Abstract—The prowfish (*Zaprora silenus*) is an infrequent component of bottom trawl catches collected on stock assessment surveys. Based on presence or absence in over 40,000 trawl catches taken throughout Alaskan waters southward to southern California, prowfish are most frequently encountered in the Gulf of Alaska and the Aleutian Islands at the edge of the continental shelf. Based on data from two trawl surveys, relative abundance indicated by catch per swept area reaches a maximum between 100 m and 200 m depth and is much higher in the Aleutian Islands than in the Gulf of Alaska. Females weigh 3.7% more than males of the same length. Weight-length functions are W (g) = 0.0164 $L^{2.92}$ (males) and W = 0.0170 $L^{2.92}$ (females). Length at age does not differ between sexes and is described by $L = 89.3(1 - e^{-0.181(t+0.554)})$, where L is total length in cm and t is age in years. Females reached 50% maturity at a length of 57.0 cm and an age of 5.1 years. Prowfish diet is almost entirely composed of gelatinous zooplankton, primarily scyphozoa and salps.

Distribution and biology of prowfish (*Zaprora silenus*) in the northeast Pacific

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Current taxonomy distinguishes the prowfish (*Zaprora silenus,* Fig. 1) as the only species and the only genus of the family Zaproridae. Other families in the encompassing suborder Zoarcoidei include Bathymasteridae (ronquils), Cryptacanthodidae (wrymouths), Pholidae (gunnels), and Stichaeidae (pricklebacks). Systematics of most families within Zoarcoidei, and of the suborder itself within the order perciforms, is uncertain (Nelson, 1994). Prowfish (adult) physical features include an elongate, laterally compressed body; a high convex brow and interorbital area ending with a short blunt snout; and a distinctive protruding area below a slightly upturned terminal mouth. Fins consist of: a long, moderately high dorsal fin; a moderately long anal fin; a discrete truncate caudal fin with a short, broad peduncle; and moderately large, rounded pectoral fins (pelvic fins are absent). Teeth are small, sharp, and close-set in a single row attached only to the jaws. Scales are ctenoid. Numerous distinctive large round pores occur on the sides and top of the head. Color is olive-gray to brown dorsally, shading lighter below, suffused on the sides and back with many small dark spots (Clemens and Wilby, 1961; Eschmeyer et al, 1983; Hart, 1973; Kessler, 1985). The maximum length reported is more than 1 m (Tokranov, 1999).

Since its original description (Jordan, 1897), the prowfish has been observed infrequently despite numerous and extensive bottom trawl surveys comprising thousands of net deployments off Alaska and the west coast of North America. It is not clear whether this lack of documentation indicates a species of low abundance or a preference by prowfish for a habitat, such as rough rock substrate or steep bottom gradients, that is poorly sampled by bottom trawl surveys. Nevertheless, the species is common enough to be considered representative of the ichthyofauna of certain benthic biotopes within its range (Allen and Smith, 1988; Tokranov, 1999). It has been encountered at locations along the outer continental shelf and upper slope ranging in a long arc from San Miguel Island, California, north through the Gulf of Alaska, west through the Bering Sea and Aleutian Islands to the Asiatic shelf, thence south to Hokkaido, at depths of 10–675 m (Allen and Smith, 1988; Hart, 1973). In addition to occurring in the catches on biological surveys, prowfish have been taken incidentally, and occasionally processed, in commercial fishing operations on the outer continental shelf (Smith, pers. obs.; Berger[1]).

Prowfish are known to be pelagic as pre-adults (Hart, 1973; Doyle et al, 2002). After larval transformation at 30 mm (Matarese et al., 1989), juveniles maintain close proximity to the medusae of pelagic cnidarians (Scheffer, 1940). Brodeur (1998) observed juveniles swimming near the bells of scyphomedusae *Cyanea capillata* and *Chrysaora melanaster* and retreating

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[1] Berger, J. 2002. Personal commun. Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Bldg 4, Seattle, WA 98115-0070.

Figure 1

Aquarium prowfish specimen, National Marine Fisheries Service, Kodiak Laboratory, Kodiak, AK. Photograph by Jan Haaga.

behind the tentacles or within the bells of these jellyfish when approached by a remotely operated vehicle, apparently as a means of protection from predators. Prowfish are also believed to later become demersal and have a preference for rocky areas (Tokranov, 1999).

The association with scyphomedusae and other large gelatinous zooplankton exhibited by juveniles may continue throughout their lives, because such prey are reported to constitute a considerable portion of the prowfish diet (Carollo and Rankin, 1998). In the stomachs of 16 juveniles of 5–13.3 cm total length captured at midwater depths in Prince William Sound in 1995, Sturdevant[2] found prey biomass was composed principally of hyperiid amphipods but also found unquantifiable gelatinous matter which was thought to be the remains of jellyfish tentacles.

Little is known regarding possible predators of prowfish, the relative frequency of prowfish among prey items, or the sizes of prowfish consumed. Prowfish have been found in the diets of diving seabirds and have comprised 25% of food biomass delivered to tufted puffin (*Lunda cirrhata*) chicks (Sturdevant[2]). Yang (1993) found prowfish in only 0.3% of 467 stomachs of Pacific halibut (*Hippoglossus stenolepis*) taken by bottom trawl in the Gulf of Alaska in 1990, accounting for 0.03% (by weight) of total food pres-

ent. Orlov (1998) found prowfish in 0.13% of stomachs of white-blotched skate (*Bathyraja maculata*) caught by bottom trawl off the Northern Kuril Islands and Southeastern Kamchatka in 1996. In comparisons of proximate composition among 17 taxa of forage-size fish from the northeastern Pacific (Van Pelt et al, 1997; Payne et al, 1999), juvenile prowfish averaged highest in moisture content (86–88% by weight) and relatively low in lipids (10.8±1.3%, dry weight analysis).

In this study we examined information on this little-known species, investigating spatial and depth distributions, size frequency, growth, reproduction, and diet in the waters off Alaska.

Materials and methods

Data and sample collection

Data used in this investigation were collected during bottom trawl surveys for groundfish and invertebrate stocks conducted by the Resource Assessment and Conservation Engineering (RACE) Division of the Alaska Fisheries Science Center (AFSC), National Marine Fisheries Service. Areas surveyed were the continental shelf and upper slope of the eastern Bering Sea, Aleutian Islands region (AI), Gulf of Alaska (GOA), and west coast of North America from Washington to California. Trawl catches were sorted to species, weighed, and individuals were counted, following procedures described in Wakabayashi et al. (1985).

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[2] Sturdevant, M. V. 1999. Forage fish diet overlap, 1994–1996. *Exxon Valdez* oil spill restoration project final report (restoration project 97163C), 184 p. Alaska Fish. Sci. Cent., Auke Bay Laboratory, Natl. Mar. Fish. Serv., NOAA, Juneau, AK. [Available by order no. PB2000-100700 from Natl. Tech. Info. Serv, 5285 Port Royal Rd., Springfield, Virginia 22161.]

To characterize prowfish distribution we obtained catch data from 42,601 bottom trawl deployments (hauls) executed from 1953 through 2000 using a variety of net designs. We used these data to determine presence or absence of prowfish at each haul location. Previous observations have indicated that prowfish tend to be pelagic as larvae and become demersal as adults (Matarese et al., 1989; Hart, 1973). A full accounting of prowfish distribution by life stage is beyond the scope of this investigation, which focuses on adults. Therefore we confined our observations to haul catches taken on bottom, as opposed to in mid-water or at the surface.

On two of the bottom trawl surveys, one in the Gulf of Alaska from 22 May to 30 July 1996, and the other in the Aleutian Islands from 10 June to 11 August 1997, additional prowfish data were collected. Consistency between these surveys in sampling procedures and equipment (Martin, 1997, and Stark[3]) facilitated subsequent data comparisons.

Density of prowfish at each sampling location was estimated as the number caught divided by the km² of area swept by the trawl (catch per unit of effort, or CPUE). Research vessels on both surveys employed the standard RACE Division model poly-Nor'eastern high-opening bottom trawl net with roller gear, and hauls were made during daylight. Net configuration and bottom contact during trawling were monitored by Scanmar instrumentation. Data were obtained from 807 hauls in the Gulf of Alaska and 408 hauls in the Aleutian Islands. The average area swept per haul was 0.025 km² in the GOA and 0.024 km² in the AI.

All prowfish were sorted to sex by examination of the gonads and then length (total length; cm) was measured. Sample sizes were 84 males and 90 females for the Gulf of Alaska; 396 males and 431 females for the Aleutian Islands. Whole-body weights (g) of 83 male and 88 female prowfish from the Gulf of Alaska were measured and the sagittal otoliths were removed and stored in 50% ethanol. Whole ovaries from a representative subsample of 39 of the females were removed, frozen, and later stored in 10% buffered formalin solution.

Diet composition was examined from stomach contents of 76 individuals (18 from the Gulf of Alaska and 58 from the Aleutian Islands). Stomachs containing food and with no signs of regurgitation or net-feeding (e.g. the stomach was in an inverted or flaccid state or there was the presence of prey in the mouth or around the gills) were removed and preserved in 10% buffered formalin.

Laboratory procedures

Standard otolith-preparation techniques for age determination were modified to accommodate the relatively small size of prowfish otoliths (usually <5 mm long). An anterior portion of each otolith was removed by a transverse cut with scalpel perpendicular to the sagittal axis and anterior to the

nucleus. The remainder, which contained the nucleus, was baked at 300–475°C for up to 17 min or heated over an alcohol flame to enhance visibility of annuli. The otoliths were then individually mounted on slides by completely embedding them in clear thermoplastic posterior end down. On hardening, each mount was wet-sanded on increasingly fine grades of sandpaper (400–2000 grit), parallel to the slide, until the surface intersected the otolith nucleus (transverse section). Preparing readable mounts was a delicate procedure; besides cutting and polishing the small otoliths precisely without fracturing them, precise heating temperature and time were especially critical to expose annuli without again causing fractures or burning the otolith. Our method had advantages over the standard "break and burn" method of simply coating the surface of a temporarily mounted specimen with oil to enhance visibility of annuli, in lieu of polishing. It allowed a more precise intersection of the nucleus by the viewed surface and eliminated the need to remove oil from specimens intended for further viewing in order to prevent blurring of annuli. After preparation, slides were placed in sufficient water to cover the surface scratches and were examined under a dissecting microscope with reflected light. Age in years was determined by counting the annuli or hyaline bands according to the criteria described in Chilton and Beamish (1982).

Prowfish ovaries were prepared for histological examination by removing a small portion from the middle of each ovary, which was then embedded in paraffin, sectioned at 6 μm, and stained with hematoxylin and eosin. The histological slides were examined under a compound microscope and donor females were classified as either sexually immature or mature based on the presence of yolk in the oocytes (i.e. vitellogenesis).

Prowfish stomachs were processed by first neutralizing the 10% formalin used for initial fixation and then by immediately transferring the stomachs into 70% ethanol. The food was removed, blotted with a paper towel, and examined with a dissecting microscope. Prey items were sorted to the lowest practical taxonomic level and then weighed to the nearest 0.1 gm. The percentage of total prey weight which each taxon comprised, as well as the percentage of stomachs containing each taxon, was calculated for each haul sample and then estimated for each of the two regions as the average of the per-haul percentages.

Analysis of data

The distribution of prowfish density over depth in the Gulf of Alaska and the Aleutian Islands was determined by calculating the mean CPUE for each 20-m depth interval from 20 m to 480 m. Both surveys utilized a stratified sampling design in which sampling density (hauls per unit area) varied by geographical subarea (Martin, 1997; Stark[3]). To compensate for this variation, the CPUE of each haul was weighted by the inverse of the sampling density in that geographic stratum. The mean bottom depth as weighted by prowfish density was calculated for each of the two regions as the weighted average of the midpoints of the depth intervals, where the weighting factors were the interval-mean CPUE values.

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[3] Stark, J. 1998. Report to industry: fishing log for the 1997 bottom trawl survey of the Aleutian Islands. AFSC Proc. Rep. 98-06, 96 p. Alaska Fish. Sci. Cent., Natl. Mar. Serv., NOAA, 7600 Sand Point Way NE, Bldg. 4, Seattle, WA 98115-0070.

Frequency distributions of prowfish total length, separated by sex and region, were calculated as the weighted percent of measurements within 10-cm length intervals. The weighting factors were calculated for each fish measurement as the inverse of geographic-stratum sampling (i.e. haul) density, multiplied by the inverse of the individual haul area that was swept . Also, differences in mean length between sexes or regions were examined by using analysis of variance (ANOVA)[4] to test the significance of statistical differences based on the weighted lengths. Because potential grouping of prowfish by size could affect within-haul variance, source haul (i.e. that in which each measured fish was caught) was included in analyses as a possible random variable affecting length. Variances in length between regions and sexes were each tested for significance against variance among hauls. The significance of the haul variable was also checked by testing variance among hauls against that among measurements.

The relationship of body weight (g; W) to total length (cm; L) was assumed to be an exponential function:

$$W = e^{\alpha}L^{\beta},$$

for which the parameters α and β were estimated from the data by first log-transforming both variables and then calculating the intercept and slope of the least squares linear regression:

$$\ln(W) = \alpha + \beta\ln(L).$$

To determine whether the relationship differed by sex, analysis of covariance (ANCOVA; Statgraphics Plus, Manugistics, Inc., Rockville, MD) was used to compare the fit of a model with two regression lines, each with a sex-specific intercept and slope, to the fit of a two-line model with sex-specific intercepts and a common slope (null hypothesis). If no significant difference was observed, then a second test was performed by testing the latter model against the null hypothesis of a common regression line with single intercept and slope for both sexes combined. The relationships in the best-fit model were then transformed back to exponential form.

Prowfish growth was described by fitting the von Bertalanffy function to length (L) and age (year; t) data by using nonlinear least squares. The function is

$$L = L_{\infty}(1 - e^{-k(t - t_0)}),$$

where L_{∞} = asymptotic maximum length;
  k = a constant (per year) affecting model early growth rate; and
  t_0 = hypothetical age at 0 length.

To determine whether parameters differed between prowfish sexes, we fitted the function separately to the data from each sex as well as to the data for both sexes combined. A

likelihood ratio test was then used to determine whether the separate-sex model fitted the data significantly better than the combined-sex model (Kimura, 1980). Significance of the likelihood ratio was based on the chi-squared statistic with degrees of freedom equal to the difference in number of parameters between the two models.

The proportion of prowfish females that were mature (P_{mat}) at a given length or age was described with logistic functions of the form $P_{mat} = 1/(1 + e^{\alpha + \beta X})$, where X is either length (L) or age in years (t), and α and β are function parameters. The models were fitted to the data by using maximum likelihood. After the relationships were estimated, the length and age at which 50% of females were mature were estimated by setting $P_{mat} = 0.5$ in each function and solving for X. The 95% confidence interval for each estimate was calculated by using the delta method (Seber, 1973).

Results

Geographic distribution

Prowfish distribution in the waters off Alaska, as indicated by their presence at 1528 out of a total of 35,159 historical bottom trawl locations, is shown in Figure 2. The total count of individuals in catches was 11,401. Distribution south of approximately 50°N latitude off Vancouver Island is not shown because here 6 of 7442 bottom trawl hauls caught a total of 8 prowfish. The southernmost occurrence was at 34°13.4′N latitude near San Miguel Island, southern California. Prowfish were taken at depths ranging from 24 m to 801 m but most frequently appeared in catches close to the break between the continental shelf and upper continental slope near 200 m depth.

Prowfish CPUE was greater than zero at 64 of 807 haul locations in the Gulf of Alaska in 1996 and at 48 of 408 locations in the Aleutian Islands in 1997. Over all areas at the depths fished the range of per-haul CPUE was 0–547.5 prowfish/km² (average=6.7 prowfish/km²) in the GOA and 0–5220.1 prowfish/km² (average=65.1 prowfish/km²) in the AI. The average CPUE within 20-m bottom depth intervals in each region indicated that fish tend to be most concentrated at intermediate depths (Fig. 3). Depth at trawl locations ranged from 20 to 479 m for the GOA and from 22 to 474 m for the AI, and prowfish were collected at 34–252 m (GOA) and 89–258 m (AI), respectively. The CPUE-weighted average bottom depth was 163.8 m for the GOA and 150.3 m for the AI.

The CPUE values within 20-m depth intervals (Fig. 3) indicated that the regional difference in mean density was largely due to differences at the same depth rather than differences between regions in the amount of area available at a given bottom depth.

Length distribution

Length-frequency histograms by region and sex for prowfish from the Gulf of Alaska (84 males, 90 females) and Aleutian Islands (396 males, 431 females) are shown in Figure 4. Analysis of variance tests for a difference in mean length

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[4] Unless otherwise specified, ANOVA, log-likelihood, and nonlinear regression analyses were accomplished by using Systat 10 software (Systat 10 Statistics I, SPSS Inc.,Chicago, IL).

Figure 2
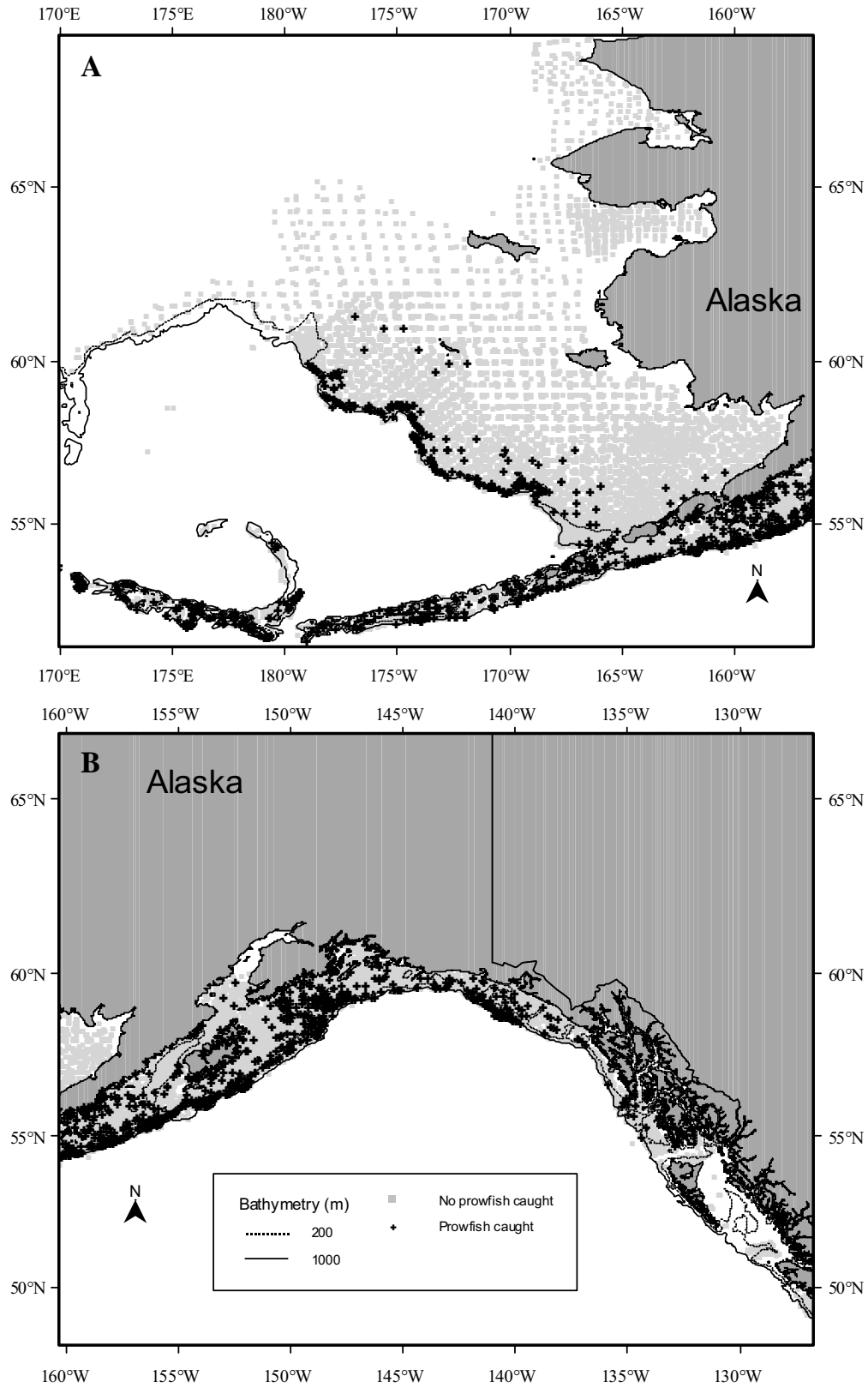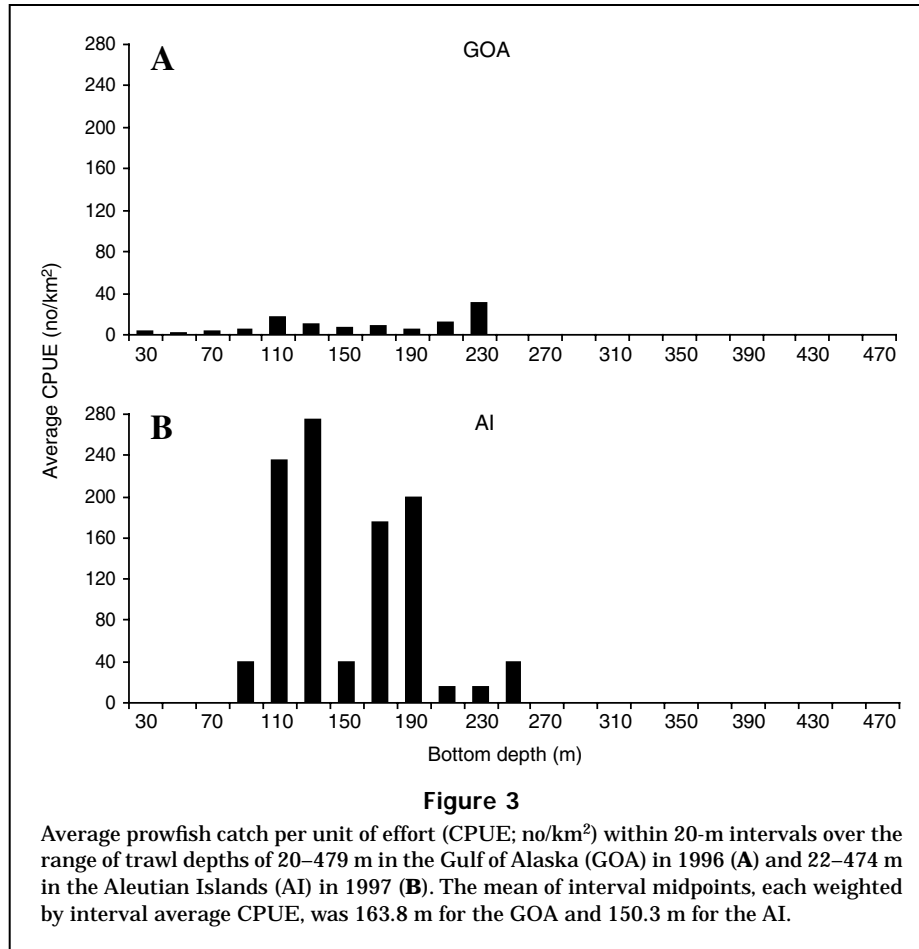
Locations of Alaska Fisheries Science Center groundfish survey bottom trawls (prior to year 2001) in (**A**) the eastern Bering Sea and the Aleutian Islands region and (**B**) the Gulf of Alaska, indicating trawls in which prowfish occurred.

Figure 3

Average prowfish catch per unit of effort (CPUE; no/km²) within 20-m intervals over the range of trawl depths of 20–479 m in the Gulf of Alaska (GOA) in 1996 (**A**) and 22–474 m in the Aleutian Islands (AI) in 1997 (**B**). The mean of interval midpoints, each weighted by interval average CPUE, was 163.8 m for the GOA and 150.3 m for the AI.

between sexes were not significant for either the GOA (*P*=0.83) or the AI (*P*=0.76). Although the weighted mean for both sexes combined was 61.0 cm (range: 11–90 cm) in the GOA and 51.9 cm (range: 25–87 cm) in the AI, the difference in length between regions was not significant (*P*=0.11). Grouping of prowfish of similar size within hauls was highly significant in both the GOA and the AI (*P*<<0.01).

Weight-length relationship

In the between-sex ANCOVA comparison of the linearized (i.e. log-transformed) weight-to-length relationships based on prowfish caught in the Gulf of Alaska, the slopes were not significantly different between sexes (*P*=0.38). However, the difference in intercepts was significant (*P*=0.044). Thus the best fitting model varied by sex with two regression lines of equal slope but with sex-specific intercepts. The equivalent functions in terms of the untransformed variables (Fig. 5) were

$$W_{males} = 0.0164 \times L^{2.922},$$

and

$$W_{females} = 0.017 \times L^{2.922}.$$

The model indicated that adult females are, on average, 3.7% heavier than males of the same length.

Age and growth

Readable otolith specimens were produced for 138 prowfish (71 males, 67 females) of the 172 from which samples were collected. Production of readable specimens did not appear related to fish size or age. The likelihood ratio test for a difference between males and females in the relationship of length to age was not significant (*P*=0.53), indicating that there was no difference in growth between sexes. The best-fit von Bertalanffy function (Fig. 6) had the following parameters (with 95% confidence intervals): L_∞ = 89.33 ±6.5 cm; k = 0.18 ±0.05/year; and t_0 = −0.55 ±0.12 year.

Female maturity

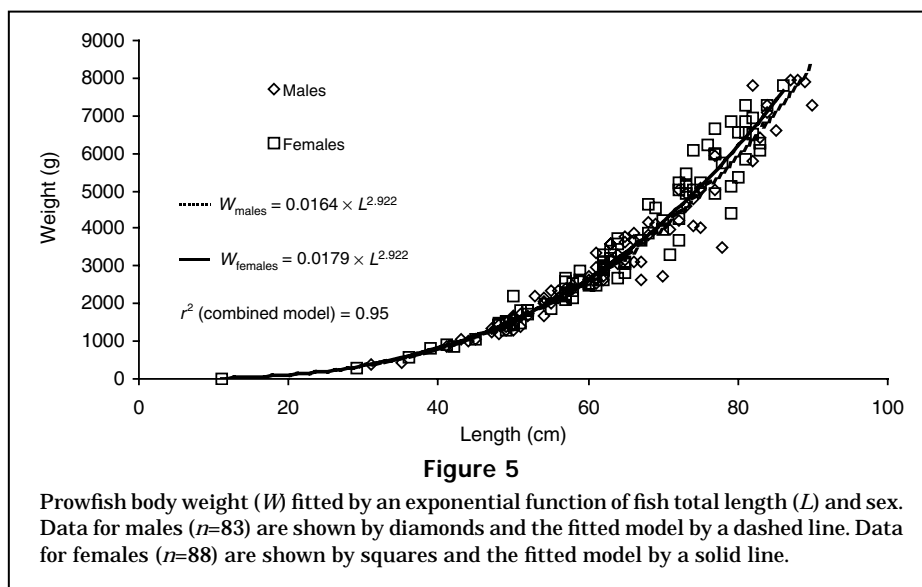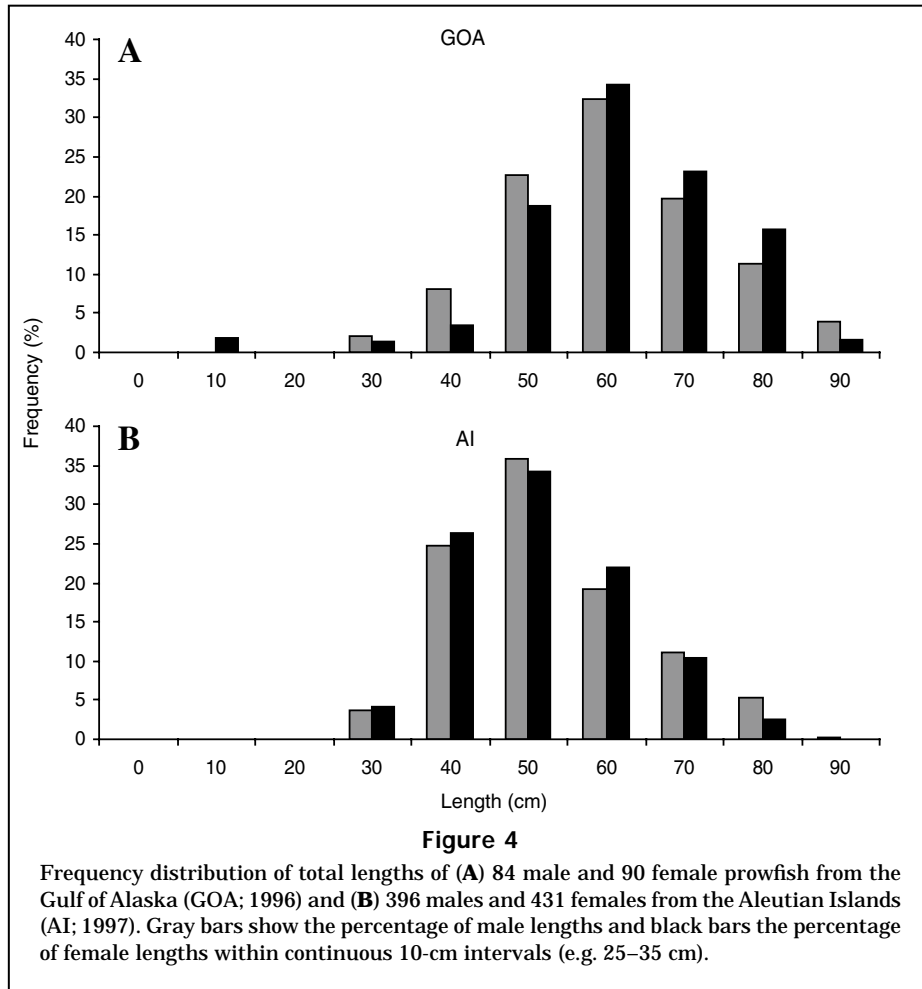The proportions of females that were mature were highly significant logistic functions of length and age (*P*<0.005; Fig. 7). The fitted functions of length and age were

$$P_{mat} = 1/(1 + e^{371.14 - 6.51L});$$
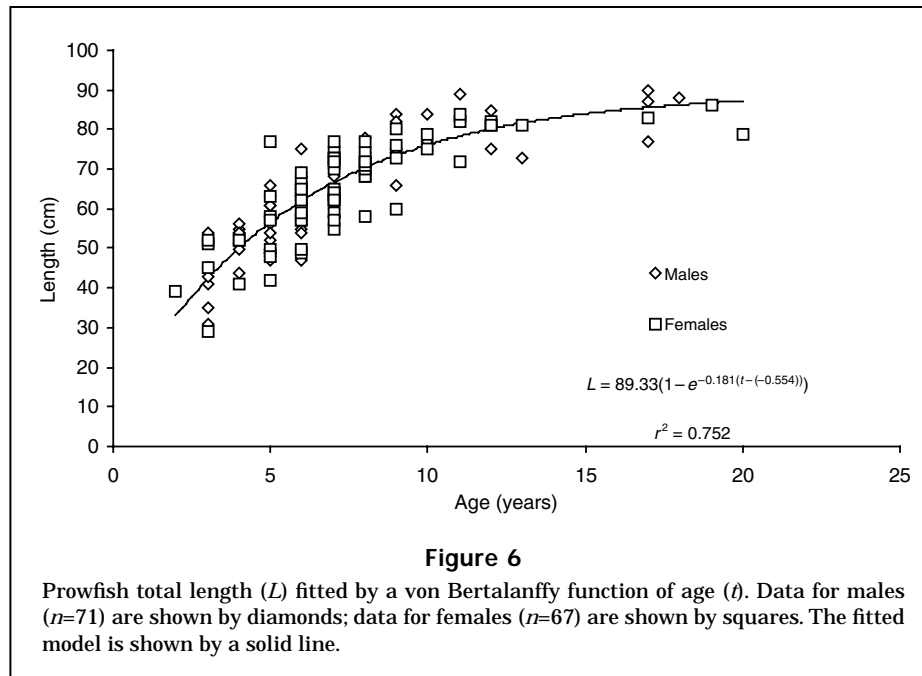
and

$$P_{mat} = 1/(1 + e^{9.66 - 1.90t}).$$

The theoretical length and age at which 50% of females were mature, with respective 95% confidence limits, were 57.0 ±0.4 cm and 5.1 ±0.7 years.

Figure 4

Frequency distribution of total lengths of (**A**) 84 male and 90 female prowfish from the Gulf of Alaska (GOA; 1996) and (**B**) 396 males and 431 females from the Aleutian Islands (AI; 1997). Gray bars show the percentage of male lengths and black bars the percentage of female lengths within continuous 10-cm intervals (e.g. 25–35 cm).

Figure 5

Prowfish body weight (W) fitted by an exponential function of fish total length (L) and sex. Data for males (n=83) are shown by diamonds and the fitted model by a dashed line. Data for females (n=88) are shown by squares and the fitted model by a solid line.

Food habits

Fish used for diet study averaged 63.8 cm in total length (range: 49–87 cm) in the Gulf of Alaska and 56.9 cm (range: 30–79 cm) in the Aleutian Islands. The contents of 18 prowfish stomachs from the Gulf of Alaska and 58 from the Aleutian Islands showed that jellyfish (99% and 31%

Figure 6

Prowfish total length (*L*) fitted by a von Bertalanffy function of age (*t*). Data for males (*n*=71) are shown by diamonds; data for females (*n*=67) are shown by squares. The fitted model is shown by a solid line.
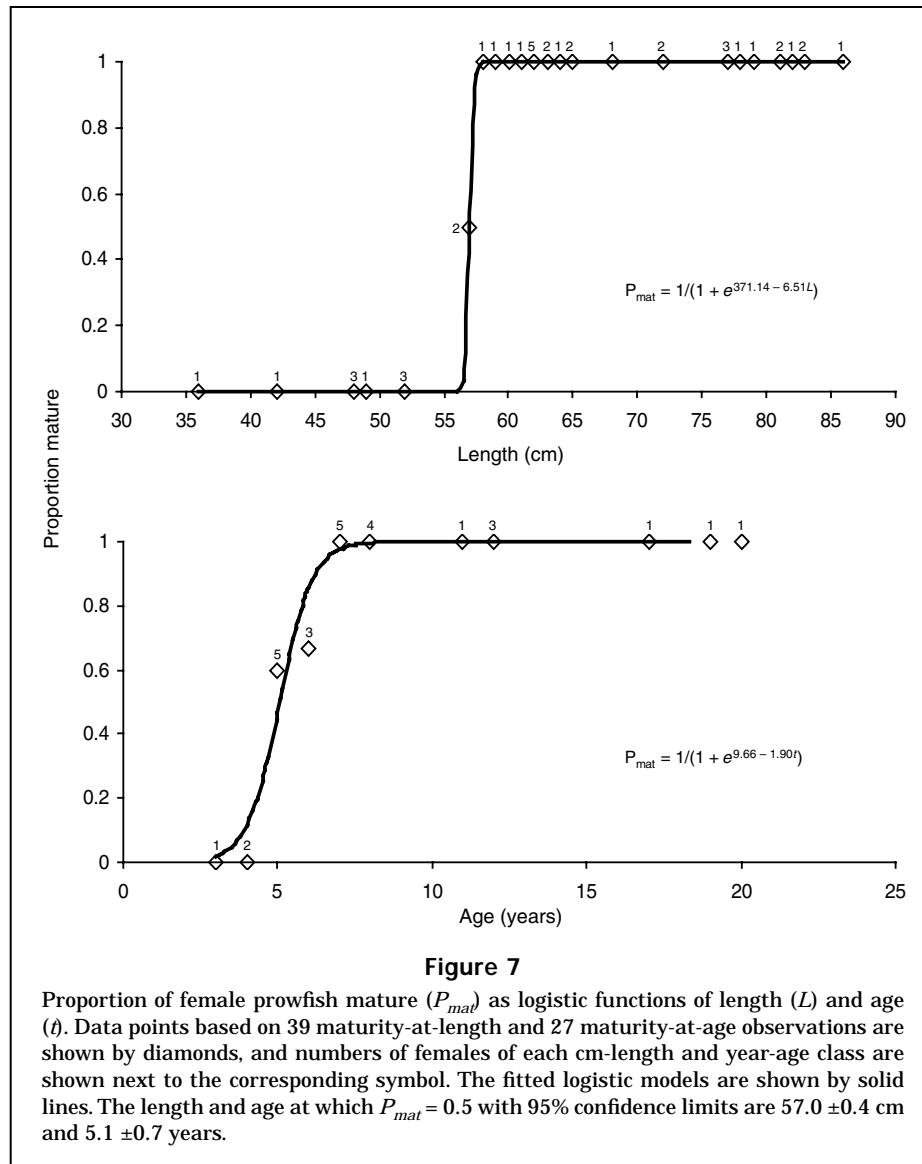
Table 1

Mean percent weight (%W) and mean percent frequency of occurrence (%FO) of the prey items from 18 prowfish stomachs collected in the Gulf of Alaska (GOA; 1996; total prey weight=299 g) and 58 stomachs from the Aleutian Islands area (AI; 1997; total prey weight=1446.6 g). Sample prowfish had an average total length of 63.8 cm (range: 49–87 cm) from the GOA and and 56.9 cm (range: 30–79 cm) from the AI.

	GOA (*n*=18)		AI (*n*=58)	
Prey name	% W	% FO	% W	% FO
Scyphozoa (jellyfish)	98.84	100	30.45	29.88
Ctenophora (comb jelly)			0.09	1.23
Polychaeta (worm)			0.03	5.8
Calanoida (copepod)	0.26	28.13	0.04	29.14
Thysanoessa raschii (euphausiid)			0.05	6.67
Mysidacea Mysida (mysid)	0.01	3.13		
Hyperiidea (amphipod)			0.19	33.46
Gammaridea (amphipod)			0.12	30.49
Themisto sp. (amphipod)	0.32	28.57	0.14	36.91
Salpa sp. (pelagic salp)			34.06	46.79
Larvacea (pelagic tunicate)	0.13	12.5		
Sebastes sp. (rockfish) larvae, 5–8 mm long	0.43	42.86		
Microsomus pacificus (Dover sole) eggs	0.01	3.13		
Unidentified organic material			34.84	32.59

by weight of total food in the two regions, respectively) and gelatinous pelagic tunicates (*Salpa* spp.; 34% in the Aleutian Islands area only) were the most important food (Table 1). Although calanoid copepods and *Themisto* sp. (amphipod) were both often present in GOA specimens (28.13% and 28.57% of stomachs, respectively), they were not important food in terms of weight. The same was true in the AI for calanoid copepods, *Themisto* sp., gammaridean amphipods, and hyperiidean amphipods (29.14%, 36.91%, 30.49%, and 33.46% respectively). Mysids and larvaceans from GOA specimens as well as ctenophors, polychaetes, and euphasiids from AI specimens occurred in trace amounts. *Sebastes* larvae (5–8 mm standard length), the only fish species found, were found in 43% of Gulf of Alaska stomachs but made up only 0.43% of prey weight. Some Dover sole (*Microstomus pacificus*) eggs had also been consumed.

Figure 7

Proportion of female prowfish mature (P_{mat}) as logistic functions of length (L) and age (t). Data points based on 39 maturity-at-length and 27 maturity-at-age observations are shown by diamonds, and numbers of females of each cm-length and year-age class are shown next to the corresponding symbol. The fitted logistic models are shown by solid lines. The length and age at which $P_{mat} = 0.5$ with 95% confidence limits are 57.0 ±0.4 cm and 5.1 ±0.7 years.

Discussion

Geographic distribution

Historically occurring in the catch in AFSC bottom trawl surveys in areas of the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska regions, prowfish were also observed more rarely farther south along the West Coast as far as the vicinity of San Miguel Island, California. This is the apparent southern limit of their range in the northeastern Pacific (Allen and Smith, 1988). They were most often encountered in the vicinity of the edge of the continental slope near 200 m depth (Fig. 2), although our data increase the maximum known depth of occurrence from 675 m (Allen and Smith, 1988) to 801 m. As indicated by survey CPUE, prowfish density was greatest between the depths of 100 m and 240 m (Fig. 3). Our distribution data show similarities with those of Tokranov (1999), who

studied >300 bottom trawls executed in 1995–97 on the shelf and slope off the southern Kamchatka Peninsula and northern Kuril Islands, in which adult prowfish were taken at 100–480 m. Tokranov often found fish concentrated in areas of high-relief, rocky bottom—a common feature of the shelf edge in the Gulf of Alaska and Aleutian Islands regions. Such areas near the shelf break may be important prowfish habitat. Underwater videos taken in the northeast Gulf of Alaska by the Alaska Department of Fish and Game (Brylinsky[5]) show numerous adult fish resting on or just above this type of substrate.

Density was greater in the AI than in the GOA, over all bottom depths combined and in most cases by individual depth interval (Fig. 3). One reason may be that preferred habitat comprises a larger proportion of the Aleutian Is-

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[5] Brylinsky, C. 2000. Pers. commun. Alaska Department of Fish and Game, 304 Lake Street, Sitka, AK 99835.

lands area. Because of the lack of a relatively broad shelf in the region, a larger proportion of trawls are in or near areas of steep seafloor gradient and therefore likely over rough bottom (Fig. 2).

Length distribution

In both the Gulf of Alaska and the Aleutian Islands, few prowfish <40 cm in length were captured (Fig. 4). This paucity of small prowfish is not due to size selection by the trawl net mesh because the codend is lined with small mesh (1.3 cm stretched measure) webbing that retains small individuals of other species. A different explanation, based on the observations of Brodeur (1998) and Scheffer (1940), is that pre-adult prowfish are pelagic, remaining in proximity with large coelenterates and thus avoiding bottom trawls. Thus, the minimum capture length may indicate the length at which prowfish recruit to a demersal habitat. Our data showed no statistically significant length difference between sexes, in contrast with the data of Tokranov (1999) who suggested a length dimorphism where females are generally longer than males.

Weight-length relationship

The best-fitting model of weight versus length predicts that for any length, female prowfish are, on average, 3.7% heavier than males (Fig. 5). It seems unlikely that this relationship exists over all developmental stages because our samples were almost all adults and such a (relative) difference might not remain constant during all ontogenetic sexual divergence. What is more certain is simply the existence of some small degree of length-weight dimorphism (females slightly heavier at a given length). Also, this dimorphism is not likely to stem primarily from a sexual difference in gonad weight because the maximum proportion of total female body weight composed of ovarian tissue was only 2.7%. Thus the difference is due to other morphological or behavioral differences.

Growth

There was no significant difference between sexes in length versus age. The predicted length of a prowfish of given age based on our samples was higher than that indicated by Tokranov (1999). In our study 5-year-old and 9-year-old fish averaged 56.6 cm and 73.5 cm in length, respectively. Tokranov (1999) considered that prowfish growth determined from otoliths of 102 specimens from the Northwest Pacific indicated a comparatively fast-growing species reaching an average length of 44.6 cm by 5 years of age and 67 cm after 9 years. These data suggest prowfish are indeed relatively fast growing and that growth rates for the Gulf of Alaska are faster than those for off southeastern Kamchatka and the northern Kuril Islands. Alternatively, size-dependent mortality from such elements as incidental capture by commercial fishing may affect the two populations differently.

Historically, two other prowfish have been aged from otoliths: a male 84 cm long taken near Eureka, CA (Fitch and Lavenberg, 1971), and a female 50.1 cm long (standard length) from off Monterey (Cailliet and Anderson, 1975). The ages estimated were 12 and 3 years, respectively. After converting the standard length record to an estimate of total length for the second specimen of 58 cm by using a ratio described by Baxter,[6] both lengths are slightly greater than our predictions for the same ages, albeit near the limits of our data range. This finding contrasts with the predictions of lesser length at a given age presented by Tokranov (1999).

Maturity

Little previous data exist with which to compare our observations of female prowfish rate of maturation. Cailliet and Anderson (1975) examined the ovaries of their 50.1-cm 3-year-old female specimen for vitellogenesis and predicted an age at first spawning of 4 years, slightly less than the lower 95% confidence limit of 4.4 years for our expected average age at 50% maturity.

Food habits

Our observation that gelatinous zooplankton was the largest constituent in the contents of prowfish stomachs (Table 1) is supported by Tokranov (1999), who found that the two most common prey taxa among the contents of 102 stomachs of adult specimens from the northwestern Pacific were Scyphozoa (59.6–62.0% of stomachs) and Ctenophora (6.0–15.4% of stomachs). Anecdotal observations have also been made of the feeding behavior of an aquarium specimen over an approximate 2-year period (Carollo and Rankin, 1998). When first obtained, the fish ate only various jellyfish species, rejecting other food, including a variety of live invertebrates. In our food samples, we observed other taxa, such as invertebrates and small fish, but these were a minor part, possibly first captured by jellyfish and then secondarily ingested by prowfish. Carollo and Rankin (1998) found that the aquarium specimen would ingest such items when eating the bells of *Chrysaora melanaster* in which such food had previously been placed, indicating the possibility of this occurring naturally. Possibly more reflective of the unnatural circumstances, the specimen later began accepting such items outside the bells of jellyfish.

Apparent adaptations of the prowfish to a diet of gelatinous zooplankton include the small, sharp, close-set teeth in a single row attached only to the jaws, which are capable of a 180-degree gape, and the large rough-scaled lips (Clemens and Wilby, 1961; Hart, 1973; Carollo and Rankin, 1998).

Acknowledgments

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