of St. Lawrence. Similarly, adult witch flounder have been reported concentrated in the deepwater of St. Georges Bay, NAFO Division 4R during the summer months where a localized fishery occurs in depths of 300 m (Bowering and Brodie 1984).

In conclusion, juvenile witch flounder are distributed differently than the adult population off continental shelf areas of the Gulf of St. Lawrence. However, the two populations are not discretely separated as proposed by Powles and Kohler's (1970) niche separation hypothesis. Bowers (1960) concluded that witch flounder in the Irish Sea have no definitive separation. Heavy exploitation of juvenile witch flounder is prevented by the behavior of this size group making them less vulnerable to commercial otter trawls. The difference may be related to difference in preferred food items or distribution of predators. Further research is required to establish the mechanisms for the difference in depth distribution documented by this study.

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Literature Cited

BEACHAM, T. D.
1983. Variability in size and age at sexual maturity of witch flounder, *Glyptocephalus cynoglossus*, in the Canadian Maritimes region of the Northwest Atlantic Ocean. Can. Field-Nat. 97(4):409-422.

BOWERING, W. R., AND W. B. BRODIE.
1980. An evaluation of recent management strategy for witch in the Gulf of St. Lawrence (NAFO Div. 4RS). CAFSAC Res. Doc. 80/49, 20 p.
1984. Distribution of witch flounder in the northern Gulf of St. Lawrence and changes in its growth and sexual maturity patterns. North Am. J. Fish. Manage. 4A:399-413.

BOWERING, W. R., AND T. K. PITT.
1974. An assessment of witch (*Glyptocephalus cynoglossus*) for ICNAF Div. 2J-3KL. ICNAF Res. Doc. 74/48, Ser. No. 3255, 7 p.

BOWERS, A. B.
1960. Growth of the witch (*Glyptocephalus cynoglossus* L.) in the Irish Sea. J. Cons. Perm. Int. Explor. Mer 25:168-176.

LAFLEUR, P. E., AND J. P. LUSSIÀA-BERDOU.
1982. La plie grise (*Glyptocephalus cynoglossus*) dans le nord du Golfe du Saint-Laurent (Div. 4R et 4S de l'opano). Donnes sur l'ecologie et l'exploitation. Gov. Quebec Minist. Agric. Pecheries aliment., Cah. Inf. No. 97, 30 p.

MARKLE, D. F.
1975. Young witch flounder, *Glyptocephalus cynoglossus*, on the slope off Virginia. J. Fish Res. Board Can. 32:1447-1450.

POWLES, P. M., AND A. C. KOHLER.
1970. Depth distribution of various stages of witch flounder (*Glypocephalus cynoglossus*) off Nova Scotia and in the Gulf of St. Lawrence. J. Fish Res. Board Can. 27:2053-2062.

SIEGEL, S.
1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., N.Y., 312 p.

SQUIRES, H. J.
1961. Shrimp survey in the Newfoundland fishing area, 1957 and 1958. Bull. Fish Res. Board Can. 129:vii + 29 p.

WALSH, S. J.
1984. Relative efficiency of two bottom trawls in catching juvenile and commercial sized flatfishes in the Gulf of St. Lawrence. J. Northw. Atl. Fish Sci. 5:181-188.

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MOVEMENT OF TAGGED LINGCOD, *OPHIODON ELONGATUS*, IN THE PACIFIC NORTHWEST

Lingcod, *Ophiodon elongatus*, is a commercially and recreationally important West Coast species. Most previous studies have indicated that lingcod is a relatively nonmigratory species (Hart 1943; Chatwin 1956; Phillips 1959). More than 90% of the adults remained within 5 mi (8.1 km) of the point of tagging for as long as several years.

We tagged lingcod in the eastern Strait of Juan de Fuca and near San Juan Island, WA, from 1976 and 1981. We present results from tags returned by fishermen through 1985. The tag returns were analyzed primarily to show the extent of migration. We also analyzed recaptures by sex, size, direction of movement, and the effects of tag type and the location of tagging.

Methods

From 1976 to 1978, relatively small numbers of lingcod were tagged, incidental to a tagging study directed to rockfish (*Sebastes* sp.) (Mathews and Barker 1984), in which rod-and-reel with artificial lures was used to capture fish for tagging. From 1979 to 1981 tagging effort was for lingcod using a chartered commercial vessel trolling with a string of 6-10 jigs or other artificial lures from a hydraulic gurdy.

A total of 1,692 lingcod were tagged during 1976-81. Most of the lingcod (over 90%) were tagged during March through May. When caught singly, they were immediately tagged and released. If several lingcod were brought aboard at the same time, they were held in a circulating seawater tank until tagged. All tagged fish were measured (fork length) to the nearest millimeter. From 1978 to 1981, sex was determined by the presence of the anal papillae in males. Only fish not injured by capture were tagged and released. Those that bled, or that were hooked in the gills or throat, or that otherwise appeared disabled were not tagged.

Three types of spaghetti end tags were used: Anchor with #20 tubing (Floy[1] FD-67, Floy Co., Seattle, WA); small dart with #20 tubing (Floy FT-2); and large dart with #13 tubing (Floy FT-1). The tagging area and number tagged at each location are shown in Figure 1. The principal tagging locations were Middle Bank, a low relief, hard rubble bottom bank of about 6 km^2 and 20-60 m deep; Hein Bank, of similar area to Middle Bank but shallower (6-30 m deep), having a softer bottom and extensive kelp beds; and San Juan Channel, a passage with high relief, rocky substrate 2-6 km wide, coursing among several of the San Juan Islands. Most of the tagging in San Juan Channel was done near Turn Island in about 30 m of water. A few lingcod were tagged at other locations near San Juan Island.

Recapture information, including primarily the date and place of capture, was obtained from tags

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

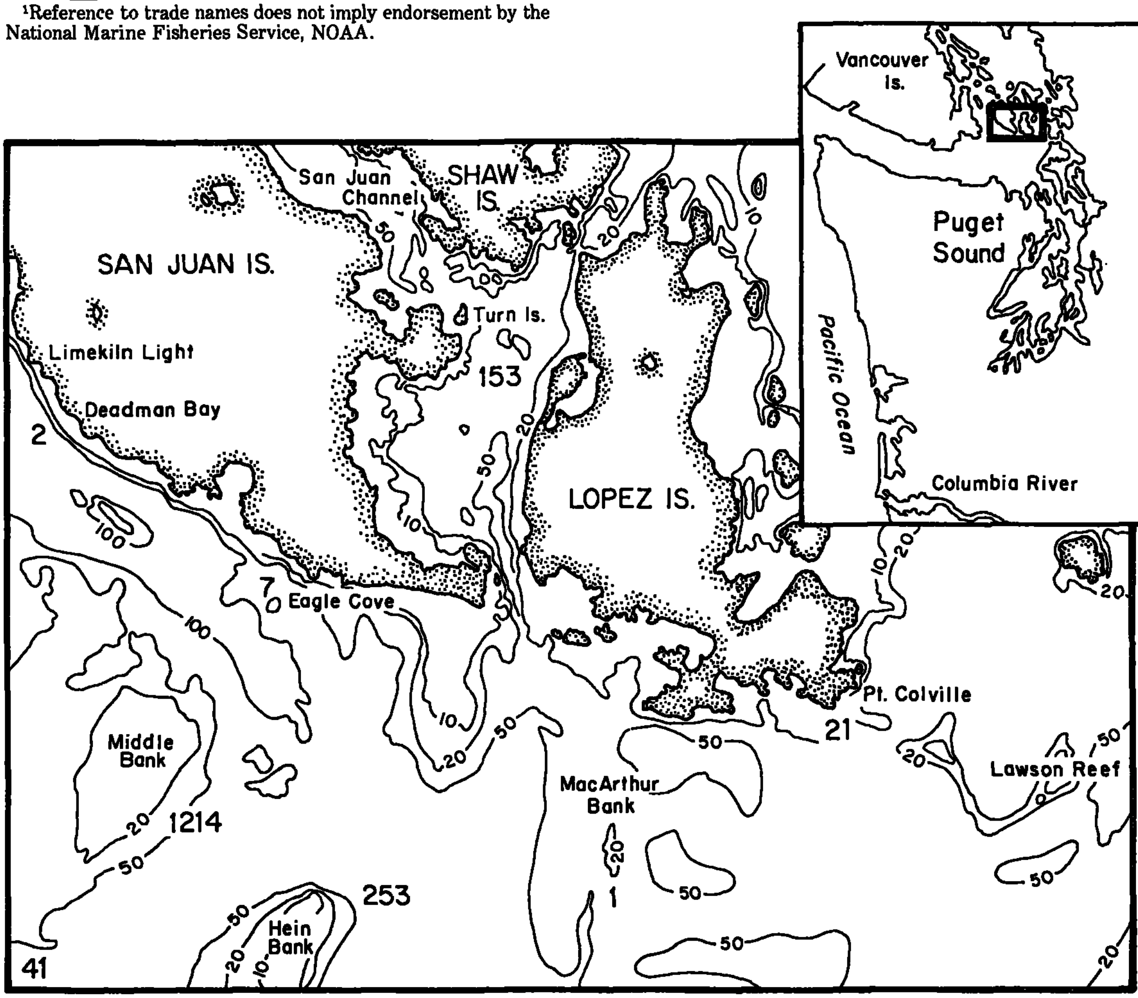

FIGURE 1.—Lingcod tagging area in relation to western Washington. Small numbers show depth contours in fathoms (1 fathom = 1.829 m) and large numbers show numbers tagged by location.

returned voluntarily by sport fishermen and commercial troll and trawl fishermen. A $2 reward was offered for the return of the tags. Several fishermen were personally contacted to clarify the information they provided and to seek specific information on where and how they fished; all the fishermen were cooperative. Assuming these fishermen were representative of all those who returned tags, we believe that the overall recovery information was accurate.

The size and sex distributions of the tagged lingcod are shown in Graphs I, II, and III of Figure 2. Eighty-six percent of all tagged lingcod were sexed, and of this sample 87% were males. The reported size ranges at maturity are 40-46 cm for males and 70-76 cm for females (Forrester 1969; Hart 1973).

Operationally, we define migratory and nonmigratory lingcod as fish recaptured at distances greater than and <8.1 km (5 mi), respectively, from the tagging site. This reference distance has been used for similar purposes in previous tagging studies. Since the recovery locations were usually given by the name of a geographical location such as "Middle Bank" or "Turn Island", there was some imprecision in estimating the distance moved. However, the fishing area associated with such named locations is <8.1 km in diameter. Thus, for example, a fish tagged on Middle Bank and recaptured on Middle Bank was assumed to have travelled <8.1 km.

Chi-square contingency table analysis was used for comparing recapture rates by tag type and sex, for comparing release-length frequency distributions of migratory and nonmigratory recoveries, and for comparing migrational tendencies by sex. A chi-square goodness of fit test was used to test the null hypothesis that the release-length distribution of all recaptured lingcod was the same as that of all tagged lingcod. For both of the length-frequency tests, lengths were grouped into 5 mm intervals, but at the tails of the distribution the intervals were wider than 5 mm to follow the rule for chi-square analysis that no expected cell frequency should be <1.0 and that no more than 20% of expected cell frequencies should be <5.0 (Zar 1974, p. 50). One-way analysis of variance was used to test the null hypothesis that the average time between tagging and recapture was the same for fish that had migrated different distances.

Most of our tagged males and about half of our tagged females were large enough to be reproductively mature when tagged.

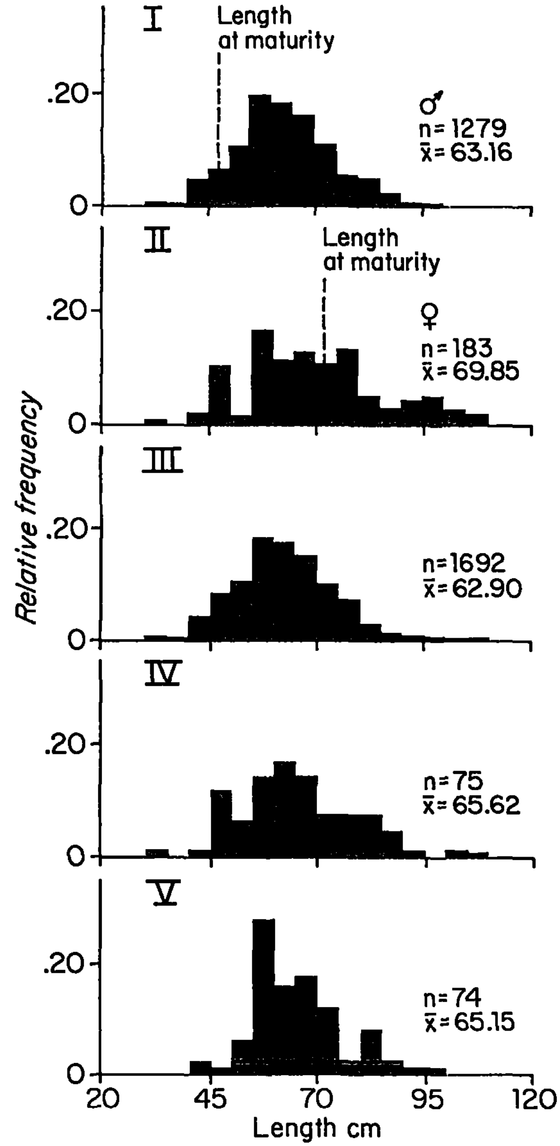

FIGURE 2.—Length-frequency distributions of tagged lingcod. I - known male lingcod tagged; II - known female lingcod tagged; III - all lingcod tagged; IV - release length distribution of all tagged lingcod recovered less than 8.1 km from release location; V - release length distribution of all tagged lingcod recovered more than 8.1 km from release location.

Results

There were no significant differences among recovery rates by tag type (χ^2 = 1.90 with 2 df; 0.26 < P < 0.50) (Table 1). However, we suspect from limited double-tagging and aquarium holding of tagged fish that the large dart had better retention qualities for lingcod than the other two tag types.

Through October 1985, 157 (9.3%) tagged lingcod

TABLE 1.—Rates of recapture of tagged lingcod for three types of tags.

Tag type	No. of lingcod tagged	No. of tags returned by fishermen	% returned
Anchor (Floy FD-67)	82	7	8.5
Small dart (Floy FT-2)	687	66	9.0
Large dart (Floy FT-1)	979	88	9.2
Total	[1]1,748	[2]161	

[1]Includes 56 fish which were double tagged with two different tag types.
[2]Includes four recoveries of double tagged fish with both tags remaining.

were recaptured. Recaptures were reported for up to 6 years following the year of tagging (Table 2).

Of the 149 lingcod with known tagging and recapture locations, 75 were recaptured <8.1 km from the tagging location and judged to be nonmigratory, whereas the remaining 74 were judged to be migratory, having been recaptured at distances >8.1 km from the tagging location (Table 3). Of the 74 that migrated, 61 were recaptured 8.1-50 km from the tagging location and 13 were recaptured farther than 50 km from the tagging location. The extent of migration depended on the location of the tagging site. Only one of 15 recaptured lingcod tagged in San Juan Channel migrated, whereas 70 of 117 (60%) tagged at Middle Bank and Hein Bank migrated (Table 3).

The predominant pattern of movement was west and south through the Strait of Juan de Fuca; 65 of the 74 migratory lingcod were recaptured south and west of the tagging site, but only 9 were recovered north and east of the tagging site (Table 3). The null hypothesis that lingcod were as likely to go south/west as north/east was rejected (χ^2 = 42.4 with 1 df; $P < 0.001$). Five recaptures from the Pacific Ocean were reported; the one farthest from the tagging location was caught off Newport, OR, a migration of 564 km.[2] The longest migration to the north/east was to Porlier Pass, BC, Canada, about 75 km from the tagging site. The greatest number of recaptures (34) was from Constance Bank, located in Canadian waters about 18 km west of Middle Bank. Most of the Constance Bank recaptures were made by Canadian trawlers. About one third of the total reported recaptures were taken in Canadian waters and two thirds in U.S. waters,

[2]This unusual recovery location was verified by follow-up correspondence. The fish was recaptured 6.5 yr after tagging by a small coastal trawler that usually fished 3-8 mi off Newport's south jetty.

TABLE 2.—Number of lingcod tagged, 1976-81, and recaptured through 1985 by year of recapture.

Year tagged	No. tagged	Number recaptured by year 1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Unknown[1]	Total	% recaptured
1976	41	1	2	0	1	0	0	1	0	0	0	0	5	12.2
1977	101		1	5	4	1	0	0	2	0	0	0	13	12.9
1978	87			1	4	0	2	0	0	0	0	0	7	8.0
1979	507				8	24	5	4	1	0	1	0	43	8.5
1980	535					19	14	3	4	0	1	0	41	7.7
1981	421						29	7	7	1	1	1	46	10.9
Unknown[2]	—					1	1	0	0	0	0	0	2	—
Total	1,692	1	3	6	17	45	51	15	14	1	3	1	157	9.3

[1]Year of recapture not reported.
[2]Tag number unreadable when recaptured.

TABLE 3.—Distribution of recoveries of tagged lingcod by location of tagging, distance of migration and direction of migration.

Tagging location	No. tagged	No. recovered <8.1 km from tagging location	No. recovered farther than 8.1 km from tagging location: 8.1-50 km W and/or S	>50 km W and/or S	8.1-50 km E and/or N	>50 km E and/or N	Recovery location unknown relative to tag location	Total recaptured	% recaptured
Middle Bank	1,214	47	50	6	4	4	6	117	9.6
Hein Bank	253	10	3	2	1	0	0	16	6.3
San Juan Channel	153	14	1	0	0	0	0	15	9.8
Miscellaneous	72	4	2	1	0	0	0	7	9.7
Unknown[1]	—	—	—	—	—	—	2	2	—
Total	1,692	75	56	9	5	4	8	157	9.3

[1]Tag number unreadable when recaptured.

which indicates that lingcod in the study region are an international resource.

The time between tagging and recapture averaged 18 mo (Table 4) and did not differ significantly by the distance traveled ($F_{2,128}$ = 1.32; 0.25 < P < 0.50).

The majority of the nonmigratory recaptures were caught in May-July, but the migratory fish were caught mostly in August-October. This difference could not be attributed to any seasonal pattern of migration and was probably a sampling artifact. Fishing effort by commercial trollers and sport fishermen in the tagging areas peaked during May-July, while the fishing effort of the trawl fleet on Constance Bank, from which many of the migratory recaptures came, peaked in late summer and fall (Smith 1981; Leaman 1982, 1983, 1984).

We found that migratory tendency apparently did not depend on individual size. Figure 2 shows a comparison of the release length-frequency distributions of lingcod recaptured <8.1 km (Graph IV) and more than 8.1 km (Graph V) from release location. The null hypothesis that migratory and nonmigratory lingcod have the same length distribution was accepted (χ^2 = 13.09 with 10 df; 0.10 < P < 0.25).

The release-length distribution of all recaptured lingcod was significantly different from that of all tagged lingcod (χ^2 = 25.42 with 10 df; P < 0.01); release lengths of recaptured lingcod averaged slightly larger than those of all tagged lingcod (Fig. 2, Graphs III, IV, and V).

Recaptured lingcod offered no evidence that males and females differ in migratory behavior. Recapture rates were virtually the same for the two sexes. The null hypothesis that male and female tagged recoveries represent two populations with equal proportions of nonmigratory and migratory individuals was accepted (χ^2 = 3.14 with 1 df; 0.05 < P < 0.10) (Table 5). However, numbers of females tagged and recaptured were so low that any conclusion from this comparison should obviously be drawn with caution.

TABLE 4.—Time span between date of tagging and date of recapture for tagged lingcod recoveries with known month of recapture.

Recoveries by distance between tagging and recapture locations	No.	Time span (mo.)	
		$\bar{X}$	Range
<8.1 km	75	15.1	0-71.2
8.1-50 km	55	18.6	3.2-76.0
>50 km	11	18.0	2.2-76.6
Total	131	18.0	0-76.6

TABLE 5.—Distributions by sex of the lingcod recaptured <8.1 km from the tagging location and of those recaptured >8.1 km from the tagging location.

Sex	No. tagged and sexed	Number recaptured		Total	% recaptured
		<8.1 km	>8.1 km		
Male	1,279	57	63	120	9.4
Female	183	12	5	17	9.3

Discussion

The highly imbalanced sex ratio of the tagged fish can be explained by different depth distributions of the two sexes. Others have found, as we did on our tagging cruises, that female lingcod tend to reside deeper than males (Chatwin 1956; Miller and Geibel 1973; Cass et al. 1984). Most of our tagging effort was at depths of 25-30 m where the abundance of lingcod regardless of sex was the greatest. We fished in depths down to 100 m and found that relative abundance of females increased with depth.

The reason that the small tagged individuals tended to be recaptured at a lesser rate than the larger ones could be the higher natural mortality of small lingcod within the size range of our tagged sample. Lingcod are renowned for their cannibalism (Chatwin 1956; Phillips 1959), which could be a likely source of size-dependent mortality.

Our results show more lingcod migratory behavior than most previous studies. Hart (1943) reviewed recovery information from 1,993 lingcod tagged during 1939-43 throughout the Strait of Georgia, BC, Canada, and stated that "some but not more than 5% of lingcod are more or less migratory." Chatwin (1956) summarized Hart's data together with information from additional tagging in the Strait of Georgia through 1954 and found that of 342 total recaptures, 41 (12%) moved more than 1 mi (1.6 km) but <5 mi (8.1 km) from the point of tagging, and 32 (9.3%) moved farther than 5 mi. Chatwin therefore concluded that lingcod was a relatively sedentary species with no well-defined migration pattern. Phillips (1959) reviewed the above two papers and concluded from these and other tag recovery observations in the literature that lingcod is a nonmigratory species, particularly after reaching maturity.

Reeves (1966) reported on results from tagging 437 lingcod on 40-Mile Bank, which is about 50 km west of Cape Flattery, WA. The overall recapture rate was very high because of an intensive trawl fishery for lingcod in the vicinity of tagging; 53.3% of all tagged fish were recaptured within 6 wk of release. Only 5% of the recaptures were farther than 5 mi (8.1 km) from the tagging site. However, the number of fish migrating may have been affected by the trawl fishery which could have removed potential migrants.

Cass et al. (1983b) reported results from tagging 2,997 lingcod off the west coast of Vancouver Island, BC, and 752 in the Strait of Georgia, BC, in 1978. However, the combined recovery rate through 1982 was so low (1%—apparently because of the excessive mortality from too high a dosage of oxytetracycline that was injected intraperitoneally in an attempt to validate aging methods) that little could be concluded on movements. Of the 21 recaptures with known recapture location, 4 (19%) had traveled more than 20 km. One of these was caught off central Oregon, 510 km from the tagging sites.

Further Canadian tagging efforts off southwest Vancouver Island in July 1982 and in the Strait of Georgia in 1982-83 are reported by Cass et al. (1983a) and Cass et al. (1984), respectively. Off Vancouver Island, 7,429 lingcod were tagged and 1,442 (19%) were recaptured through 1982. Very little movement was indicated, since 97% of the recaptures were taken in the area of release by Canadian trawlers. As with the Reeves' (1966) study, the initial recapture rates were very high because of intensive trawling in the tagging area. The Strait of Georgia tagging effort indicated relatively little movement. A total of 3,991 lingcod were released from November 1982 to March 1983 in three areas: Campbell River (76%), Pender Harbor (16%), and Stuart Island (8%). Through November 1983, 392 recaptures were reported by sport and commercial fishermen, and location of recovery was known for 383 of these. Of the latter number, 354 (92%) were recaptured within 5 km of their release site and 235 of these (61%) showed no detectable movement. From these observations the authors concluded that lingcod do not undertake extensive short-term movements.

We are aware of only one other lingcod tagging study that shows migration similar to that in the present study. H. Horton[3] reported results from 552 lingcod tagged on the central Oregon coast from June 1978 to January 1982. Nineteen recaptures were reported through 1985: 10 had not moved significantly and 9 had migrated more than 10 km. Of those that migrated, 2 went a distance of more than 100 km.

Our study gives evidence that certain populations of lingcod have a high proportion of individuals likely to migrate. Large, mature individuals may have migration patterns similar to individuals smaller than the reported sizes at maturity. The movement pattern in our tagged sample was directional, not random. In assuming that the fraction of total recaptures more than 8.1 km from the tagging site represents the migration within the population, we also assumed that migrating lingcod had fishery exploitation rates similar to those that did not migrate. Since lingcod are highly valued, they attract commercial and/or recreational fishing in virtually every known area of concentration. The ranges in recapture rates were narrow among years (Table 2), among tagging locations (Table 3), and between sexes (Table 5), suggesting that the probability of recapture was independent of migratory behavior.

[3]H. Horton, Oregon State University, Corvallis, OR 97331, pers. commun. October 1985.

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Literature Cited

CASS, A. J., E. CAMERON, AND I. BARBER.
1983a. Lingcod tagging study off southwest Vancouver Island, M/V Pacific Eagle - July 14-27, 1982. Can. Data Rep. Fish. Aquat. Sci. 406, 84 p.

CASS, A. J., G. A. MCFARLANE, K. RUTHERFORD, AND I. BARBER.
1984. Lingcod tagging study in the Strait of Georgia, Nov. 1982-March 1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1791, 49 p.

CASS, A. J., M. S. SMITH, I. BARBER, AND K. RINHOFER.
1983b. A summary of lingcod tagging studies conducted in 1978 by the Pacific Biological Station. Can. Data Rep. Fish. Aquat. Sci. 417, 283 p.

CHATWIN, B. M.
1956. Further results from tagging experiments on lingcod. Fish. Res. Board Can., Prog. Rep. Pac. Coast Sta. 107:19-21.

FORRESTER, C.
1969. Life history information on some groundfish species. Fish. Res. Board Can., Tech. Rep. 1054, 15 p.

HART, J. L.
1943. Migration of lingcod. Fish. Res. Board Can., Prog. Rep. Pac. Coast Sta. 57:3-7.
1983. Pacific fishes of Canada. Fish. Res. Board Can., Bull. 180, 740 p.

LEAMAN, J. E.
1982. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1981. Can. Tech. Rep. Fish. Aquat. Sci. 1124, 90 p.
1983. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1982. Can. Tech. Rep. Fish. Aquat. Sci. 1226, 88 p.

1984. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in 1983. Can. Tech. Rep. Fish. Aquat. Sci. 1312, 87 p.

MATHEWS, S. B., AND M. W. BARKER.
1983. Movement of rockfish (*Sebastes*) in northern Puget Sound. Fish. Bull., U.S. 81:916-922.

MILLER, D. J., AND J. J. GEIBEL.
1973. Summary of blue rockfish and lingcod life histories; a reef ecology study; and giant kelp, *Macrocystis pyrifera*, experiments in Monterey Bay, California. Calif. Dep. Fish Game, Fish Bull. 158, 131 p.

PHILLIPS, J. B.
1959. A review of the lingcod, *Ophiodon elongatus*. Calif. Fish Game 45(1):19-27.

REEVES, J. E.
1966. An estimate of survival, mortality, and the number of lingcod (*Ophiodon elongatus*) off the southwest coast of Vancouver Island, British Columbia. Wash. Dep. Fish., Fish. Res. Pap. 2(4):55-66.

SMITH, J. E.
1981. Catch and effort statistics of the Canadian groundfish fishery on the Pacific Coast in 1980. Can. Tech. Rep. Fish. Aquat. Sci. 1032, 90 p.

ZAR, J. H.
1974. Biostatistical analysis. Prentice-Hall Biological Science Series, Prentice-Hall, Inc., Englewood Cliffs, NJ, 620 p.

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DIGESTION RATES AND GASTRIC EVACUATION TIMES IN RELATION TO TEMPERATURE OF THE SACRAMENTO SQUAWFISH, *PTYCHOCHEILUS GRANDIS*

Squawfish, *Ptychochilus* sp., are large piscivorous cyprinids which have a reputation of being major predators on salmon and trout, although documentation for this is poor. Brown and Moyle's (1982) review on squawfish concluded that squawfish are not likely to affect salmonid populations in free flowing streams (Falter 1969; Ebel 1970; Buchanan et al. 1980, 1981), but that significant predation could occur in areas where streams are altered (dams, diversions) and in relation to fish releases.

Sacramento squawfish, *Ptychocheilus grandis*, have been reported to prey heavily on juvenile salmonids in the Sacramento River, CA, especially below Red Bluff Diversion Dam (RBDD) (Hall 1977), and have been implicated in the continuous decline of chinook salmon, *Oncorhynchus tshawytscha*, in recent decades (U.S. Bureau of Reclamation 1983, 1985). Currently governmental agencies charged with the management of anadromous fishes in California are attempting to decrease the number of squawfish in the Sacramento River, especially near RBDD. The justification for Sacramento squawfish removal is based on a report by Hall (1977). Unfortunately, the estimate of squawfish predation rates by Hall (1977) were made without knowledge of the digestion rates or gastric evacuation times of Sacramento squawfish in relation to temperature and is likely an overestimate.

Bentley and Dawley (1981) found that northern squawfish, *P. oregonensis*, consumed 14.3 g of fish per day at 10°C. Based on this estimate Sacramento squawfish below RBDD would consume only 3 or 4 salmon/day (mean size of hatchery salmon released into the Sacramento River is 4.0 to 5.0 g). This estimate is lower than the 20 salmon/day calculated by Hall (1977) for Sacramento squawfish below RBDD. The ability of predatory fish to consume prey is mediated, at least in part, by the digestion rate and the extent of gastric evacuation (Grove and Crawford 1980; Jobling and Wandsvik 1983). Several workers (Falter 1969; Steigenberger and Larkin 1974; Persson 1979, 1981, 1982; Jobling 1980; Smith 1980; Hofer et al. 1982) have shown that digestion rates in fishes increases with increasing temperature.

The purpose of this study was to determine digestive rates and time for gastric evacuation of the Sacramento squawfish in relation to temperature. Sacramento squawfish digestion rates increased with increasing temperature, while evacuation times decreased with increasing temperature.

Methods

Sacramento squawfish ($\bar{x}$ = 370 mm standard length [SL], range = 300-456 mm SL) were captured, using hook and line or a boat electrofisher, immediately below Red Bluff Diversion Dam (RBDD). The length-weight relationship for Sacramento squawfish was $Y = 4.03 + 2.66X$. Fish were transported to University of California, Davis, and treated immediately with nitrofurazone or potassium permagnate. The fish were held for several days at their capture temperature before the tem-