		10	0.4762	0.0000	0.5000	0.8531
4	0.3800	0.0000	0.5000		11	0.3901	0.0000	0.5000	1.3338
5	0.3200	0.0001	0.5000		12	0.3040	0.0000	0.5000	1.4451
6	0.2000	0.0072	0.5000		13	0.2179	0.0000	0.5000	1.7305
7	0.2000	0.0665	0.5000		14	0.1319	0.0000	0.5000	2.0164
8	0.2003	0.2371	0.5000		15	0.1240	0.0000	0.5000	2.1684
9	0.2079	0.5295	0.4998		16	0.1161	2.6616	0.5000	2.6074
10	0.2326	0.9149	0.4959		17	0.1082	3.0731	0.5000	2.9140
11	0.2638	1.3594	0.4795		18	0.1004	3.4966	0.5000	3.2946
12	0.2856	1.8362	0.4464		19	0.1110	3.9283	0.5000	3.7476
13	0.2929	2.3254	0.3996		20	0.1217	4.3648	0.5000	3.9233
14	0.2891	2.8116	0.3454		21	0.1324	4.8028	0.5000	4.3570
15	0.2792	3.2825	0.2896		22	0.1431	5.2396	0.5000	5.2424
16	0.2669	3.7284	0.2367		23	0.1538	5.6728	0.5000	5.6707
17	0.2546	4.1423	0.1895		24	0.1645	6.1001	0.5000	6.0915
18	0.2435	4.5198	0.1491		25	0.1645	6.5199	0.5000	6.5187
19	0.2340	4.8591	0.1158		26	0.1645	6.9305	0.5000	6.9348
20	0.2262	5.1599	0.0889		27	0.1645	7.3307	0.5000	7.3382
21	0.2201	5.4236	0.0677		28	0.1645	7.7195	0.5000	7.7317
22	0.2152	5.6526	0.0513		29	0.1645	8.0961	0.5000	8.1113
23	0.2115	5.8499	0.0386		30	0.1645	8.4598	0.5000	8.4765
24	0.2086	6.0187	0.0290		31	0.1645	8.8104	0.5000	8.8301
25	0.2065	6.1623	0.0217		32	0.1645	9.1474	0.5000	9.1887
26	0.2048	6.2838	0.0162						
27	0.2036	6.3863	0.0121						
28	0.2027	6.4724	0.0090						
29	0.2020	6.5446	0.0067						

Table S3. Maximum likelihood estimates of fixed effects (SE) in the best-fitting generalized linear mixed models. We modeled the frequency of occurrence and the conditional percent mass contribution (non-zero observations) of skipjack and yellowfin tunas in the diets of apex predators using primary food habits data. The first level of each categorical variable (e.g. predator: *Acanthocybium solandri*; set/gear type: pole and line) was treated as the reference level and subsequent coefficients were estimated in relation to this baseline. –: no estimate for this variable

Explanatory variable	Frequency of occurrence		Percent composition by mass	
	Skipjack	Yellowfin	Skipjack	Yellowfin
Set/Gear Type				
Pole and line	0.00	0.00	–	0.00
Dolphin set	2.13 (1.77)	0.83 (1.52)	0.00	–0.35 (1.98)
Floating-object set	3.07 (1.84)	1.20 (1.61)	0.46 (1.05)	0.06 (1.84)
Unassociated set	0.76 (1.97	–0.55 (1.78)	–0.02 (2.21)	0.05 (2.19)
Predator				
Acanthocybium solandri	0.00	0.00		
Carcharhinus falciformis	1.47 (0.34)	2.53 (0.51)		
Carcharhinus limbatus	3.80 (1.75)	–		
Carcharhinus spp.[a]	0.68 (1.15)	4.25 (0.90)		
Coryphaena hippurus	–1.62 (0.62)	–0.81 (0.81)		
Coryphaenidae	–	0.09 (0.93)		
Elagatis bipinnulata	–1.36 (0.65)	–0.31 0.83)		
Istiophorus platypterus	0.78 (1.71)	–		
Makaira spp.[b]	0.89 (0.67)	3.69 (0.71)		
Seriola rivoliana	–1.03 (1.18)	1.43 (0.90)		
Sphyrna spp.[c]	0.24 (1.55)	4.83 (1.11)		
Stenella attenuata	–3.09 (1.41)	–		
Thunnus albacares	–2.02 (0.65)	–2.25 (0.83)		

[a] *Carcharhinus* spp. includes unidentified *Carcharhinus* and *C. longimanus*
[b] *Makaira* spp. includes unidentified *Makaira*, *M. indica* and *M. nigricans*
[c] *Sphryna* spp. includes unidentified *Sphryna* and *S. lewini* (yellowfin model only)

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