SURVEY OF THE PELAGIC FISHES OF THE NORTHWESTERN HAWAIIAN ISLANDS

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ABSTRACT

Longline fishery catch statistics were used to estimate relative abundance of true pelagic species within the Fishery Conservation Zone of the Northwestern Hawaiian Islands. Relative apparent abundance of coastal pelagic species was determined by trolling surveys. Growth curves for Euthynnus affinis and Thunnus alalunga were estimated from otolith age determinations. A study of the fecundity of Acanthocybium solandri has begun.

fecundity
relative apparent abundance
Northwestern Hawaiian Islands
age and growth
pelagic fishes

INTRODUCTION

The survey area in the Northwestern Hawaiian Islands (NWHI) included in this study extends from Nihoa to Kure Atoll and is about 1,700 km long and 640 km wide. Much of this area is in the pelagic realm. The pelagic resources considered in this report consist of the true pelagic and the coastal pelagic fishes.

The foreign longline fishery in the Pacific has been harvesting the true pelagic fishes from an area northwest of the inhabited high islands. This fishing ground extends into the U.S. 200-mile Fishery Conservation Zone (FCZ) around the NWHI. The true pelagic species include the bigeye tuna, Thunnus obesus; yellowfin tuna, T. albacares; albacore, T. alalunga; northern bluefin tuna, T. thynnus; skipjack tuna, Katsuwonus pelamis; swordfish, Xiphias gladius; striped marlin, Tetrapturus audax; shortbill spearfish, T. angustirostris; blue marlin, Makaira nigricans; black marlin, M. indica; sailfish, Istiophorus platypterus; mahimahi, Coryphaena hippurus; and sharks, Carcharhinus maou (C. longimanus), C. falciformis, Isurus oxyrinchus, and Prionace glauca. Yong and Wetherall (1980) have estimated the foreign longline monthly effort and catch within the 200-mile FCZ for 1965 through 1977.

The Japanese baitboat fishery has also harvested skipjack, bigeye, and yellowfin tunas in the FCZ. In 1972, the eastward expansion of the albacore baitboat fishery reached the NWHI (Fisheries Agency of Japan, 1977a). Albacore was caught only in 1972, 1975, and 1977 in the vicinity of Hancock Seamounts. Yellowfin and bigeye tunas were caught primarily on or near the banks of the NWHI; skipjack tuna was also caught on or near the banks but was also caught in abundance on the open sea southwest of the FCZ (Fisheries Agency of Japan, 1977b; Yong and Wetherall, 1980). Catches of skipjack tuna, the target species, peaked for about a period of a month between May and August. Whereas the catch rates of skipjack tuna have averaged between 6 and 11 metric tons (MT)/vessel/day, single-day catches up to 50 MT a day have been reported (Tanaka, n.d.). Yong and Wetherall (1980) also estimated the monthly fishing effort and skipjack tuna catch within the 200-mile FCZ for 1972 through 1977.

Besides skipjack and yellowfin tunas, which are also considered as true pelagic species, the coastal pelagic species include the ono, Acanthocybium solandri; kawakawa, Euthynnus affinis; rainbow runner, Elagatis bipinnulatus; bigeye scad, Trachurops crumenophthalmus; Japanese mackerel, Scomber japonicus; and four species of mackerel scad, Decapterus macarellus (= D. pinnulatus), D. maruadsi, D. muroadsi (= D. russellii), and D. macrosoma. At present, a commercial fishery for the coastal pelagic resources does not exist in the NWHI. On a few occasions, lobster fishing vessels have trolled for kawakawa and yellowfin tuna to use as bait in lobster traps. Mahimahi and ono caught on trolling lines by lobster fishermen are sold at the Honolulu fish auction.

Research cruises to the NWHI were made on 30 occasions during the 1950s and 1960s and data on trolling and fish school and bird flock sightings from these cruises have been published by Murphy and Ikehara (1955), Graham (1957), and Waldron (1964). And prior to the current series of NWHI survey cruises, the NOAA ship Townsend Cromwell made a search-survey cruise for skipjack tuna in 1975 which included parts of the NWHI.

Except for these fish school surveys and some baitfish surveys in the NWHI, the pelagic resources have not been studied. Records of the foreign longline fishery and baitboat fishery provide us with estimates of relative apparent abundance of tunas and billfishes. This study includes the distribution, catch rates, age and growth, fecundity and spawning, and foraging habits of the coastal pelagic species.

MATERIAL AND METHODS

Trolling and tagging operations

The seven survey cruises of the Townsend Cromwell since the summer of 1977 included a standard trolling procedure. Nine lines were trolled at 7 knots during various times of the day at the edge of banks between the

73 and 274-m depth contours. When a fish was landed, it was measured for fork length, sexed, and sometimes weighed. Time of landing, position, and depth were also recorded on the Standardized Surface Trolling Data Sheet (SSTDS). Ovaries and stomach contents were preserved in a solution of 4% formaldehyde and seawater. Otoliths were extracted and frozen in water for examination at the laboratory.

Kawakawa, yellowfin tuna, and ono were tagged in 1977. Troll-caught fishes were measured, tagged with a dart tag (Yamashita and Waldron, 1958), and released.

Distribution and relative apparent abundance

Yong and Wetherall (1980) tabulated the catch and effort by 1° squares from Japanese and unpublished Taiwan longline fishery data for 1971 through 1975 and from Japanese baitboat data for 1972 through 1977. Catch and effort data were estimated by 5° squares for 1965 through 1970, 1976, and 1977. They estimated the catch of major tuna and billfish species and effort within the FCZ around the NWHI using these tabulations.

The distribution of troll-caught pelagic fishes was analyzed by comparing the number of fishes caught per line-hour of fishing in each 6-min cell around the NWHI. The position of capture on the SSTDS was used to place the fish into cells. When the position of capture was missing, the position was estimated using the ship's track chart and the time of capture.

Age and growth studies

In the laboratory, sagittae, the largest of the otoliths, were cleaned, etched, mounted, and read as described by Uchiyama and Struhsaker (in press). Age-length determinations were used to calculate the von Bertalanffy growth parameters.

Experiments were also conducted to verify that growth rings were deposited daily. At the Kewalo Research Facility, pelagic fishes maintained in aquaria were either injected or orally fed oxytetracycline at a rate of about 33 mg oxytetracycline/kg of fish to mark a spot on the sagittae. The daily deposition of growth rings was verified by matching the number of daily growth rings counted between the mark, which was visible under ultraviolet excitation, and the edge of the rostrum or postrostrum with the number of days the fish was kept alive and feeding after marking.

Fecundity and spawning season

Since 1978, all developing and ripe ovaries of pelagic fishes were collected to determine the length of the spawning period. Immature ovaries were noted in the remarks column of the SSTDS. The maturity of the ovary was determined on the basis of the most advanced ova present as described by Uchiyama and Shomura (1974). Then the monthly percentage distribution of sampled ovaries in each developmental stage, i.e., immature, developing, advanced developing, early ripe, and ripe, was calculated.

Fecundity estimates were made only on ovaries in the advanced developing, early ripe, and ripe stages. The ova development within an ovary was tested for homogeneity and fecundity estimates were made as described by Otsu and Uchida (1959).

Study on foraging habits

The volume and individual counts of forage items were determined for each stomach. Each item was identified to species when possible and measured for volume and length.

Night-light stations

A 1,500-W bulb night light was used to attract bigeye scad, mackerel scad, and other organisms. Dip nets and jig lines were used to capture organisms attracted to the light. Hourly data on organisms caught and estimates of the quantity of organisms attracted to the light were kept.

RESULTS

Distribution and relative apparent abundance

Annual catch rates of tunas and billfishes were estimated using catch and effort data obtained from foreign longline vessels operating within the FCZ around the NWHI (Table 1). The catch rate of the whole mixed species fishery remained stable during the 5 years of study, but fluctuations in the catch rates of individual species such as bigeye tuna, albacore, and striped marlin occurred. Although the longline fishery was a winter fishery in the 1970s (Figure 1), there was also a summer fishery in the 1960s. The estimated annual catch of major tuna species was obtained by combining the catch by longliners with the catch by the baitboats (Table 2).

Kawakawa was the species most frequently caught by trolling gear (Figure 2). Areas where large numbers of kawakawa were caught have remained productive for this species throughout the survey period. Yellowfin tuna was plentiful at Pearl and Hermes Reef. Trolling at Kure was very poor.

Trolling catch rates for coastal pelagic fishes decreased toward the northwest end of the chain (Table 3). This decrease could be due to environmental conditions, or to the pole-and-line fishing by the Japanese, or other factors. The catch rates of coastal pelagic fishes appeared to decline with time (Figure 3). A regression of catch rate on time produced a significant negative slope for both Nihoa ($P = 0.024$) and Laysan ($P = 0.006$) indicating a decline in apparent abundance over time.

TABLE 1. ESTIMATED ANNUAL CATCH, EFFORT, AND CATCH PER UNIT EFFORT BY FOREIGN LONGLINERS WITHIN 200 MILES OF THE NORTHWESTERN HAWAIIAN ISLANDS, 1971-75 (Yong and Wetherall, 1980)

Year	Species[1]	Effort		Catch		CPUE
		Days	Hooks	(kg)	(No.)	No./1,000 Hooks
1971	YF	1,592	3,184,000	467,437	9,872	3.10
	BE	—	—	820,988	19,155	6.02
	AL	—	—	397,875	15,658	4.92
	BF	—	—	1,121	6	0.00
	SJ	—	—	1,604	353	0.11
	All tunas	—	—	1,689,025	45,044	14.15
	BLM	—	—	81,496	838	0.26
	BM	—	—	2,700	56	0.02
	SM	—	—	261,192	8,583	2.70
	SWF	—	—	58,233	747	0.23
	SBSF, SF	—	—	8,271	512	0.16
	All billfishes	—	—	411,894	10,736	3.37
1972	YF	1,747	3,494,000	260,452	5,391	1.54
	BE	—	—	1,284,487	28,250	8.08
	AL	—	—	478,494	18,713	5.36
	BF	—	—	1,534	8	0.00
	SJ	—	—	1,982	273	0.08
	All tunas	—	—	2,026,949	52,635	15.06
	BLM	—	—	53,382	690	0.20
	BM	—	—	2,281	38	0.01
	SM	—	—	172,714	5,394	1.54
	SWF	—	—	178,456	2,289	0.66
	SBSF, SF	—	—	8,195	477	0.14
	All billfishes	—	—	415,028	8,888	2.54
1973	YF	985	1,970,000	132,825	2,706	1.37
	BE	—	—	496,445	10,244	5.20
	AL	—	—	348,159	15,150	7.69
	BF	—	—	1,661	8	0.00
	SJ	—	—	625	102	0.05
	All tunas	—	—	979,716	28,210	14.32
	BLM	—	—	17,695	251	0.13
	BM	—	—	1,087	14	0.01
	SM	—	—	78,215	2,966	1.50
	SWF	—	—	82,431	1,057	0.54
	SMSF, SF	—	—	9,951	559	0.28
	All billfishes	—	—	189,379	4,847	2.46
1974	YF	444	888,000	118,991	2,411	2.72
	BE	—	—	95,463	2,457	2.77
	AL	—	—	280,710	11,755	13.24
	BF	—	—	1,631	8	0.01
	SJ	—	—	547	108	0.12
	All tunas	—	—	497,345	16,739	18.85
	BLM	—	—	24,429	371	0.42
	BM	—	—	1,172	18	0.02
	SM	—	—	20,191	725	0.82
	SWF	—	—	41,981	538	0.61
	SBSF, SF	—	—	7,014	439	0.49
	All billfishes	—	—	94,787	2,091	2.35
1975	YF	832	1,664,000	170,677	3,798	2.28
	BE	—	—	512,260	11,792	7.09
	AL	—	—	169,695	7,446	4.47
	BF	—	—	1,652	8	0.00
	SJ	—	—	695	169	0.10
	All tunas	—	—	854,979	23,213	13.95
	BLM	—	—	13,766	178	0.11
	BM	—	—	649	11	0.01
	SM	—	—	69,622	2,447	1.47
	SWF	—	—	24,798	318	0.19
	SBSF, SF	—	—	6,775	408	0.24
	All billfishes	—	—	115,610	3,362	2.02

[1]YF = yellowfin tuna, Thunnus albacares; BE = bigeye tuna, T. obesus; AL = albacore, T. obesus; AL = albacore, T. alalunga; BF = bluefin tuna, T. orientalis; SJ = skipjack tuna, Katsuwonus pelamis; BLM = blue marlin, Makaira nigricans; BM = black marlin, M. indica; SM = striped marlin, Tetrapturus audax; SWF = swordfish, Xiphias gladius; SBSF = shortbill spearfish, T. angustirostris; and SF = sailfish, Istiophorus platypterus.

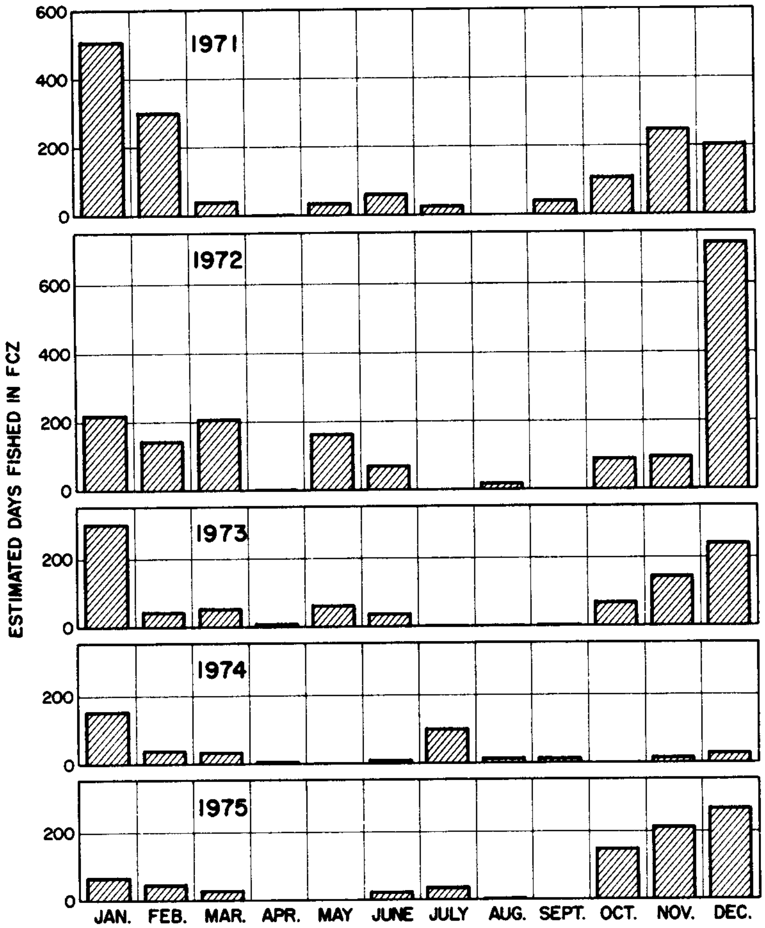

Figure 1. Estimated monthly effort by Japanese longliners within the 200-mile Fishery Conservation Zone of the Northwestern Hawaiian Islands, 1971-75 (Yong and Wetherall, 1980).

TABLE 2. ESTIMATED ANNUAL CATCH (METRIC TONS) OF TUNAS IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1972-77[1]

Year	Albacore	Yellowfin tuna	Bigeye tuna	Bluefin tuna	Skipjack tuna
1972	577	277	1,287	2	2
	26	19	105	26	1,282
	603	296	1,392	28	1,284
1973	348	133	496	2	1
	0	20	109	0	823
	348	153	605	2	824
1974	281	119	95	2	1
	0	50	147	0	1,971
	281	169	242	2	1,972
1975	170	171	512	2	1
	89	167	71	25	1,906
	279	338	583	27	1,907
1976	912	330	1,155	1	1
	0	124	92	0	4,294
	912	454	1,247	1	4,295
1977	480	308	1,514	1	1
	49	337	734	0	4,375
	529	645	2,248	1	4,376

[1]First line is annual catch by foreign longliners.
Second line is annual catch by baitboats.
Third line is total annual catch (line 1 + line 2).

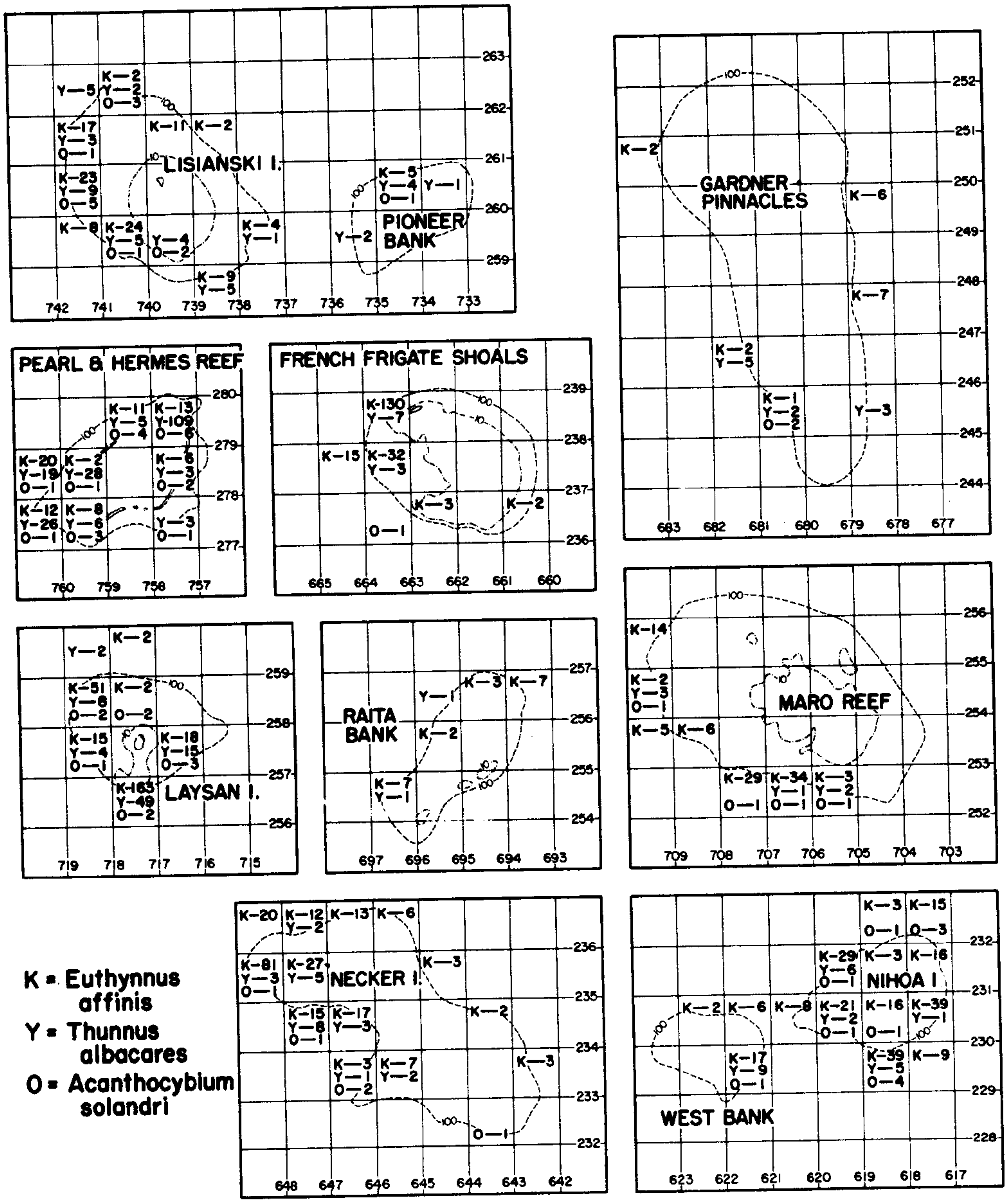

Figure 2. Distribution of coastal pelagic fishes in the Northwestern Hawaiian Islands as depicted by the number of fishes caught per cell by trolling, 1976-79

TABLE 3. RELATIVE APPARENT ABUNDANCE OF TROLL-CAUGHT COASTAL PELAGIC FISHES IN THE NORTHWESTERN HAWAIIAN ISLANDS

Island/Bank	Effort (Hook/h)	Total Catch (No.)	Catch Rate (No./Hook/h)	No. of Each Species Caught:[1]										
				KK	YF	SJ	WA	DO	RN	BA	C1	C2	C3	BLM
Nihoa	375.2	363	0.97	319	29	4	11	--	--	--	--	--	--	--
Necker	413.4	285	0.69	227	30	10	6	6	2	3	--	1	1	--
French Frigate Shoals	303.1	224	0.74	183	13	19	2	3	1	--	--	3	--	--
Brooks	13.8	7	0.51	7	--	--	--	--	--	--	--	--	--	--
Gardner Pinnacles	200.3	59	0.29	43	10	--	4	1	1	--	--	--	--	--
Raita	12.8	21	1.64	19	2	--	--	--	--	--	--	--	--	--
Maro	241.4	175	0.72	129	3	6	4	7	1	--	10	2	13	--
Laysan	457.1	389	0.85	252	78	18	11	--	2	15	5	5	4	--
Northampton Seamount	99.0	42	0.42	15	15	1	10	--	--	--	--	--	--	1
Pioneer	32.5	24	0.74	6	7	--	3	--	--	--	8	--	--	--
Lisianski	404.7	206	0.51	121	33	6	13	1	--	--	32	--	--	--
Salmon	10.1	6	0.60	1	4	1	--	--	--	--	--	--	--	--
Pearl and Hermes Reef	889.3	379	0.43	77	248	7	18	1	6	--	22	--	--	--
Midway	29.8	2	0.07	--	2	--	--	--	--	--	--	--	--	--
Kure	58.2	1	0.02	--	1	--	--	--	--	--	--	--	--	--

[1]KK = kawakawa; YF = yellowfin tuna; SJ = skipjack tuna; WA = ono; DO = mahimahi; RN = rainbow runner; BA = barracuda, Sphyraena helleri; C1 = white ulua, Caranx ignobilis; C2 = omilu, C. melampygus; C3 = kahala, Seriola dumerili; and BLM = blue marlin.

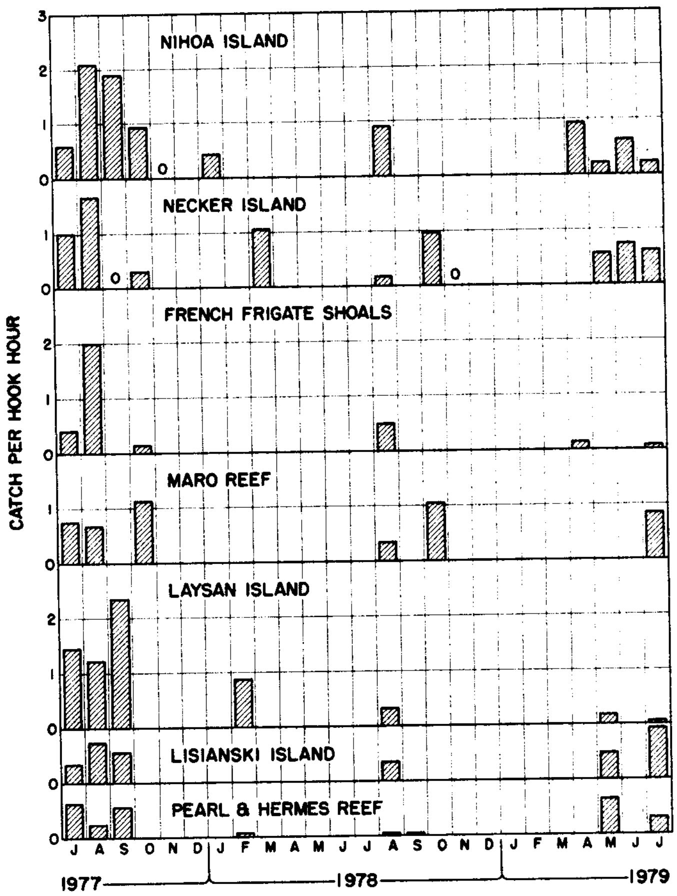

Figure 3. Changes in the catch rate of coastal pelagic fishes with time.

Age and growth

Preliminary von Bertalanffy growth curves were calculated for kawakawa and albacore (Figures 4 and 5).

Fecundity and spawning season

Yellowfin tuna caught on the banks were undeveloped throughout the year. Work to obtain fecundity estimates of ono are presently in progress. Ova development does not appear to be homogeneous within the ono's ovary.

Foraging habits

Over 285 stomach content samples have been collected from troll-caught kawakawa, yellowfin tuna, skipjack tuna, ono, mahimahi, and rainbow runner.

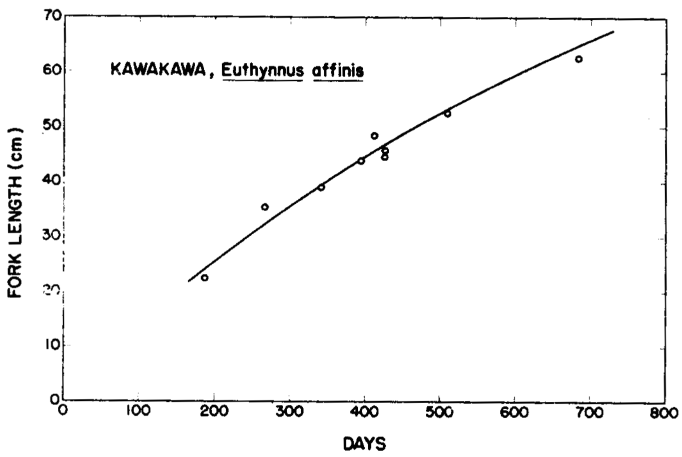

Figure 4. Growth curve of kawakawa from the Northwestern Hawaiian Islands. Von Bertalanffy growth parameters: L_∞ = 117.8 cm, K = 0.42 cm, and T_O = -0.03.

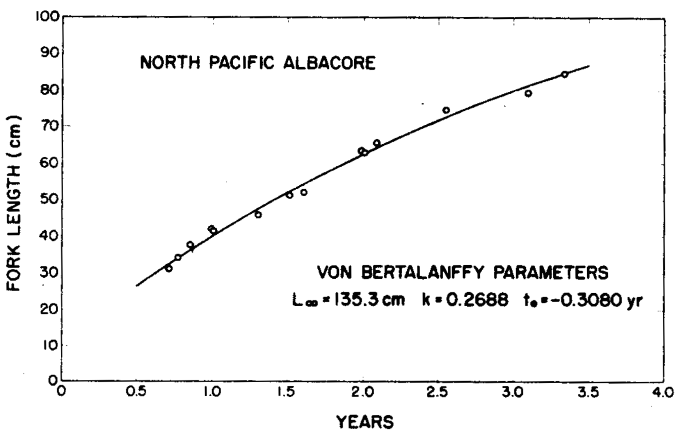

Figure 5. Growth curve of North Pacific albacore

Tagging

Nine-hundred ninety-nine kawakawa, yellowfin tuna, and ono were tagged in 1977. Only a single recovery has been reported, thus far. A yellowfin tuna tagged at Pearl and Hermes Reef was recovered by a Japanese pole-and-line fishing vessel northwest of Pearl and Hermes Reef (lat. 27°40'N, long. 170°30'W). The fish had traveled at least 31 nmi in 37 days.

Night-light stations

Twenty-four night-light stations, mostly during the summer months, have been occupied since 1978. Mackerel scad were attracted to the light at French Frigate Shoals and Kure.

DISCUSSION AND CONCLUSIONS

The catch statistics of foreign longline operations probably provides the best measure of apparent abundance. Estimates of catch and effort by Korean longline vessels operating in the FCZ will also be analyzed in the future.

Because the results are only preliminary no conclusions are made at this time.

FUTURE RESEARCH NEEDS

More fishing effort is needed to observe a change in the relative abundance of the coastal pelagic fishes and to be able to estimate stock size. To determine seasonal availability, more fishing effort is required during the fall, winter, and early spring. Experiments to validate daily growth rings on otoliths have begun for kawakawa and the bigeye scad. Other pelagic species should also be aged. A study of the pelagic squid resource is also needed.

SUMMARY

The relative apparent abundance of longline and troll-caught pelagic species were estimated. Growth curves of *Euthynnus affinis* and *Thunnus alalunga* were estimated from daily growth rings on otoliths. Maturation of ovarian ova in ono was nonhomogeneous at the preripe stage.

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