INTERNATIONAL PACIFIC HALIBUT COMMISSION

ESTABLISHED BY A CONVENTION BETWEEN
CANADA AND THE UNITED STATES OF AMERICA

Scientific Report No. 73

Recent Studies of Pacific Halibut Postlarvae in the Gulf of Alaska and Eastern Bering Sea

by

Gilbert St-Pierre

SEATTLE, WASHINGTON
1989

The International Pacific Halibut Commission has three publications: Annual Reports (U.S. ISSN 0074-7238), Scientific Reports, and Technical Reports (U.S. ISSN 0579-3920). Until 1969, only one series was published (U.S. ISSN 0774-7246). The numbering of the original series has been continued with the Scientific Reports.

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P.O. BOX 95009
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ABSTRACT

The International Pacific Halibut Commission (IPHC) searched for postlarval Pacific halibut in March and June 1985 and during May-June 1986, in the Gulf of Alaska and the southeastern Bering Sea with a nine square meter plankton trawl. This report discusses the results of these surveys and includes annotations on survival, predation, and cannibalism of halibut postlarvae. Results depict the westward drift of halibut postlarvae in the Gulf of Alaska and suggest that many are carried into the Bering Sea by the Alaska Coastal current.

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INTRODUCTION

Previous studies on the early life history of Pacific halibut *(Hippoglossus stenolepis)* have been conducted by the International Fisheries Commission (IFC) later known as the International Pacific Halibut Commission (IPHC). Thompson and Van Cleve (1936) is probably the most extensive single source of information on the development, distribution, and drift of halibut eggs and larvae. They documented the biology of the Pacific halibut; their larval distribution and early life history, and provided anatomical description of the various larval stages.

Van Cleve and Seymour (1953) reported on the production and distribution of halibut eggs near Cape St. James in British Columbia. Skud (1977) reviewed previous studies on the drift of eggs and larvae, the migration of juvenile halibut, and the movement of adults. He concluded that halibut stocks intermingle at all stages of their life history and proposed a thesis of countermigration by juvenile halibut to explain how halibut stocks maintain their geographic position, since currents carry eggs and larvae away from their spawning grounds. Latterly, St-Pierre (1984) reviewed the literature and summarized unpublished material collected by the IPHC relating to spawning locations and season for Pacific halibut and associated migrations involved in the process.

No extensive larval sampling has been undertaken for Pacific halibut in the northeast Pacific since the pioneering work of Thompson and Van Cleve (1936) in the early 1930s and Van Cleve and Seymour (1953) during 1935 to 1946. In the expectation of obtaining recent and additional information on the drift and distribution of Pacific halibut postlarvae, the IPHC participated in the March 1985 National Oceanic and Atmospheric Administration (NOAA) Fishery Oceanography Experiment (FOX) conducted from the oceanographic research vessel DISCOVERER. The purpose of this experiment was to study the processes which affect the air-ocean-biology and their interrelations with the walleye pollock (*Theragra chalcogramma*) fishery in Shelikof Strait.

Following the March 1985 survey, a nine square meter single-net plankton trawl was deployed from the trawler chartered to conduct the annual abundance assessment of juvenile halibut. A few days of charter time in the beginning of June 1985 were devoted to locating and catching some larval halibut in the FOX study area, and concentrations of larval halibut were readily found. Encouraged by the relative ease at finding postlarval halibut in June 1985, the 1986 juvenile halibut survey was modified to spend 28 days in May and June surveying the waters from Dixon Entrance to the eastern Bering Sea.

Ideally, a comprehensive study on larval halibut in the north Pacific and eastern Bering Sea waters would necessitate the utilization of at least three vessels operating continuously from January 1 to the end of June. This would allow a comprehensive monitoring of the changes in age and abundance of larval halibut at many sites over time. Sampling on a day and night basis would contribute data on the distribution and movement through the water column by the postlarvae. Unfortunately, such a research program would have required expenditures in personnel and financial resources exceeding IPHC budgetary means. In spite of the aforementioned shortcomings, the recent studies provided useful information on the distribution of halibut postlarvae.

In a review of the literature and unpublished material collected by IPHC, St-Pierre (1984) concluded that the spawning period for Pacific halibut starts as early as the beginning of November, with most of the spawning being over by the end of March. He indicated that the period of greatest spawning intensity falls between the last week of December and the third week of January. Thus, the 1986 survey is characterized by the fact that it took place some four months after the peak spawning period and two months after the last spawning. Hence, the 1986 survey investigates the drift of postlarvae arising mainly from the February and March spawning, i.e., the tail end of the spawning period. Accordingly, the data do not show a consistent cline in size of postlarvae over time and distance for the following two reasons: (1) it is estimated that a large number of postlarvae representing the season's progeny had already settled down, especially in the eastern region of the Gulf, and (2) the lack of postlarvae younger than stage five and the low number of stages five and six in a catch composed mostly of individuals of stages 8 to 10 uphold the opinion that we were probably sampling the last of this season's progeny.

The results of the FOX experiment, the June 1985 survey, and the May-June 1986 survey are presented in this report. Pertinent observations on survival, cannibalism, and predation relating to postlarval halibut are given in the appendix. The designation of halibut larval stages referred to in this paper are the same as described in IPHC Report number 9 by Thompson and Van Cleve (1936). They are summarized and shown in Figure 1. The location of geographic names mentioned in this report are shown on Figures 4 and 5.

LIFE HISTORY OF THE EGGS AND LARVAE

Information excerpted from IPHC publications indicates that the pelagic life of Pacific halibut, which is limited to egg and larval stages, lasts six to seven months from the time spawning takes place to the time they commence their bottom dwelling existence. The spawning period for Pacific halibut occurs mostly from December through March and is concentrated near the edge of the continental shelf, generally in depths between 180 and 500 m. Halibut eggs are first found in the deep waters along the outer edge of the spawning banks. After two to three weeks, pelagic larvae 8 to 15 mm in overall length are hatched. The newly-hatched larvae apparently have a higher specific gravity than the eggs and are therefore found at greater depths. Although the newly-hatched larvae are found below depths of 200 meters, the stage 3 or older postlarvae gradually rise into the faster-moving surface currents and are carried westward (Thompson and Van Cleve, 1936). Knowledge of the general circulation pattern in the Gulf of Alaska and eastern Bering Sea helps to explain the distribution of postlarvae observed in these waters. The circulation and current patterns in the Gulf of Alaska and the eastern Bering

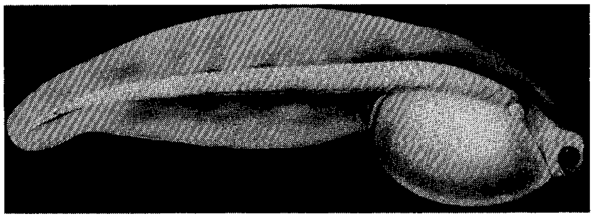

Figure 1a. Stage 1 larva. Average length 11.2 mm.

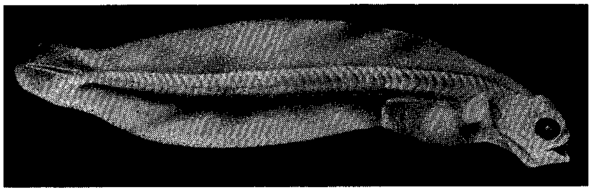

Figure 1b. Stage 2 larva. Average length 13.4 mm.

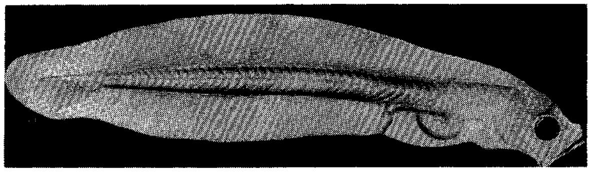

Figure 1c. Stage 3 postlarva. This stage is called postlarva because all yolk has been absorbed. Average length 15.0 mm.

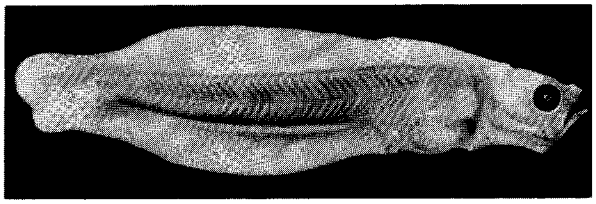

Figure 1d. Stage 4 postlarva. Average length 15.2 mm.

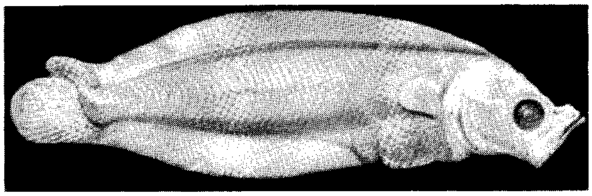

Figure 1e. Stage 5 postlarva. Note especially the appearance of the basal structures in the dorsal and anal fins. Average length 16.2 mm.

Figure 1. Growth and developmental stages in Pacific halibut larvae and post-larvae. N.B. Measurements in the first five stages are to the end of the notochord.

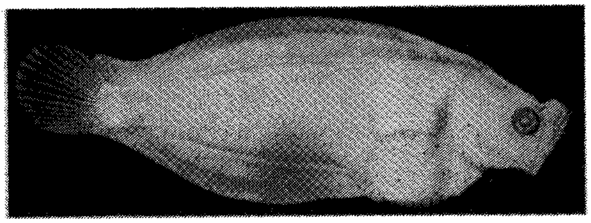

Figure 1f. Stage 6 postlarva. Fin-rays well developed in the dorsal and anal fins but have not completely replaced the larval folds. Average length 15.9 mm.

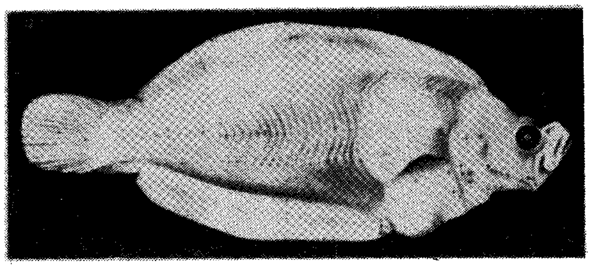

Figure 1g. Stage 7 postlarva. Average length 17.8 mm.

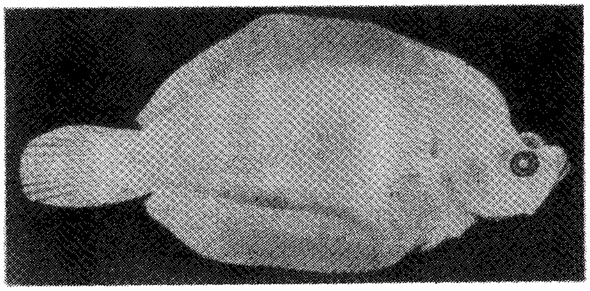

Figure 1h. Stage 8 postlarva. Definite grouping of chromatophores into the postlarval pattern first becomes evident at this stage. Average length 19.6 mm.

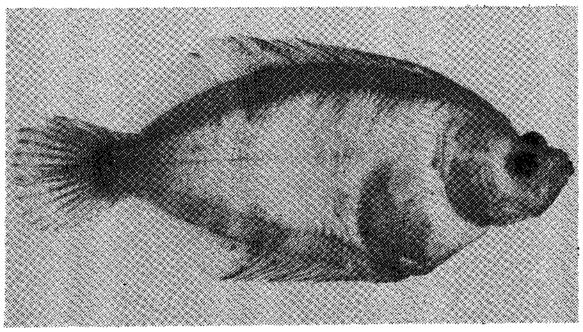

Figure 1i. Stage 9 postlarva. The postlarval pigment is nearly complete. Average length 20.8 mm.

Figure 1. ***(continued)*** **Growth and developmental stages in Pacific halibut larvae and post-larvae. N.B. Measurement of stages 6 to 12 are to the end of the hypural plate.**

Figure 1j. Stage 10 postlarva. The eye has not quite reached the dorsal profile of the head and the pectoral fin is still large, very delicate and thin in structure. Average length 21.3 mm.

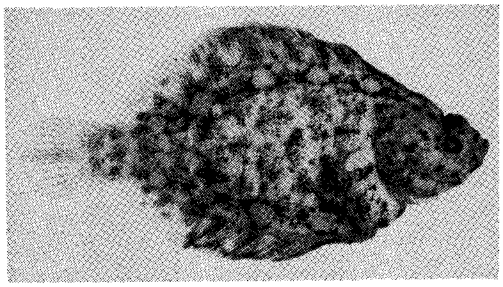

Figure 1k. Stage 11 postlarva. The postlarval pattern is gradually lost while the pectoral fin is reduced in size. The left eye has passed the dorsal profile of the head. Average length 22.1 mm.

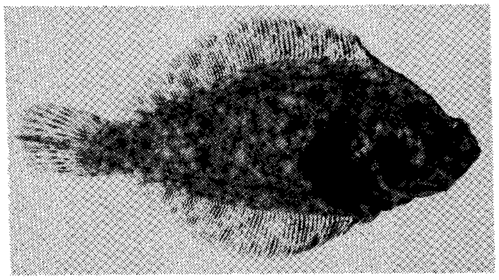

Figure 1l. Stage 12 postlarva. The pectoral fin has become pointed in profile and is now by actual measurement shorter than was the base of the larval pectoral in Stage 10. Average length 25.7 mm.

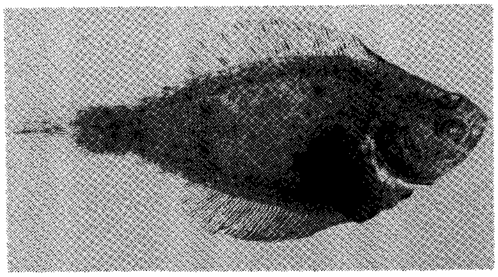

Figure 1m. Young halibut. Length of 28.8 mm for this specimen.

Figure 1. ***(continued)*** **Growth and developmental stages in Pacific halibut larvae and post-larvae. N.B. Measurement of stages 6 to 12 are to the end of the hypural plate.**

Sea as adapted from Thompson (1981), Schumacher and Reed (1983), and Reed and Schumacher (1986) are shown in Figure 2. By the age of three to five months (stages five to nine) all halibut postlarvae are found at depths of 180 m or less. They are then carried inshore by the currents, where they are found in shallow waters during May and June.

SAMPLING GEAR

Plankton tows in the March 1985, postlarval survey were made using a large, nine square meter Tucker trawl sampling system. The multiple-closing trawl, capable of taking three independent samples per deployment, was used only during the FOX experiment. Unfortunately, this trawl was lost during the third deployment and a new trawl frame had to be built. The constructed frame was designed with simplicity in mind and outfitted for single net sampling (Figure 3). This latter frame is described below and was used as the principal sampling gear in these recent studies.

The plankton trawl frame consisted of a top and bottom member constructed ot three meter long sections of 76 mm diameter galvanized pipe. The sides were made of stainless steel cables fastened to the ends of each pipe. The apparatus weighed approximately 90 kg and the bottom pipe carried an additional 200 kg of lead attached to it. The plankton trawl was pulled by a single wire which was connected to a bridle attached to the top pipe of the frame. The trawl was designed to filter a nine square meter area when the side cables between the top and bottom pipes are kep at an angle of 45 degrees during deployment.

The stability of this 45 degree orientation was verified by making subsurface tows at various speeds. It was observed that this 45 degree angle was reached at 1.5 km/hour approximately and remained quite stable as the speed was increased to about 6.5 km/hour. Meanwhile, the angle of the towing wire varied from about 70 degrees at slow speed to about 50 degrees at higher speed, while the angle of the side cables remained steady at 45 degrees. For this reason, it is believed that the orientation of the mouth of the net at the target depth might remain fairly stable, not duly affected by the catenary of the towing wire. The measurements taken from the towing wire varied from 55 to 65 degrees during the surveys and averaged 61 degrees.

The rectangular plankton nets measured three meters in width by approximately 4.2 meters in height, resulting in an effective nine square meter filtering area during deployment. The plankton nets were 10 m long and were made of 1.6 or 2.0 mm knotless mesh size netting. The 1.6 mm mesh net was used for all tows made in 1985, whereas both mesh size nets were used in the 1986 survey. The smaller mesh net worked very well in the sheltered waters of southeastern Alaska and in the open waters of the Gulf of Alaska on calm days. However, on days when the swell was approaching moderate levels in amplitude (over two meters) the 1.6 mm mesh net was inadequate, as the resulting surge on the vessel had the effect of adding large sudden strains on the net, causing it to burst from end to end. Fortunately, the 2.0 mm mesh net with its reduced drag proved to be more sturdy and operated successfully in such weather conditions. I doubt that the two mesh sizes affected the retention of halibut postlarvae which were from stages 5 to 12

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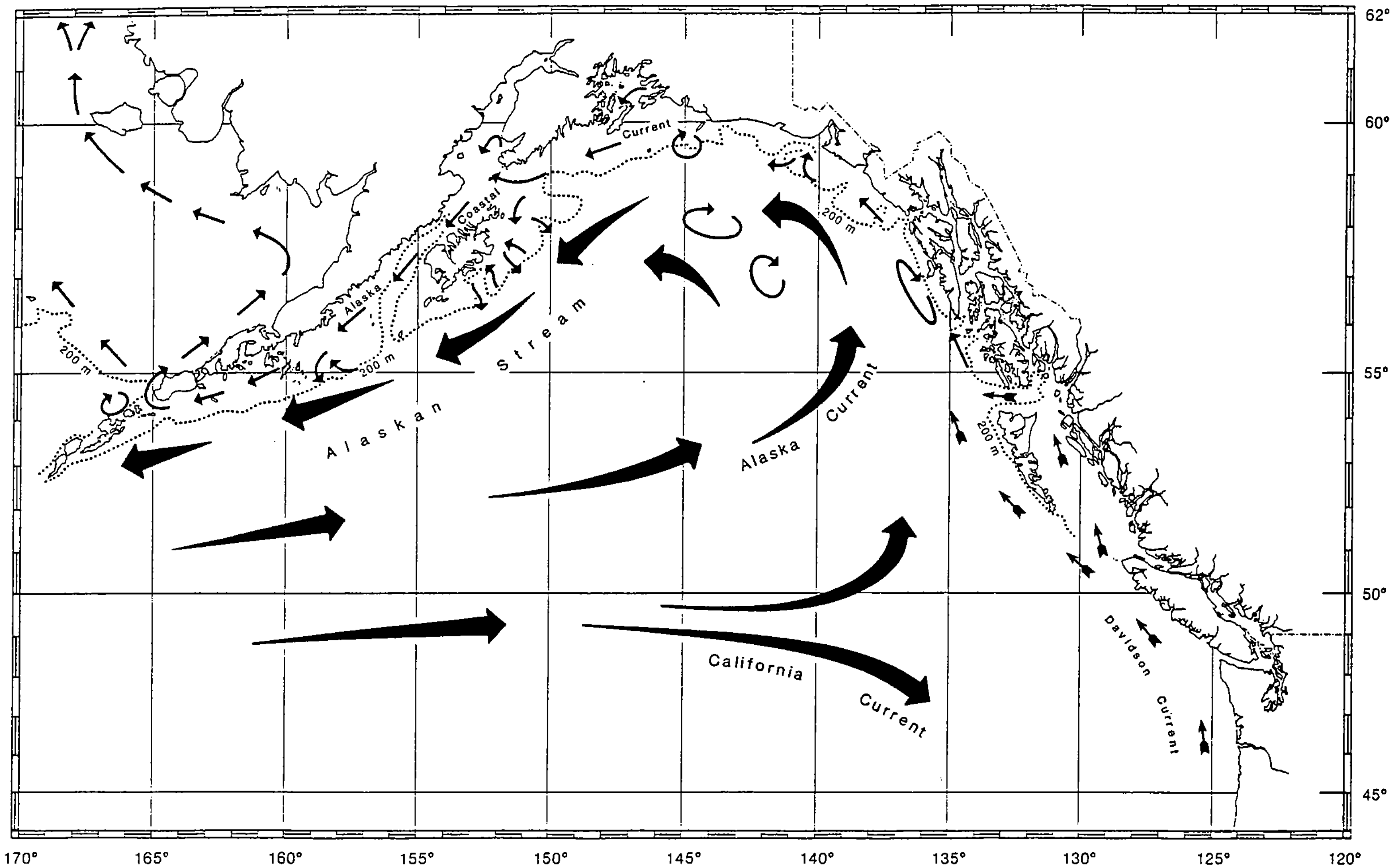

Figure 2. General circulation and current patterns in the northeast Pacific. Adapted from Thompson (1981), Schumacher and Reed (1983), and Reed and Schumacher (1986).

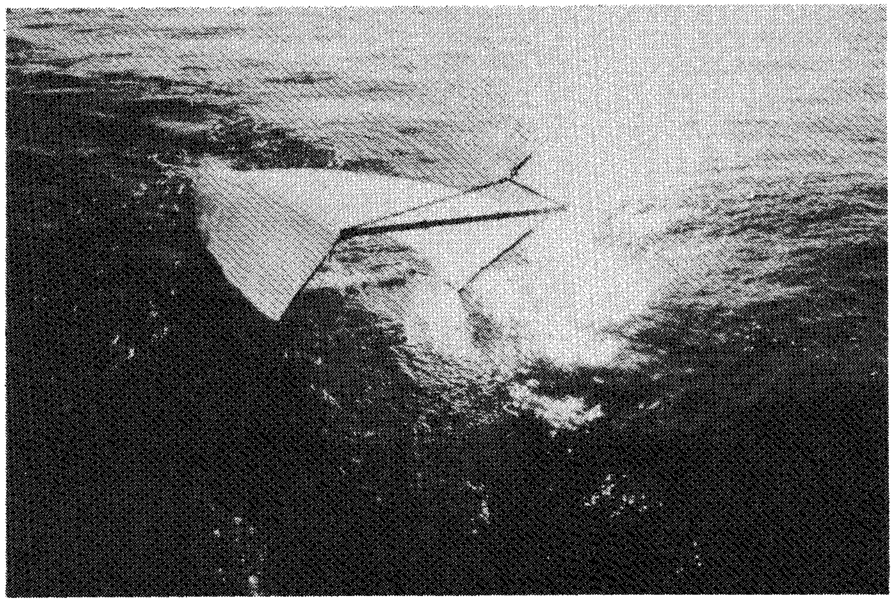

Figure 3. Tucker trawl sampling system with plankton net attached.

and measured from 16 to 25 mm in overall length. However, excessive towing speed could create hydrodynamic back pressure sufficient to deflect some larvae away from the mouth of the net.

The limitation of not using a three-net array to monitor the catch at different depth strata is considered negligible in these studies since Thompson and Van Cleve (1936) have shown that postlarvae at this time in their development are distributed in the upper water column. In their study on the distribution and early life history of Pacific halibut they reported that no postlarvae of stage five or older were found in depths greater than 170 meters and that 85 percent were found in depths of 85 meters or less. Of the 1,562 halibut postlarvae caught in 1985 and 1986, most had reached the development shown in stages 7 to 11, with stage five representing the youngest individuals captured. Data from a comparative tow made in 1985 and described later in this report support the notion that stage five or older halibut postlarvae are distributed in the upper layers of the water column.

A bottom trawl was also used in the inside waters of southeastern Alaska during July 1985 and July 1986 to search for newly settled halibut (zero-age halibut). The sampling gear used was a small-mesh Pacific coast two-seam trawl with 17.4 m footrope and 14.3 m headrope with three 203 mm metal floats attached; wings and body of 64 mm netting; intermediate of 32 mm netting; and codend of 32 mm netting equipped with a 12.7 mm netting liner.

SAMPLING METHODS

All tows were fished as double-oblique hauls, i.e., the trawl gear continuously sampled the water column during deployment both in the descending and ascending mode. The retrieval speed approximately matched the speed at which the net was lowered. The winch was operated at the lowest possible setting to maximize the filtering performance of the trawl, the filtering rate being affected mostly by current strengths. Sometimes the vessel speed was kept at a minimum by shifting back and forth between forward and neutral gears. The filtering speed averaged 4.0 km/hour under all conditions and ranged from 1.1 to 6.5 km/hour, based on the estimated distance towed (loran) in 1985 and from values obtained from a marine log in 1986. The marine log was attached to the top pipe of the trawl frame and recorded the distance in feet that the trawl was towed through the water. The log was angled at 45 degrees to the rear to assume the same presentation as the trawl frame while under tow.

The duration of each tow varied with the depth sampled. The net was lowered and raised at an average rate of four meters/minute. When the maximum intended sampling depth was neared, the winch was stopped for two to five minutes depending on the rate of descent of the net and the depth sampled. This was done to insure that the water column was proportionally sampled since the net continued its descent for a time as the catenary of the towing wire was being reduced.

The plankton trawl was rigged with a depth sensor riding inside the trawl bridle and affixed so as to keep a horizontal plane to the surface when fishing. The progression of the descent through the water by the trawl was less confusing to monitor when the net depth sensor was rigged to record the distance between the net and the water surface rather than the distance to the bottom. The monitoring of the depth sounder and the trawl sensor was made easier as both instruments recorded the relative distance to the surface on the same plane.

The plankton trawl caught large quantities of euphausids, amphipods, copepods, and lesser amounts of isopods, shrimps, jellyfish, and several species of fish larvae. The plankton catches were promptly sorted at sea for postlarval halibut, which were then preserved in 80 percent ethanol. All other specimens in the catch were fixed for 24 hours in a solution of sea water and five percent formalin buffered with marble chip and then transferred into 80 percent ethanol for long-term preservation. The plankton collection was later given to the Northwest and Alaska Fisheries Center of the U.S. National Marine Fisheries Service.

The bottom trawl used to sample the inside waters of southeastern Alaska caught several species of roundfish and flatfish. The catches were composed mostly of juvenile fish. The entire catch was sorted to search specifically for zero-age halibut which were found to range from 37 to 81 mm in length. A sampling strategy was used to estimate the catch of other species. The entire catch was sorted and enumerated in 73 percent of the tows. In the remaining cases, a fraction of the total catch which could be sorted and enumerated in one hour was taken.

FOX Experiment

The IPHC anticipated that the collection of extensive oceanographic data on coastal circulation and mixing could provide additional information on the transport of larval halibut and the factors affecting their distribution, survival, and recruitment to the halibut fishery. Consequently, the IPHC participated in this experiment with the expectation of obtaining halibut larvae specimens within the FOX sampling grid

Shelikof Strait

A nine square meter multiple-closing (triple net) Tucker trawl and a constructed frame equipped with a single nine square meter net were used by the IPHC to capture halibut larvae. A total of nine effective tows for halibut larvae were made in the Shelikof Strait region; two tows in the vicinity of the Barren Islands and the remainder in the waters west of Low Cape.

The results proved very disappointing as no halibut larvae were taken in those tows. Adverse weather and sea conditions, the low priority of the halibut larval survey, the malfunction of the release mechanism, and the unfortunate loss of the entire Tucker trawl system during the third deployment plagued the IPHC portion of the experiment. A new substitute trawl frame was immediately built and, although designed to use a single net, fished very well and proved easier to deploy. A full description of this larval survey and additional information on this cruise is given by Parker (1988) in his Ph.D. dissertation.

1985 Survey

The nine square meter plankton trawl was deployed in June 1985 from the trawler chartered to conduct the annual assessment of juvenile halibut. The main objective of the 1985 survey was to establish if postlarval halibut could be captured in early June in the same geographic area studied in March by the FOX experiment. Secondary objectives of the 1985 survey included the collection of larval specimens for the study of daily otolith growth rings and to establish if larval work using such a large net could be carried out from a much smaller platform.[1]

Shelikof Strait

On June 6 and 7, 1985, seven double-oblique plankton tows were made across Shelikof Strait from Low Cape at the west end of Kodiak Island to Cape Providence off the Alaska Peninsula (Figure 4). Those tows were located in the area studied by FOX in March 1985. The sites for the tows were usually locations where the color video sounder showed large concentrations of plankton in the water column.

The plankton trawl was towed for a cumulative lateral distance of 31.7 km and resulted in the capture of 80 postlarval halibut. The developmental stages of the captured postlarvae ranged from stage 7 to 11 with the majority of them having reached stage 10 in their development. The results for each station fished during the 1985 survey are given in Appendix Table 1.

The first six tows were fished to sample the entire water column from surface to bot-

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[1]The PACIFIC HARVESTER, the IPHC chartered vessel, measured only 30 m, whereas, the DISCOVERER is 92 m long.

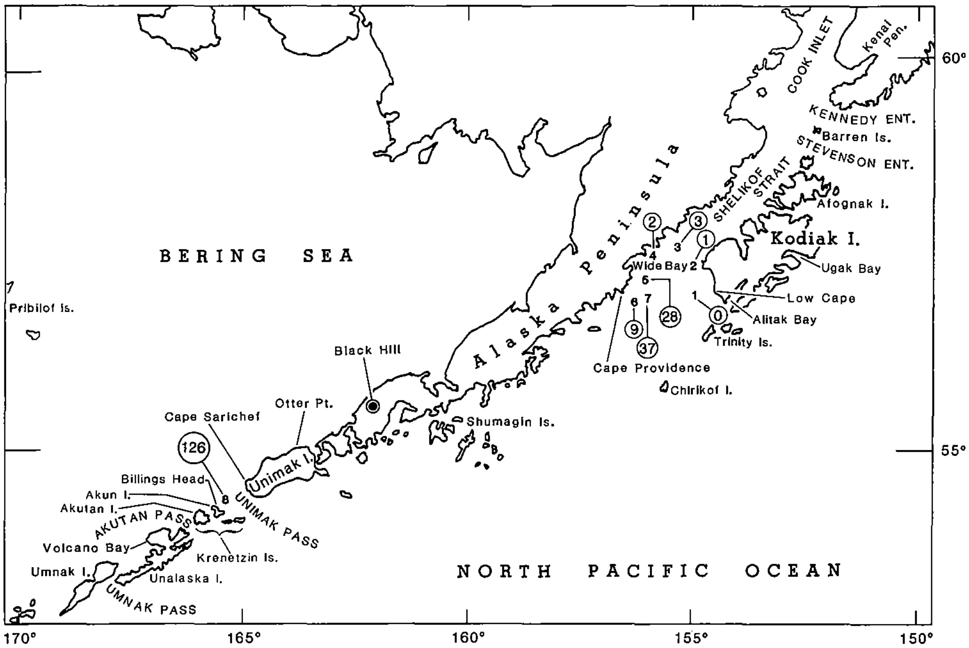

Figure 4. Locations fished during the June 1985 survey with the number of postlarvae caught indicated by the encircled numerals.

tom. A cumulative lateral distance of 29.4 km was covered and 43 postlarval halibut were caught. Tow number seven was intentionally fished alongside tow number six as a comparative tow to verify the distribution of older halibut postlarvae (stage five or older) in the surface layers. This comparative tow covered 2.2 km, was made in the top 48 m of the water column, and 37 halibut postlarvae were captured. Results of the comparison between the surface-bottom-surface tow (#6) and the tow sampling only the first 48 m of the water column (#7) confirm that older halibut postlarvae are found in the upper portion of the water column. The latter tow averaged 16.7 postlarvae per km versus 2.0 in the former.

Unimak Pass

On June 9, 1985, a single tow was made off Akun Island in Unimak Pass, some eight km north of Billings Head. The trawl was towed for a lateral distance of 4.6 km and resulted in the capture of 126 postlarval halibut for an average 27.2 halibut per km. The catch of postlarval halibut in Unimak Pass was made up of individuals having reached stages five through nine in their developmental progress, comparatively younger stages than those found in Shelikof Strait.

1986 Survey

Three primary objectives of the 1986 survey were: (1) to obtain information on the distribution of postlarval halibut in the inside waters of southeastern Alaska, the Gulf of Alaska, and eastern Bering Sea; (2) to identify the origin and relative abundance of the zero-age halibut found in the inside waters of southeastern Alaska during the juvenile trawl survey in July 1985; and (3) to document the contribution of the Gulf of Alaska

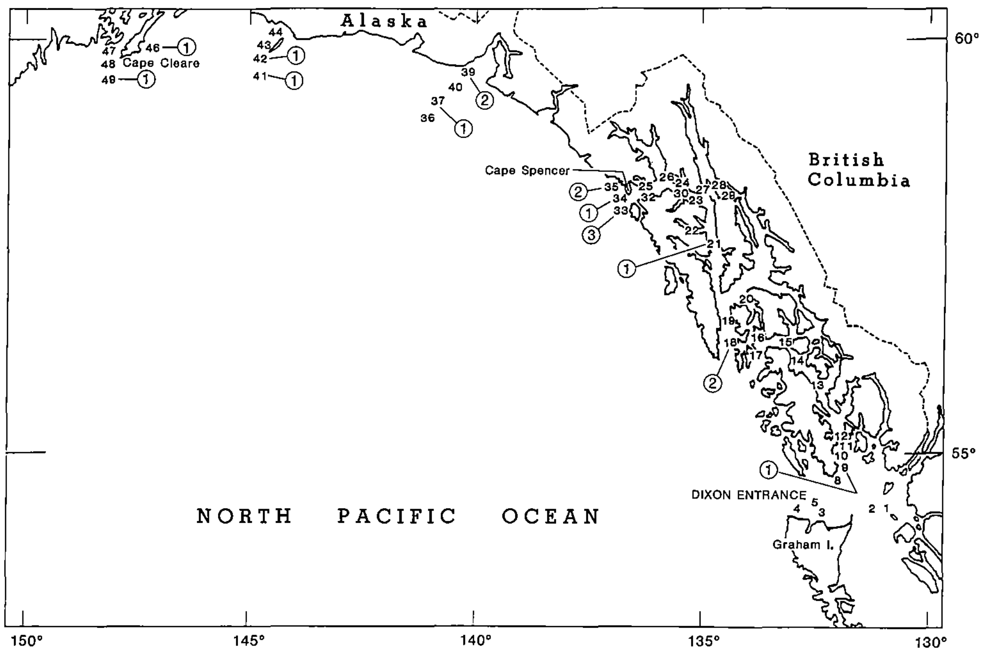

Figure 5a. Locations fished during the 1986 survey with the number of post-larvae caught indicated by the encircled numerals.

spawning to the eastern Bering Sea recruitment. Secondary objectives were the collection of postlarval halibut specimens from various geographic locations for an area-of-origin comparison in the study of daily growth rings in the otoliths of halibut.

The 1986 survey for halibut postlarvae was divided into two cruises. The first cruise took place from May 10 to May 20 and sampled the inside waters of southeastern Alaska from Graham Island in northern British Columbia to Cape Spencer, Alaska. The second cruise sampled the waters from Cape Spencer to the southeastern Bering Sea and took place from May 21 to June 6.

Ninety-four successful plankton tows were made, and pertinent information for each station fished with the catch of halibut postlarvae are given in Appendix Table 2. Figures 5a and 5b show the location of each station where successful plankton tows were made. Stations at which the plankton net was damaged are considered unsuccessful tows and were omitted in Figures 5a and 5b and Appendix Table 2. Table 1 summarizes the catch of halibut postlarvae by region sampled. Because of time limitation, consistency, and safety reasons, the plankton trawl was fished only during daylight hours. No comparison tows to verify differences in diurnal-nocturnal larval capture rates were carried out. However, since plankton tows were made in all kinds of milieux, many of them reaching to great depths, I doubt that nocturnal sampling would have changed the conclusion concerning the distribution of postlarvae in any area.

Southeastern Alaska

On cruise 1, twenty-nine plankton tows were made in numerous straits, inlets, and bays situated in the inside waters from Dixon Entrance to Cape Spencer with the capture of only four halibut postlarvae. Three to four stations were sampled every day and the

Table 1. Summarization of catches of halibut postlarvae by region sampled with the nine square meter plankton trawl in 1986.

Location Sampled	No. of Tows	No. of Halibut	No. of m Filtered	No. of Halibut Per Km Filtered
Southeastern Alaska	29	4	104,184	0.04
Cape Spencer -Cape Cleare	15	13	50,580	0.26
East, South, and West of Kodiak Is.	22	170	70,586	2.41
Shumagin Islands	5	83	14,102	5.89
South Unimak Is. -Akutan Pass	7	363	15,496	23.43
North of Unalaska Is. - Akun Is.	9	401	19,165	20.92
North of Unimak and East	7	337	12,084	27.89
TOTAL:	94	1371	286,197	4.79

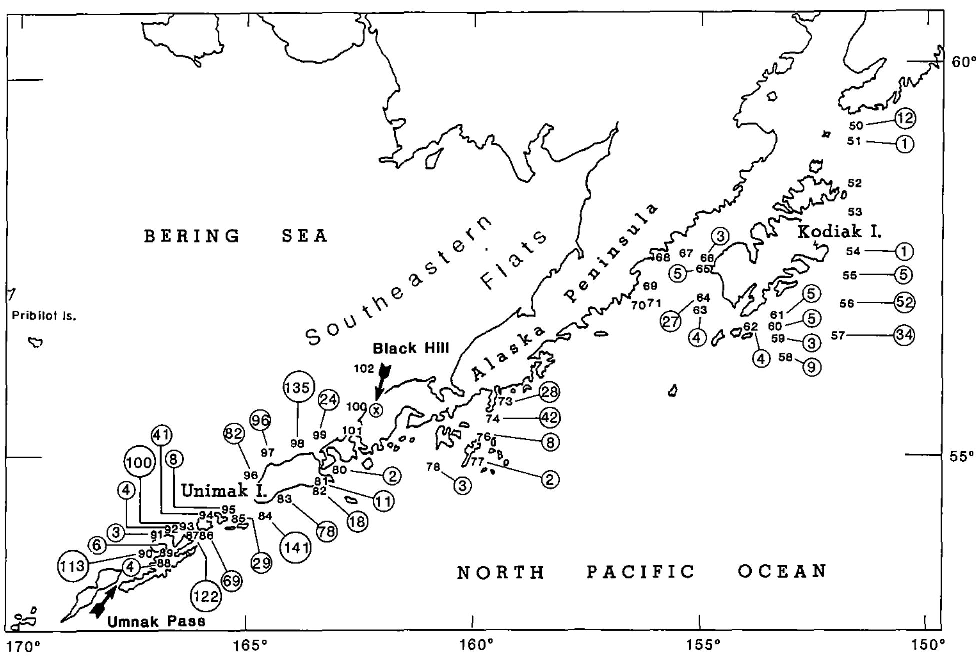

Figure 5b. Locations fished during the 1986 survey with the number of postlarvae caught indicated by the encircled numerals.

sites were chosen specifically with the intent of sampling as many different habitats as possible, especially where geographic features could favor larval retention.

To verify if the larval survey results were reliable and to check if larval halibut had settled to the bottom earlier than expected, twelve bottom trawl tows for zero-age (young-of-the-year) halibut were made in July 1986 at the same locations and period where six similar tows had been made in July, 1985 (IPHC 1986). No zero-age halibut were captured after 107 cumulative minutes of towing in 1986, compared to a catch of 55 halibut in 60 minutes of fishing in 1985.

Origin of Zero-Age Halibut

Prevailing hypotheses regarding the origin of the zero-age halibut found in the inside waters of southeastern Alaska are: (1) currents transport the halibut larvae from outside spawning grounds situated to the south; or (2) spawning actually occurs in these inside waters. The low catch of postlarval halibut and the apparent absence of zero-age halibut in this region in 1986 suggest that the currents were not favorable to the inflow of larvae from the outside spawning grounds. Spawning in inside waters should trap a large number of postlarvae in the numerous straits, bays, inlets, and canals, and these should be susceptible to capture either in the larval stages by the plankton trawl or in mid-summer as young-of-the-year by the bottom trawl.

I suspect that the origin and densities of zero-age halibut in these inside waters are associated with current transport. However, this conclusion is guarded since there is a possibility that halibut postlarvae had already settled on the bottom by the time the survey was carried out. It is conceivable that faster development in larval halibut had occurred since slightly warmer waters were observed in this region.

Sampling with bottom trawl gear to check if young-of-the-year had newly settled down is difficult because of the rough and irregular bottom configuration found in these inside waters. The easiest way to sample these waters for young-of-the-year is when the halibut are off-bottom, in their larval stages, and the plankton trawl remains an effective sampling gear for the task. Accordingly, I suggest that future postlarval surveys in this region be conducted earlier in the year to see if larger numbers of postlarvae are present. Whether currents or local spawning are responsible for the presence of zero-age-halibut in these waters may be determined by studying the temporal distribution and abundance of postlarvae at various sites compared to the distribution at peripheral locations where outside currents are known to flow into these inside waters.

Gulf of Alaska

Sampling on cruise 2 between Cape Spencer and the Shumagin Islands was conducted on transects spaced every 130 to 185 km, with stations extending from the shore outward. Spacing between transects and the number of stations sampled on each one were generally restricted by the distance the vessel could travel each night. From Unimak Island westward and in the southeastern Bering Sea, the stations were picked somewhat randomly, taking into account weather conditions and, when feasible, sampling sites near many of the passages where Gulf of Alaska waters flow into the Bering Sea.

Forty-nine plankton tows were made in the Gulf of Alaska between Cape Spencer and Akutan Pass, and sixteen in the southeastern Bering Sea, with the capture of 629 and 738 postlarvae, respectively. The data in Table 1 show that the abundance of halibut postlarvae increases from east to west and that by the beginning of June, large concentrations were found on both sides of the Alaska Peninsula and the Aleutian Islands from longitude 163° W. to 167° W.

Distribution

The catch of postlarval halibut in the region encompassed by Cape Spencer and Cape Cleare was very low, suggesting that most of the postlarvae which had not already settled on the bottom by the time of the survey may have been carried past this section of the coast by the currents. This is noticeable since this region encloses the largest, most productive, and best known halibut spawning grounds of the north Pacific Ocean (Skud 1977, St.-Pierre 1984).

In the Kodiak region, an average of 1.3 halibut postlarvae per km filtered were caught off the Barren Islands, which are situated between the Kenai Peninsula and Afognak Island. This implies that some postlarvae are carried through Kennedy Entrance and Stevenson Entrance into Cook Inlet and Shelikof Strait by the Alaska Coastal Current, some of them to be carried further west. Conversely, an average of 7.3 halibut postlarvae per km filtered were found east of Kodiak Island, which suggested that a greater number of postlarvae are carried by the currents which flow south of Kodiak Island. The 1986 data show that the distribution of postlarvae in the western section of the Kodiak region appears to proceed from the southern portion of this region, whereas the 1985 data imply that a large number of postlarvae were carried by the Alaska Coastal Current through Shelikof Strait.

Sampling in the area west of Kodiak Island and off Wide Bay in 1986 incorporated the same stations sampled in 1985. Sampling was 10 days earlier in 1986 compared to 1985 and this may explain the different distribution of postlarvae between the two years (Figures 4 and 5). The 1986 data suggest that the largest number of halibut postlarvae are carried by the currents which flow south of Kodiak Island. I suspect that upon reaching the south end of Kodiak Island, a number of postlarvae may be carried north along the west coast of Kodiak Island, many of them to drift until they fall under the influence of the Alaska Coastal Current coming out of Shelikof Strait. Meanwhile, the remainder of the postlarvae at the south end of Kodiak Island are probably carried in a westerly direction towards the Shumagin Islands and the Alaska Peninsula, to eventually fall under the influence of the Alaska Coastal Current coming out of Shelikof Strait. Such a conjecture is supported by the fact that very large numbers of one- to two-year-old halibut were commonly found in Ugak Bay, Alitak Bay, all around the Trinity Islands, and on the shallow flats to the north of Chirikof Island (Best and Hardman, 1982).

The Shumagin Islands region exhibited a definite increase in the average number of postlarvae (5.9 per km) over the two adjacent areas sampled to the east, where 3.0 postlarvae per km filtered were captured in the area west of Kodiak Island and none in Shelikof Strait off Wide Bay. The distribution of postlarvae was denser in the waters adjacent to the Alaska Peninsula and thinner in open waters further from the coast. This distribution pattern is compatible with the fact that these postlarvae were in an advanced stage of development and approaching the stage when they will settle as bottom dwellers.

The highest densities of halibut postlarvae were found in the Pacific Ocean and the Bering Sea waters off Unimak Island, Unalaska Island, and the Krenitzin Islands (Figure 5). An average of 23.4 halibut postlarvae per km filtered were caught in the Pacific waters encompassing an area extending 100 km to the east and to the west of Unimak Pass. Similarly, in the Bering Sea waters, 20.9 postlarvae per km were caught in the area extending 125 km to the west of Unimak Pass and 27.9 postlarvae per km were caught in the area extending 220 km to the east. High concentrations of Postlarvae were found south and north of Unimak Island and the Aleutian Islands, especially in the vicinity of sea passages where the Gulf of Alaska flows into the Bering Sea. Sampling locations 84 and 96 in Unimak Pass and locations 87 and 93 off Akutan Pass are examples which suggest transport of postlarvae into the Bering Sea. Although no sampling was done in the immediate vicinity of Umnak Pass, the large number of halibut postlarvae capture off Volcano Bay in the Bering Sea (station #90) supports the conjecture that a sizeable number of postlarvae may enter the Bering Sea through this pass.

Bering Sea Recruitment

The transport of halibut postlarvae into the Bering Sea is based on the general circulation pattern of currents as Gulf of Alaska waters flow through sea passages into the Bering Sea. Schumacher and Reed (1983) summarized that coastal waters from the Gulf of Alaska flow into the Bering Sea through Unimak Pass and continue northeastward along the Alaska Peninsula (Figure 2). In the waters surrounding Unimak Island, the number of halibut postlarvae caught per km filtered at stations 83, 84, and 96 through 99 (Appendix Table 2) certainly illustrate this transport of postlarvae from the Gulf of Alaska into the Bering Sea. A significant number of postlarvae appear to have been carried into the Bering Sea through Unimak Pass with many being transported to the northeast along the Alaska Peninsula by the continuation of the Alaska Coastal current. The drastic reduction in the catch of postlarvae at station 99, followed by their absence at station 100 off Black Hill indicates that the easternmost point of their drift in the eastern Bering Sea likely had been reached as of June 6. Accordingly, stations 101 and 102 were sampled to determine that the postlarval drift had not shifted in a shoreward or offshore direction from station 100. As shown in Appendix Table 2 and Figure 5, no halibut postlarvae were captured at stations 101 or 102.

The speculation that the postlarvae found by the 1985 and 1986 surveys originated from Bering Sea spawning is not consistent with the locations of known spawning grounds and the circulation pattern observed in the eastern Bering Sea. Spawning in the Bering Sea has been documented by Moiseev (1953), Musienko (1963), Novikov (1964), Best (1977), Skud (1977), Bell (1981), Best (1981), and St-Pierre (1984). Spawning in the eastern Bering Sea takes place at the edge of the continental shelf in depths over 180 m and the largest spawning grounds are located along the shelf between Cape Sarichef and the Pribilof Islands. Favorite (1974) suggested that the circulation pattern in the eastern Bering Sea is such that the eggs and larvae resulting from spawning on these grounds should remain within the Bering Sea. He also indicated that progeny from spawning at the above locations should be carried in a northwesterly direction to nursery areas on the Asiatic coast. Musienko (1963) reported the collection during March of halibut larvae west of the Pribilof Islands. Given Favorite's (1974) hypothesis, it is likely that the halibut larvae observed by Musienko were the result of spawning southeast of the Pribilof Islands.

The transport into the Bering Sea of larvae originating from the Gulf of Alaska spawning has been implied or suggested by Thompson and Van Cleve (1936), Bell and St-Pierre (1970), Best (1977), Skud (1977), IPHC (1978), Bell (1981), Best (1981), and St-Pierre (1984). Their evidences were mainly circumstantial, based on the general direction and strength of the currents in the Gulf of Alaska and/or on the emigration of tagged halibut from the Bering Sea to the Gulf of Alaska or further south. This eastward migration of tagged halibut was regarded as a compensatory movement to the drift of eggs and larvae and was deemed necessary to maintain the species in its habitat.

The age and length data collected in 1986 suggested that the growth rate of halibut is similar for the eastern Bering Sea and Gulf of Alaska (Table 2). Although this alone does not suggest an interrelation between halibut from the two areas, it lends support to the interrelationship demonstrated from tagging and ocean currents. Earlier investigations suggested that halibut from the Gulf were larger than those from eastern Bering Sea (Southward, 1967). However, halibut in the earlier studies generally were collected later in the year in the Gulf than in the Bering Sea and this appears to account for the observed differences in growth.

The interrelation between halibut from the eastern Bering Sea and those from the Gulf of Alaska is further reinforced here and the data presented in this report document the contribution of the Gulf of Alaska spawning to Bering Sea recruitment.

Table 2. Average length (cm) by age of juvenile halibut from the eastern Bering Sea and the Gulf of Alaska, 1986.

	Age			
Area	3	4	5	6
Eastern Bering Sea Nursery Area	35	44	50	58
Gulf of Alaska	36	43	50	56

SUMMARY

A search for postlarval halibut in the Gulf of Alaska and the southeastern Bering Sea was conducted on a trial basis in June 1985 and was expanded to a coastwide survey in May-June 1986. The purpose of the 1985 survey was to establish if halibut postlarvae could be captured in June and to collect specimens for the study of daily growth rings in the otoliths of postlarval halibut. The primary objectives in the 1986 survey were to identify the origin and importance of the zero-age halibut from the inside waters of southeastern Alaska, to establish the distribution of halibut postlarvae in the Gulf of Alaska, and to document their contribution to the eastern Bering Sea recruitment. All plankton tows were made with a nine square meter plankton trawl.

Eighty halibut postlarvae were captured during the 1985 survey at seven locations west of Kodiak Island and 126 postlarvae at a single station fished in Unimak Pass off Akun Island. The 1986 survey was divided into two cruises. The first cruise sampled the inside waters of southeastern Alaska where 29 plankton tows were made for the capture of four postlarvae. The second cruise was conducted between Cape Spencer and the southeastern Bering Sea. Forty-nine tows with a catch of 629 postlarvae were made in the Gulf of Alaska between Cape Spencer and Akutan Pass, whereas 16 tows with a catch of 738 postlarvae were made in the southeastern Bering Sea.

The decidedly low catch of halibut postlarvae in the plankton tows and the apparent absence of zero-age halibut in the bottom tows made in 1986 suggest that major halibut spawning may not take place in the inside waters of southeast Alaska. The zero-age halibut found in these waters appear to originate from current-transport rather than from local spawning. The densities of zero-age halibut are hard to establish because bottom configuration in this region makes it difficult to survey the grounds with bottom trawl gear.

The inshore edge of the Alaskan Stream and the Alaska Coastal Current are the principal forces behind the westward drift of halibut larvae in the Gulf of Alaska and the eventual transport of a large portion of them into the Bering Sea, especially by the Alaska Coastal Current through Unimak Pass. By the beginning of June, large concentrations were found on both sides of the Alaska Peninsula and the Aleutian Islands. The largest concentrations were found in Unimak Pass, in the area north of Unimak Island in the Bering Sea, and in the waters to the south and north of the Aleutian Islands, especially in the vicinity of sea passages which connect the Gulf of Alaska and Bering Sea waters.

The evidence of interrelation between the halibut of the eastern Bering Sea and the Gulf of Alaska is apparent and clearly shown by the data obtained during the 1986 postlarval halibut survey. The results of the plankton survey support the hypothesis that a large portion of the halibut population found along both sides of the Aleutian Islands, including those from the nursery area in the eastern Bering Sea (southeastern flats), originate from spawning in the Gulf of Alaska.

It is thus likely that the IPHC annual trawl survey conducted in the southeastern Bering Sea since the 1960s may have been sampling a component of juvenile halibut originating from the Gulf of Alaska rather than members of the progeny originating solely from the Bering Sea spawning. An important management implication is that the incidental catch (bycatch) of juvenile halibut in the groundfish fisheries of the eastern Bering Sea have a potential adverse impact on recruitment to the commercial fishery in the Gulf of Alaska, with repercussions to be felt even in the British Columbia, Washington, and Oregon fisheries.

ACKNOWLEDGEMENTS

Many IPHC staff members have reviewed drafts of this manuscript and I am grateful to all of them for their criticism and comments, with special thanks to Stephen H. Hoag, Robert J. Trumble, and Gregg Williams. Preparation of figures by Kenneth W. Exelby is gratefully acknowledged.

I want to thank Bruce M. Leaman for critically reviewing the manuscript and providing helpful suggestions. The cooperation and assistance of Captain Al Salo and the two-member crew R. Trelvik and M. Marshall of the fishing vessel Pacific Harvester contributed greatly to the success of the operation.

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APPENDIX

Observations on the survival, cannibalism, and predation on postlarval halibut were made in 1985 and 1986 during the postlarval and juvenile surveys. The results which are of importance in understanding the life history of halibut are given below.

Observations on Survival

To observe how long postlarval halibut could be kept alive on board the research vessel, 30 stage 10 and 11 halibut postlarvae were put in a covered 23 liter bucket which was secured on the sorting table. The postlarvae were chosen from sampling locations 80 through 82 (Figure 5), where the trawl was towed for an average duration of 20 minutes per station. The choice of postlarvae involved in this experiment was confined to the first 30 live postlarvae found during the sampling of the catch, regardless of their condition. No attempt was made to supply oxygen or keep the water at a constant temperature, nor was food made available.

Condition of the postlarvae was checked twice daily and dead halibut were removed. Half were dead after eight hours of captivity with the remaining halibut sustaining a 30 percent mortality every 12 hours. The experiment was terminated 67 hours after it began with one live halibut remaining which was easily induced to swim around. This simple experiment shows that with discriminate choice of postlarvae, good care and proper handling, postlarval halibut could be successfully shipped live to a laboratory for further observation and study.

Observations on Cannibalism

During routine sex and age composition sampling on the 1986 juvenile halibut survey, casual observations of stomach contents provided the first tangible proof of cannibalism on postlarval halibut. Stage 11 and 12 halibut postlarvae were found, counted and preserved from the stomachs of three- and four-year-old halibut. Also, one newly settled halibut with almost normal color pigmentation common to the bottom form was found among the stomach contents. This cannibalism was observed on June 18, at two adjacent juvenile survey stations in the region south of Unimak Island. These locations are close to shore, in depths ranging from 10 to 29 fathoms, and in close proximity to postlarval survey station number 83 (Figure 5).

At those two stations, eleven halibut ranging in size from 27 to 38 cm were examined for stomach contents and 28 halibut postlarvae were found. The number of postlarvae in each stomach varied from zero to eight. The largest number were found in the stomachs of two individuals: a three-year-old, 33 cm male with eight postlarvae and a four-year-old, 38 cm female with six halibut postlarvae. Additional sampling of 15 halibut ranging in size from 40 to 79 cm at the remaining nine stations fished in this region but at depths ranging from 39 to 62 fathoms, produced no further observation of cannibalism.

It appears that cannibalism is greater at shallower depths and involves smaller two- to four-year-old juvenile halibut preying on settling or newly-settled halibut. Halibut postlarvae are most likely too large for one-year-old halibut and probably represent such a small prey as to be of limited interest to large halibut. Best and St-Pierre (1986) reported that halibut appear to be opportunistic feeders and that the incidence of cannibalism occurs at irregular intervals. The significance of cannibalism in respect to recruitment is uncertain, and present observations indicate that the incidence rate is probably at its highest when postlarvae settle to the bottom to begin their bottom-dwelling existence. This rate of cannibalism conceivably remains high during their first year of bottom existence and perhaps longer.

Observations on Postlarvae Predation

No predation by other species on halibut postlarvae was found during a cursory examination of stomach contents of other flatfish species captured at the two stations where cannibalism had been observed during the 1986 juvenile survey. Butter sole (*Isopsetta isolepis*), rock sole (*Lepidopsetta bilineata*), and starry flounder (*Platichthys stellatus*) made up the bulk of the catch at these two stations and the food items in their stomachs, by order of importance, consisted of clams, mussel necks, gastropods, marine worms, shrimps, and small crabs.

In 1985, postlarvae were captured at a site where grey whales (*Eschrichtius glaucus*) were observed feeding on a plankton concentration. Since 28 halibut postlarvae were captured at this station, it is probable that incidental predation by whales occurs. Similarly, postlarvae were captured in 1986 at location number 83 (Figure 5) where an intensive salmon seine fishery was taking place. It is only conjecture at this point, but salmon may also prey upon halibut postlarvae.

Appendix Table 1. Station information for the 1985 postlarval halibut survey.

Station No.	Date	Geographic Location	Long.	Lat.	Depth in Meters			Temperature °C		Mesh Size (mm)	Estimated No. of m Filtered	No. of Halibut	Halibut per km. Filtered
					Minimum	Maximum	Sampled	at Surface	Sampled Depth				
1	6/06	W. End of Kodiak	155:00	56:58	101	101	91	—	—	1.6	3704	0	0.0
2	6/06	W. End of Kodiak	154:52	57:14	90	99	91	—	—	1.6	4074	1	0.2
3	6/07	Wide Bay Area	155:32	57:20	285	287	183	—	—	1.6	10000	3	0.3
4	6/07	Wide Bay Area	155:59	57:18	187	203	188	—	—	1.6	5186	2	0.4
5	6/07	Wide Bay Area	156:13	57:07	57	91	59	—	—	1.6	2037	28	13.7
6	6/07	Wide Bay Area	156:18	56:55	176	179	163	—	—	1.6	4445	9	2.0
7	6/07	Wide Bay Area	156:22	56:55	172	188	48	—	—	1.6	2222	37	16.7
8	6/09	Off Akun Island	165:27	54:23	86	99	84	—	—	1.6	4630	126	27.2

Note: Station 1 through 8 were also sampled in 1986 with stations number 64, 65, 67, 68, 69, 70, 71 and 95 corresponding in that order to the above stations.

Appendix Table 2. Station information for the 1986 postlarval halibut survey.

Station No.	Date	Geographic Location	Long.	Lat.	Depth in Meters: Minimum	Depth in Meters: Maximum	Depth in Meters: Sampled	Temperature °C: at Surface	Temperature °C: Sampled Depth	Mesh Size (mm)	Number of Meters Filtered	No. of Halibut	Halibut per km. Filtered
1	5/10	Dixon Entrance	131:00	54:17	101	146	121	8.3	6.8	1.6	1979	0	0.0
2	5/10	Dixon Entrance	131:19	54:18	84	104	91	8.2	6.6	1.6	2137	0	0.0
3	5/11	Dixon Entrance	132:34	54:09	66	69	55	9.7	7.4	1.6	1920	0	0.0
4	5/11	Dixon Entrance	132:54	54:12	79	108	91	7.8	7.4	1.6	4822	0	0.0
5	5/11	Dixon Entrance	132:39	54.08	35	42	18	7.8	7.2	1.6	1607	0	0.0
8	5/12	Dixon Entrance	132:07	54:22	285	300	113	8.0	5.2	1.6	4528	0	0.0
9	5/12	Dixon Entrance	131:50	54:32	349	349	110	8.5	6.2	1.6	4539	1	0.2
10	5/12	Clarence Strait	131:54	54:50	406	415	146	9.1	6.8	1.6	6243	0	0.0
11	5/13	Clarence Strait	131:55	55:13	327	413	37	8.4	6.6	1.6	4321	0	0.0
12	5/13	Clarence Strait	132:01	55:28	362	371	128	8.8	6.0	1.6	4054	0	0.0
13	5/13	Clarence Strait	132:26	55:46	134	201	77	8.8	6.7	1.6	1549	0	0.0
14	5/14	Clarence Strait	132:46	56:13	196	316	183	7.8	5.8	1.6	4147	0	0.0
15	5/14	Sumner Strait	133:08	56:24	73	80	55	7.2	6.4	1.6	2040	0	0.0
16	5/14	Sumner Strait	133:46	56:25	64	293	146	7.1	6.3	1.6	4431	0	0.0
17	5/14	Sumner Strait	133:55	56:17	115	132	110	8.0	6.1	1.6	3767	0	0.0
18	5/15	Catham Strait	134:20	56:19	71	91	73	7.0	6.2	1.6	2812	2	0.7
19	5/15	Catham Strait	134:25	56:43	132	225	91	7.1	5.4	1.6	2442	0	0.0
20	5/15	Frederic Sound	134:02	56:58	91	137	110	6.1	5.3	1.6	4857	0	0.0
21	5/16	Catham Strait	134:40	57:35	203	304	91	6.4	4.9	1.6	4560	1	0.2
22	5/16	Catham Strait	135:11	57:45	157	232	99	6.2	5.4	1.6	2724	0	0.0
23	5/16	Icy Strait	135:14	58:06	90	144	95	5.0	4.7	1.6	4285	0	0.0
24	5/17	Icy Strait	135:31	58:19	44	155	91	5.7	4.4	1.6	4251	0	0.0
25	5/17	Icy Strait	136:12	58:18	150	203	183	5.8	5.8	1.6	5923	0	0.0
26	5/17	Icy Strait	135:51	58:21	55	60	55	6.0	5.6	1.6	4843	0	0.0
27	5/18	Icy Strait	135:04	58:17	40	126	55	6.1	4.6	1.6	2019	0	0.0
28	5/18	Stephens Passage	134:57	58:27	115	128	110	6.8	4.2	1.6	6591	0	0.0
29	5/18	Stephens Passage	134:42	58:13	69	77	64	6.8	4.1	1.6	2653	0	0.0
30	5/20	Icy Strait	135:31	58:21	57	141	69	6.5	4.6	1.6	2405	0	0.0
32	5/20	Icy Strait	136:13	58:10	64	73	59	9.0	5.6	1.6	1735	0	0.0
33	5/21	Cape Spencer	136:43	58:02	130	258	128	7.2	6.7	1.6	4545	3	0.7
34	5/21	Cape Spencer	136:47	58:09	115	130	110	7.4	6.3	1.6	2761	1	0.4
35	5/21	Cape Spencer	136:59	58:20	93	128	110	7.1	5.9	1.6	4126	2	0.5
36	5/22	Off Yakutat Bay	141:05	59:08	194	198	183	7.2	5.5	1.6	5155	0	0.0
37	5/22	Off Yakutat Bay	140:50	59:18	154	159	146	7.8	5.9	1.6	5059	1	0.2
39	5/22	Off Yakutat Bay	140:24	59:27	68	106	73	7.8	5.5	1.6	854	2	2.3

Appendix Table 2. ***(cont.)*** **Station information for the 1986 postlarval halibut survey.**

Station No.	Date	Geographic Location	Long.	Lat.	Depth in Meters: Minimum	Depth in Meters: Maximum	Depth in Meters: Sampled	Temperature °C: at Surface	Temperature °C: Sampled Depth	Mesh Size (mm)	Number of Meters Filtered	No. of Halibut	Halibut per km. Filtered
40	5/22	Off Yakutat Bay	140:37	59:27	238	282	201	7.2	6.0	1.6	5069	0	0.0
41	5/23	Off Cape St. Elias	144:41	59:32	157	187	165	7.1	5.8	1.6	2448	1	0.4
42	5/23	Off Cape St. Elias	144:47	59:42	84	95	73	7.2	5.7	1.6	2435	1	0.4
43	5/23	Off Cape St. Elias	144:41	59:50	62	62	55	7.3	6.4	1.6	1833	0	0.0
44	5/23	Off Cape St. Elias	144:25	60:01	42	53	46	8.8	5.9	1.6	3399	0	0.0
46	5/24	Off Cape Cleare	147:13	59:54	106	141	101	7.0	5.5	1.6	2444	1	0.4
47	5/24	Off Cape Cleare	148:04	59:52	55	146	128	7.2	5.2	1.6	4553	0	0.0
48	5/24	Off Cape Cleare	148:05	59:37	80	88	73	8.8	5.2	1.6	875	0	0.0
49	5/24	Off Cape Cleare	148:06	59:24	186	199	183	10.0	5.4	1.6	5024	1	0.2
50	5/25	N. Afognak Island	151:24	58:58	104	128	110	6.4	5.3	1.6	1894	12	6.3
51	5/25	N. Afognak Island	151:26	58:35	159	161	140	6.8	5.3	1.6	4768	1	0.2
52	5/25	N. Afognak Island	151:28	58:20	79	108	73	6.8	5.6	1.6	3414	0	0.0
53	5/25	East End of Kodiak	151:31	57:58	73	75	64	5.1	4.7	1.6	1007	0	0.0
54	5/26	East End of Kodiak	151:42	57:36	84	86	82	6.0	5.1	1.6	3243	1	0.3
55	5/26	East End of Kodiak	151:46	57:15	49	51	46	5.6	5.1	1.6	1483	5	3.4
56	5/26	East End of Kodiak	151:48	56:52	80	90	73	7.0	5.2	1.6	3498	52	14.9
57	5/26	East End of Kodiak	152:04	56:34	90	130	106	7.3	5.0	1.6	3345	34	10.2
58	5/27	So. End of Kodiak	153:15	56:16	68	347	183	6.1	5.1	1.6	3675	9	2.4
59	5/27	So. End of Kodiak	153:30	56:27	86	101	77	6.9	4.8	1.6	3545	3	0.8
60	5/27	So. End of Kodiak	153:39	56:40	84	146	110	8.8	4.8	1.6	3002	5	1.7
61	5/27	So. End of Kodiak	153:29	56:45	77	77	69	8.5	5.3	1.6	630	5	7.9
62	5/27	So. End of Kodiak	153:59	56:36	31	44	27	6.1	5.5	1.6	3686	4	1.1
63	5/28	West End of Kodiak	155:06	56:51	95	99	88	4.8	4.5	1.6	3193	4	1.3
64	5/28	West End of Kodiak	155:00	56:58	101	102	91	5.8	5.1	1.6	3170	27	8.5
65	5/28	West End of Kodiak	154:52	57:14	90	97	80	6.8	4.2	1.6	3117	5	1.6
66	5/28	West End of Kodiak	154:46	57:23	38	69	46	8.0	4.8	1.6	3717	3	0.8
67	5/28	Wide Bay Area	155:31	57:21	287	287	282	7.3	4.4	1.6	6547	0	0.0
68	5/29	Wide Bay Area	155:58	57:18	185	199	188	6.0	3.8	1.6	4868	0	0.0
69	5/29	Wide Bay Area	156:14	57:07	66	91	64	5.0	4.9	1.6	3080	0	0.0
70	5/29	Wide Bay Area	156:19	56:55	163	190	168	5.5	4.8	1.6	2301	0	0.0
71	5/29	Wide Bay Area	156:22	56:55	170	181	46	6.0	4.6	1.6	3403	0	0.0
73	5/30	Shumagin Islands	159:23	55:38	93	102	84	5.1	3.7	2.0	3300	28	8.5
74	5/30	Shumagin Islands	159:31	55:28	157	183	157	4.4	4.2	2.0	2177	42	19.3
76	5/30	Shumagin Islands	159:46	55:21	102	102	88	5.3	4.1	1.6	3178	8	2.5
77	5/30	Shumagin Islands	160:25	55:05	86	113	97	4.8	4.2	1.6	3783	2	0.5

Appendix Table 2. *(concl'd.)* **Station information for the 1986 postlarval halibut survey.**

Station No.	Date	Geographic Location	Long.	Lat.	Depth in Meters: Minimum	Depth in Meters: Maximum	Depth in Meters: Sampled	Temperature °C: at Surface	Temperature °C: Sampled Depth	Mesh Size (mm)	Number of Meters Filtered	No. of Halibut	Halibut per km. Filtered
78	5/31	Shumagin Islands	161:01	54:54	79	91	69	5.1	3.9	1.6	1664	3	1.8
80	5/31	So. of Unimak Is.	163:07	54:49	82	93	73	4.2	3.4	2.0	3761	2	0.5
81	6/01	So. of Unimak Is.	163:22	54:41	59	73	49	4.2	4.0	2.0	1667	26	15.6
82	6/01	So. of Unimak Is.	163:23	54:40	64	73	60	4.3	4.0	2.0	3362	18	5.4
83	6/01	So. of Unimak Is.	164:13	54:31	91	97	84	4.9	3.6	2.0	1895	78	41.2
84	6/01	Unimak-Akutan Pass	164:40	54:18	93	101	75	5.2	4.6	2.0	810	141	174.1
85	6/02	Unimak-Akutan Pass	165:19	54:08	59	62	53	4.8	4.5	2.0	1225	29	23.7
86	6/02	Unimak-Akutan Pass	165:58	54:00	95	144	82	4.8	4.6	2.0	2776	69	24.9
87	6/02	Off Unalaska Island	166:21	54:03	77	112	73	5.5	4.8	2.0	3227	122	37.8
88	6/04	Off Unalaska Island	166:53	53:43	144	168	106	5.5	3.9	2.0	2231	4	1.8
89	6/04	Off Unalaska Island	166:48	53.43	79	95	84	5.6	4.0	2.0	2626	6	2.3
90	6/04	Off Unalaska Island	167:07	53:48	88	91	80	5.0	4.6	2.0	1189	113	95.0
91	6/04	Off Unalaska Island	166:34	54:05	86	108	80	5.6	4.5	2.0	923	3	3.3
92	6/04	Off Unalaska Island	166:37	53:57	53	152	104	6.5	4.3	2.0	3374	4	1.2
93	6/05	Off Unalaska Island	166:10	54:07	66	75	62	4.7	4.5	2.0	3170	100	31.5
94	6/05	Off Akun Island	165:47	54:16	104	106	91	4.8	4.7	2.0	878	41	46.7
95	6/05	Off Akun Island	165:27	54:23	86	108	75	5.0	4.5	2.0	1547	8	5.2
96	6/05	No. of Unimak Is.	164:53	54:40	51	53	42	5.1	4.5	2.0	1508	82	54.4
97	6/05	No. of Unimak Is.	164:30	55:03	60	64	55	5.1	4.3	2.0	664	96	144.6
98	6/06	No. of Unimak Is.	163:55	55:14	55	59	46	4.4	3.3	2.0	1639	135	82.4
99	6/06	No. of Unimak Is.	163:31	55:21	57	57	49	3.6	3.1	2.0	1317	24	18.2
100	6/06	Off Black Hill	162:52	55:42	55	57	46	4.9	3.9	2.0	1737	0	0.0
101	6/06	Off Black Hill	162:29	55:37	31	31	22	4.9	3.8	2.0	1469	0	0.0
102	6/06	Off Black Hill	162:25	55:58	75	77	66	4.2	2.6	2.0	3750	0	0.0