THE FEEDING HABITS AND DISTRIBUTION OF JUVENILE-SMALL ADULT CALIFORNIA HALIBUT *(PARALICHTHYS CALIFORNICUS)* IN COASTAL WATERS OFF NORTHERN SAN DIEGO COUNTY

KENNETH M. PLUMMER[1], EDWARD E. DEMARTINI[2], AND DALE A. ROBERTS[2]
Marine Science Institute
University of California
Santa Barbara, California 93106

ABSTRACT

The stomach contents of 336 California halibut 109-689 mm standard length (SL) were examined. Halibut were trawled from 6-m, 18-m, and 30-m depths off San Onofre and near Oceanside from March 1981 to March 1982. The relative influences on diet of depth of capture, predator body size, and the seasonal abundances of major prey types were examined. Major prey by frequency of occurrence were northern anchovy *(Engraulis mordax)* and large mysids, notably *Neomysis kadiakensis*. Northern anchovy dominated by weight; mysids dominated in terms of numbers consumed. Halibut <25 cm SL ate mostly mysids and some larval fishes; halibut >30 cm SL ate mostly northern anchovy and other juvenile and adult fishes. Fish of intermediate (25-30 cm SL) size consumed both prey types in roughly equal frequency. Prevalence of anchovy in the diet tracked the seasonal (summertime) increase of anchovy in nearshore waters. Extent of feeding on mysids reflected mysid abundance much less perfectly. Depth of capture influenced diet little, except indirectly, since relatively small halibut tended to predominate at the shallowest depth sampled.

Otter trawl, bag seine, and ichthyoplankton data suggest that the California halibut spawns in nearshore coastal waters, utilizes embayments as nursery grounds while a young juvenile (age-group 0 and yearling), and inhabits shallow, open coastal waters during late juvenile and later life-history stages.

RESUMEN

Se examinó el contenido estomacal de 336 *Paralichthys californicus* (Halibut de California) de 109-689 mm de longitud normal. Estos peces capturaron en arrastres efectuados a 8, 18 y 30 m de profundidad, frente a San Onofre y en las cercanías de Oceanside (California) durante el período de Marzo 1981 a Marzo 1982. Se relaciona la influencia de la profundidad de captura y la talla del depredador,con la dieta y abundancia de la presa en la región. El alimento que aparecía con mayor frecuencia en el estómago era la anchoa *(Engraulis mordax)*, y Misidáceos grandes, principalmente *Neomysis kadiakensis*. La anchoa dominaba en peso y los Misidáceos en número. *Paralichthys californicus* de menos de 25 cm de longitud normal se alimentaba frecuentemente de Misidáceos junto con algunas larvas de peces, y los de más de 30 cm devoraban con preferencia anchoas y otros peces, tanto adultos como jóvenes. Los peces de tallas intermedias (25-30 cm de longitud normal) consumían ambos tipos de presa con igual frecuencia. La predominancia de la anchoa en la dieta marcaba el incremento de este pez en la regioń costera durante el verano. La captura de Misidáceos indicaba con menor precisión la abundancia de estos crustaceos. La profundidad habitada por *Paralichthys californicus* influye, aunque indirectamente, en la dieta, ya que los ejemplares pequeños tienden a predominar en los estratos menos profundos.

Los datos obtenidos con redes de arrastre y de cerco, así como los análisis del ictioplancton, indican que *Paralichthys californicus* efectua la puesta en aguas costeras, utilizando los bancos como zonas de cria y habitando ahí los jóvenes hasta de un año de edad, mientras que los estados más avanzados de la fase juvenil y adultos habitan aguas someras y costeras no protegidas.

INTRODUCTION

The California halibut *(Paralichthys californicus)* is a species of major economic importance in California. However, its sport and commercial catches have steadily declined since catch records have been kept (Frey 1971). In recent years, the southern California partyboat fishery (MacCall et al. 1976) and the statewide partyboat and commercial catches (e.g., see Oliphant 1979) have remained at low levels. Possible explanations for this decline are naturally occurring population fluctuation, overexploitation of adult stocks by commercial fishing, alteration of nursery grounds, a northern shift in the center of population density (Frey 1971), or, most probably, some combination of the four explanations. A more complete understanding of the feeding habits and other details

[1]Present address: Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92093

[2]Present address: Marine Review Committee Research Center, 531 Encinitas Boulevard, Encinitas, California 92024

[Manuscript received January 31, 1983.]

of the life history of this important sport and commercial species could help avert further declines in its abundance.

Food habits data are fragmentary for the various life history stages of California halibut. The foods of adult halibut have been generally described by Frey (1971) for fish caught in trawls throughout California waters; by Quast (1968) and Feder et al. (1974) for halibut in or near giant kelp *(Macrocystis)* beds off southern California; and by Ford (1965) for fish on the La Jolla intercanyon shelf near San Diego. Haaker (1975) and Barry and Cailliet (1981) described the food habits of juvenile halibut in Anaheim Bay, Orange County, and Elkhorn Slough, Monterey County, respectively.

This study together with that of Roberts et al. (1982) provides the first comprehensive food habits data for the juveniles and small adults of this species in southern California coastal waters. Specifically, we characterize the diet of California halibut in terms of body size, depth of capture, seasonal variation, and their interrelationships. We further relate halibut diet to the abundance of major prey estimated during the same annual period.

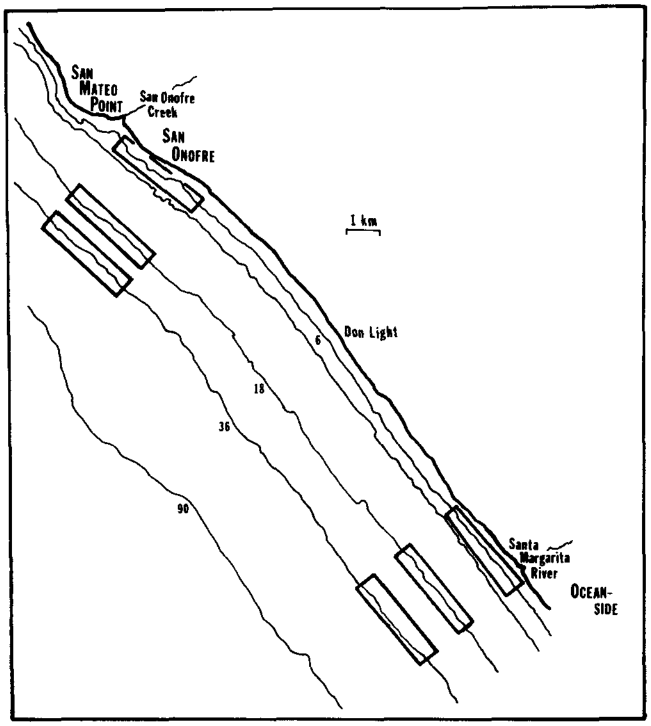

Figure 1. Chart of the nearshore waters between San Clemente and Oceanside, California, showing the locations off San Onofre and near Oceanside at which California halibut were trawled. Depth contours are meters below MLLW.

METHODS

Methods of Capture

California halibut were collected at two longshore locations off San Onofre and about 18 km downcoast, near Oceanside, at 6-m, 18-m, and 30-m bottom depths (Figure 1). Standard (7.5 m) otter trawls with 1.3-cm stretch mesh cod-end liners (Mearns and Allen 1978) were used. During a major yearlong collection period from March 1981 through March 1982, 243 night trawls were made; an additional 34 daytime trawls were made during April and May 1981. Incidental food habits data for halibut captured after March 1982 are included for comparison but were not rigorously analyzed.

Stomach Analysis

The alimentary tract of each halibut collected was fixed in 10% Formalin immediately following capture. Fish were macroscopically sexed, measured (SL in mm), and weighed (0.1 g, wet weight) in the laboratory.

The viscera were fixed for a minimum of 4 days, soaked in tap water for 24-48 hrs, and stored in 70% ethanol prior to further examination.

Prey items in the stomachs were identified to the lowest possible taxa and sex/maturity classes. All prey items were assigned reconstructed wet weights; several methods were used. Clothier (1950) was used to identify fish skeletal remains. Fish prey were assigned reconstructed (undigested) wet weights derived from standard length-wet-weight regressions. Partial remains of fish prey, identified to species, were assigned lengths by comparing key vertebral measures to reference specimens. Mysids were assigned reconstructed weights based on sex and maturity criteria rather than length classes (L. Gleye, Marine Ecological Consultants of Southern California, unpubl. data.).

Statistical Analysis of Diet

Major prey categories were tabulated by percent frequency of occurrence (% FO), percent reconstructed weight (% W), and percent number (% N) using all halibut stomachs collected from March 1981-March 1982. An index of relative importance (IRI; Pinkas et al. 1971) was calculated based on these parameters. Prey categories accounting for less than 0.4% of the total IRI were pooled to form a single group. Prey categories were then ranked by their IRI.

Day samples (16 stomachs with food) were pooled with night samples (26 stomachs) for halibut collected in April and May 1981. There was no statistical difference ($P > 0.1$) between total stomach contents of these day and night sample fish in mean percentage digested (estimated by eye to the nearest 25%). There also was no diel difference in mean reconstructed weight of prey standardized by halibut weight (all $P >$

0.1). Stomach samples of fish from both longshore locations were pooled, since there was no difference ($P > 0.2$) between them in the mean weight of either of two major prey taxa (northern anchovy, mysids) scaled for halibut weight.

Interrelations among halibut size, depth of capture, and % FO of two major prey (anchovy, mysids) were examined with a threeway test of independence (G-test; Sokal and Rohlf 1969:601). The analysis was restricted to halibut captured at the 6-m and 18-m depths. Too few halibut were caught at the 30-m depth to be included in the analysis. Seasonal variation in diet also could not be simultaneously examined because of insufficient sample sizes. Halibut were divided into two length classes (≤245 and >245 mm SL) in order to minimize the number of cells containing zeros. These length classes also roughly reflect the size at which a major dietary shift occurs (see Results). Stomachs in which anchovies and mysids co-occurred were excluded from this analysis, because the added variability obscured the distinction between occurrence of the two types.

Estimates of Prey Abundance

The relative abundance (mean monthly CPUE) of northern anchovy *(Engraulis mordax)* was estimated from lampara seine hauls made at 5-16-m depths in the San Onofre-Oceanside area from March 1981 through March 1982 (E. DeMartini, unpubl. data). Abundances of mysids were estimated based on epibenthic sled samples from 6-m, 8-m, 12-m, 15-m, 23-m, 30-m, and 37-m depths in the San Onofre-Oceanside area on four daytime cruises (June, September, December 1981; March 1982) by Marine Ecological Consultants of Southern California (S. Watts, pers. comm.). For additional description of sampling gears see Roberts et al. (1982). Mysid abundance was expressed as numbers per m^2 area integrated throughout the water column from surface to seabed. Two rare species of mysids not present in our halibut stomach samples were excluded from the mysid abundance estimate.

RESULTS

Prey Eaten

Northern anchovy and mysids were the two most important prey types when ranked by IRI (Table 1). Northern anchovy had the greatest total frequency of occurrence in halibut stomachs and constituted nearly 82% by weight of all prey. Two mysid species, *Neomysis kadiakensis* and *Metamysidopsis elongata*, plus northern anchovy accounted for >90% of the total IRI. Each of the remaining prey taxa accounted for <0.4% of total IRI. Of the 336 California halibut captured (size range 124-476 mm SL), 155 (46%) had empty stomachs. There were no marked differences in the number of empty stomachs among the depths, seasons, and halibut body sizes examined. Large adult halibut seemed to specialize on fishes larger than northern anchovy. For example, the largest halibut (689 mm SL) that we captured during the major, yearlong part of the study had consumed two adult white croaker, *Genyonemus lineatus*. Another large adult halibut (820 mm SL) captured in May 1982 had consumed two adult hornyhead turbot, *Pleuronichthys verticalis*.

TABLE 1
Major Prey Categories of California Halibut, *Paralichthys californicus*, Ranked by IRI*

	IRI (%)	% W	% N	% FO[1]
Northern anchovy	3675 (54.0)	81.6	7.1	41.4
Small mysids[2]	1608 (23.7)	0.3	59.1	27.1
Large mysids[3]	1066 (15.7)	1.6	29.6	34.2
Other fish species[4]	440 (6.5)	16.0	3.0	23.2
Caridean shrimp	9 (0.1)	0.4	0.8	7.2
All other prey	2 (0.0)	0.1	0.4	3.9

[1]Sums to >100% caused by co-occurrences of prey categories in stomachs.
[2]All mysid species, including *Neomysis* spp immatures and juveniles.
[3]*Neomysis* spp adults only.
[4]Includes unidentifiable fish remains.
*(Index of Relative Importance: Pinkas, Oliphant, and Iverson 1971). Components of the IRI—percent of total weight (%W), percent of total number (%N), and percent frequency of occurrence (%FO) of prey in halibut stomachs—are also given. Data represent 336 stomachs (155 empty) of halibut trawled at 6-m, 18-m, and 30-m depths from off San Onofre and near Oceanside from March 1981 through March 1982.

Factors Influencing Prey Eaten

Both halibut body size (S, either ≤245 mm or >245 mm SL) and depth of capture (D, 6 or 18 m) are related to the percent frequency of occurrence (% FO) of two (northern anchovy, mysid) major prey types (Table 2). The size of halibut influenced the type and frequency of prey consumed. Larger juvenile and small adult (>300 mm SL) halibut fed primarily on northern anchovy; small juvenile (<245 mm SL) halibut fed on mysids and larval fish; and intermediate halibut fed on both northern anchovy and mysids to a large extent (Figure 2).

Halibut captured at 6 m were smaller than fish captured at 30 m (Table 2; Figure 3). However, the prey type (mysids or anchovy) in stomachs and the depth of capture were independent for halibut of all sizes pooled (Table 2). This indicates that the relative frequency of the two prey consumed is primarily dependent on the size of halibut, regardless of depth.

Monthly variation in the % FO of mysids in stomachs did not appear to track the monthly variation in mysid abundance (Figure 4). For example, the % FO

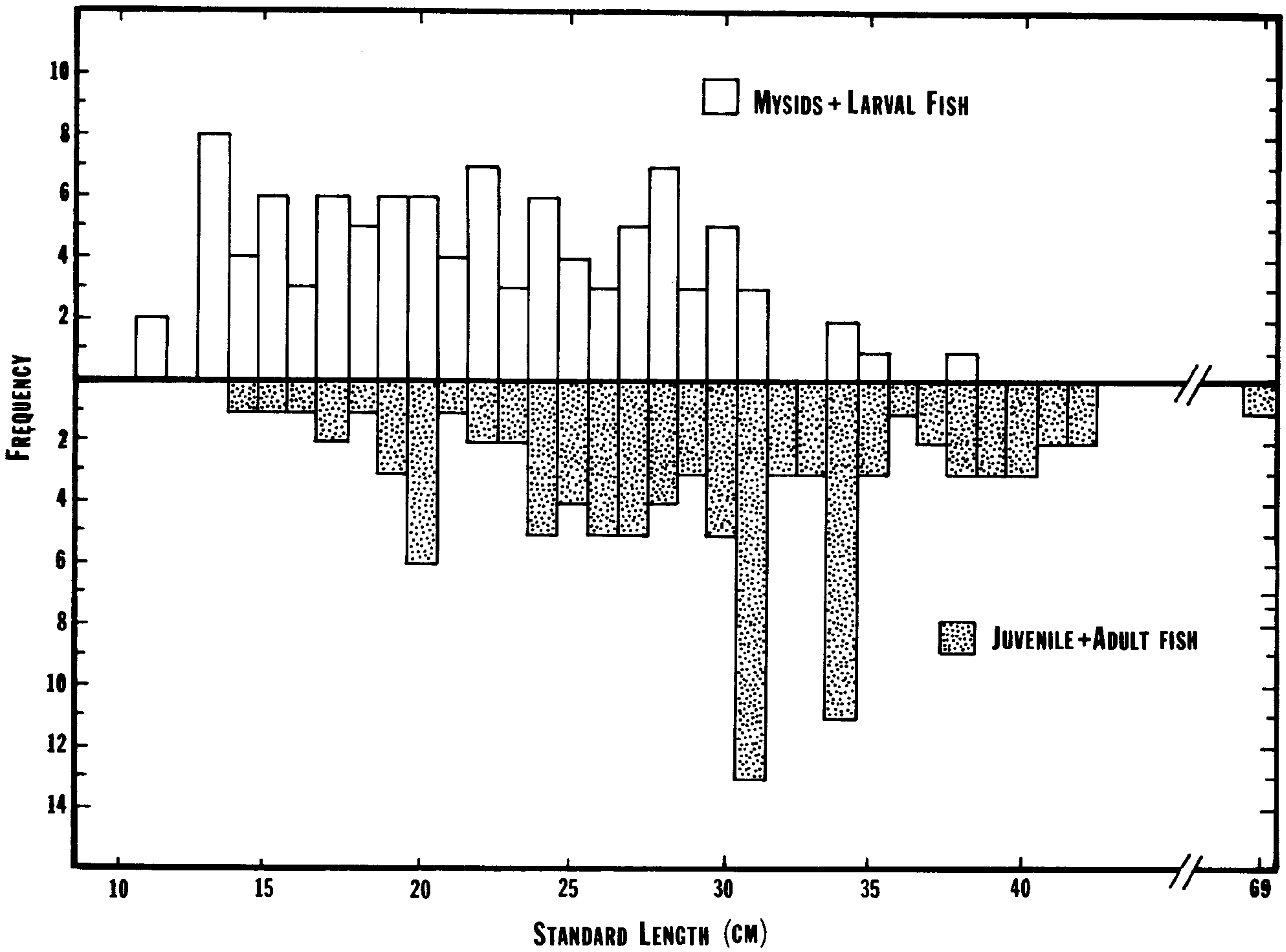

Figure 2. Bar histogram chart of the absolute frequency of occurrence of two major prey categories (mysids and larval fishes; juvenile and adult fishes) found in the stomachs of California halibut of various body sizes that were trawled at 6-m, 18-m, and 30-m depths from off San Onofre and near Oceanside during March 1981 through March 1982. Total number of prey occurrences (201) exceeds the number of stomachs containing these major prey because of co-occurrences of prey categories.

TABLE 2
Results of Threeway Test of Independence for California Halibut

Halibut size (mm SL)	Trawl depth (m)	Prey frequency of occurrence: Mysids	Prey frequency of occurrence: Anchovy
≤245	6	21	12
≤245	18	25	0
>245	6	1	6
>245	18	24	44

Factors	Type of test	G-value	df	Alpha-level
SxDxP	Independence	83.3	4	0.005
SxDxP	Interaction	17.3	1	0.005
SxP	Independence	29.2	1	0.005
SxD	Independence	36.8	1	0.005
PxD	Independence	0.1	1	0.9>P>0.5

Factors analyzed were size (S—either ≤245 mm or >245 mm SL); depth of capture (D—either 6 or 18 m); and frequency of occurrence of two major prey categories (P—either mysids or northern anchovy) in stomachs. Stomachs in which mysids and anchovy co-occurred were excluded from the analysis. Halibut captured at the 30-m depth were too few to be included in the analysis.

of mysids in the stomachs of halibut <245 mm SL was higher during June 1981 than September 1981, even though mysids (primarily *Metamysidopsis elongata*) were twice as abundant during September.

The % FO of northern anchovy in stomachs of halibut >245 mm SL, however, closely tracked the abundance of anchovy. For example, both the % FO in stomachs and the CPUE of anchovy were elevated from June 1981 to September 1981 (Figure 4).

DISCUSSION

General Aspects of Diet

The major prey (mysids, small fishes) of juvenile and small adult California halibut, *Paralichthys californicus*, of coastal waters resemble the foods of juvenile and small adult summer flounder *(Paralichthys dentatus)*, a morphologically similar congener found in North Atlantic bays and estuaries (Powell and

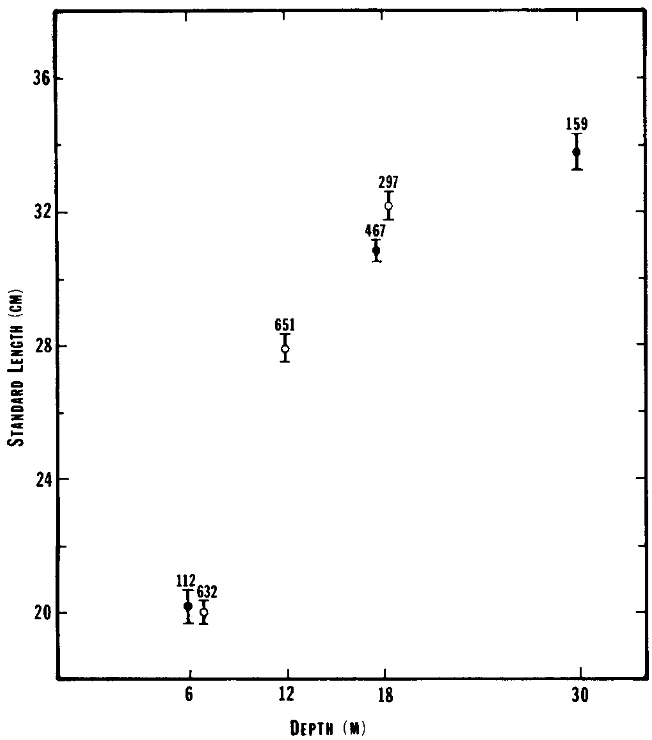

Figure 3. Mean body sizes (standard length in mm) of California halibut trawled at 6-m, 12-m, 18-m, and 30-m depths from the area between San Onofre and Oceanside. Two standard errors of means and sample sizes are noted. Length data for halibut present in trawls (1.3-cm stretch mesh cod-end liner) made by Lockheed Ocean Sciences Laboratory at 6-m, 12-m, and 18-m depths during 1978, 1979, 1980, and 1981 (see Southern California Edison Company 1979, 1980, 1981, and 1982) are represented by the hollow circles. Length data collected by the authors for trawls made from April 1980 through March 1982 are noted by the solid circles.

Schwartz 1979; Poole 1964; Smith and Daiber 1977). The diet of California halibut in coastal waters, however, differs from that of juvenile halibut from Anaheim Bay (Haaker 1975). These differences in prey eaten probably reflect differences in prey abundance (availability) in the two habitats. For example, gobies are an important prey of small juvenile halibut in Anaheim Bay (Haaker 1975), and gobies are known to be abundant in Anaheim Bay (MacDonald 1975). Conversely, gobies are not abundant in the shallow (<30 m) coastal waters between San Onofre and Oceanside (E. DeMartini, unpubl. data), and they did not occur in our sample halibut.

Northern anchovy are a major prey of adult California halibut (Frey 1971). Our data demonstrate that northern anchovy also are an important food for juvenile and small adult halibut in the coastal waters of southern California. Most (96%) of our sample halibut that ate anchovies had eaten immature stages (<10 cm SL; Hunter and Leong 1981). Of all anchovy prey, 97% and 94% by number and weight, respectively, were immature fish.

Mysids also are important in the diet of juvenile halibut in coastal waters, although they seem insignificant in Anaheim Bay (Haaker 1975). Ford (1965) found mysids in the stomachs of 8 halibut (average 305 mm TL, equal to 263 mm SL; Haaker 1975) out of 36 collected from coastal waters near San Diego, 45-65 km downcoast of our sampling areas. Moreover, small juvenile halibut appear to selectively feed on the larger, rarer mysids available. Although large mysids (*Neomysis* spp adults) were about 28 times less abundant than small mysids, they represented nearly one-third of the total numbers of mysids consumed by our sample halibut (Table 1). Large mysids occurred more frequently than small mysids in halibut stomachs with food and accounted for about 5 times the total weight of small mysids (Table 1). Slower rates of digestion for large mysids might have caused us to overestimate the importance of large mysids. However, we feel this influence was minor, since most mysids of all sizes encountered in stomachs were relatively undigested. The generally faster digestion and gut evacuation rates for mysids versus fish, though, probably caused some unavoidable underestimation of the importance of mysids in halibut diet.

Influences of Body Size, Depth, and Season on Diet

Changes in diet with increased body size have been demonstrated for small juvenile California halibut in Anaheim Bay (Haaker 1975) and for the juveniles and small adults of two congeners in North Carolina estuaries (Powell and Schwartz 1979). Halibut in Anaheim Bay (Haaker 1975) and the two Atlantic *Paralichthys* spp (Powell and Schwartz 1979) switch to a more piscivorous diet as they grow larger. Our data show that juvenile-small adult halibut in coastal waters also switch to a more piscivorous diet with increased body size (Figure 2; Table 2).

The body length (~25 cm SL) at which halibut in coastal waters begin to shift to a more piscivorous diet roughly corresponds to the length (9 inches or about 23 cm TL; Frey 1971) at which male halibut begin to mature. Females begin to mature at a much larger size (17 inches or 43 cm TL; Frey 1971). Hence our samples characterize the diet for fish of a range of maturity states of both sexes: 61% of our halibut were adult males, 15% adult females, and 24% immatures—the latter probably mainly juvenile females. Sample sizes were insufficient, however, to analyze diet by sex as well as body size. Only one of our sample halibut exceeded the current minimum legal size (22 inches or 559 mm TL) of sport-caught halibut (Figure 2).

Clark (1930, 1931) notes that young California halibut occur in shallow water, while larger fish frequent greater depths except for an onshore spawning migra-

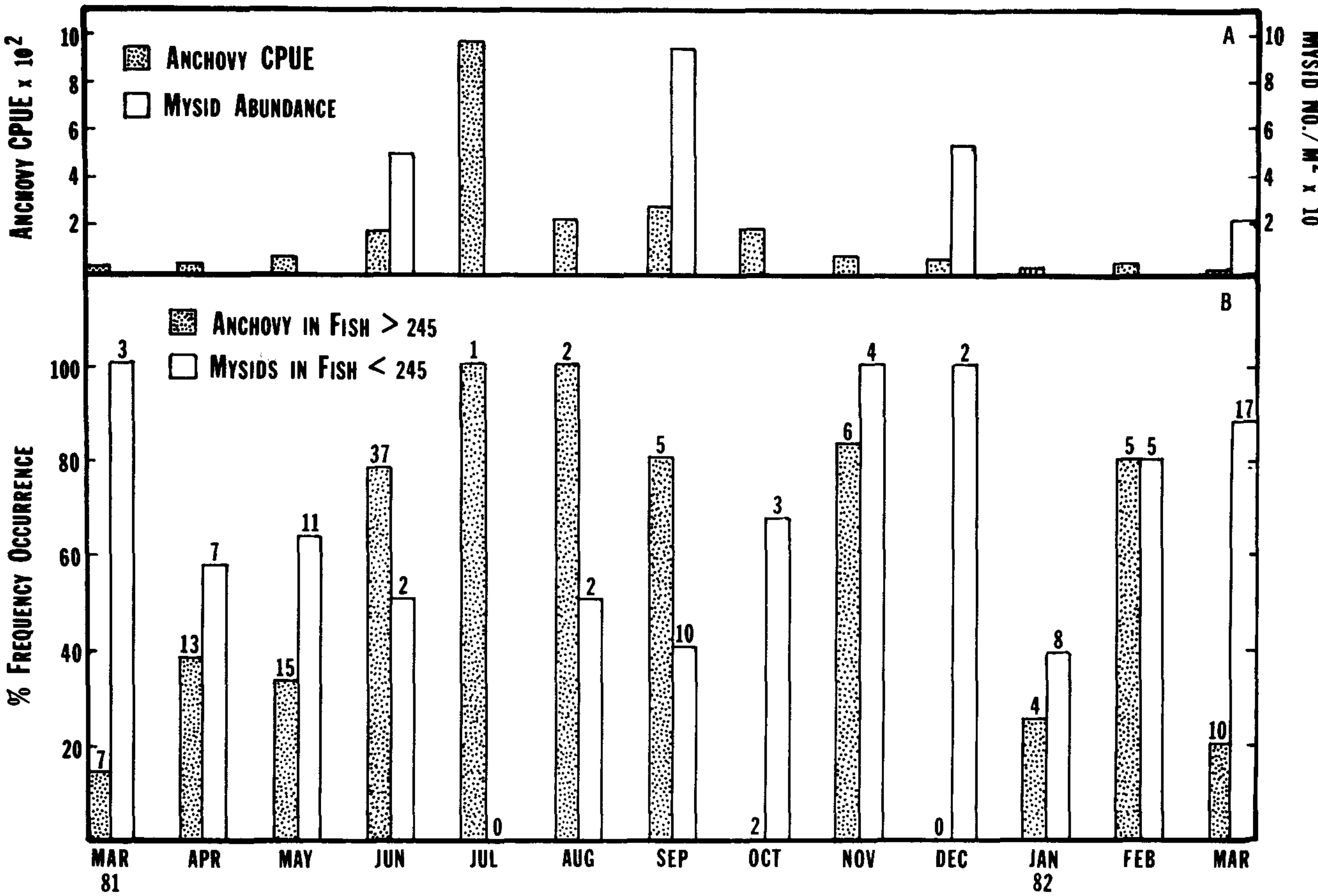

Figure 4. *(A)* Relative abundance (CPUE) of northern anchovy and abundance (number per m²) of mysids in the San Onofre-Oceanside region at the various sampling depths and longshore locations pooled. Mysid data are restricted to species that occurred in our halibut stomach samples. *(B)* Relative frequency (% FO) of anchovy and mysid prey present in stomachs of halibut from all depths of capture and both longshore locations pooled. Numbers of stomachs with food are noted by month and by halibut length class (≤245 or >245 mm SL).

tion. Our data show that juveniles smaller than about 10 cm SL do not occur in shallow (<30 m) coastal waters. Age I+-sized fish (15-25 cm SL) and II+ (30-45 cm SL) and older-sized fish (Haaker 1975; Innis 1980) segregate by depth, with older juveniles and young adults occurring deeper than younger juveniles (Figure 3). Undoubtedly, our trawls grossly undersample adult-sized halibut at all depths, and this accounts for our inability to detect the seasonal onshore spawning migration of adults (see Barry and Cailliet 1981).

The % FO of northern anchovy and mysids in the stomachs of juvenile-small adult halibut of all sizes pooled is independent of depth (Table 2). Differences in diet (mysids vs northern anchovy) between small juvenile (≤245 mm) and larger (>245 mm) halibut, however, are dependent on depth (Table 2). Small juveniles inhabited shallow (6 m) depths and consumed mysids, while larger fish frequented deeper waters and ate mostly northern anchovy. Northern anchovy were eaten more frequently by juvenile and small adult halibut during summer-fall, despite the fact that mysids were also relatively abundant then. At this time anchovy were more abundant nearshore, and this is typically the case (see Huppert et al. 1980). These data corroborate the preliminary observations of Roberts et al. (1982) and are consistent with a major prediction of Optimal Foraging Theory—namely, that more-preferred, often larger prey are eaten regardless of the relative abundance of less-preferred prey (Hughes 1980). Our data lend further support to Roberts et al. (1982), who also suggested that the differences in diet between juvenile and small adult halibut might be due to prey selection and that small juveniles may inhabit shallow coastal waters because mysids, their preferred prey, are more abundant there.

In summary, northern anchovy and mysids are the major prey of juvenile and small adult California halibut in the coastal waters of the San Onofre-Oceanside region. The relative importance of these two prey varies with size of halibut and season. Anchovies are most important during summer-fall. Smaller juvenile halibut tend to inhabit shallower coastal waters and consume mysids more frequently than anchovies, despite the insignificant relation between depth per se and the relative frequency of mysids versus anchovies eaten.

Implications of Size-Specific Depth Distributions

Our data indicate that California halibut <10 cm SL are largely absent from shallow (6-30-m depth) coastal waters off northern San Diego County (Figures 2,3). Moreover, only 2% of 1580 halibut trawled at 6-m, 12-m, and 18-m depths in another coastal monitoring study off northern San Diego County were <10 mm SL (Table 3). These data contrast sharply with a majority of other studies done in Elkhorn Slough, Mugu Lagoon, Anaheim Bay, and Newport Bay (Table 3), which show that juvenile halibut <10 cm SL are an abundant size group during certain times of year. None of the few California halibut captured in the surfzone (<5-m depths) using a bag seine in the San Onofre-Oceanside region were <205 mm SL (Table 3). Mostly large juvenile halibut were caught in a subsequent study, analogous to the latter, made in the same area and at La Jolla near San Diego (Table 3).

On the basis of these data we tentatively conclude that juvenile halibut <10 cm SL reside primarily in embayments and not in shallow coastal waters. Haaker's (1975) data for Anaheim Bay suggested this. There is an obvious need for further studies of juvenile halibut distribution designed specifically to test this hypothesis. We feel, though, that surfzone sampling using 1.3-cm stretch mesh bag seines (Table 3) should have collected greater numbers of small juveniles between 5-10 cm SL, if young-of-the-year were abundant in surfzone regions.

California halibut apparently spawn in nearshore coastal waters (Frey 1971; Gruber et al. 1982). The planktonic larval stages (≤ ~1 cm SL; J. R. Hunter, H. G. Moser, W. Watson, pers. comm.) occur throughout the water column, primarily over 12-45-m bottom depths within 1.9-5.4 km of shore in the San Onofre-Oceanside region (A. Barnett, Marine Ecological Consultants of Southern California, unpubl. report); and larger larvae occur closer to shore (A. Barnett, unpubl. data). Halibut larvae are most abundant in this region during March-September (A. Barnett, unpubl. report), which agrees with the February-July spawning season noted by Frey (1971).

We do not yet know whether halibut larvae metamorphose in nearshore coastal waters and then migrate into embayments, or transform to juveniles within embayments after somehow reaching these areas while in the plankton. The former seems more likely based on the early life history of other *Paralichthys* spp. A western Atlantic congener, *Paralichthys dentatus,* spawns in offshore coastal waters, and larvae probably metamorphose nearshore before entering estuaries (Smith 1973). Juvenile *P. dentatus* are restricted in their distribution to estuaries (Smith 1973).

TABLE 3
Summary of Gear and Sampling Designs, Sampling Effort, and Catches of Juvenile-Small Adult California Halibut for Various Studies Made in Central and Southern California Waters

Sample type(s)	Mesh size (cm)	Region sampled	Collection period	No. samples (effort)	No. halibut ≤10 cm	No. halibut >10 cm	Source
Otter trawl	1.3	Elkhorn Slough, Monterey Bay	Oct 78-May 80	146	7	64	Barry and Cailliet (1981); J.P. Barry, pers. comm.
Bag seine	1.0	Mugu Lagoon, Ventura County	Feb 77-Nov 81	228	975	278	C. Onuf, pers. comm.
Otter trawl	2.5 0.6	Anaheim Bay, Orange County	Jan-Apr 70 May 70-Feb 71	~ 48 ~120	~ 44 ~487	~182 ~ 603	Haaker (1975, Fig. 41)
Otter trawl, bag seine	0.8, 0.3	Newport Bay, Orange County	Mar 74-Sep 75	129, 24	18	111	L.G. Allen, pers. comm.
Otter trawl, bag seine	0.8, 0.3		Jan 78-Jan 79	48, 48	11	52	
Otter trawl	1.3	San Mateo Pt.—Don Light, north San Diego County; coastal waters (6, 12, & 18 m)	Mar 78-Dec 81	831	34	1546	SCE (1979, 1980, 1981, 1982)
Bag seine	1.3	San Onofre—Oceanside surfzone (≤5-m depth)	Jun-Dec 76; Mar-Apr 77	68	0	5	Tetra Tech (1977)
Bag seine	1.3	San Onofre—Oceanside, La Jolla surfzone (≤5-m depth)	Nov 78-Jul 79	175	2	13	E. DeMartini (unpubl. data)

Halibut catches are divided into individuals ≤10 cm and >10 cm SL. All mesh-size data are stretch measurements for the bag or cod-end liner sections, as appropriate. Apparent differences among embayments in the relative proportions of halibut ≤10 and >10 cm undoubtedly reflect both differences in gear and variable recruitment in the different years of study.

Paralichthys olivaceus has a similar early life history in Japan (Minami 1982).

Shallow waters of the open coast serve as a nursery ground for many species of nearshore fishes in the Southern California Bight (Sherwood 1980). The California halibut may be one of a minority of species for which embayments are essential during the early juvenile stage.

We feel that the major alteration and destruction of bays and estuaries in southern California (e.g., see Reish et al. 1980) undoubtedly has eliminated many of the nursery grounds that are necessary during the early life history of the California halibut.

ACKNOWLEDGMENTS

We thank Cathy Engel for aid in the mysid prey identification and data tabulation and Jan Fox for typing the manuscript. We also thank Larry Allen, Jim Barry, Pete Haaker, and Chris Onuf for sharing their unpublished data on halibut size-frequency distributions, and Larry Allen and Jim Barry for their constructive comments on the final draft. This paper is the result of research funded by the Marine Review Committee (MRC), Encinitas, California. The MRC does not necessarily accept the results, findings, or conclusions stated herein.

LITERATURE CITED

Barry, J. P., and G. M. Cailliet. 1981. The utilization of shallow marsh habitats by commercially important fishes in Elkhorn Slough, California. *In* D. Koch (ed.), Cal-Neva Wildlife Transactions, 1981, p. 38-47.

Clark, G. H. 1930. California halibut. Calif. Fish Game 16:315-317.

———. 1931. The California halibut *(Paralichthys californicus)* and an analysis of the boat catches. Calif. Div. Fish Game , Fish Bull. 32, 52 p.

Clothier, C. R. 1950. A key to some southern California fishes based on vertebral characters. Calif. Dept. Fish Game, Fish Bull. 79, 83 p.

Feder, H. M., C. H. Turner, and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in southern California. Calif. Dept. Fish Game, Fish Bull. 160, 144 p.

Ford, R. F. 1965. Distribution, population dynamics and behavior of a bothid flatfish, *Citharichthys stigmaeus.* Ph.D. dissertation, University of California, San Diego, 243 p.

Frey, H. W., ed. 1971. California's living marine resources and their utilization. Calif. Dept. Fish Game. 148 p.

Gruber, D., E. H. Ahlstrom, and M. M. Mullin. 1982. Distribution of ichthyoplankton in the Southern California Bight. Calif. Coop. Oceanic Fish. Invest. Rep. 23:172-179.

Haaker, P. L. 1975. The biology of the California halibut, *Paralichthys californicus* (Ayres), in Anaheim Bay, California. *In* E. D. Lane and C. W. Hill (eds.), The marine resources of Anaheim Bay. Calif. Dept. Fish Game, Fish Bull. 165:137-151.

Hughes, R. N. 1980. Optimal foraging theory in the marine context. Oceanogr. Mar. Biol. Ann. Rev. 18:423-481.

Hunter, J. R., and R. Leong. 1981. The spawning energetics of female northern anchovy, *Engraulis mordax.* Fish. Bull., U.S. 79:215-230.

Huppert, D. D., A. D. MacCall, G. D. Stauffer, K. R. Parker, J. A. MacMillan, and H. W. Frey. 1980. California's northern anchovy fishery: biological and economic basis for fishery management. NOAA Tech. Memo. NMFS-SWFC-1. April 1980.

Innis, D. B. 1980. Growth characteristics and temperature preference behavior of juvenile California halibut, *Paralichthys californicus,* and their relationship to the effects of thermal effluent. Master's thesis, San Diego State University, 110 p.

MacCall, A. D., G. D. Stauffer, and J. P. Troadec. 1976. Southern California recreational and commercial marine fisheries. Mar. Fish. Rev. 38, 32 p.

MacDonald, C. K. 1975. Notes on the family Gobiidae of Anaheim Bay. *In* E. D. Lane and C. W. Hill (eds.), The marine resources of Anaheim Bay. Calif. Dept. Fish Game, Fish Bull. 165:117-135.

Mearns, A. J., and M. J. Allen. 1978. Use of small otter trawls in coastal biological surveys. Southern California Coastal Water Research Project, Contribution No. 66. EPA-600/3-78-083.

Minami, T. 1982. The early life history of a flounder *Paralichthys olivaceus.* Bull. Jap. Soc. Sci. Fish. 48:1581-1588. (In Japanese, with English abstract.)

Oliphant, M. S. 1979. California marine fish landings for 1976. Calif. Dept. Fish Game, Fish Bull. 170, 56 p.

Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. Calif. Dept. Fish Game, Fish Bull. 152, 105 p.

Poole, J. C. 1964. Feeding habits of the summer flounder in great South Bay. New York Fish Game J. 11:28-34.

Powell, A. B., and F. J. Schwartz. 1979. Food of *Paralichthys dentatus* and *P. lethostigma* (Pisces:Bothidae) in North Carolina estuaries. Estuaries 2:276-279.

Quast, J. C. 1968. Observations on the foods of the kelp bed fishes. *In* W. J. North and C. L. Hubbs (eds.), Utilization of kelp-bed resources in southern California. Calif. Dept. Fish Game, Fish Bull. 139:109-142.

Reish, D. J., D. S. Soule, and J. D. Soule. 1980. The benthic biological conditions of Los Angeles-Long Beach harbors: results of 28 years of investigations and monitoring. Helgolander Meeresuntersuchungen 34:193-205.

Roberts, D., E. DeMartini, C. Engel, and K. Plummer. 1982. A preliminary evaluation of prey selection by juvenile-small adult California halibut *(Paralichthys californicus)* in nearshore coastal waters off southern California. *In* G. M. Cailliet and C. A. Simenstad (eds.), Gutshop '81, Fish Food Habits Studies, Proceedings Third Pac. Workshop; Asilomar Conf. Center, Pacific Grove, Calif.; December 6-9, 1981, p. 214-223.

Sherwood, M. 1980. Recruitment of nearshore demersal fishes. *In* W. Bascom (ed.), Coastal Water Research Project, biennial report for the years 1979-1980. Southern California Coastal Water Research Project, Long Beach, Calif. 90806, p. 319-333.

Smith, R. W., and F. C. Daiber. 1977. Biology of the summer flounder, *Paralichthys dentatus,* in Delaware Bay. Fish. Bull., U.S. 75:823-830.

Smith, W. G. 1973. The distribution of summer flounder, *Paralichthys dentatus,* eggs and larvae on the continental shelf between Cape Cod and Cape Lookout, 1965-66. Fish. Bull., U.S. 71:527-548.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco, 776 p.

Southern California Edison Company (SCE). 1979. January-December 1978 annual operating report, San Onofre Nuclear Generating Station. Vol. IV. Biological, sedimentological, and oceanographic data analyses 1978. SCE Research and Development Rep. No. 79-RD-54.

———. 1980. 1979 annual operating report, San Onofre Nuclear Generating Station. Vol. IV. Biological data report, nekton. SCE Research and Development Rep. No. 80-RD-13.

———. 1981. 1980 annual operating report, San Onofre Nuclear Generating Station. Vol. II. Comprehensive data supplement, part 2 of 2, biological. SCE Research and Development Rep. No. 81-RD-8.

———. 1982. 1981 annual report. San Onofre Nuclear Generating Station. Data appendix. SCE Research and Development Rep. No. 82-RD-52.

Tetra Tech, Inc. 1977. MRC Fish Program: final report, appendices, December 1977. Report submitted to the Marine Review Committee of the California Coastal Commission.