AN ABSTRACT OF THE THESIS OF

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Title: REEF FISHES NEAR DEPOE BAY, OREGON: MOVEMENT AND THE RECREATIONAL FISHERY

Approved: Redacted for privacy

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The recreational fishery on reefs near Depoe Bay, Oregon, was monitored to determine the nature and extent of existing fishing pressure. Species composition and seasonal variation of the sport and research catch on these reefs are described. Adult lingcod (*Ophiodon elongatus*), black rockfish (*Sebastes melanops*), blue rockfish (*S. mystinus*), and yelloweye rockfish (*S. ruberrimus*) were tagged to determine if they are resident on the reefs or are transient or migratory. The study was conducted from July 1976 to September 1978.

Fishing pressure from recreational anglers increased from 1976 to 1978. The number of fishing trips and number of anglers was highest in April and May and relatively high in September and October. The catch per unit effort was consistently higher on charter boats (three year mean = 2.73 fish/angler hour) than on private boats (three year mean = 1.57 fish/angler hour) and increased three-fold on charter boats from 1976 to 1978.

The five most important species by numbers recorded in the recreational catch were black rockfish, lingcod, yelloweye rockfish, canary rockfish (*S. pinniger*), and China rockfish (*S. nebulosus*). Two species, black rockfish and lingcod, comprised 59% of the total bottomfish catch. Lingcod and black rockfish showed a marked difference in seasonal abundance with black rockfish being least abundant in winter and lingcod being most abundant in winter. Lengths and weights of blue and black rockfish tended to be smaller in winter 1976 than in summer and fall 1976 and spring 1977, but these values were lower for these species in summer 1977. Lingcod lengths and weights showed no significant seasonal differences ($P \gtrsim 0.95$)

Thirteen hundred fish were tagged on three reefs from August 1976 to October 1977. Tag return for 33 yelloweye rockfish was 21%. Recaptured individuals exhibited no movement from the reef of tagging. Of 186 lingcod tagged, 5% were recaptured. Two of these fish exhibited movement; one was recaptured 39 km and the other 228 km from the reef of capture. One percent of 916 black rockfish tags were returned. Two of these fish moved; one was recaptured 24 km and the other 619 km from the reef of tagging. No blue rockfish were recaptured, out of 138 tagged.

These data suggest that localized overfishing on reefs near Depoe Bay may already exist. Management and research recommendations are given emphasizing the need to determine where recruitment to neritic reefs originates. Area closures at first indication of localized stock depression are recommended as a possible conservation measure.

Reef Fishes Near Depoe Bay, Oregon: Movement and the Recreational Fishery

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

REEF FISHES NEAR DEPOE BAY, OREGON:
MOVEMENT AND THE RECREATIONAL FISHERY

INTRODUCTION

This thesis reports on a tagging study of four species of bottomfish found on neritic reefs off the central Oregon coast, and characterizes the effort expended by the recreational fishery out of Depoe Bay, Oregon, associated with these and other neritic reef fishes. The research was initiated to provide biological and statistical criteria for use in managing these stocks of reef fishes. The study was conducted from July 1976 through September 1978 in Depoe Bay and on the neritic reefs just north of Depoe Bay from Government Point to Cascade Head.

In the Pacific Northwest, pressure from recreational (both charter and private) and commercial fishing is reported to be increasing rapidly on stocks of neritic reef fishes. Competition between recreational and commercial fishermen has occurred in central California neritic areas (Parrish and Miller 1971) and has been predicted for Oregon waters (Barker 1974). To date, the recreational fishery for bottomfish off the central Oregon coast has not been quantified.

General concern for conservation of neritic reef species resulted in the establishment in 1975 by the Oregon Department of Fish and Wildlife (ODFW) of a 25-fish bag limit for recreational harvest of marine food fishes. Biologists of ODFW agreed that this legislation was based on a paucity of biological information and that further studies were needed (personal communication, Jerry Butler, ODFW, Newport, OR). The 25-fish bag limit set in 1975 allowed for two halibut (Hippoglossus stenolepis), three lingcod (Ophiodon elongatus) and 20 of all other ocean fish per day. The regulation made no breakdown of the "other ocean fish". In an attempt to begin regulating the harvest of rockfish while biological data was being collected, ODFW biologists recommended in 1978 that the allowable daily catch of ocean food fish be reduced to 10 (including three lingcod and two halibut). The wording of this new regulation generated public efforts to liberalize the bag limits for anglers who desired to catch more than 10 ocean fish other than rockfish. A revised wording of the 1978 regulation put the daily rockfish limit at 15.

The recreational fishery out of Depoe Bay is typical for small fishing ports along the Oregon coast. The charter boat fishery consists of two distinct operations: trolling for salmon (Oncorhynchus sp.) and albacore (Thunnus alalunga) and jigging for bottomfish. The main emphasis of the fishery is on salmon. Most angling for bottomfish traditionally occurs in the early spring (late March through June) and in the fall (September and October) when the abundance of salmon decreases and the weather still allows for some predictability in the scheduling of trips. In 1976-77 there were 4-5 offices handling approximately 20 actively operating charter boats (6- and 12-man boats). One boat operated year-round in 1975, two in 1976, and three in 1977. Concern has been expressed by local charter boat operators and by R. W. Jacobson (Marine Extension Agent in Fisheries, Newport, OR) that at the current rate of increase in fishing pressure, depletion of certain local stocks may occur. Fred Robison (Charter boat operator, Jimco Dock, Depoe Bay, OR) reported that the reefs are apparently "fished-out" progressively from south to north as the number of boats fishing on the reef areas increases and the season progresses.

There is a general supposition held by fishermen and biologists that onshore migrations during the spawning period of offshore stocks of both lingcod (Wilby 1937; Chatwin 1956; Phillips 1958; Hart 1973; Miller and Geibel 1973) and certain species of rockfish (Genus Sebastes) (Miller and Geibel 1973) serve to repopulate these "fished-out" areas. However limited tagging studies of offshore populations (Reeves 1966; Miller and Geibel 1973) have failed to confirm this seasonal migration. On the other hand, there is also little evidence to suggest that these offshore populations are resident.

Observations by Miller et al. (1967) on blue rockfish (Sebastes mystinus) and by Carlson and Haight (1972) on adult yellowtail rockfish (S. flavidus) indicate a disjunct distribution of these species that aggregate on inshore reefs. If shown for other rockfish species, such discreteness would be an important consideration in decisions affecting their management. Studies by Chatwin (1956) and Reeves (1966) indicate that such discreteness may also describe the distribution of lingcod inhabiting inshore reefs.

In an effort to develop needed biological and statistical information for conservation of the bottomfish and the recreational bottomfish fishery off the central oregon coast, the specific objectives of this investigation were:

1) To determine if adult lingcod, yelloweye rockfish (*Sebastes ruberrimus*), black rockfish (*S. melanops*), and blue rockfish tagged on neritic reefs adjacent to Depoe Bay, Oregon, exhibit residual or migratory behavior.
2) To characterize the recreational bottomfish fishery currently existing on neritic reefs adjacent to Depoe Bay, Oregon.
3) To determine the species composition of the recreational bottomfish catch on neritic reefs adjacent to Depoe Bay, Oregon, and to describe any seasonal variation in this catch.

MATERIALS AND METHODS

Study Area

The tagging study area was located just north of Depoe Bay, Oregon, and extended from Government Point to Cascade Head between the 10- and 50-m depth contours (Fig. 1). Three reefs were selected as capture, tagging, and release sites on the basis of depth, species composition, and probable fishing pressure as reported for previous years by captains of charter boats. Two of these reefs, Nelscott and Government Point, were shallow and ranged in depth from 10-20 m; while D River Reef was deeper and ranged in depth from 20-30 m. A detailed description of the hydrography of the study area was given by Steiner (1979).

Sampling Methods

Fishing was conducted from August 1976 to October 1977 from the R/V Tooshqua, a 7.8-m (26-ft) Oregon dory powered by a 140-hp inboard-outboard OMC stern drive engine. The dory was equipped with a citizens band radio, VHF radio, navigation compass, continuously recording depth sounder, and LORAN A.

Fish to be tagged were captured by use of jigs and baited fish traps. The jigs were both chrome Norwegian and conventional lead as described by Barker (1974). One or two small plastic lures (hootchies) were affixed with a hook in a 1-m spacing above the jig. The fish traps (Marine Manufacturing, Bellingham, Washington) measured 240 cm (8 ft) long by 84.6 cm (34 in) square with a netting of 36-strand No. 72 nylon with an approximate 6.35-cm (2 1/2-in) stretch mesh. The traps were baited with herring (Clupea harengus pallasi), or with fresh rockfish carcasses and fished overnight or as weather permitted. After capture, fish were identified, weighed, measured, and tagged. A Floy Model FDM-68 tagging gun and serially numbered Floy FDB anchor tags (Floy Tag and Manufacturing, Inc., Seattle, Washington) of green

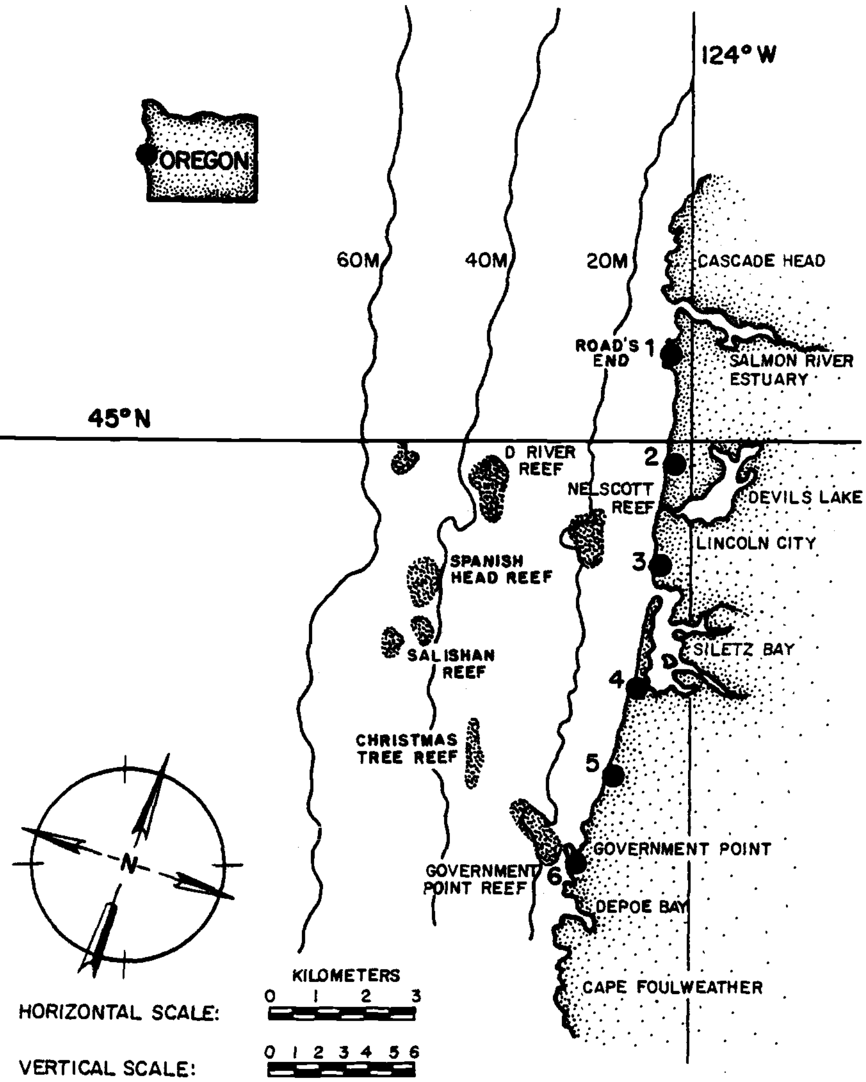

Figure 1. Map of the reef fish study area from Government Point to Cascade Head, Oregon. (Horizontal scale west of the coastline is enlarged 2X.)

vinyl plastic "spaghetti" tubing were used. Tags were marked with the following return instructions: "Return to Fisheries, OSU, Corvallis, OR. Tell size, date, and where caught." Tags were inserted into the musculature between the pterygiophores of the dorsal fin.

During the initial stages of the study, an attempt to increase the survival of tagged rockfish displaying effects of rapid decompression (i.e., everted stomach or bulging eyes) was made by deflating the swim bladder with a syringe using the methods described by Gotshall (1964). Because I didn't know what internal injury this practice might produce, I adopted a new method. Fish displaying effects of rapid decompression were lowered to the ocean bottom immediately after tagging using a weighted, inverted, star crab trap. Substantial numbers of yelloweye rockfish lowered to the bottom using this star trap method were subsequently recaptured, indicating the effectiveness of the method. There were no recaptures of fish whose swim bladders had been deflated with a syringe.

Fish to be released on the reef of capture were released immediately after tagging, while fish to be displaced were held in a 114-l plastic barrel containing sea water. The sea water was replaced periodically to maintain existing surface water temperature and sufficient oxygen levels, and to decrease mucus build-up in the water. During periods of high fishing success, fish were sometimes held in the barrel for up to 20 min before they were tagged and released. Fish to be displaced were held for up to three hours before being released.

Five black rockfish and three lingcod were captured and tagged in the study area and were then transported and placed in the public viewing aquarium at the Undersea Gardens (267 SW Bay Blvd., Newport, Oregon, 97365) to assess the length of tag retention and to observe post-tagging behavior. The five black rockfish and one of the lingcod were held for seven months and two lingcod were held for five months. A description of post-tagging behavior is given in Appendix 1.

A survey of the recreational boat use of neritic reefs in the study area was conducted from July 15 to September 15 in 1975, during July in 1977 and from June 15 to September 15 in 1978. Six sampling stations (approximately equidistant) were selected on the coast between Government Point and Road's End near Cascade Head (Fig. 1). These stations provided an adequate view of boats using all reefs in the study area. A 30X telescope was used to help identify boats as charter or private, to determine whether the occupants were bottomfishing or trolling for salmon, and to count the number of rods in use.

In 1976, 1977, and 1978 the survey was conducted daily between 0930 and 1130 except on foggy days or days when small craft warnings were issued. In 1976 the five stations were visited repeatedly until 1700 every fifth day. In 1977 and 1978 the survey was conducted for five consecutive days followed by a 2-day break. The break was rotated to fall on different days of the week. The scheduling books of the three charter offices handling 90% of the charter boats in Depoe Bay were examined for the years 1976 and 1977 to obtain accurate data on the number of bottomfish trips, dates and lengths of trips, and number of people fishing.

A creel census of private and charter boats was conducted from July 15 to September 15 in 1976, from July 7 to August 13 in 1977, and from June 16 to September 12 in 1978. Data were obtained from boat operators as to location of catch, length of trip, and number of people fishing. The fish were identified and counted and selected species were weighed, measured, and sexed. Additional information on species composition of the 1977 private and charter bottomfish catch in Depoe Bay was obtained from the creel census conducted from June to September by personnel of ODFW. The catch per unit of effort (CPUE) of charter and private boats was computed using the number of fish caught per person per trip.

An untransformed Students "t" test was used to determine significance of difference to the 95 percent confidence level of lengths and weights of captured rockfish.

RESULTS

Tagging

Thirteen hundred fish were tagged on the three study reefs over a 15-month period. There were marked differences in percentage tag return and evidence of movement among the different species (Tables 1 and 2). Twenty-one percent of the tagged yelloweye rockfish were recaptured. All recaptures occurred on reefs where the fish were originally caught. One yelloweye was recaptured twice over a span of 10 months. Five percent of the lingcod tags were returned. Two of the recaptured lingcod had moved a substantial distance from their reef of capture. One tagged on D River Reef in 45 m (25 fm) of water was recaptured by a commercial trawler in 104-108 m (58-60 fm) of water 39 km SW (225°) of the D River Reef. Another, tagged on Government Point Reef, was landed at Westport, Washington, 228 km north (by the most direct navigable route) by a commercial trawler operating off the Washington coast. All other recaptured lingcod exhibited no movement from the reef of capture.

One percent of the black rockfish tags were returned. Two of the black rockfish tagged on Government Point Reef were recaptured by

Table 1. Percentage return of fish tagged on reefs adjacent to Depoe Bay, Oregon, from July 1976 to October 1977.

	Number tagged	Number recaptured	Percent return
Sebastes melanops	916	9	1
Ophiodon elongatus	186	9	5
Sebastes mystinus	138	0	0
S. ruberrimus	33	7	21
S. flavidus	13	0	0
S. nebulosus	9	0	0
Scorpaenichthys marmoratus	3	1	33
Sebastes pinniger	2	0	0

Table 2. Catch and recovery information for four bottomfish species tagged on reefs adjacent to Depoe Bay, Oregon.

Species and tag number	Site of capture and release (reef)	Date of capture	Site of recapture	Date of recapture	Days at liberty	Distance moved (km)
S. ruberrimus						
01061*	D River	Aug 1976	D River	Nov 1976	92	0
01243	D River	Aug 1976	D River	Jan 1977	156	0
01085	D River	Aug 1976	D River	Apr 1977	268	0
01061**	D River	Aug 1976	D River	Jun 1977	305	0
01290	D River	Sep 1976	D River	Jul 1977	308	0
00507	D River	May 1977	D River	Jul 1977	56	0
01429	D River	Nov 1976	D River	Jul 1977	248	0
S. melanops						
01321	Govt Pt	Sep 1976	Govt Pt	Apr 1977	221	0
01462	D River	Nov 1976	D River	May 1977	174	0
01192	D River	Aug 1976	D River	May 1977	285	0
01676*	Govt Pt	Dec 1976	Govt Pt	Jun 1977	191	0
01481	D River	Nov 1976	D River	Jul 1977	251	0
Unk+	Unk	Unk	Govt Pt	Sep 1977	Unk	Unk
00359	Govt Pt	Sep 1976	Off North Yaquina Bay Jetty	Jan 1978	105	24
01369	Govt Pt	Oct 1976	Seattle, Wash.	Fall 1977	∿360	619
00953	Govt Pt	Jul 1977	Govt Pt	Apr 1978	263	0
O. elongatus						
01044*	D River	Aug 1976	D River	Nov 1976	92	0
00538	D River	May 1977	D River	Jun 1977	22	0
01819	Govt Pt	Feb 1977	Govt Pt	Mar 1977	49	0
00936	D River	Jun 1977	D River	Jul 1977	20	0
00882	D River	Jun 1977	D River	Jul 1977	33	0
Unk+	Unk	Unk	D River	Jul 1977	Unk	Unk
01633	D River	Dec 1976	Off Oregon coast 1L02365-2420	Jul 1977	244	39
01678	Govt Pt	Dec 1976	Westport, Wash.	May 1977	∿166	228
00934	D River	Jun 1977	D River	Sep 1978	∿448	0
S. marmoratus						
00802	D River	Jul 1977	D River	Jul 1977	4	0

* = re-released; **re-recaptured;

\+ = incomplete or incorrect tag return information provided.

commercial trawlers at a considerable distance from the point of original capture. One was caught off the north Yaquina Bay jetty 24 km south of the Government Point Reef. The other was landed in Seattle, Washington 619 km north (by the most direct navigable route) by a commercial trawler fishing in Puget Sound. All other black rockfish were recaptured on the reef of original capture. No tagged blue rockfish were recaptured.

All recaptured fish other than those cited above were caught by research personnel of the R/V Tooshqua, or by anglers fishing on charter or private boats originating from Depoe Bay. Only four tags (15%) were recovered by research personnel.

A small number (49) of black rockfish were displaced from Nelscott Reef across open water with a sandy bottom to the D River and Government Point Reefs. Nineteen fish were taken to the D River Reef a distance of 2.2 km NW (258°) and 30 fish were taken to Government Point Reef a distance of 14.2 km SW (185°). There were no recaptures of displaced black rockfish.

Thirteen yellowtail rockfish, 9 China rockfish (Sebastes nebulosus), 3 cabezon (Scorpaenichthys marmoratus) and 2 canary rockfish (Sebastes pinniger) also were tagged. One cabezon was recaptured four days later on the reef of original capture. No tagged individuals of the other species were recaptured.

Recreational Fishery

In both 1976 and 1977, the number of fishing trips and anglers was highest in April and May and was relatively high in September and October (Fig. 2, 3). The number of charter boat trips and anglers was higher in 1977 than in 1976 for all months recorded.

In 1976, out of 156 boats sighted in the summer survey, 80% were private and 20% were charter (Table 3). Sixty-five percent of all anglers were on the private boats and 35% were on the charter boats. In 1977, out of 75 boats sighted, 77% were private and 23% were charter. Sixty-two percent of the anglers were on the private boats and 37% on the chartered craft. In 1978, out of 62 boats sighted, 52%

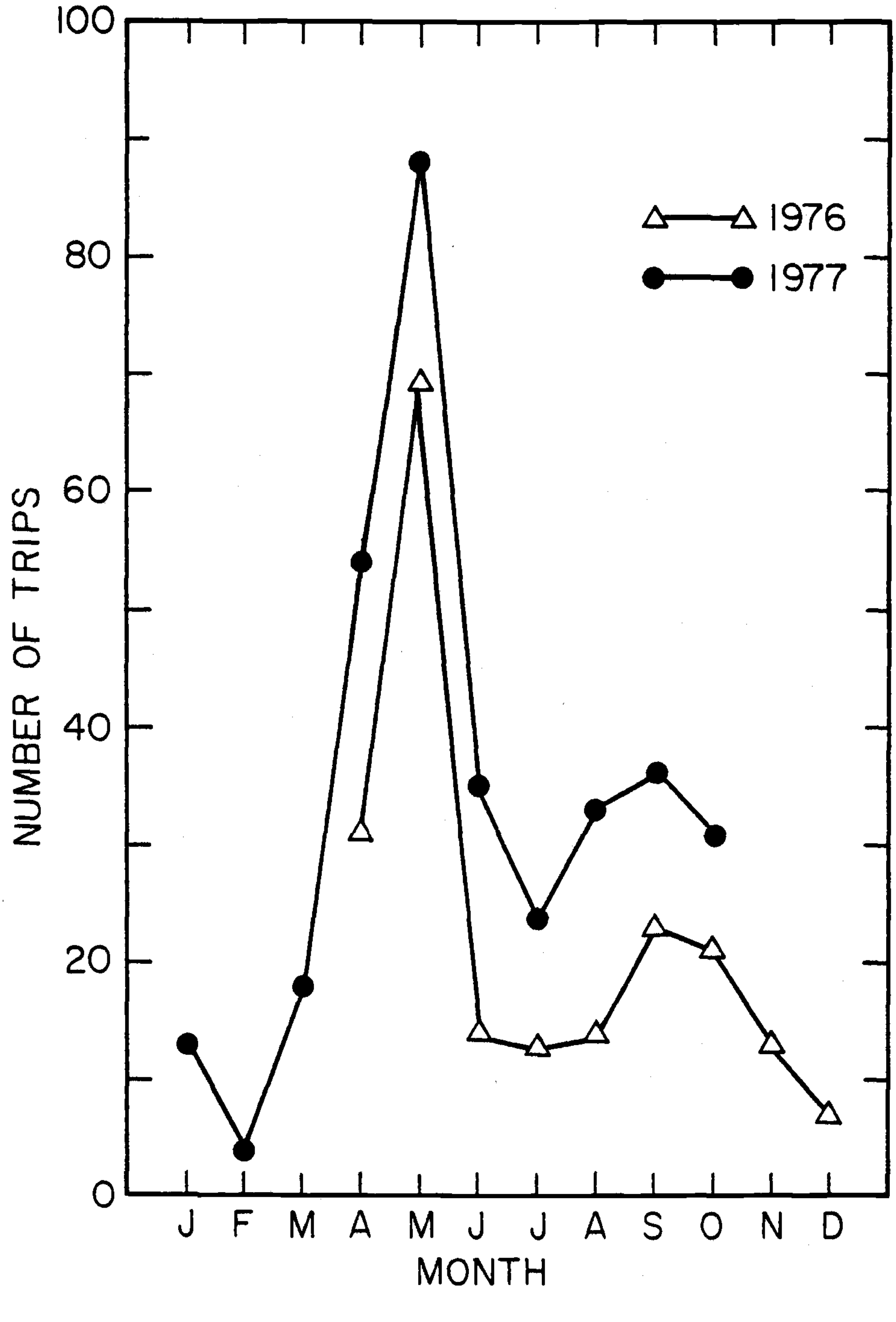

Figure 2. Number of trips per month by charter boats with passengers who angled for bottomfish on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

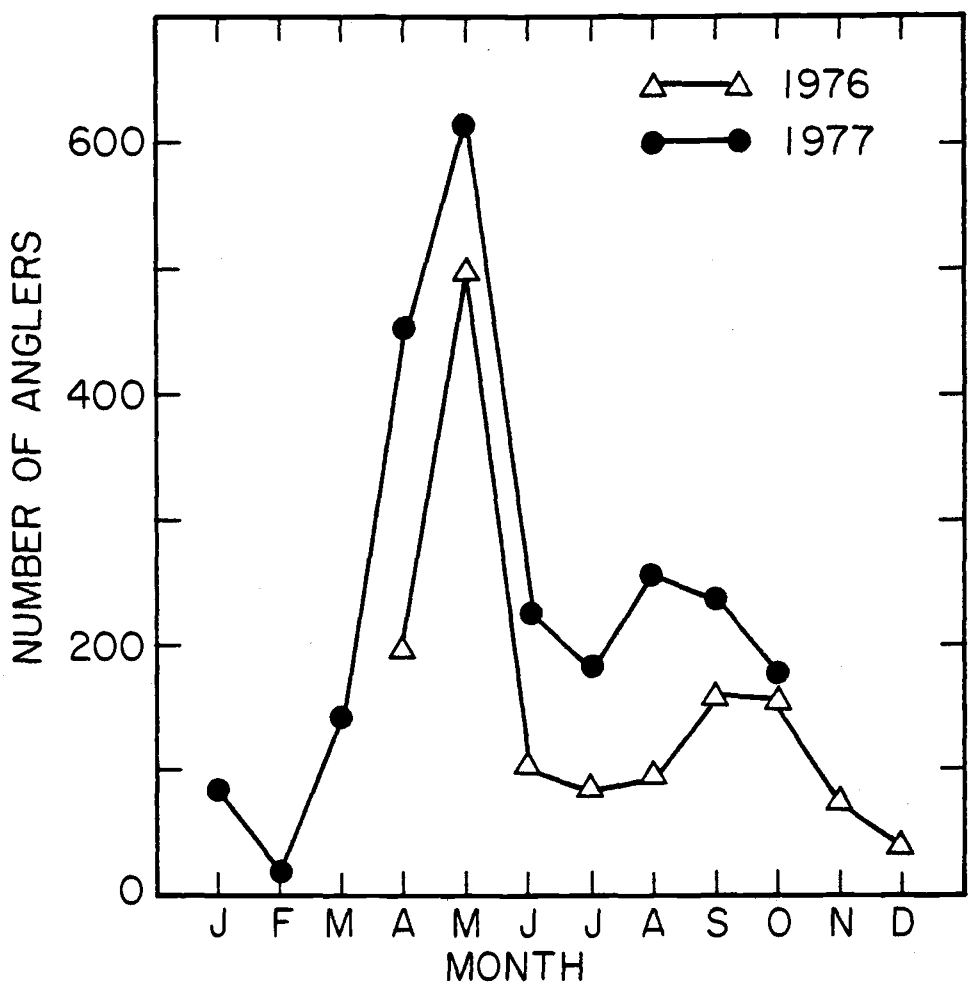

Figure 3. Number of anglers per month who bottomfished from charter boats on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

Table 3. Number of charter boats and private boats with passengers who angled for bottomfish on reefs adjacent to Depoe Bay, Oregon, during 1976-78.

	1976[a]		1977[b]		1978[c]	
	Charter	Private	Charter	Private	Charter	Private
No. boats	31	125	17	58	30	32
Est. no. anglers	179	339	106	177	200	81
Percentage total rods	35	65	37	62	71	29
Percentage total boats	20	80	23	77	48	52

[a]Data collected during July 15-September 15, 1976.

[b]Data collected during July 1-31, 1977.

[c]Data collected during June 16-September 12, 1978.

were private and 48% were charter. Twenty-nine percent of anglers were on the private boats and 71% were on the charter boats.

The 1976 creel census showed the CPUE was 1.09 fish/angler hour for the private boats and 1.35 fish/angler hour for the charter boats (Table 4). In 1977 the CPUE was 2.25 fish/angler hour for the private boats and 2.69 fish/angler hour on the charter boats. In 1978 the CPUE was 1.37 fish/angler hour for private boats and 4.16 fish/angler hour on the charter boats.

Table 4. Catch per unit of effort (CPUE) on charter and private boats with passengers who angled for bottomfish on reefs adjacent to Depoe Bay, Oregon, during 1976-78.

	1976[a]		1977[b]		1978[c]	
	Charter	Private	Charter	Private	Charter	Private
No. passengers	168	24	26	90	1021	72
Hours fished	84	23	16	77	644	104
Catch	793	67	43	172	2678	142
CPUE	1.35	1.09	2.69	2.25	4.16	1.37

[a]Data collected during July 15-September 15, 1976.

[b]Data collected during July 1-31, 1977.

[c]Data collected during June 16-September 12, 1978.

Species Composition

In all, 32 species representing 12 families were recorded in the bottomfish catch by anglers fishing offshore from Depoe Bay (Table 5). These were captured primarily with jigs. Table 6 shows the species composition of the recreational catch taken from the 1976, 1977 and 1978 marine angler surveys and the composition of the catch from the R/V Tooshqua. The two most commonly caught species on all of the four surveys were black rockfish and lingcod. Yelloweye rockfish, canary rockfish and China rockfish were next in abundance based on totals but not necessarily on each survey. The catch of the R/V Tooshqua was analyzed to test the assumption that the June to September survey period was representative of the catch during all seasons. The composition of the catch of the R/V Tooshqua was in accordance with the survey findings except that blue rockfish and cabezon replaced canary and China rockfish in the top five bottomfish species by numbers.

Table 7 shows the species composition of each reef and Figure 4 shows the relative percentage of this catch made up by the principal species. Two species, black rockfish and lingcod, comprised from 67-85% of the catch. Black rockfish was the dominant species in the catch on all three reefs. This species constituted a larger relative percentage (73-76%) of the catch on the inshore reefs (10-20 m) than on the deeper D River Reef (20-30 m) (47%). The species composition on the deeper reef was more varied and lingcod and yelloweye rockfish made up a larger percentage of the catch.

Black rockfish and lingcod exhibited the most marked difference in seasonal abundance (Table 8). The relative percentage of black rockfish in the catch was lower in the winter while that of lingcod was greater in the winter.

The mean length and weight by season of black rockfish, lingcod and blue rockfish during the 1976-77 study period is shown in Figures 5, 6, and 7. The average length of black rockfish was significantly ($P \geq 0.95$) smaller in the winter than in the summer and fall, and weights were significantly ($P \geq 0.95$) smaller in the winter than in summer, fall, and spring in 1976, but not from summer 1977. Blue

Table 5. Families and species of fish captured by recreational anglers who bottomfished on reefs adjacent to Depoe Bay, Oregon, from Jun-Sep in 1976-78.

Family - Common name	Scientific name
Carcharhinidae	
blue shark	Prionace glauca (Linnaeus 1758)
Squalidae	
spiny dogfish	Squalus acanthias (Linnaeus 1758)
Rajiidae	
big skate	Raja binoculata Girard 1854
Chimaeridae	
ratfish	Hydrolagus colliei (Lay and Bennett 1839)
Salmonidae	
Chinook salmon	Oncorhynchus tshawytscha (Walbaum 1792)
Merluciidae	
Pacific hake	Merluccius productus (Ayres 1855)
Carangidae	
jack mackerel	Trachurus symmetricus (Ayres 1855)
Anarhichadidae	
wolfeel	Anarrhichthys ocellatus Ayres 1855
Scorpaenidae	
copper rockfish	Sebastes caurinus Richardson 1845
yellowtail rockfish	S. flavidus (Ayres 1862)
quillback rockfish	S. maliger (Jordan and Gilbert 1880)
black rockfish	S. melanops Girard 1856
vermilion rockfish	S. miniatus (Jordan and Gilbert 1880)
blue rockfish	S. mystinus (Jordan and Gilbert 1880)
China rockfish	S. nebulosus Ayres 1854
tiger rockfish	S. nigrocinctus Ayres 1859
bocaccio	S. paucispinis Ayres 1854
canary rockfish	S. pinniger (Gill 1864)
rosy rockfish	S. rosaceus Girard 1854
yellow~~tail~~eye rockfish	S. ruberrimus (Cramer 1895)
flag rockfish	S. rubrivinctus (Jordan and Gilbert 1880)
Hexagrammidae	
kelp greenling	Hexagrammos decagrammus (Pallas 1810)
rock greenling	H. lagocephalus (Pallas 1810)
lingcod	Ophiodon elongatus Girard 1854
Cottidae	
cabezon	Scorpaenichthys marmoratus (Ayres 1854)
red Irish lord	Hemilepidotus hemilepidotus (Tilesius 1810)
Pleuronectidae	
petrale sole	Eopsetta jordani (Lockington 1879)
Pacific halibut	Hippoglossus stenolepis Schmidt 1904
rock sole	Lepidopsetta bilineata (Ayres 1855)
English sole	Parophrys vetulus Girard 1854
starry flounder	Platichthys stellatus (Pallas 1811)
sand sole	Psettichthys melanostictus Girard 1854

Table 6. Species composition, expressed as percentage, of neritic fishes captured adjacent to Depoe Bay, Oregon, by offshore anglers and research personnel during 1976-78.

	1976[a] (N=684)	1977[b] (N=2848)	1976-77[c] (N=1731)	1978[d] (N-2597)	Total catch (N-7860)
Sebastes melanops	45	39	63	35	43
Ophiodon elongatus	13	18	14	16	16
Sebastes ruberrimus	14	8	3	12	9
S. pinniger	5	4	1	14	7
S. nebulosus	7	8	2	5	6
Scorpaenichthys marmoratus	6	6	3	4	4
Hexagrammos decagrammus	4	6	1	5	4
Sebastes mystinus	4	t	11	t	3
Unidentified mackerel	0	6	0	t	2
Sebastes flavidus	t[g]	t	1	2	1
Hemilepidotus hemilepidotus	1	1	t	t	t
Sebastes maliger	t	t	0	1	t
S. caurinus	0	t	t	t	t
Psettichthys melanostictus	0	t	0	t	t
Sebastes miniatus	0	0	0	1	t
Platichthys stellatus	t	t	t	t	t
Sebastes nigrocinctus	t	t	0	t	t
Prionace glauca	0	t	0	t	t
Sebastes paucispinis	0	t	0	0	t
Merluccius productus	0	t	0	t	t
Hexagrammos lagocephalus	t	0	t	0	t
Hydrolagus colliei	t	t	0	t	t
Raja binoculata	0	t	0	t	t
Eopsetta jordani	0	0	t	t	t
Parophrys vetulus	0	0	0	t	t
Hippoglossus stenolepis	0	0	0	t	t
Sebastes rosaceus	t	0	0	0	t
Squalus acanthias	0	t	t	t	t
Anarrhichthys ocellatus	0	t	t	t	t
Lepidopsetta bilineata	0	0	t	0	t
Sebastes rubrivinctus	0	0	t	0	t
Oncorhynchus tshawytscha	0	0	t	0	t
Trachurus symmetricus	0	0	t	0	t
Total[f]	99	95	99	95	95

(a) Data from census conducted by research personnel Jul 15-Sep 15, 1976; (b) Data from the ODFW (Jerry Butler), census conducted Jun-Sep 1977; (c) Data from specimens captured by research personnel aboard R/V Tooshqua Aug 1976-Oct 1977; (d) Data from census conducted by research personnel Jun 16-Sep 12, 1978; (e) Recorded as unidentified mackerel by the ODFW, I assume they were Carangids; (f) Percentage do not add to 100 due to rounding error; (g) t = <1%.

Table 7. Species composition by reef of fish caught adjacent to Depoe Bay, Oregon from August 1976 to October 1977.

Species	Government Point Reef			Nelscott Reef			D River Reef			
	Number caught	% for species	% all species	Number caught	% for species	% all species	Number caught	% for species	% all species	Total
Sebastes melanops	573	53	73	212	20	76	301	28	47	1086
Ophiodon elongatus	92	37	12	26	10	9	130	52	20	248
Sebastes mystinus	90	47	11	9	5	3	92	48	14	191
Sebastes rubberimus	1	2	t*	0	0	0	55	98	9	56
Scorpaenichthys marmoratus	17	38	2	15	33	5	13	29	2	45
Hexagrammos decagrammus	4	22	t	9	5	3	5	3	t	18
Sebastes nebulosus	3	11	t	5	19	2	19	70	3	27
S. pinniger	5	36	t	1	7	t	8	57	1	14
S. flavidus	4	24	t	0	0	0	13	76	2	17
S. caurinus	0	0	t	0	0	0	1	100	t	1
Lepidopsetta bilineata	0	0	0	1	100	0	0	0	0	1
Sebastes rubrivinctus	0	0	0	0	0	0	1	100	t	1
Total	789		98	278		98	638		98	1705

*t = less than 1%.

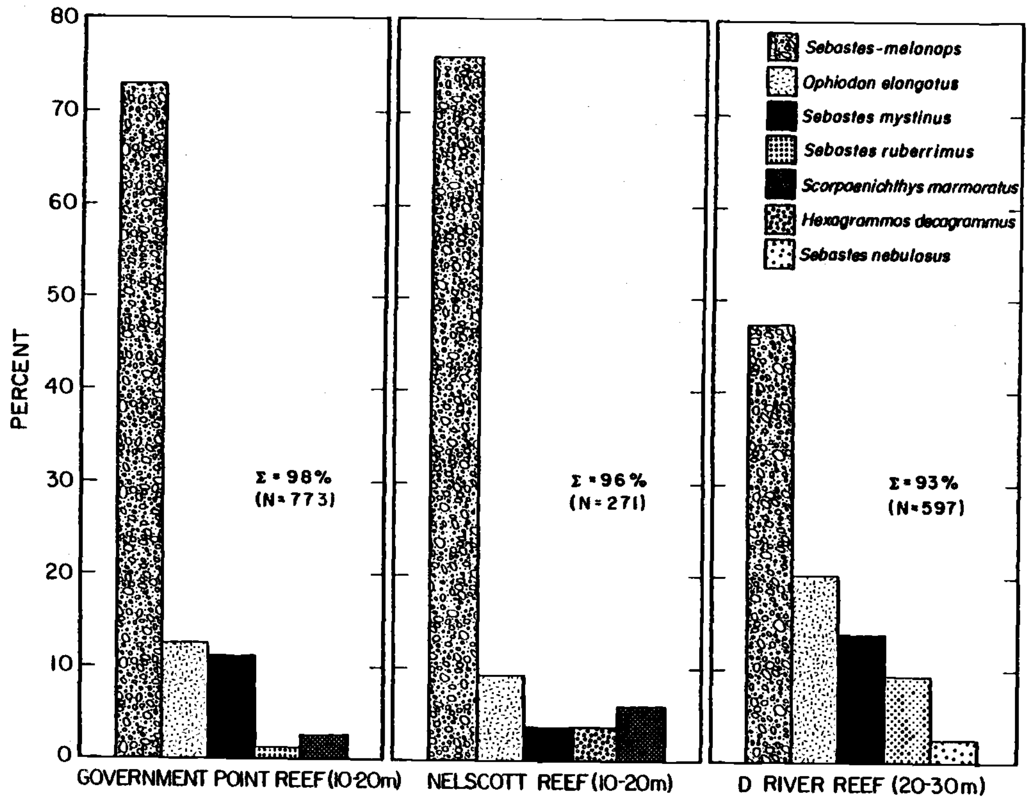

Figure 4. Relative percentage of total catch comprised of the five principal species caught on the Government Point, Nelscott and D River reefs, respectively, adjacent to Depoe Bay, Oregon, 1976-77.

Table 8. Seasonal abundance, expressed as percentage, of species captured by research personnel on reefs adjacent to Depoe Bay, Oregon, during 1976 and 1977.

Season	*Sebastes mystinus*		*S. melanops*		*S. ruberrimus*		*Ophiodon elongatus*		Total catch	Percent
	Number caught	% of total catch	Number caught	% of total catch	Number caught	% of total catch	Number caught	% of total catch		
Summer	48	14	246	71	21	6	32	9	347	100
Fall	47	14	254	73	4	1	42	12	347	100
Winter	31	16	88	47	9	5	61	32	189	100
Spring	27	11	169	70	4	2	43	18	243	100
Summer	35	9	313	82	6	2	30	8	384	100
Total	188		1070		44		208		1510	

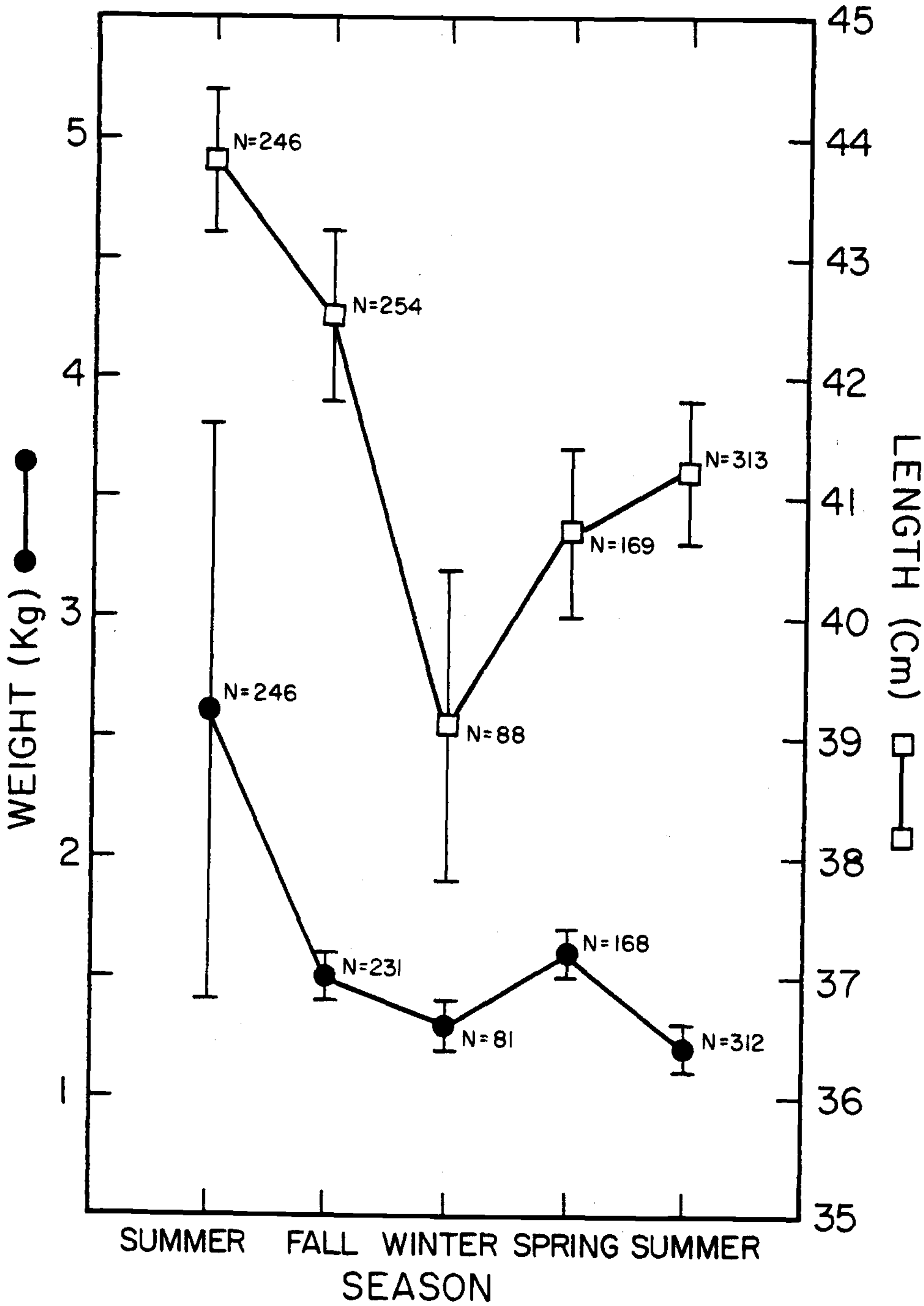

Figure 5. Mean weight and length ($P \geq 0.95$) by season of *Sebastes melanops* caught by research personnel on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

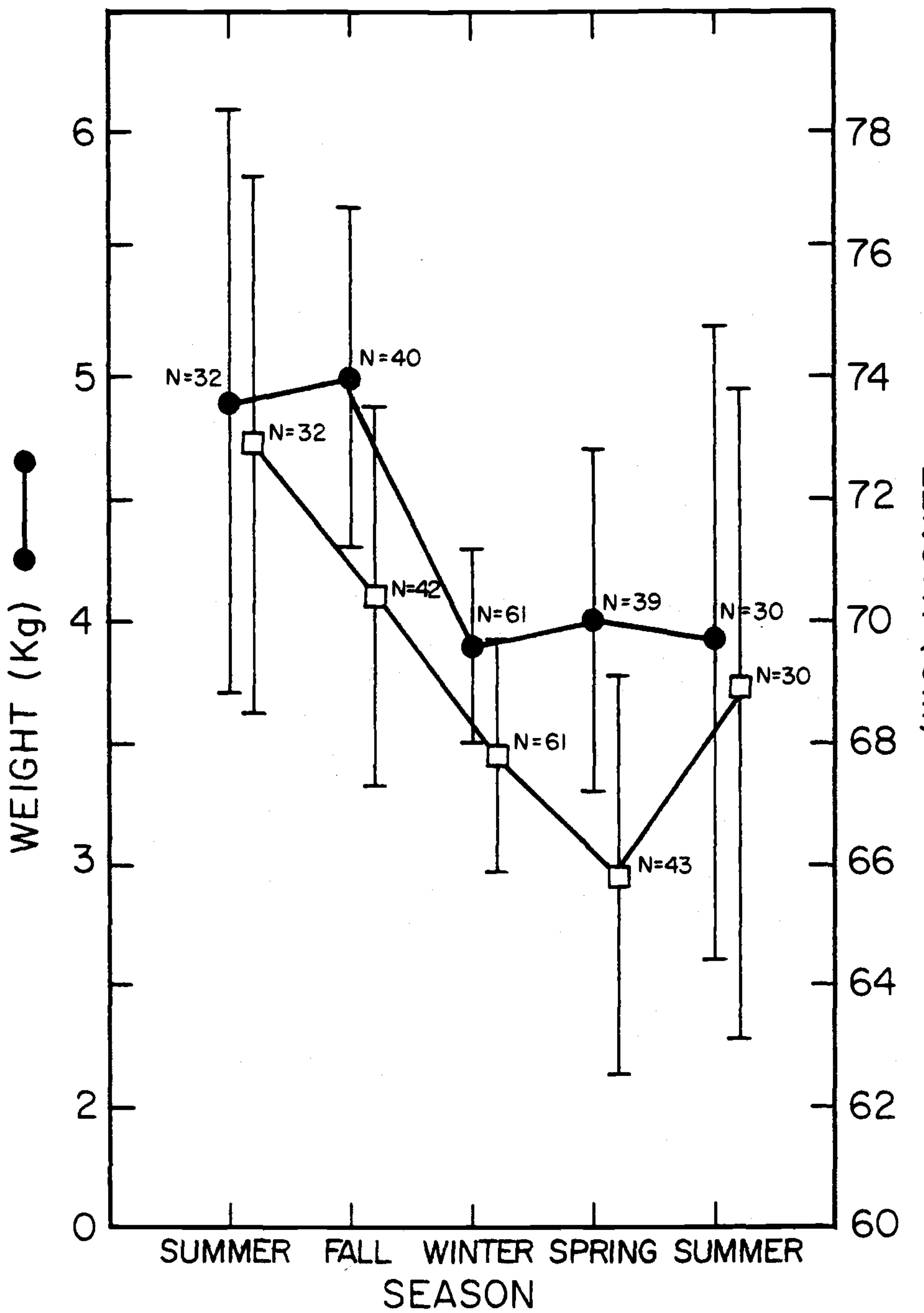

Figure 6. Mean weight and length (P ≥ 0.95) by season of <u>Ophiodon elongatus</u> caught by research personnel on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

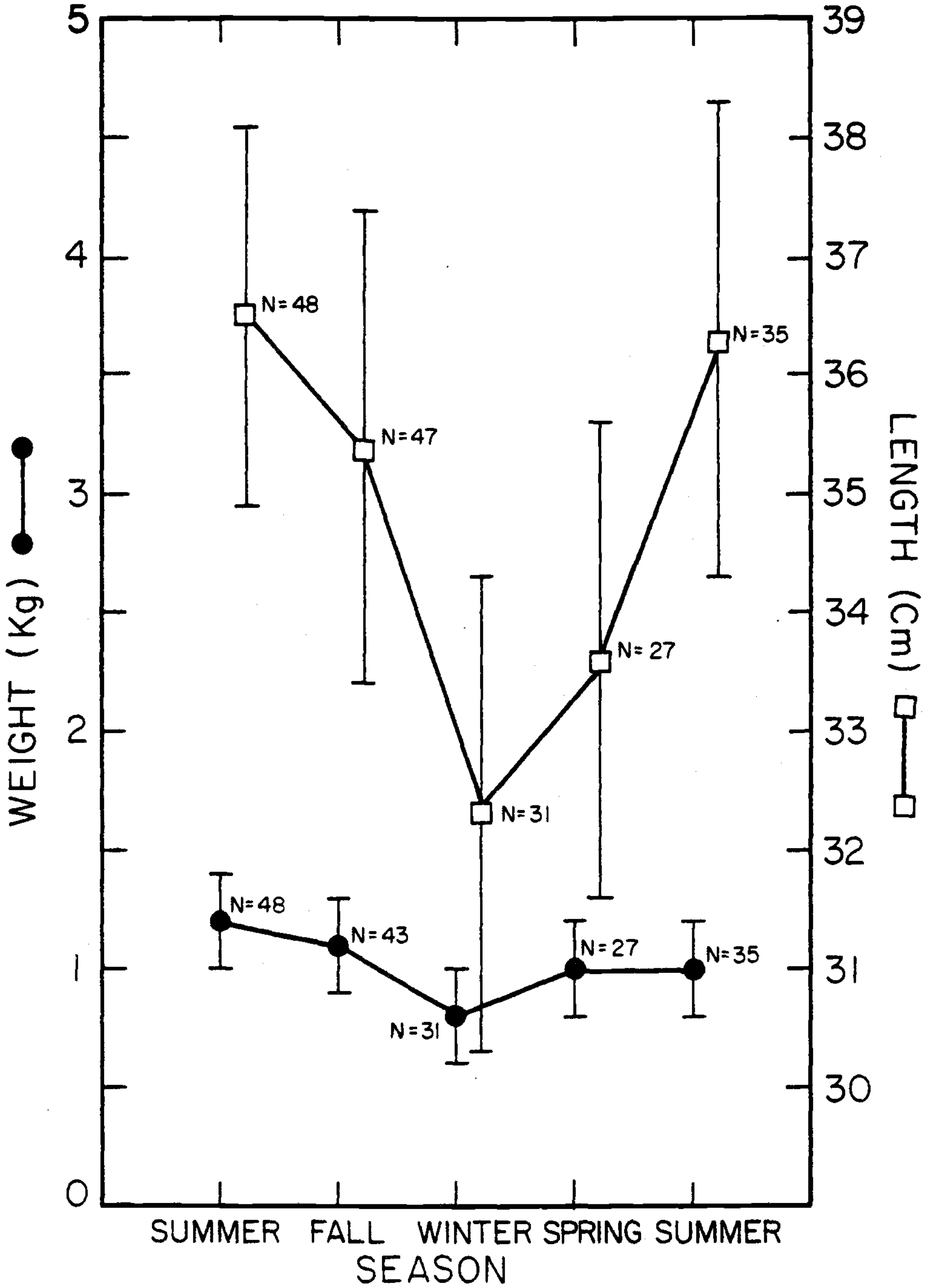

Figure 7. Mean weight and length ($P \geq 0.95$) by season of _Sebastes mystinus_ caught by research personnel on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

rockfish lengths were smaller in the winter than in the summer, spring, and fall and were significantly ($P \geq 0.95$) smaller than in summer 1976. Their weights were significantly ($P \geq 0.95$) smaller in winter 1976 than in summer 1976. Lingcod lengths and weights showed no significant differences ($P \geq 0.95$), but the lengths tended to be smaller in winter while weights were smaller in spring. The mean length and weight of Yelloweye rockfish showed no significant ($P \geq 0.95$) difference between seasons (Fig. 8). The lack of seasonal differences was likely due to the small sample size.

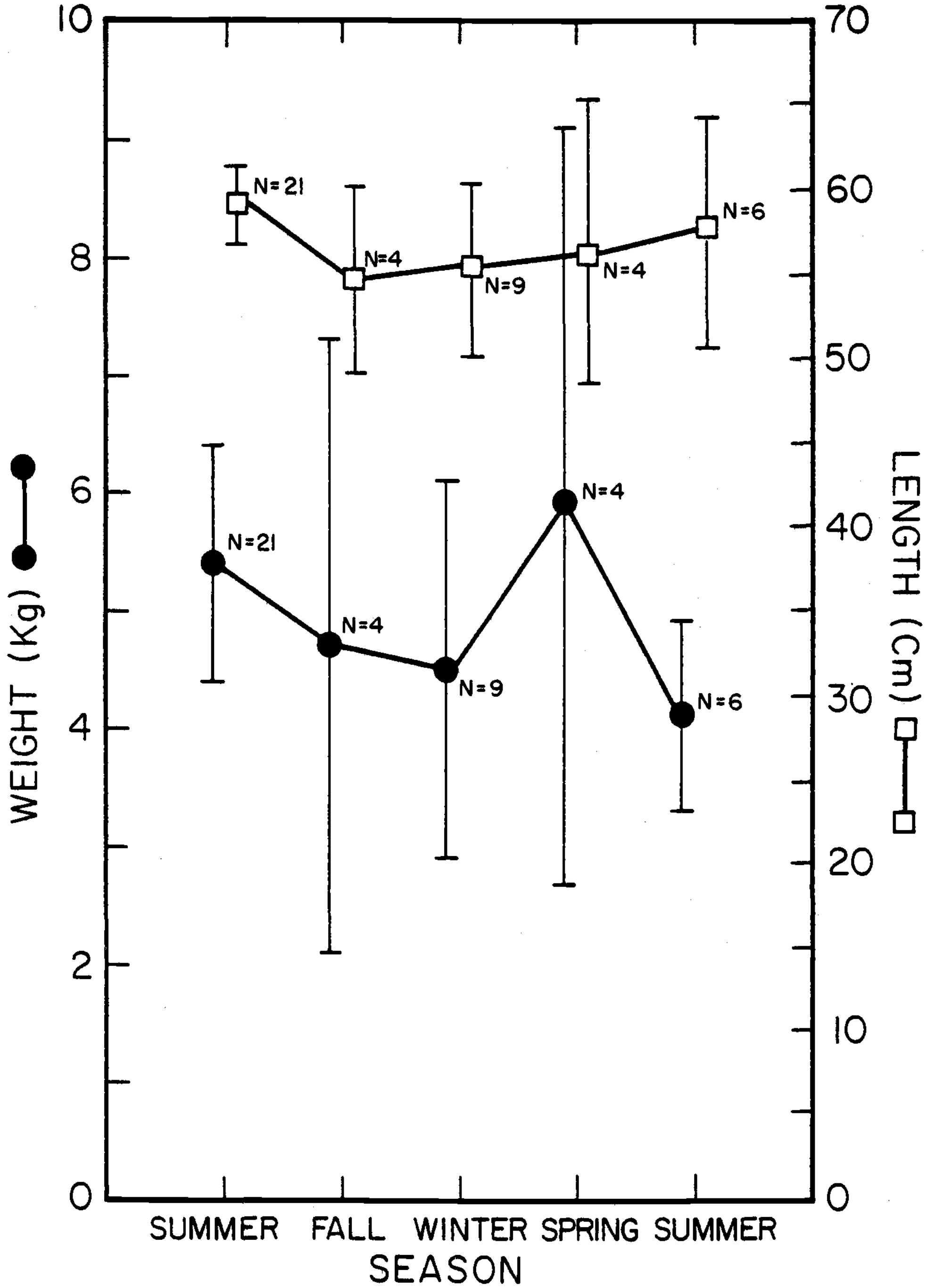

Figure 8. Mean weight and length ($P \geq 0.95$) by season of <u>Sebastes ruberrimers</u> caught by research personnel on reefs adjacent to Depoe Bay, Oregon, during 1976-77.

DISCUSSION

Movement and Migration

The low tag return of 2% in this study may be the result of some of the following:

1) Random recovery effort. As described previously, the study reefs were selected as areas where charter boat fishing had reportedly been concentrated in previous years. Table 9 shows that the specific reefs used by the charter boats changed during the 1976-78 study period. The D River and Nelscott reefs still received some pressure but boats moved to deeper reefs in the center of the study area (Fig. 1). I was told by several charter boat captains that this change to new reefs was initiated in an attempt to increase their CPUE. Once we had selected the reefs to be used in this investigation, the nature of my study and that of a concomitant study on food habits of neritic reef species (Steiner 1979) restricted our fishing to the three study reefs. Thus the number of tagged fish recaptured was possibly lowered because the charter boats were dispersed to several new reefs.

2) Non-return of tags. I made no attempt to ascertain the percentage of non-return of tags by anglers from private or charter boats. I did not publicize the tagging program, or offer rewards for returned tags because the use of the reefs in the study area for bottomfishing is almost exclusively by anglers in boats originating from Depoe Bay. All the charter boat office staffs, charter boat captains, and bottomfish filleters were aware of the study and some private boat captains actually participated in the tagging program. Even so, tags on three fish that were caught by anglers on charter boats were not noticed by the individual who caught the tagged fish or by the boat captain or bait person. These tags were noticed and returned to me by the filleters working on the charter docks. Three other tags noticed in this manner were lost or returned to me with no recapture information.

Table 9. Relative percentage of use of specific reefs by charter and private boats with passengers who angled for bottomfish adjacent to Depoe Bay, Oregon, during 1976 and 1978.

Reef	Depth (m)	No. boats observed 1976 Jul	Aug	Sep	Total number boats	Relative percentage
D River	20-30	6	32	5	43	20
Nelscott	10-20	7	28	5	40	19
Spanish Head	40-50	0	0	0	0	0
Salishan	40-50	6	6	0	12	6
Christmas Tree	20-30	8	5	1	14	7
Government Point	10-20	29	61	11	101	48
Total		56	132	22	210	100

Reef	Depth (m)	No. boats observed 1978 Jun	Jul	Aug	Sep	Total number boats	Relative percentage
D River	20-30	9	8	5	8	30	19
Nelscott	10-20	9	8	3	2	22	14
Spanish Head	40-50	7	6	1	2	16	10
Salishan	40-50	6	32	4	0	42	27
Christmas Tree	20-30	2	2	5	4	13	8
Government Point	10-20	10	11	12	2	35	22
Total		43	67	30	18	158	100

The low percentage of tag-return may have resulted from a lack of publicity or an absence of a reward incentive for returned tags as found by Paulik (1963). Another cause of low tag return may have been the use of tags that were not conspicuous to some anglers as suggested by Margetts (1963).

3. Tag retention. There is evidence to suggest that tag retention for three of the tagged species was high. Tagged individuals of two species (lingcod and black rockfish) placed in an observation tank at the Undersea Gardens retained their tags for seven months. Individual days at liberty exceeded eight months for all three species for which tags were returned. As no blue rockfish were recaptured or placed in an observation tank, I cannot predict possible tag retention for this species.

4. Viability of tagged fish. Maximum depth at which specimens were captured was 54 m and most fish were caught in depths less than 30 m. Only a small number of fish (yelloweye and black rockfish) showed signs of rapid decompression and of these only the most active were released with the star trap as described above. Observations of tagged fish in a tank (Appendix 1) didn't reveal any behavioral differences that would suggest an increase in mortality of tagged fish. However, only fish with no apparent signs of the effects of rapid decompression were placed in the tank.

Of the 26 tags that were returned, 22 fish exhibited no movement from the reef of capture. Yelloweye rockfish appear to be the most sedentary. They had a high rate of tag return (21%) for the low number of individuals tagged (33), and were caught almost exclusively (98%) on the deeper D River Reef. The recaptured yelloweye had all been tagged on the D River Reef. The maximum number of days between tagging and recovery was 308 days and one individual was recaptured twice over a period of 10 months. This sedentary behavior of some individuals and lack of any evidence of movement suggests strongly that some adult yelloweye rockfish inhabiting the neritic reefs in the study area are residental.

Black rockfish and lingcod also displayed some indication of residency. Individuals of both these species were recaptured on the reef of tagging after 10 months. The contention of Miller and Geibel (1973) that some lingcod remain residential in a restricted area and do not participate in a vertical or horizontal coastal migration is supported by the fact that seven of the recaptured lingcod remained on the reef of tagging, one for 16 months. All of the recaptured lingcod were tagged at a size exceeding that given by Miller and Geibel (1973) as the size of maturity (51 cm ♀ and 39 cm ♂). More tag recoveries are needed to determine whether residency by lingcod on neritic reefs is related to maturity as suggested by Chatwin (1956) and Phillips (1958).

The five black rockfish that were recaptured on the reef of tagging were tagged at lengths greater than that at which 50% are considered mature (40 cm--based on data collected by Jerry Butler, ODFW, on reefs adjacent to Newport, OR). Miller and Geibel (1973) in their study on the central coast of California, concluded that blue rockfish stocks are not migratory and concentrate in dense aggregations in rocky reef areas. During my study, I only observed blue rockfish in dense aggregations. However, no tagged blue rockfish were recaptured, so I cannot confirm their residential tendencies.

Some black rockfish and lingcod moved away from the reef of capture and to deeper waters. The two lingcod that were recaptured at some distance from the reef of tagging were tagged within four days of each other (15.8 km apart) in December and were recaptured 267 km apart five (for one) and seven (for the other) months later. This is certainly not conclusive evidence, but it does lend support to the supposition held by Wilby (1937), Chatwin (1956) and Phillips (1958) that some members of an offshore stock(s) may utilize the neritic reefs to spawn and then return offshore.

A study of the movements of adjacent offshore populations of lingcod (similar to Reeves' [1966] tagging study of lingcod on commercial fishing grounds off the Washington coast) is needed to help resolve the questions involving possible spawning migrations. In 1977, the ODFW began tagging lingcod in the offshore commercial trawl fishery during prespawning months (personal communication,* Jerry Butler, ODFW, Newport, OR). Barker (1979) also placed tags in lingcod on commercial trolling sites in Washington, but has had no reports of movement to date. Recapture of these tagged fish in neritic areas during the December to March spawning period (and possible re-recapture back in offshore waters) will help to elucidate the question of possible lingcod spawning migrations.

The two black rockfish that exhibited movement away from the reef of capture were tagged at lengths less than that given by ODFW as the length at which 50% are considered mature (40 cm). These two rockfish were tagged on the same reef within 20 days of each other and were recovered 643 km apart one 12 and the other 16 months later. Evidence for black rockfish movement reported here is supported by a study conducted in Puget Sound by Barker (1979) in which he reported a tag recovery approximately 320 km south of the tagging site. Dunn and Hitz (1969) reported a spent black rockfish captured in a surface gillnet more than 445 km south of the Alaska Peninsula where water depth exceeded 4,938 m. They suggested that black rockfish may be pelagic and possibly move offshore to spawn. These data suggest the possibility of different migratory behavior for juvenile and adult fish and further investigation is needed.

Although the number of black rockfish displaced from their reef of tagging was low, none of the displaced fish exhibited a homesite specificity as was shown by Carlson and Haight (1972) for yellowtail rockfish. This may reflect a behavioral difference among species or an intraspecific behavioral difference in an oceanic vs an inland sound environment. Carlson and Haight (1972) felt that open stretches of deep water may form a partial barrier or hindrance to homing ability. The water separating Nelscott Reef from the D River and Government Point Reefs was not as deep as that mentioned by Carlson and Haight (ibid.) but perhaps oceanic water conditions off the Oregon coast (currents, turbidity) could restrict homing ability. The random recovery effort by charter and private boats on Nelscott Reef may also have contributed to the lack of tag returns for displaced fish.

Recreational Fishery

The increase in the number of charter boats and anglers pursuing bottomfish on neritic reefs adjacent to Depoe Bay from 1976 to 1978 seems to support the contention that pressure from recreational anglers on stocks of neritic fishes in the northwest is on the rise. In 1978, the charter boat offices scheduled more bottomfish trips not only during the traditional spring and fall months but also during the summer and winter months than they did in either 1976 or 1977. The year-round charter boat operation out of Depoe Bay has increased by one boat a year since 1975. The increase in bottomfishing trips during the summer of 1976 may have been a result of the poor salmon catches by recreational anglers that year. But the general year-round increase in bottomfishing trips would suggest that the summer increase reflects a definite expanding interest by anglers in recreational bottomfishing.

The increase in the relative percentage of charter boats to private boats using the study area may reflect the general increase in public demand for bottomfishing. It could also reflect the time of day the survey was taken. Most charter boats leave Depoe Bay at 0930 for bottomfish trips and would thus be sighted during the morning survey. Many private boats (and some charter boats) often will troll for salmon in the morning and bottomfish in the afternoon. Another possible cause for the decrease in private boats observed in the survey was the closure in 1978 of the one hydraulic hoist used to launch private boats for a fee into an often congested Depoe Bay harbor. The public launch for boats on trailers remained open, free, and much used.

Table 9 shows a breakdown of which reefs were used by boats sighted in the survey and boats whose captains responded to questions in the creel census regarding areas fished. The data do not support the contention that as the season progresses boats move progressively from southern reefs to northern reefs. In 1976, charter boats tended to use the northern D River Reef while private boats fished on the Government Point Reef just north of Depoe Bay. In 1978, there were three areas of concentration with both charter and private boats using even deeper reefs (40-50 m) in the center of the study area.

The CPUE of the charter boats tripled from 1976 to 1978. This may be a reflection of the shift away from the D River Reef and to the new reefs that hadn't previously been exploited. The species composition in 1978 included more species which may also be a result of this change in reefs. Steiner (1979) found that the 20-30 m depth interval is a boundary to the distribution of several neritic reef fish species.

Species Composition

The high relative percentage of blue and black rockfish in the species composition of the catch of the R/V Tooshqua may be the result of the selectivity of hootchies for rockfish. The charter boats generally use live bait on their jigs and don't add hootchies. Also, some charter boat captains consider black and blue rockfish undesirable because of the high incidence of internal parasites, and throw them back. The low percentage of black and blue rockfish in the species composition obtained from charter boats may be a result of this selection against rockfish.

The low relative abundance of black rockfish in the winter months may be related to a seasonal change in food habits. Steiner (1979) reported that the percentage of empty black rockfish stomachs was greatest during the winter months on the neritic reefs adjacent to Depoe Bay. Miller and Geibel (1973) concluded that the seasonal change (lower in winter) in availability of blue rockfish to hook-and-line fishing is due primarily to feeding habits rather than to extensive movements. Perhaps the residential black rockfish on the reefs adjacent to Depoe Bay are displaying a similar change in winter food habits making then unavailable to recreational anglers. The mean length for black and blue rockfish was significantly shorter ($P \geq 0.95$) in the winter than in the summer and fall indicating that larger fish are for some reason not available to the hook-and-line fishery.

This lack of availability could reflect food habits (and concomitantly availability of prey species) or might suggest that large fish are for some reason leaving the area. This idea was not borne out by the data as the black rockfish that moved were smaller fish. The mean black rockfish weight was also significantly ($P \geq 0.95$) lower in the winter than in summer of 1976 and the fall and spring of 1976-77. But the weights were low again in the summer of 1977. The mean weight of blue rockfish followed a similar trend but didn't fall as low in the summer of 1977. The lower values for length and weight in the summer of 1977 may indicate the entrance into the fishery of a strong new year class. These data might also suggest that some facter interfered with adult recruitment on the reefs. More length and weight data is currently being collected and these trends will be more meaningful with additional information.

The increase in relative abundance of lingcod in the winter supports the contention that some lingcod may make a seasonal offshore-inshore migration during the winter months (Wilby 1937; Chatwin 1956; Phillips 1959; Hart 1973; Miller and Geibel 1973). Miller and Geibel (1973) compared sex ratios and sizes of lingcod by season and depth in the trawl, skindiver, and partyboat fisheries off the central California coast. They found that males were larger and more numerous in shallow water whereas females were larger and more numerous in deep water. They also reported a significantly higher percentage of adults compared to immature fish in shallow water during the October-January spawning period than in the February-May postspawning period, with the converse ratio appearing in the deeper water trawl fishery during the same months. Steiner (1979) reported that the ratio of females to males for lingcod caught on the reefs in the study area changed from 1:5.3 during the summer to 1:1.1 during the winter. These data support the idea that the winter increase in relative abundance of lingcod is related to spawning.

The increase in the relative percentage of females caught on reefs in the winter months should result in a nearly equal sex ratio in the winter catch. However, lingcod captured in the study area tended to be smaller in the winter. Because adult female lingcod are larger than adult male lingcod at a given age, these data suggest that more males are being caught. This discrepancy may result from some protective, aggressive behavior by nest-guarding males which makes them more available to the hook-and-line fishery.

I conclude on the basis of this study that the recreational fishing pressure on neritic reefs adjacent to Depoe Bay, Oregon is increasing. The data presented here suggest that adult yelloweye rockfish may exhibit residency on these reefs. These data also indicate that some black rockfish and lingcod are resident while others exhibit some form of movement.

Recommendations

The goal of management is to obtain the optimal renewable catch (resource) with management strategies based upon biological knowledge of the species. The establishment of catch regulations for a multi-species fishery on bottomfish should encompass some consideration of the discreteness of aggregations of certain species on individual reefs, and the possible migratory behavior of other reef associating species. Additional biological data on recruitment needs to be gathered. The most important issue to address is where recruitment to the neritic reefs originates. Are adult fish coming from larval replacement on the reef itself or from a replacement by adults from a much larger stock, broadly distributed in offshore areas? One way to approach this question of recruitment is to determine in more detail the species composition of bottomfish on these reefs. We need to look at all sizes of fish, not just at those that occur in the recreational catch. All kinds of sampling gear should be used (i.e., small gill nets, plankton nets, trammel nets), and year-round sampling should be conducted to determine constancy of species composition and seasonal size variance. We need to know if juvenile rockfish are on, around, or between the reefs.

Another way to approach the question of recruitment is to look at how many fish a reef can support. Is there a fixed number of fish for any given reef? Adult removal studies currently being conducted in Puget Sound by Barker (1979) may help to elucidate this question.

To further investigate the possibility of an inshore-offshore migration, we need to get a better idea of which species we're dealing with. Charter boat captains should be required to keep records of the species composition of their bottomfish catches (similar logs are currently required in the California recreational fishery). Fish companies could be required to report trawler catches in more detail. Instead of lumping all rockfish together, at least the more easily identifiable species should be recorded separately. We need to tag more rockfish and lingcod in inshore areas and more lingcod in offshore areas, in an effort to increase tag recovery. We also need to look at the offshore trawl catch in more detail to determine the seasonal sex ratios by depth and how the size composition changes by depth.

There is already evidence, presented in this thesis, that new reefs are being exploited by charter boat captains in an effort to increase their CPUE. The high tag recovery rate for yelloweye rockfish suggests heavy exploitation of this species. At the first indication of localized stock depression, an attempt should be made to regulate the catch of these neritic species to gain lead time for biological investigations. Catch limits might be set differently for different species of rockfish taking into account possible future evidence for resident or migratory behavior patterns. A significant biological problem is that of mortality caused by extended gas bladders among rockfish caught and released from deeper reefs. To minimize this problem, the total number of rockfish caught by anglers will have to be limited, regardless of species caught, rather than individual species bag limits. Local area closures would seem an appropriate way to resolve this problem.

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APPENDIX

Post-Tagging Behavior

Five black rockfish and one large male lingcod captured and tagged on reefs adjacent to Depoe Bay, Oregon were placed in the public viewing aquarium at the Undersea Gardens in December 1976 to assess the length of tag retention and to observe post-tagging behavior. Two additional smaller male lingcod were placed in the aquarium in February 1977. These eight fish were observed through June 30, 1977.

The Undersea Gardens aquarium is a circular tank in which various species of common bay and nearshore marine fishes of Oregon are displayed. When I introduced the tagged fish into the aquarium, there were no lingcod in the tank, but there were many black rockfish. All of the tagged fish were released into the tank at the same location. They all swam directly to the bottom of the tank and placed themselves under rocks or between rock crevices. One black rockfish was temporarily caught by its tag in a crevice but was set free by a diver before I could observe whether it could have freed itself. The tagged fish all stayed in the general area of release for several days. After four to nine days, they all began to swim around the tank in an apparently exploratory manner. Both the lingcod and black rockfish were nipped by shiner perch (Cymatogaster aggregata) as they swam near concentrations of the perch. This nipping behavior continued throughout my period of observation. I never observed the nipping to be directed at the tags but rather at the fins.

Fish in the aquarium are fed twice a week with pieces of frozen herring and Dungeness crab (Cancer magister). The first tagged fish I observed feeding was a black rockfish on December 30. I assume that some had fed before this date and they all were observed feeding after this date.

The five black rockfish established a "preferred" spot within two weeks and they were seldom observed away from these spots during the remaining period of observations. Four of the black rockfish formed pairs and established themselves on opposite ends of the tank. The fifth black rockfish established itself a short distance from one of the pairs. Other non-tagged black rockfish were in the general area of these three preferred spots. The tagged black rockfish were seldom observed swimming around but seemed to remain stationary in the water column. This behavior was the same for non-tagged fish, with active swimming occurring only during feeding periods or when a diver swam around the tank.

The first (and largest) lingcod also established a preferred area within one week of its introduction. This area was on the opposite side of the tank from the point of initial release. The lingcod moved around frequently within a restricted area, settling down on the bottom between periods of swimming. This behavior pattern held until the introduction of the second two lingcod. They too remained in the area of release for several days. Then they independently started exploratory ventures around the tank. The first lingcod was immediately aware of the presence of these new fish as they swam around the tank. The first lingcod began to patrol a much larger section of the tank than it previously occupied. The first lingcod now changed its swim/rest pattern to one of nearly constant swimming. It occupied one-half of the tank area and swam rapidly from one side to the other of this new territory. For periods of up to three hours, I observed the first lingcod swimming this patrol pattern constantly. The other two lingcod never seemed to establish a preferred area. They were sometimes observed to lie next to each other and sometimes to lie alone. They rarely ventured into the half of the tank where the first lingcod was swimming its patrol. On occasion, one of the second pair would enter the edge of the other half of the tank and lie still on the sand. The first lingcod would extend its patrol, but I never observed any overt aggression or physical contact with the other two lingcod. Occasionally, the first lingcod would swim all the way around the tank two or three times and then resume the half-tank patrol.

The point of insertion of some of the tags appeared pink and swollen at times and white at other times, but none seemed seriously infected. The smallest lingcod lost his tag after two months.

I observed no behavioral differences that would suggest an increase in mortality of the tagged fish. There was also no observed reaction on the part of non-tagged fish to the tag itself in terms of nipping. The tags on one pair of black rockfish grew algae which covered the entire tag while the tags on the other three black rock-fish and the three lingcod remained clean.