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# Alaska Fisheries Science Center

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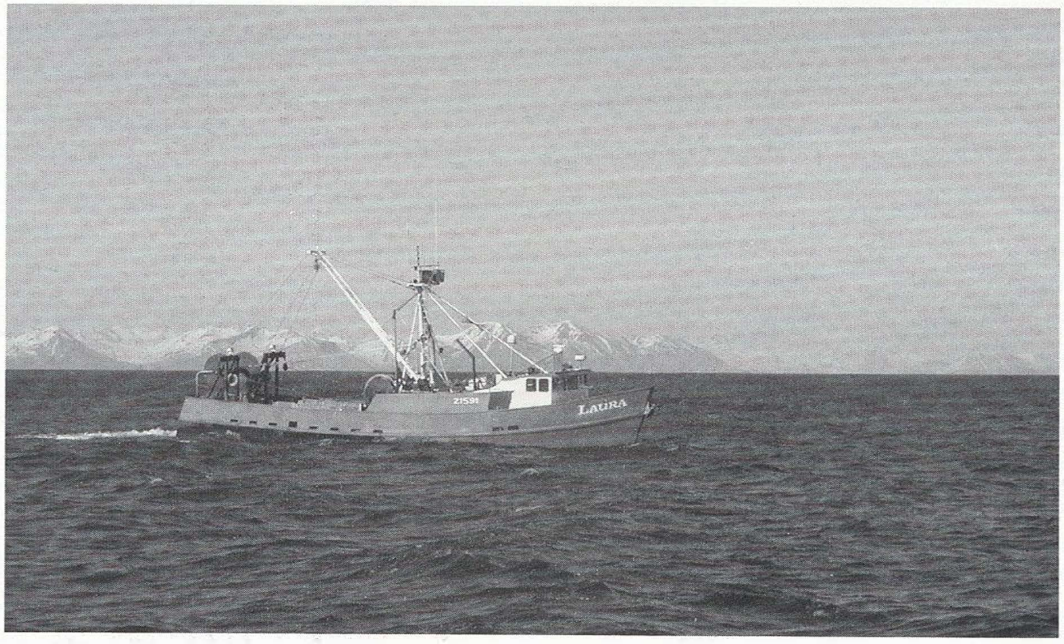


# Interactions Between Commercial Fishing and Walleye Pollock

Part of a multidiscipline research effort to determine if commercial fishing activities significantly impact the availability of forage fish species to endangered Steller sea lions.

*The mission of the Alaska Fisheries Science Center is to generate scientific information necessary for the conservation, management, and utilization of the region's living marine resources.*

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# Interactions Between Commercial Fishing And Walleye Pollock

*by*

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Scientists from the Alaska Fisheries Science Center (AFSC) initiated a multiyear field experiment in August 2000 near Kodiak Island in the Gulf of Alaska (GOA) to characterize the effects of commercial fishing activity on the distribution and abundance of walleye pollock (*Theragra chalcogramma*) over short spatiotemporal scales. The work forms part of a larger research effort designed to determine whether commercial fishing activities significantly impact the availability of walleye pollock and other forage fish species, such as capelin (*Mallotus villosus*) to endangered Steller sea lions (*Eumetopias jubatus*).

The impetus for the work was a need to understand possible mechanisms that produced the precipitous decline in the western stock of Steller sea lions, which began in the 1970s. One of several explanations offered for the declining number of Steller sea lions was that large-scale commercial fisheries, such as those for walleye pollock and Atka mackerel (*Pleurogrammus monopterygius*), compete with sea lion populations by reducing the availability of potential prey in relatively localized areas. The home range of a foraging Steller sea lion could be considered a localized area. A reduction in prey availability may result from a reduction in prey abundance or a disruption in the spatial patterns of the sea lion prey. The spatiotemporal extent of the perturbation to the prey field could determine the impact on the foraging success of the sea lion. For example, fishing removals may cause a decline in the abundance of a prey species within a localized area, but recovery to prefishery levels may be so quick that impacts to predator foraging success would be negligible. Alternatively, disturbances from fishing operations may elicit longer-term behavioral responses by prey species that might affect spatial patterns and impact Steller sea lion foraging behaviors. For example, disturbed fish might move deeper in the water column to form smaller, denser aggregations. This change may adversely impact the foraging behavior of Steller sea lions. Unfortunately, no data exist to answer two important questions regarding interactions between commercial fishing, Steller sea lions, and their prey. First, do commercial fishing activities affect the distribution and abundance of potential Steller sea lion prey species significantly? And secondly, if the fishery induces perturbations in prey spatial patterns or abundance, how do these perturbations impact Steller sea lion foraging success?

The primary goal of the AFSC study was to develop a field program to investigate the first question of whether measurable changes in spatial patterns and abundance occurred in walleye pollock at scales relevant to sea lion foraging. This article reports on preliminary results from the first 2 years of the field study to examine the spatiotemporal characteristics of pollock and other sea lion forage species before, during, and after a commercial fishing season. Future directions for this type of fishery-interaction research are also discussed.

## Study Area/Season

The east side of Kodiak Island in the GOA (Fig. 1) was chosen as the study area for the fishery-interaction work for several reasons. Two adjacent submarine troughs with similar topographical features characterized the area. One trough, Barnabas, would serve as a treatment site where commercial fishing was

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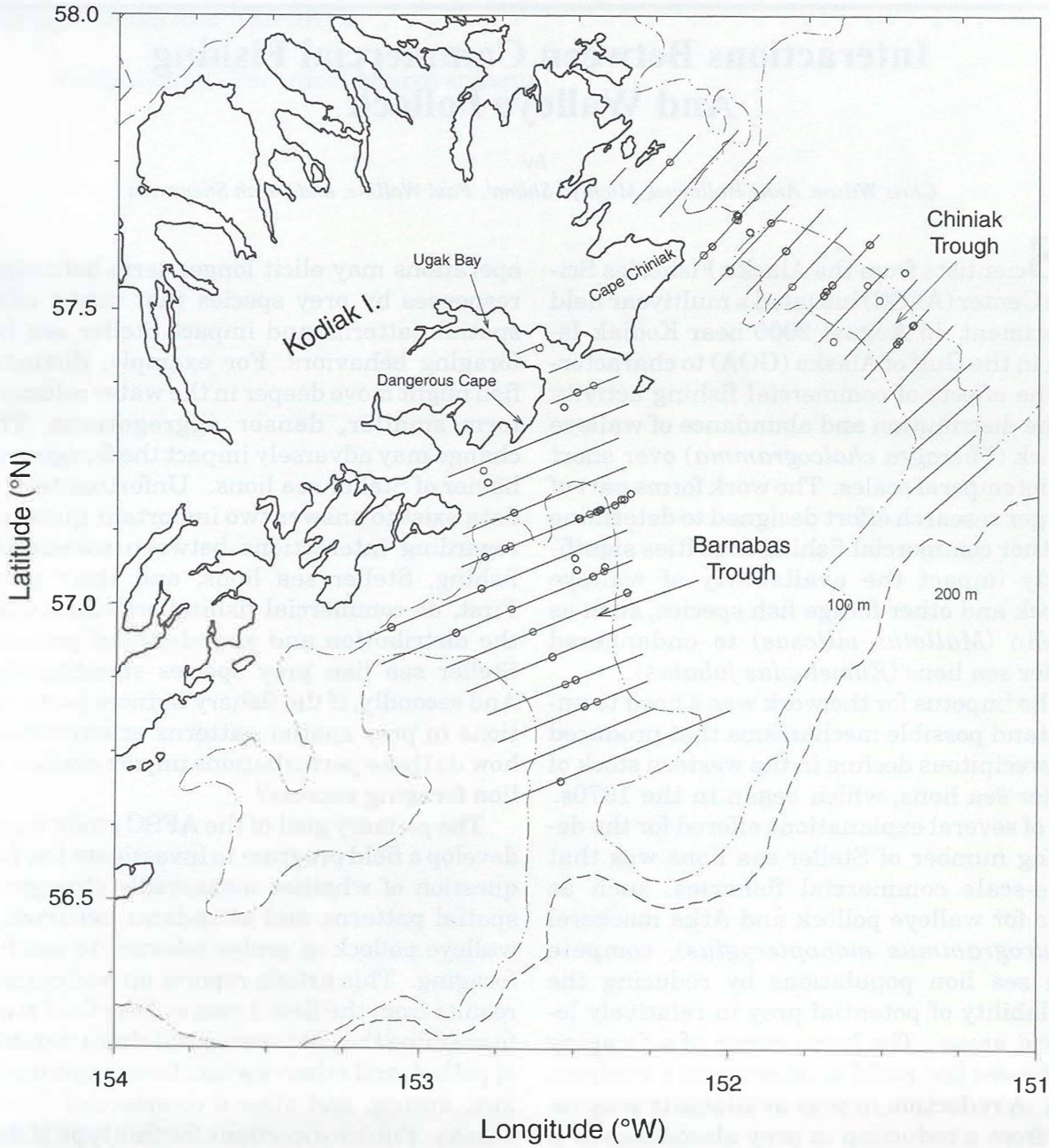


**Figure 1. Fishery interaction study area off the east side of Kodiak Island, Alaska, showing survey transects used for all passes during August 2000 and 2001 and trawl locations (open circles) for August 2001. Similar number of trawl hauls were conducted during August 2000.**

allowed and the other, Chiniak, would serve as a control site where fishing was prohibited. A well established commercial fishery for pollock occurs within the area so that implementation of a fishery "perturbation" during the experiment would be relatively easy. Additionally, the existence of the commercial fishery provided valuable evidence that pollock regularly occurred within the area; this knowledge augmented the limited information from stock assessment surveys.

The field-season for the fishery interaction experiment was scheduled for August. This period was chosen because postweaning Steller sea lion juveniles (1 year olds) were considered vulnerable to nutritional stress in

late summer and fall due to their high caloric needs per unit body weight and their inexperience at capturing prey. Additionally, fishery management regulations specified an August opening for the commercial pollock fishery in the area which coincided with the timing of the experiment. The study was designed to extend over several years because natural shifts in ocean conditions or variations in the age composition of the pollock stock might influence responses to fishing activities.

### Field Methods

The survey methods were similar to those used during other routine echo integration-trawl (EIT) surveys conducted by AFSC scientists. Multiple EIT surveys of the control and treatment sites were conducted during daylight hours (ca. 15 hours/day in August) in 2000 and 2001. The surveys consisted of a series of uniformly spaced (3 nmi) parallel transects (Fig.1) to describe patterns in the distribution and abundance of pollock and other selected species over a period of several weeks for each year of the study. A complete sampling of all transects within a trough was considered a survey pass.

The number of survey passes differed between years. Two survey passes were conducted within each trough before the fishery in August 2000. No surveys were conducted during or after the fishery in the first year. The work during the first year served two purposes. Because the EIT methods (see below) had not been used in the area during the summer, the suitability of using acoustic methods at that time and location needed testing. For example, the presence of acoustic backscatter from nonpollock scatterers could potentially prevent discrimination of the pollock echosign. Additionally, the natural variability in the temporal and spatial patterns of the pollock distribution and abundance over the 2-4 week field season (in the absence of a fishery) needed to be characterized. Repeated survey passes were conducted during the second year before and *during* the fishery to investigate whether fishery-induced changes occurred in the fish distribution. A similar number of days elapsed between repeated surveys in each trough during both years.

The acoustic data were collected with a calibrated Simrad EK 500 echosounder operating at 38 and 120 kHz. Results in this report were based on the 38 kHz data. Because the acoustic data were only collected to within about 0.5 m of the bottom, it is unlikely that the resulting biomass estimates reflect the total biomass within the troughs.

Trawls were conducted during all EIT surveys to identify the species composition of selected echosign and to collect biological samples needed to estimate abundance and distribution patterns. A large midwater Aleutian wing trawl (AWT) and smaller midwater Marinovich trawl were used to target midwater echosign, and a Poly Nor'eastern (PNE) bottom trawl was used to target near-bottom echosign. The codends of the AWT and PNE were fitted with a 32-mm (1 1/4 in) mesh codend liner and the Marinovich with a 3.2-mm (1/8 in) mesh liner except in August 2001, when a 9.5-mm (3/8 in) mesh liner was used in the AWT. A relatively small Methot midwater net with a 1-mm mesh codend liner was used several times during the second year to determine whether some scattering layers consisted of macrozooplankton or micronekton.

Each haul was kept to the minimum duration necessary to ensure an adequate sample. Standard catch sorting and biological sampling procedures were used to provide weight and number by species for all hauls. Pollock were further sampled for stomach contents and to determine sex, fork length, age, maturity, and body and ovary weights. Capelin were also sampled for individual body weights and lengths.

During the hours of darkness (ca. 9 h/day), transects were resurveyed to characterize diel trends for the dominant species, additional trawls were conducted to identify the species composition of selected echosign, additional conductivity-temperature-depth (CTD) data were collected, and *in situ* target strength (TS) measurements were made on pollock and capelin.

Oceanographic data to characterize the physical environment and its influence on the distribution of pollock and other important species were collected with a trawl-mounted temperature-depth instrument, CTDs, expendable bathythermographs (XBT), and a vessel-mounted thermosalinograph during August 2000. These instruments, as well as five current meter moorings, satellite-tracked drifters, and a vessel-mounted acoustic Doppler current profiler were used during August 2001.

### Data Analysis

Data analyses for this work have progressed to the stage where tentative results are available, but final analyses are not yet completed. For this report, estimates of variance for all point estimates are represented by 95% confidence intervals generated using a model-based one-dimensional geostatistical procedure for biomass estimates, bootstrapping methods for fish depth estimates, and traditional sample-based methods for fractal estimates of pollock aggregations.

A commercial software package (SonarData Echoview Ltd., Tasmania, Australia) that included patch recognition algorithms was utilized for the identification and analyses of the spatial patterns of the fish aggregations. Patches were identified using objective criteria that remained constant for all survey passes. Efforts are currently under way to extract data for various patch size- and shape-related variables to determine the influence that dynamic mechanisms such as fishing activity levels and biophysical factors have in generating the observed spatial patterns. Fractal measurements of schools, which relate school perimeter to school area, are presented to illustrate one of several potential types of school descriptors that can be used to quantify spatial patterns of pollock and other species. For example, an increase in fractal value, which indicates a more complex school shape, may be indicative of a redistribution process of the fish aggregation (e.g., potential indicator of school disruption into smaller groups). Statistical significance among fractal estimates was based on ANOVA test results.

### Results and Discussion

The following preliminary results can be used to illustrate the kind of information that can be gained with this type of approach to fishery interaction experiments. Final conclusions will not be drawn until the 4-year study is completed.

The EIT survey for the first year of the study was conducted 8-20 August 2000. Two survey passes were completed in both Chiniak and Barnabas Troughs. Thirty-five hauls were conducted during the first year with the AWT, five with the PNE, and five with the Marinovich net. The EIT survey for the second year of the study was conducted 9-31 August 2001. Three survey passes were conducted in each trough, and a fourth partial pass was also completed in Barnabas Trough over the area where pollock had been encountered during earlier passes. Forty-one hauls were conducted during the second year with the AWT, 16 with the PNE, and 4 with the Methot net. No commercial fishing was allowed in either Barnabas or Chiniak Troughs during survey passes 1-2 in either year. Commercial fishing operations occurred in Barnabas during passes 3-4 in 2001.

Acoustic backscattering from unidentified organisms did not prevent the identification of backscattering attributed to pollock and capelin in either Barnabas or Chiniak Troughs in either year (Fig. 2). Most of the backscattering was assigned to four types of fish echosign: 1) adult pollock, 2) age-1 pollock , 3) a mix of capelin/age-0 pollock in August 2000 or capelin in August 2001, and 4) other fishes. Classification of the echosign types was difficult and in some cases not possible during darkness when acoustic scattering layers attributed to capelin and juvenile pollock often dispersed and merged to form a single, relatively broad and undifferentiated layer. The deeper adult pollock echosign was generally identifiable during darkness.

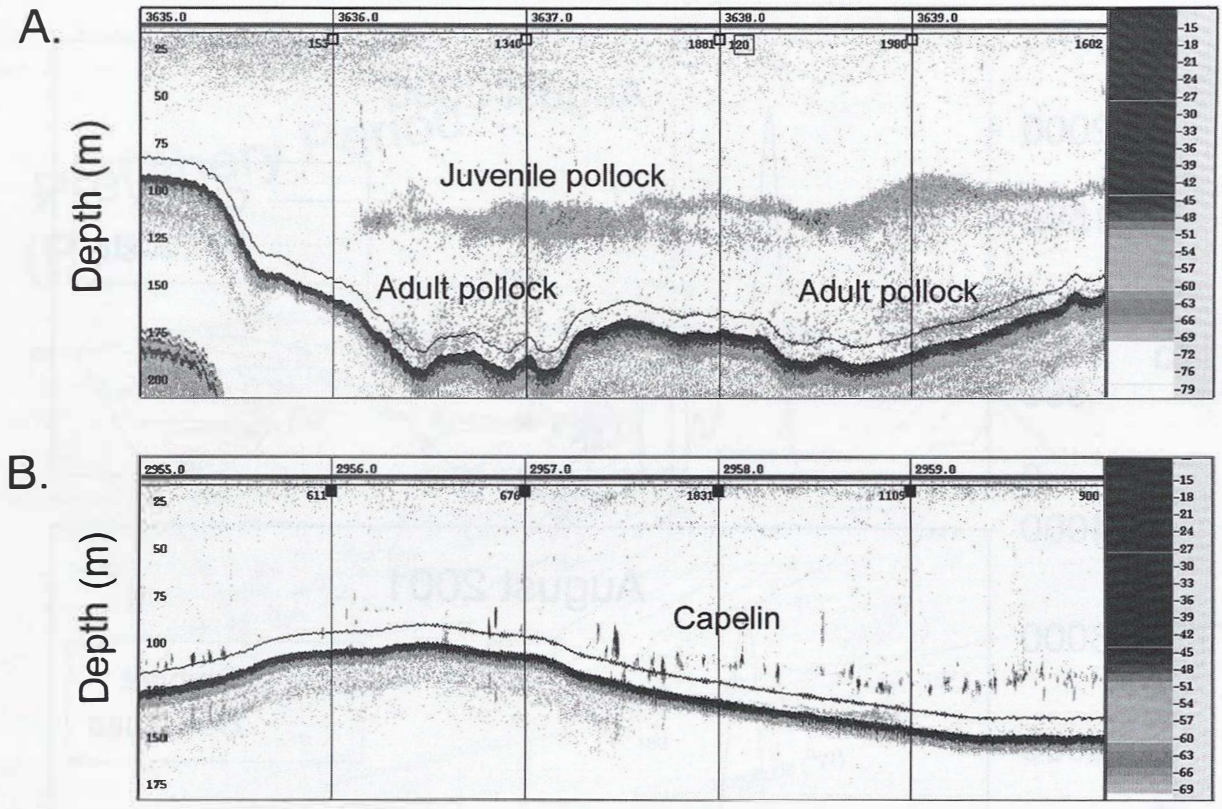


**Figure 2. Example echograms illustrating echosign layers attributed to pollock (A) and capelin (B) from the August 2001 fishery interaction study.**

The size composition of pollock was generally similar between years and troughs although age-1 pollock were largely absent in Barnabas during the first year (Fig. 3). Capelin size compositions (not shown) during the second year, when the smaller mesh codend liner was used, were slightly bimodal in Barnabas but not in Chiniak, where generally smaller fish were observed (Chiniak: mean length = 8.5 cm, SD = 1.4, n = 474; Barnabas mean length = 9.6 cm, SD = 1.4, n = 1,389).

### August 2001 Fishery

Because pollock spatial patterns and abundances were estimated both before and during the commercial trawl fishery during the second year of the experiment, it was important to determine the level of fishing activity that was directed at fish in the treatment area. Data have been compiled for 27 of 28 vessels that were fishing in Barnabas Trough during the experiment. These data account for about 99% of the total catch removed from this trough (based on Alaska Department of Fish and Game fish ticket data). The 27 vessels spent about 1,074 hours fishing to complete 167 hauls during 22-31 August (i.e., during Chiniak survey pass 3 (23-26 Aug.) and Barnabas passes 3 (26-29 Aug.) and 4 (29-30 Aug.)). Vessel deliveries during this period indicated that this effort removed nearly 2,850 metric tons (t) of pollock from Barnabas Trough. Based on historical fishing trends, this did not appear to be an unusual level of effort.

### Geographical Distribution and Abundance

The geographical distribution of pollock and capelin were similar between years although some notable differences existed for juvenile pollock. Adult pollock were distributed throughout Chiniak Trough, whereas in Barnabas Trough they tended to concentrate more towards the northern half of the trough during both years (Fig. 4). Age-1 pollock were

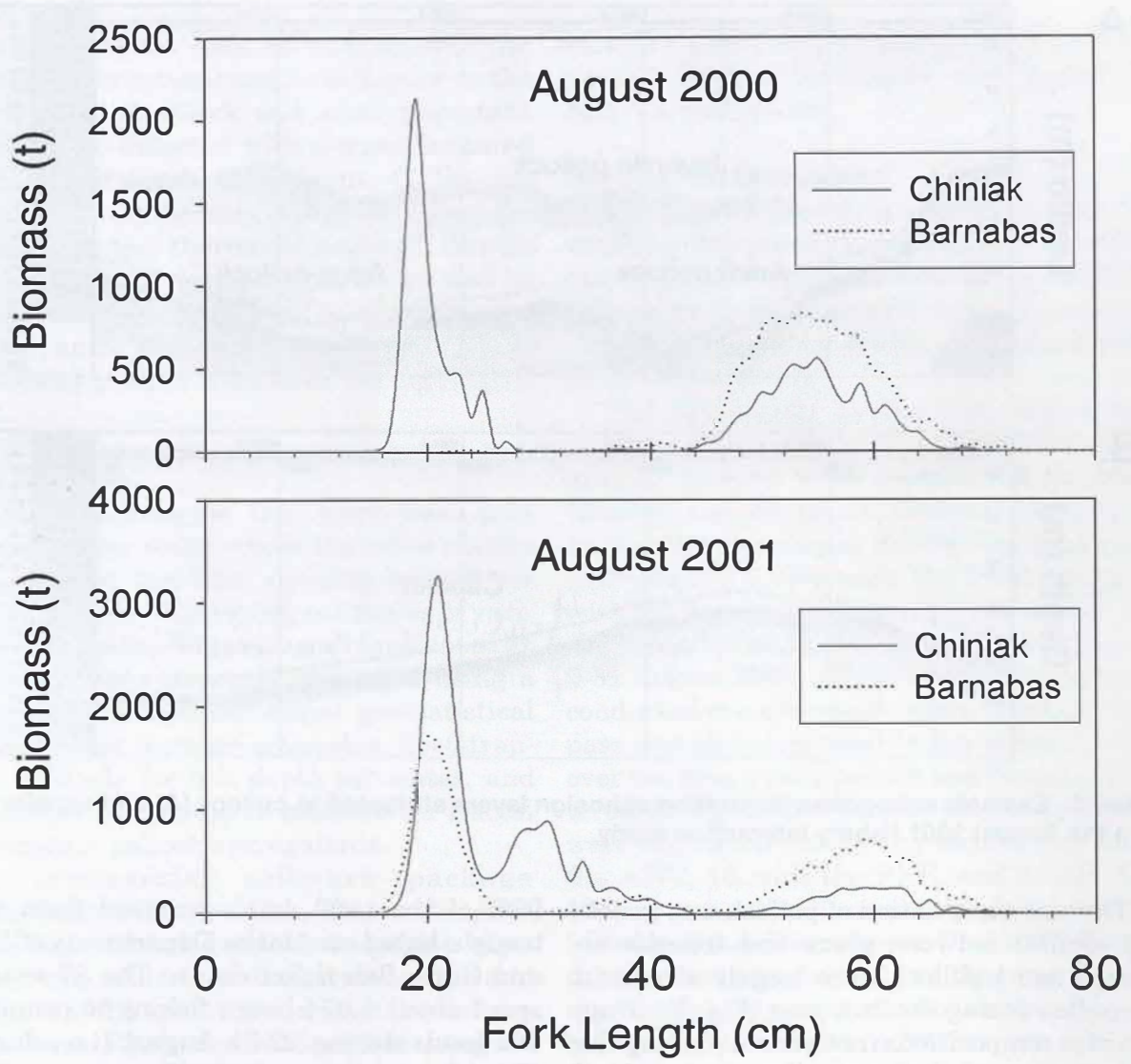


**Figure 3. Pollock size composition estimates for Chiniak and Barnabas Troughs from the August 2000 and August 2001 fishery interaction studies.**

broadly distributed in Chiniak but virtually absent in Barnabas during the first year. They occurred in both troughs during the second year, with distributions similar to the adults (Fig. 5). The mix of age-0 pollock and capelin were broadly distributed in both troughs during the August 2000 survey. The following year, age-0 pollock were only detected at the east end of one transect in Chiniak during the second survey pass. Capelin were often present over the shallower edges of Chiniak Trough, but were concentrated in the deeper waters within the southern half of Barnabas Trough during the second year. These geographical patterns generally persisted for all species and age groups during all passes for each year. This suggests that the distributional patterns were quite stable, at least during the several week study period and, further, that no major disruptions to these patterns occurred in response to the commercial fishing activities in Barnabas during the second year.

Although capelin contributed substantially to the total fish abundance based on the acoustic data for both years, results of these

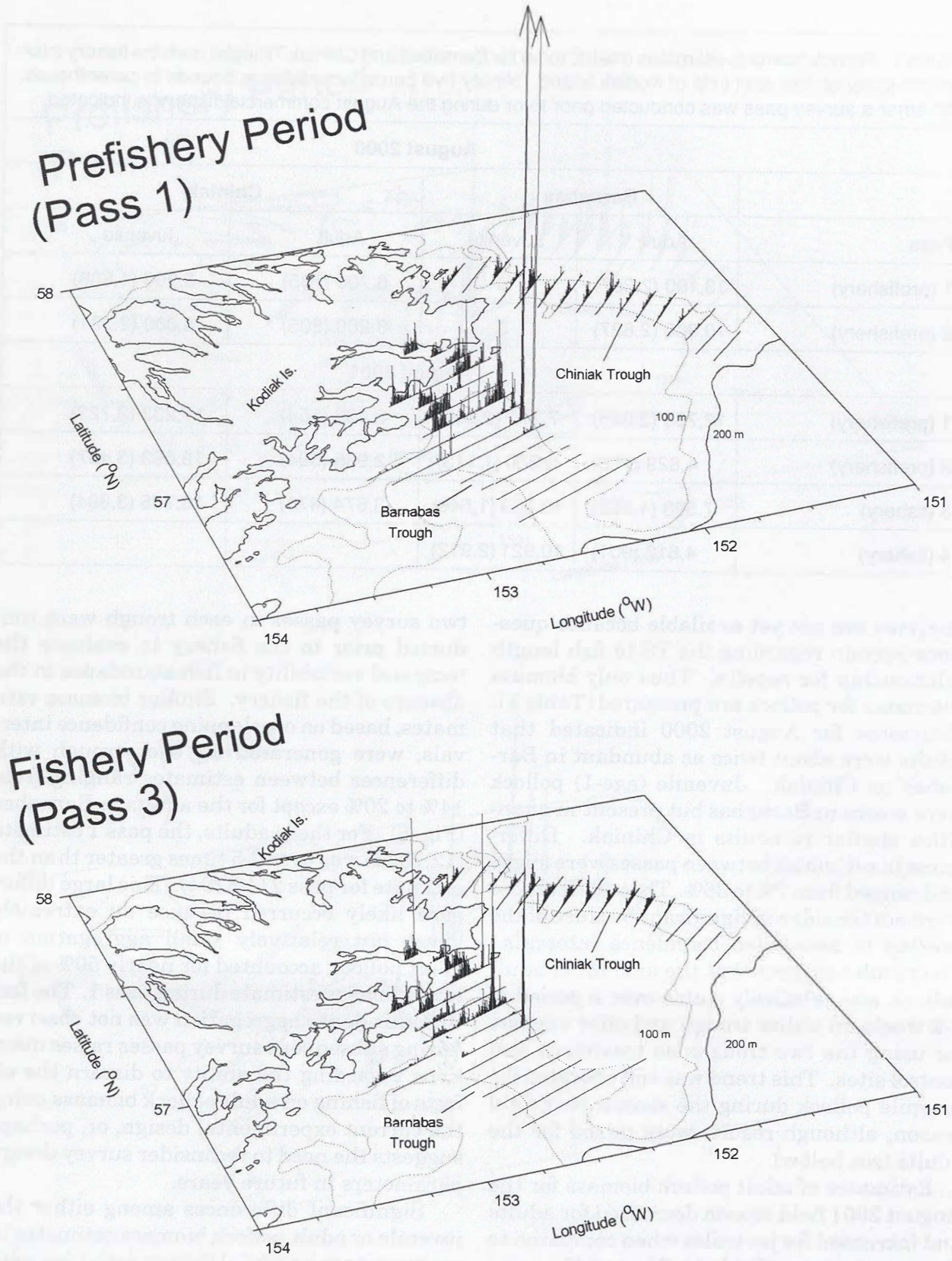


**Figure 4. Acoustic backscatter attributed to adult pollock along transects during a representative pass from the prefishery period and fishery period in August 2001. See text for explanation.**

Table 1. Pollock biomass estimates (metric tons) for Barnabas and Chiniak Troughs from the fishery interaction study off the east side of Kodiak Island. Ninety-five percent confidence bounds in parentheses. Whether a survey pass was conducted prior to or during the August commercial fishery is indicated.

| August 2000 | | | | |
|---|---|---|---|---|
| | Barnabas | | Chiniak | |
| Pass | Adult | Juvenile | Adult | Juvenile |
| 1 (prefishery) | 13,100 (2,387) | 0 | 6,700 (785) | 5,900 (1,638) |
| 2 (prefishery) | 10,800 (2,627) | 0 | 6,200 (805) | 8,000 (2,221) |
| **August 2001** | | | | |
| 1 (prefishery) | 12,733 (3,046) | 7,771 (2,838) | 3,492 (554) | 17,233 (2,723) |
| 2 (prefishery) | 4,829 (700) | 9,320 (1,113) | 2,905 (594) | 19,693 (3,497) |
| 3 (fishery) | 7,593 (1,652) | 10,659 (1,546) | 3,674 (473) | 18,705 (3,894) |
| 4 (fishery) | 4,612 (901) | 10,921 (2,912) | | |

analyses are not yet available because questions remain regarding the TS to fish length relationship for capelin. Thus only biomass estimates for pollock are presented (Table 1). Estimates for August 2000 indicated that adults were about twice as abundant in Barnabas as Chiniak. Juvenile (age-1) pollock were scarce in Barnabas but present in quantities similar to adults in Chiniak. Differences in estimates between passes were slight and ranged from 7% to 36%. These differences were not considered significant because of the overlap in associated confidence intervals. The results suggest that the amount of adult pollock was relatively stable over a period of 1-2 weeks in either trough and offer support for using the two troughs as treatment and control sites. This trend was corroborated for juvenile pollock during the second year field season, although results were mixed for the adults (see below).

Estimates of adult pollock biomass for the August 2001 field season decreased for adults and increased for juveniles when compared to the previous year (Table 1). These differences highlight the value of a multiyear research effort. As was the case in 2000, in 2001 the first two survey passes in each trough were conducted prior to the fishery to evaluate the temporal variability in fish abundance in the absence of the fishery. Similar biomass estimates, based on overlapping confidence intervals, were generated for each trough with differences between estimates ranging from 14% to 20% except for the adults in Barnabas (Fig. 6). For these adults, the pass 1 estimate (12,733 t) was over 2.5 times greater than the estimate for pass 2 (4,829 t). This large difference likely occurred because an extremely dense but relatively small aggregation of adult pollock accounted for nearly 50% of the total biomass estimate during pass 1. The fact that this dense aggregation was not observed during subsequent survey passes raises questions regarding the ability to discern the effects of fishing on adult pollock biomass using the current experimental design, or, perhaps suggests the need to reconsider survey design parameters in future years.

Significant differences among either the juvenile or adult pollock biomass estimates in response to commercial fishing activities were not detected (Table 1, Fig. 6). For example, confidence bounds for juvenile estimates

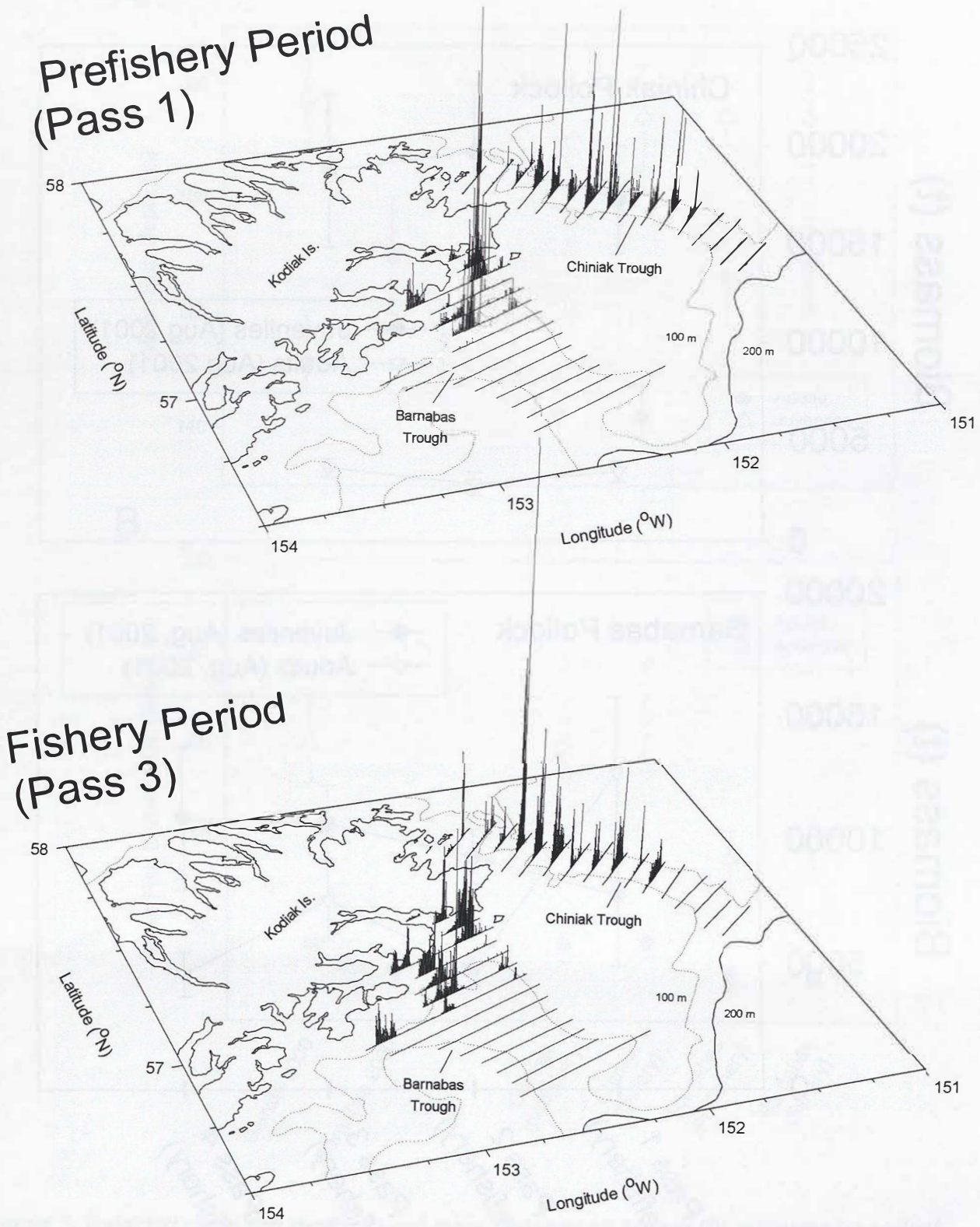


**Figure 5. Acoustic backscatter mainly attributed to age-1 pollock along transects during a representative pass from the prefishery period and fishery period in August 2001.**

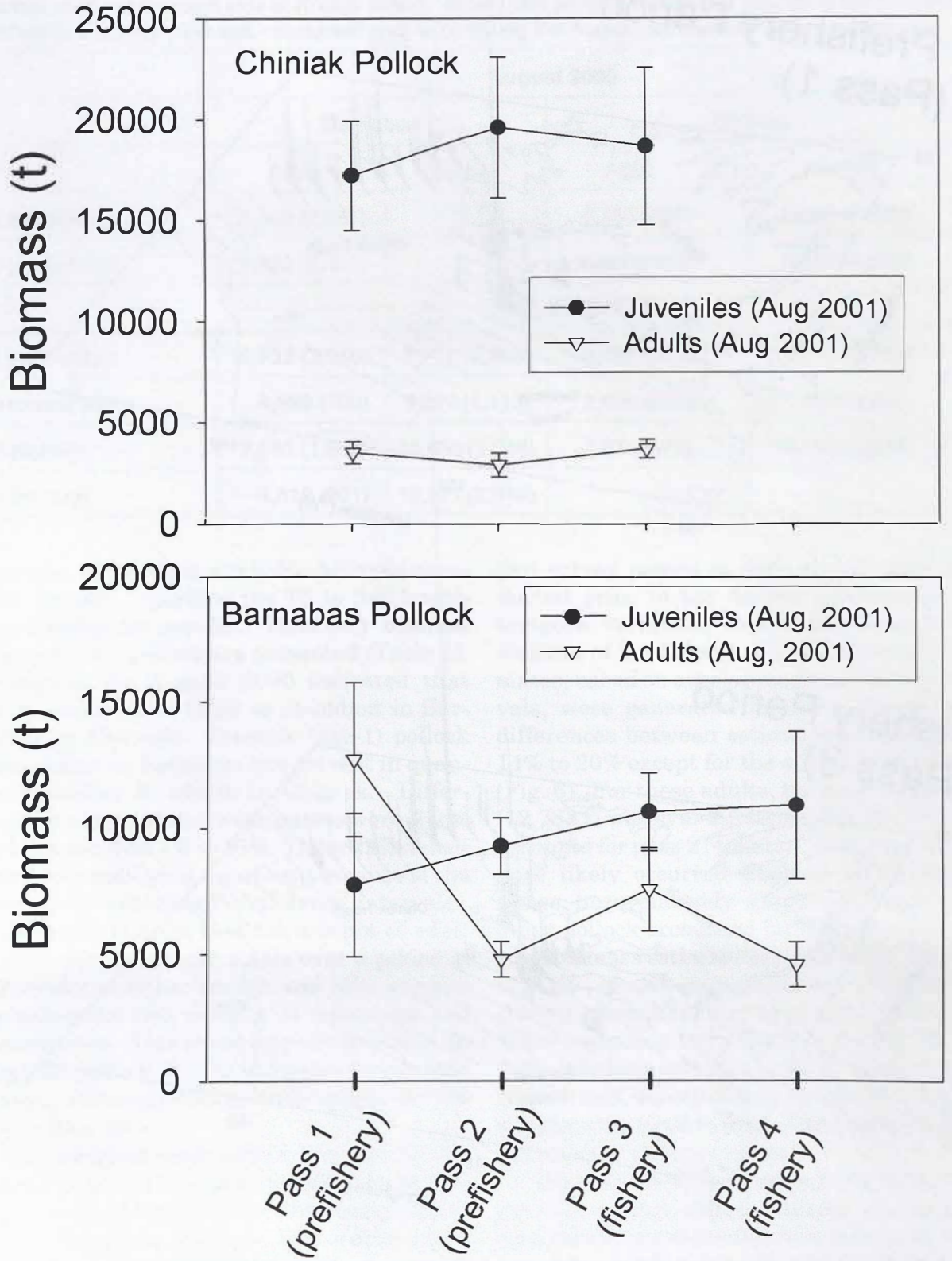


**Figure 6. Pollock biomass estimates for August 2001 in Barnabas and Chiniak Troughs.**

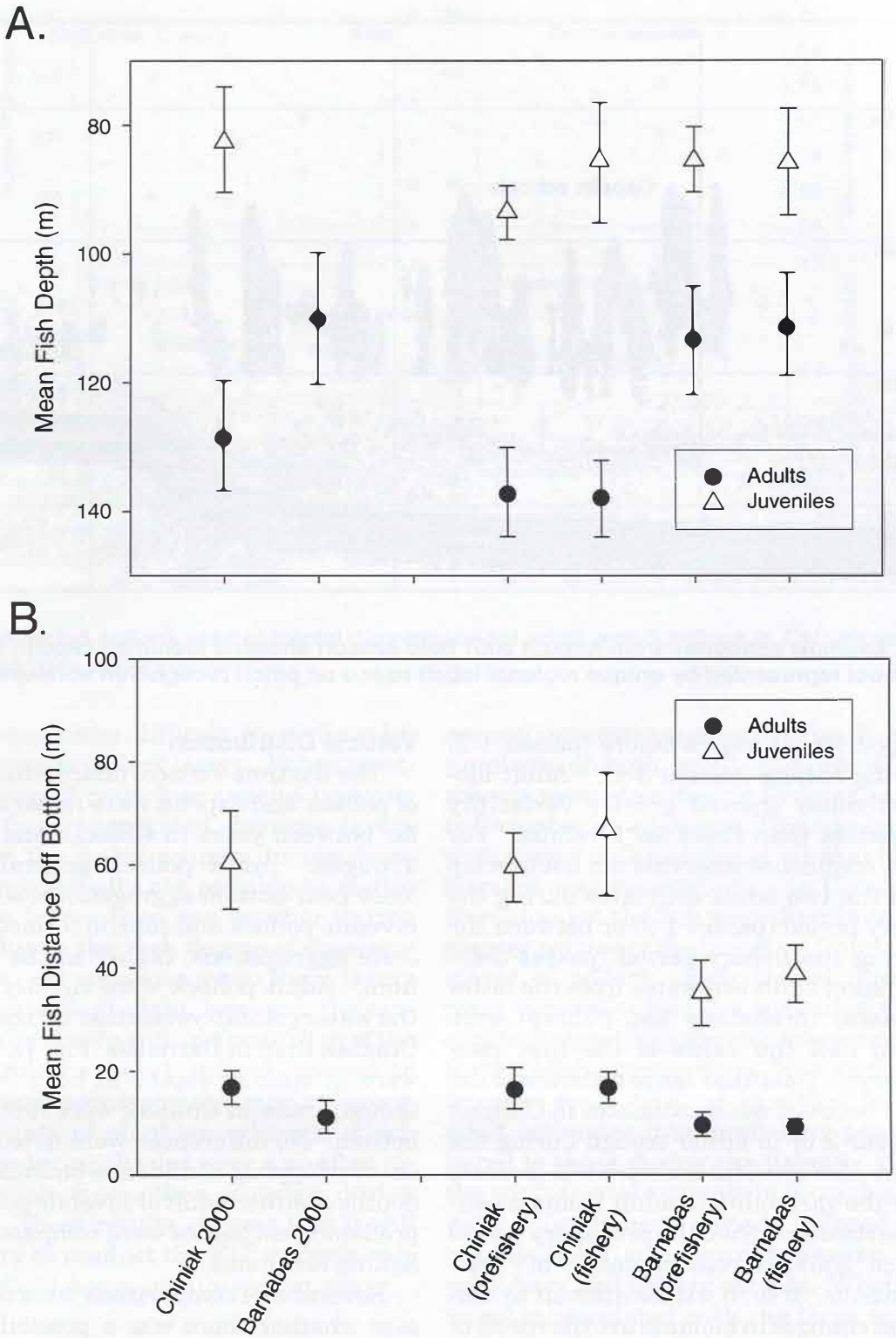


**Figure 7. Weighted mean fish depth (A) and mean distance off bottom (B) estimates for pollock in Barnabas and Chiniak Troughs for each pass during August 2000 and for passes combined into prefishery and fishery periods during August 2001. Ninety-five percent confidence intervals are shown.**

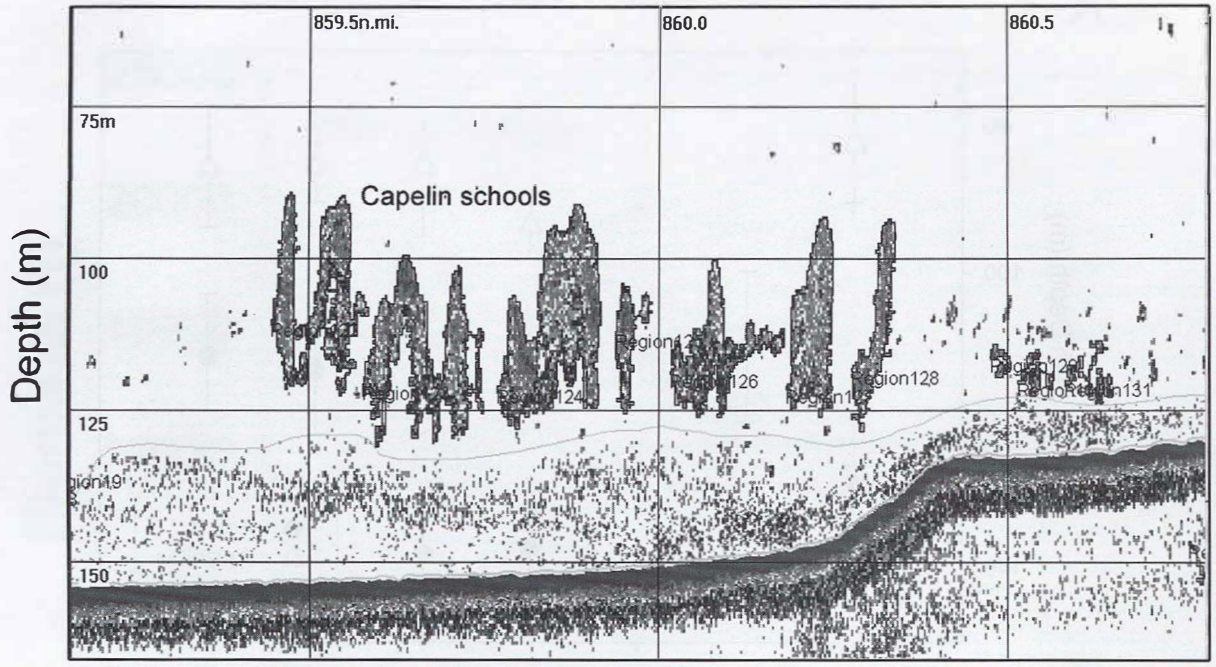


**Figure 8. Example echogram from August 2001 field season showing identified capelin schools (each school represented by unique regional label) based on patch recognition software.**

overlapped for all passes before (passes 1-2) and during fishing (passes 3-4). Adult biomass estimates showed greater variability among passes than those for juveniles. For example, confidence intervals did not overlap between the two adult estimates during the prefishery period (passes 1-2) or between the two during the fishery period (passes 3-4). Furthermore, adult estimates from the latter three passes (prefishery and fishery) were less than half the value of the first pass (prefishery). Note that large differences did not occur between adult estimates in Chiniak during year 2 or in either trough during the first year. However, future work will indicate whether the variability in adult biomass estimates, particularly from the prefishery period in August 2001, is representative of "typical"conditions. If so, it will be difficult to conclude that changes in biomass are the result of commercial fishing activity unless differences in estimates between the prefishery and fishery periods are quite dramatic (e.g., > 65% reduction) given the large natural variability observed in the existing estimates.

### Vertical Distribution

The daytime vertical distribution patterns of pollock and capelin were remarkably similar between years in Chiniak and Barnabas Troughs. Adult pollock generally formed loose near-bottom aggregations, whereas the juvenile pollock and capelin formed more discrete aggregations, higher in the water column. Adult pollock were slightly deeper in the water column yet further off the bottom in Chiniak than in Barnabas (Fig. 7). Juveniles were at similar depths in both troughs, although those in Chiniak were further off the bottom. No differences were detected, based on overlapping confidence bounds, in mean depths of either adult or juvenile pollock when prefishing estimates were compared with the fishing estimates.

Several diel comparisons were made to assess whether there was a possibility of conducting the survey 24 hours per day. Adult pollock exhibited relatively little dispersion and typically did not rise in the water column, remaining within about 30 m of the bottom at night. In 2001, however, the adult pollock lay-

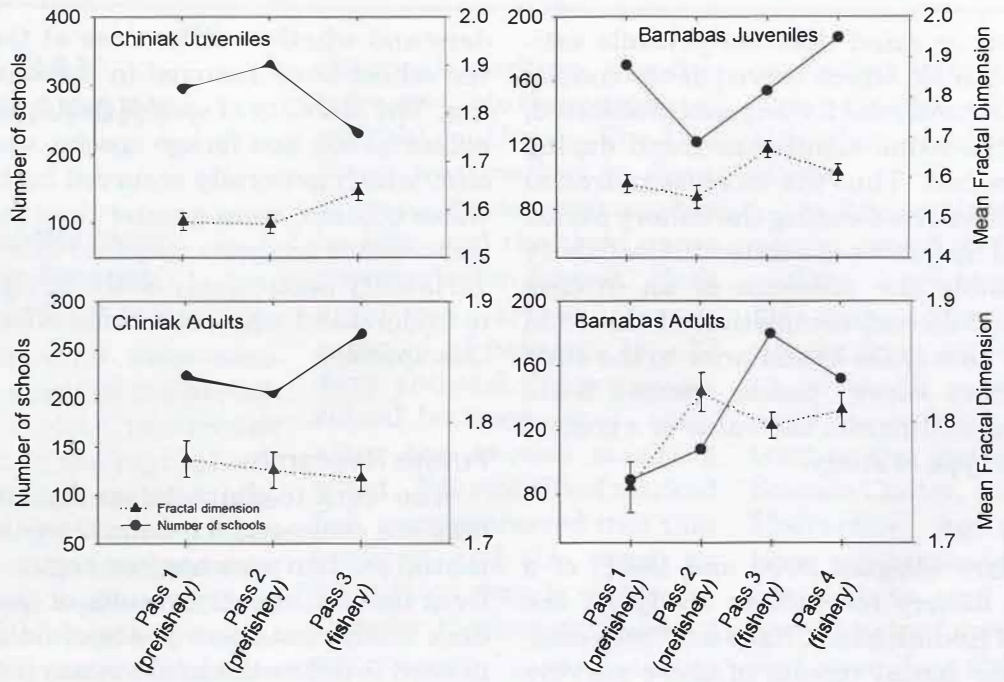


**Figure 9. Estimated pollock school fractal dimensions for adult age-1 pollock in Chiniak and Barnabas Troughs in August 2001.**

ers were sometimes difficult to distinguish from the juvenile pollock layers. Echosign attributed to age-1 pollock or capelin typically dispersed from aggregated daytime layers and rose in the water column during darkness. It was usually not possible to distinguish these layers from one another during the night due to the high degree of dispersal and mixing. On occasions when these layers were recognizable at night, however, the capelin generally rose to within about 20 m of the surface, and the age-1 pollock moved to depths immediately below the capelin layers. Small amounts of plankton echosign which were visible during the day were also often indistinguishable from other echosign during the night. These results suggest that it will be necessary to conduct the EIT surveys only during daylight hours in subsequent years.

## Patch Analysis

The analysis of adult and juvenile pollock and capelin patch (or aggregation) dynamics may help in determining the impact of commercial fishing activities at these spatial scales (Fig. 8). The following results suggest several interesting patterns (Fig. 9). Greater numbers of both adult and age-1 pollock schools were identified in Chiniak compared to Barnabas on all passes. This was intriguing with regard to the adults, given that the adult biomass was generally less in Chiniak than Barnabas yet the fish were distributed over a greater portion of the trough in Chiniak. Estimates of pollock patch fractal dimensions were generally less for juveniles than for adults, suggesting a greater shape complexity for the adult aggregations. No significant differences were detected in either trough for adult estimates from prefishery passes compared to those during the fishery. However, the adult fractal estimate in Barnabas during pass 1 (prefishery period) differed significantly from subsequent passes during prefishery and fishery periods. Whether this trend is associated with the large estimated biomass that occurred for pass 1 is uncertain at this time, and verification of these initial patch analyses must still be completed.

Juvenile pollock fractal estimates from the prefishery survey passes were significantly less than those during the fishery. It is impor-

tant to bear in mind that the juvenile estimates in Chiniak, which served as the control site where commercial fishing was prohibited, exhibited the same significant trend during this time period. Thus the increase in fractal values that occurred during the fishery period was caused by factors unrelated to the fishery itself; possibly the presence of an intense storm that followed completion of the final prefishery pass (pass 2) and prior to the start of the fishery survey passes (passes 3-4). These results illustrate the value of a control site in this type of study.

## Summary

Two years (August 2000 and 2001) of a multiyear fishery interaction study off the east side of Kodiak Island have now been completed. The initial results of these surveys provide important information that begins to address the question of whether the abundance and spatial patterns of various species, including walleye pollock and capelin, are impacted by commercial fishing activities over short spatiotemporal scales. These preliminary results highlight potentially important findings. The successful application of EIT survey methods demonstrated that these methods could be used in this time of year in this region of the GOA to assess pollock and capelin. The biomass and distribution of pollock were reasonably stable over periods of days to weeks, although during the second year an unusual, extremely dense, small-scale pollock aggregation was detected (Barnabas pass 1). It may be necessary to adjust survey methods to account for this high level of patchiness if this is common for adult pollock during August. Preliminary results from the second year, when the commercial fishery took place within the study area, have yet to suggest a significant link between fishing activities and changes in adult and age-1 pollock geographical distribution, biomass, vertical distribution, or school fractal dimensions. It will be important, however, to evaluate whether these trends persist during subsequent years. Other descriptors of school size and shape will be evaluated to better understand whether differences at the scale of the school level occurred in response to fishing. The stability of spatial patterns for other potential sea lion forage species such as capelin, which generally occurred higher in the water column, were greater than for pollock. Subsequent analyses may find this increased variability particularly challenging in efforts to understand whether fishing effects impact this species.

## Future Research

The work to characterize the interactions between commercial fishing activities and potential sea lion prey has just begun. It is clear from the preliminary results of the east Kodiak study that more years of fieldwork are needed to define the limits in any potential interactions that may exist between the fishery and potential sea lion prey species. The incoming strong year class of pollock observed in 2001 (Fig. 3) will provide an important opportunity during the next 2 years of the study to investigate whether variations in the pollock age composition influence responses to fishing activities. If significant responses by pollock or other species are detected, additional survey passes will be conducted following completion of the fishery to document the duration of the perturbation. Other developing technologies will be used in future field efforts to improve the species identification of scattering layers; they include the addition of an open/closing codend for the research trawls and the use of multiple acoustic frequencies. Additional bottom trawling efforts may be included to provide abundance estimates for demersal (i.e., within 0.5 m of bottom) pollock, which are unavailable to the acoustic survey method. *In situ* target strength measurements will be collected on forage species so that estimates of absolute abundance can be made. Finally, as resources become available, efforts will be made to expand the east Kodiak fieldwork to other seasons and then to design similar experiments in other areas and seasons to evaluate whether regional differences exist.

# AUKE BAY LABORATORY (ABL)

## Young-of-the-Year Sablefish Age and Growth in Gulf of Alaska

Experiments were completed to examine the periodicity of otolith increment formation in the sagittal otoliths of juvenile sablefish (age 0, size range 73 mm to 186 mm). Otolith increments are alternating light and dark bands visible under a transmitted light compound microscope at magnifications of 250X to 1,000X. A daily periodicity of otolith increment formation in juvenile sablefish (age 0) has been postulated but never validated. The periodicity of otolith increment formation was tested in this study by chemically marking the otoliths of captive juvenile sablefish with strontium chloride ($SrCl_2$).

Approximately 30 post larval neustonic sablefish were captured along the continental shelf and transported alive to Auke Bay Laboratory on 1 June 2000. The fish were maintained in seawater tanks for up to 104 days. The water temperature was elevated and held at a constant 13°C, and the photo period was lengthened and held at a constant 16 hours of light per day. The otoliths were chemically marked by immersing the live fish in seawater containing 1,000 ppm $SrCl_2$. For chemical marking, the fish were split into three groups of roughly equal size. The first group was marked in June, the second group was marked in July, and the third group was marked in August. Each group was marked twice over a period of between 15 - 17 days, and each group was sacrificed between 14 -17 days after the second marking event. The otoliths of marked fish were processed into thin sections and the resulting strontium bands were detected with electron scanning microscopy by staff at the University of Alaska, Fairbanks. For each otolith, the number of increments between strontium bands were counted and compared to the number of days between $SrCl_2$ immersions. The number of otolith increments detected between strontium bands ranged from 10 to 25, and in general did not agree with the number of days between marking events (15 - 17 days, average percent error in agreement 19.5%). These results suggest that either the otolith increments detected in this study did not form with a daily periodicity or that the methods used in the study to detect otolith increments were not accurate. In either case, the use of a less complicated structure, such as the lapilli otolith, or a more accurate otolith increment detection method, such as scanning electron microscopy, may be required to validate the periodicity otolith increment formation for the size range of juvenile sablefish examined in this study.

Age determinations of juvenile sablefish from lapilli otoliths were completed for fish collected in the Gulf of Alaska from 1999-2001. Up to 30 lapilli were read for daily age by staff under contract at the Hatfield Marine Science Center, Oregon State University. Age determinations will be used to estimate birth date and calculate growth rates for comparisons with year-class strength, estimated from age-structured modeling of adult sablefish.

By Dean Courtney.

## Sablefish Tag Recovery Program Provides Data and Otoliths for Young and Old Fish

Data entry of sablefish tag releases and recoveries and administration of the tag reward program continues. About 600 tags have been received for 2001 so far, down slightly from the last 3 years. Tag releases for adults and juveniles, now total 308,970. There are 24,004 recoveries to date. Over 17% of the fish recovered in 2001 had been at liberty longer than 15 years. The three fish at liberty the longest (28+ years) were all released in upper Chatham Strait in 1973. Two were recovered in Chatham Strait and one off Queen Charlotte Sound in Canada.

The tagged fish otolith collection was brought up to date recently. There are now over 900 sets of otoliths in the collection. The number of tagged fish otoliths being collected has increased dramatically during recent years, due to increased coverage of the fishery by National Marine Fisheries Service (NMFS) observers. Many of the recovered fish were out over 10 years and most were out at least 2 years before recapture, and they should provide good information on growth and ageing when they are processed.

By Nancy Maloney.

## Variability in Trawl Survey Catches of Pacific Ocean Perch, Shortraker Rockfish, and Rougheye Rockfish in the Gulf of Alaska

All the abundant species of slope rockfish in Alaska are usually assumed to be extremely variable or clustered in their distribution. Little analysis, however, has been done on this subject, especially regarding comparisons of variability among the different species. In this study, ABL scientists first examined data for Pacific ocean perch, shortraker rockfish, and rougheye rockfish from three experimental bottom trawl surveys in the Gulf of Alaska in 1993, 1998, and 1999 to compare the variability of catches for each species. Although these surveys were relatively small in scope, they all used the same survey vessel, the F/V *Unimak* and the same experienced rockfish commercial captain, together with a net specifically designed for catching rockfish. Thus, they likely provide some of the best survey data available for these three species in Alaska. When catches of each species were analyzed within their optimum habitat, the coefficient of variation for Pacific ocean perch was approximately 2.5 to 3 times greater than that of shortraker and rougheye rockfish, indicating that Pacific ocean perch are much more clustered in their distribution. Shortraker and rougheye rockfish were similar to each other in their variability.

To provide additional comparisons of variability over a broader geographic area, catches of the three species were also examined from seven large-scale trawl surveys conducted by the AFSC Resource Assessment and Conservation Engineering (RACE) Division in the Gulf of Alaska from 1984 to 2001. Again, the analysis only included hauls that were made within the optimum habitat for each species. Results were very similar to the previous results from the experimental surveys: variability of Pacific ocean perch catches was about 2-3 times greater than that for either shortraker or rougheye rockfish. Overall results of this study indicate that a stratified random trawl survey directed at shortraker and rougheye rockfish would be logistically feasible, because the low variability of these two species would require relatively few hauls to be made. However, a similar random survey aimed at a highly variable species such as Pacific ocean perch is probably not feasible because it would require too many stations to be cost effective. New and innovative methodologies for surveying Pacific ocean perch, such as the use of echosounders in combination with trawling, will be necessary to improve assessment of this species. Results of this study were presented at the 2002 Western Groundfish Conference in Ocean Shores, Washington, in February 2002.

By David Clausen.

## Distribution, Habitat, and Behavior of Rockfish in Nearshore Waters of Southeastern Alaska

We examined distribution, habitat, and behavior of rockfish, *Sebastes* spp., with a remotely operated vehicle (ROV) in coastal waters less than 90 m deep of southeastern Alaska from 1998 to 2000. We identified black, canary, China, copper, dusky, harlequin, Puget Sound, quillback, redstripe, rosethorn, silvergray, tiger, yelloweye, and yellowtail rockfish. Quillback and dusky rockfish were the most widely distributed species, China and har-

lequin rockfish were the least widely distributed species. Species abundance was greater at sites on or near the outer coast than at sites in more inside, sheltered waters. Most (>75%) observations of rockfish were over complex bottoms of boulder and rock or in vertical bedrock wall habitats. Few rockfish were observed over soft bottoms with no relief. Median depth of observation was less than or equal to 30 m for black, copper, dusky, and yellowtail rockfish and greater than 30 m for all other species. Median temperature of observation ranged from 6.1°C for harlequin rockfish to 9.4°C for black rockfish. Size of fish was positively correlated ($p \leq 0.036$) with depth for dusky, quillback, and yelloweye rockfish. Species often observed alone were China (67%), copper (46%), quillback (46%), and rosethorn (43%) rockfish. Most (≥70%) observations of harlequin, Puget Sound, silvergray, tiger, and yelloweye rockfish were in mixed species assemblages. When first observed, the behavior of most rockfish species was swimming or hovering. Notable exceptions were China, harlequin, rosethorn, and tiger rockfish; 33-57% were resting on bottom or in a hole or crevice. This information will be helpful in defining the habitat requirements of rockfish species in southeast Alaska.

By Scott Johnson.

## Seasonal Increases in Polycyclic Aromatic Hydrocarbons in Auke Lake

Passive sampling devices were deployed into Auke Lake, a small oligotrophic lake near Juneau, Alaska, to determine seasonal input of aromatic hydrocarbons. Auke Lake, which provides rearing and/or spawning habitat for seven salmonid species, receives hydrocarbon input both from seasonal recreational use of personal watercraft with two-stroke engines and from year-round urban use such as automobile highway runoff and fuel oil spills. Sampling devices were deployed in the lake for 21-day periods throughout 2001. Like many recreational lakes, Auke Lake had seasonal increases in petroleum hydrocarbon input, primarily into the surface waters. Relative input of polycyclic hydrocarbons increased in the summer with peaks occurring during times of highest recreational personal watercraft use. The characterization of the aromatic hydrocarbon profiles by gas chromatography mass spectrometry (GC/MS) was consistent with the exhaust output of small combustion engines rather than from urban runoff.

By Jeep Rice.

## ABL Supports Science in Local Schools

ABL staff serve as mentors for high school students during the local school-sponsored science fair. The Alaska Science Fair, sponsored by the Society for Technical Communications (STC), is an opportunity for local high school students to do hands-on science. Students seek out mentors from the scientific community in a variety of disciplines and compete at local, state, and international levels. ABL staff members Mark Carls, Scott Johnson, K Koski, Adam Moles, and Joe Orsi served as project mentors for secondary school students competing at the local level in Juneau, and six staff members volunteered as judges. Eight projects were conducted in Auke Bay laboratories over the winter. The winning entry at the statewide fair held in Anchorage on 14 March was a project mentored and conducted at ABL on the effects of untreated sewage on mussels. That project qualified to compete at the International Science and Engineering Fair in Tennessee in May of 2002.

By Adam Moles.

## Sea Ranching of Pink Salmon in Prince William Sound, Alaska

The total run of pink salmon, *Oncorhynchus gorbuscha,* in Prince William Sound (PWS), Alaska, for the years 1990-2001 averaged 31.0 million fish per year. Sea ranching from a system of large hatcheries produced over 80% of the run. The de-

gree to which hatchery production actually may have replaced, rather than enhanced, wild stock production is controversial. To examine if hatchery releases have reduced wild stock productivity, a generalized linear version of the Ricker spawner-recruit model was used to analyze the relationship of wild stock productivity with the number of hatchery juveniles released and an array of other environmental variables. Three time periods of wild stock spawner-recruit data were analyzed; the time periods were defined by the availability of the associated environmental data. For all time periods, indices of conditions in the marine environment best explained the variability in wild stock production in PWS. No significant effect of hatchery releases on productivity was observed for the 1980-98 brood years (with the most comprehensive set of environmental variables) or for the 1960-98 brood years (with the longest time series of spawner/recruit data and measures of environmental change). For the time period of the 1975-98 brood, hatchery releases were identified as affecting wild stock productivity, but did not explain as much of the variability as did an index of density-independent marine survival conditions. Based on these results and a simulation model for the time period in which a detectable hatchery effect was identified, for return years 1990-2000 the annual loss in wild production due to displacement by hatchery fish was estimated to be 0-4.6 million pink salmon, and the commensurate annual net gain in total returns was estimated to be 20.6 million-25.3 million pink salmon. Thus sea ranching of pink salmon in PWS has provided large net benefits to the salmon fisheries of the region.

By Alex Wertheimer.

## Steelhead Research at Little Port Walter

Research is currently under way at Little Port Walter (LPW) to provide more information on the complex relationship between anadromous steelhead and resident rainbow trout inhabiting the same sections of streams. Currently, little is known about the genetic relationships between the two groups. Recent genetic studies have indicated that in one population in Oregon there appears to be little interchange and the groups are genetically distinct, while another population in British Columbia appears to have significant gene flow. For accurate determination of evolutionarily significant units (ESUs) and their status, this type of information is critical.

A small stream (Sashin Creek) at LPW with a wild steelhead population and a large resident rainbow trout population may provide additional information on gene flow between groups including frequency and quantity. Researchers at LPW are PIT-tagging all adult steelhead entering the creek and taking DNA samples on each fish. A new smolt and kelt trap is now allowing the monitoring of all fish migrating to the sea, and up to 50% of the smolt migration each year is PIT-tagged and sampled for DNA. We currently are reaching enough years of sampling to soon be able to determine the proportion of each years' smolt production that was produced by anadromous fish or resident fish. The project is already yielding new important life history information on Southeast Alaska coastal steelhead trout with regard to stream life of males and females, repeat spawning frequency, and mortality rates. The project is part of a long-term inbreeding and outbreeding depression project designed to provide more information for captive breeding programs and hatchery-wild interactions.

By Frank Thrower.

## Annual Auke Creek Cooperative Research And Planning Meeting

Cooperative research on salmon and trout using the Auke Lake system continued in the first quarter of this year. The system supports endemic populations of pink,

chum, sockeye, coho salmon, Dolly Varden char, and cutthroat and steelhead trout. Some of the data sets have been continued since the early 1960s. In 1983 an interagency cooperative agreement relating to Auke Creek weir was established between the NMFS, University of Alaska-Fairbanks (UA), and the Alaska Department of Fish and Game (ADF&G). Many cooperative studies and graduate theses have been conducted under this agreement. An interagency meeting of all participating interagency personnel is held annually. A report of fish counts from daily weir operations and other information related to salmonid research at Auke Creek is prepared by the NMFS project leader. The Auke Creek weir annual report is available on the Auke Bay Laboratory website, http://www.afsc.noaa.gov/abl.

The Auke Creek interagency meeting was held 21 February 2002 with summaries and operational plans presented on projects for 2002 at Auke Creek weir. In general, ADF&G will continue with their long-term research programs. The UA will not have any incubation projects or graduate students at Auke Creek in 2002. An interesting summary at the meeting was Leon Shaul's report (ADF&G) on the southeast Alaska coho index stocks showing marine survival decreasing in all areas except at Auke Creek. Auke Creek is one of the ADF&G index coho stocks. Rick Focht, Macaulay Hatchery, Douglas Island Pink and Chum Corporation (DIPAC), presented a summary of the 2001 return of chinook released in Auke Bay near Auke Creek (this includes returns from 5 brood-year releases). The 2001 returns totaled 4,064 fish, including 1,497 commercial fishery, 1,287 sport fishery (including 399 taken at the DIPAC dock), and 1,291 fish that returned to Macaulay hatchery. The returns from releases in Auke Bay accounted for 52% of the total DIPAC return in 2001, even though only 27% of the smolts were released in Auke Bay. The summary did not include the shoreline/dock sport fishery in Auke Bay, or the returns to Auke Creek weir. Two UA graduate students presented summaries of their thesis research performed at Auke Creek during the last year.

By Jerry Taylor.

# NATIONAL MARINE MAMMAL LABORATORY (NMML)

## Juvenile Steller Sea Lions Captured for Foraging Behavior and Health Studies

Scientists from the National Marine Mammal Laboratory (NMML) Alaska Ecosystems Program have been conducting studies of juvenile Steller sea lion (*Eumetopias jubatus*) foraging ecology and health status in the Gulf of Alaska and Aleutian Islands to test hypotheses of mechanisms underlying Steller sea lion population declines and to test the efficacy of fisheries management actions. Twenty-five juvenile sea lions were captured at haul-out sites from Kodiak Island and the eastern Aleutian Islands from 24 February to 14 March using a combination of scuba-based underwater and on-land hoop net capture techniques. The capture cruise, conducted on board the U.S. Fish and Wildlife research vessel *Tiğlax*, was coordinated with echo-integration and trawl surveys of groundfish and other fish biomass in the Umimak Pass/Bering Sea and Kodiak Island areas by the AFSC Midwater Assessment and Conservation Engineering Program (MACE) and in the Chiniak Gully and Long Island areas by several projects through the University of Alaska.

Satellite-linked depth recorders (SDRs) were attached to each sea lion to track movements and record diving behavior, from which foraging behavior and changes associated with weaning are inferred. In addition to being outfitted with SDRs, sea lions were weighed, measured, and given complete physical exams. Blubber biopsies were taken for fatty acids and con-

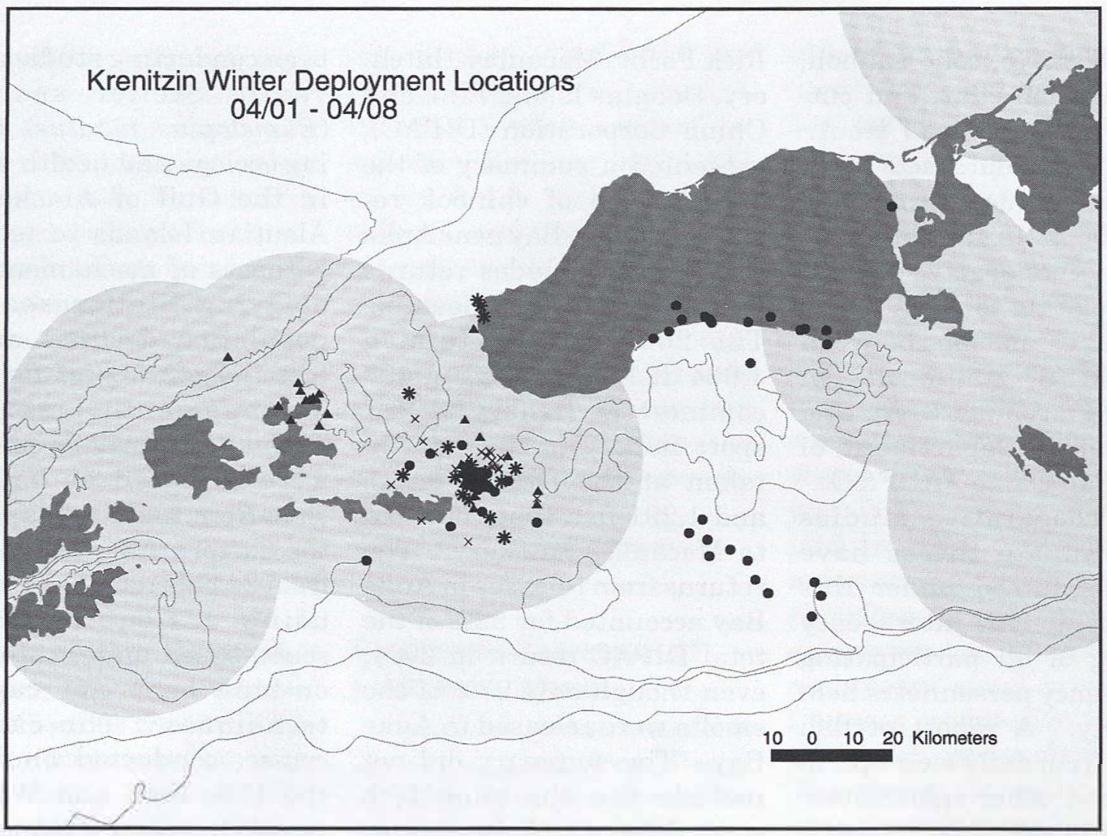


**Figure 1. Locations of ten Steller sea lion 10-month olds instrumented near Unimak Pass, Alaska. Lightly shaded circular areas denote no-trawl zones.**

taminants analysis, and skin samples taken for genetics analysis. Blood samples were taken for subsequent clinical health determinations. Two sea lions captured, sampled, and instrumented during the cruise had been previously tagged as pups (at Chowiet Island and Ugamak Island) in 2001, thus providing additional critical life history information such as growth rate. All 25 sea lions were estimated to be 9 months of age at the time of capture. Because some pups may wean at about 11 months of age, the SDR data could provide unique insights as the pups learn to become independent foragers. Even at this age, however, there are a variety of movement patterns among pups. Figure 1 shows the locations of ten pups instrumented near Unimak Pass, one of which made several forays into deeper waters while the others remained closer to islands.

In addition to these captures, scats were collected at two sites in the eastern Aleutian Islands for food-habits analysis, and two aborted fetuses were found and necropsied. Sightings were made of 23 sea lions tagged or branded as pups on rookeries or as juveniles during previous capture trips, which will be used to infer long-term movements and contribute to estimates of survival.

By Brian Fadely.

## Gray Whale Census

NMFS observers documented the Eastern North Pacific gray whale southbound migration from 12 December 2001 to 5 March 2002 at Granite Canyon, California. This followed the unexpectedly low counts and irregular migratory timing from the previous winter. Seasonal sighting distributions are usually represented by a symmetrical, bell-shaped curve, but in 2000-01, the distribution was very irregular, and whales

continued migrating south more than 3 weeks later than in any previous season. It was unclear whether the low counts were caused by the irregularity of the migration (possibly, many whales did not migrate as far south as central California), or if there really was a major drop in abundance. For three decades, abundance estimates had been steadily increasing at 2.5% from about 12,000 in 1967-68 to 26,600 in 1997/98. However, in both 1999 and 2000, there were 200-300 dead gray whales stranded on beaches from Mexico to Alaska, well above an average of 38 per year. During those two years, calf counts were unusually low, and adults were visibly skinny even from a distance. The preliminary abundance estimate for 2000/01 was under 19,000 – about 7,000 less than the previous year's estimate.

To maximize interyear compatibility, research protocol in 2001-02 was essentially identical to that used in previous surveys. Single observers independently searched for whales and recorded data on time, location of sightings, count, direction, and environmental conditions. The counting system and observer performance were tested through paired, independent observer effort. In addition, observations made with high-power (25X) binoculars provided an index of the offshore distribution of migrating whales passing within the sighting range of the observers. Last winter's migratory timing was typical of most observed migrations: the sighting distribution appeared as a nearly symmetrical bell-shaped curve centered on 16 January and most sightings occurred in January and early February. More pods were counted in 2001/02 than in the previous year (1,689 in 2000/01 versus 1,711 in 2001/02), but when correction factors were applied, the abundance estimate was only about 17,500. Although this may appear at first to be a continuing decline, the past two season's abundance estimates are not statistically different. Instead, scientists suspect that what may be happening is a recovery in the population following a catastrophic event in 1998 and 1999, the details of which we may never fully understand. Since then, the whales have looked healthier, stranding rates have dropped, and calf counts (this winter) have rebounded.

By Dave Rugh.

## Estimating Abundance of Glacial Ice Harbor Seals With Aerial Photography

The Polar Ecosystems Program conducts annual surveys of harbor seal haul-out sites in Alaska to estimate population abundance and distribution. Although observer-based aerial surveys have been effective for counting seals that haul out on sand and rock habitats, it is estimated that up to 20% of seals in the Gulf of Alaska (GOA) haul out on ice floes in glacial fjords. These sites present a challenge to standard aerial survey techniques because the topography of the fjords and glaciers often preclude low-level flights, the ice floes are dispersed and mobile, and glacial ice is sometimes dirty, making it difficult to detect and count seals.

To overcome these problems, the NMML contracted an aerial survey company in Anchorage, Alaska, to survey 14 glacial sites in the GOA, Prince William Sound, and Kenai Peninsula, using large-format (23X 23 cm) photography linked to a GPS (global positioning system) mapping system. During August-September 2001, each site was photographed two or three times, at altitudes ranging from 610 m to 1,463 m, producing more than 1,200 photographic negatives. To transform the negatives into a medium suitable for quantifying seals and ice habitat, the Polar Ecosystems Program developed an image analysis facility that includes a large-format scanner and other specialized equipment and software for processing the large-format imagery. First, negatives are scanned at high resolution (1,600 dpi), so that seals are plainly visible when the images are enlarged. Next, a GIS (geographic information system) based imaging software

application is used to georectify (i.e., assign GPS coordinates) the resulting images and create a seamless mosaic of images for each glacier site. This process will allow a more accurate estimate of the number and distribution of seals by ensuring that all available habitat is surveyed and that no seals are counted twice.

By Alana Phillips and John Bengtson.

## California Current Ecosystem Program:

### West Coast Pinniped Meeting

The West Coast Cooperative Pinniped Program met 14-15 March 2002 in Clackamas, Oregon, to discuss issues of expanding harbor seal and California sea lion populations in Washington, Oregon and California. A total of 20 participants attended representing the NMML, Northwest Fisheries Science Center, Southwest Fisheries Science Center, Northwest Region (NWR), Southwest Region, Moss Landing Marine Laboratory, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, and Pacific States Marine Fisheries Commission. Participants reported on population assessment of harbor seals and California sea lions (including life history parameters and genetics), pinniped food habits and predation on Endangered Species Act (ESA)-listed salmonids in Washington (Hood Canal, Lake Ozette, Columbia River), Oregon (Rogue River, Alsea Bay, Willamette Falls), and California (Scott Creek, Ano Nuevo Island, San Lorenzo, Klamath, Eel, Mad and Smith Rivers).

### Sea Lion Brand Evaluation at San Miguel Island

In early February 2002, researchers from the California Current Ecosystem Program went to San Miguel Island to evaluate brands and general health of California sea lion pups branded in September 2001 as part of a long-term study begun in 1987 to assess the health, vital parameters, and population trends of the California sea lion population.

### JASON Project

In mid-February 2002, the JASON Project, an educational outreach program that develops science curriculum for grades 7-12, filmed California sea lion and northern elephant seal behavior at San Miguel Island, California. Bob DeLong and Tony Orr assisted the JASON staff with developing curriculum related to the natural history of seals and seal lions to be distributed to classrooms during the 2002-2003 school year.

### Killer Whale Stranding, Dungeness, WA

On 2 January 2002, staff from NMML and other Northwest regional agencies, plus numerous other killer whale scientists responded to the stranding of two killer whales in Dungeness Bay, Washington. A dead 20-ft adult female was necropsied, but several analyses are still pending to determine cause of death. A 21-ft adult male was successfully released. Data from a suction-cup attached time-depth recorder showed normal diving behavior for 3 days post-release (until the tag memory was filled) indicating the male survived. Both whales were identified as transients and had been observed only once previously off the coast of Oregon in 1996.

### Orphaned Killer Whale in Central Puget Sound

During mid- to late January 2002, a lone juvenile female killer whale was routinely observed in the vicinity of the Fauntleroy-Vashon Island ferry route in Puget Sound, Washington. Concerns about the animal's health arose because she was alone, was somewhat underweight, and had an extensive skin disease. NMML staff worked with other killer whale researchers to identify her as A73, a member of a northern resident pod, none of which have ever been known to range into this area of Puget Sound. She may have strayed from her pod because her mother was missing from the A4 group in 2001 and may have died. A73's ex-

tensive skin disease, body condition, and propensity to approach boats led NMML staff to work with other researchers and veterinarians to assess her health status using behavioral data and respiratory gas samples. Although the whale had been observed to pursue and capture salmonids on several occasions and appeared to be maintaining her weight, her variable activity levels and high ketone content in the respiratory gas samples indicated the need for an ongoing assessment of her health status. NMML staff worked with other NMFS staff readying logistical plans should intervention be necessary.

By Harriet Huber.

### Alaska Scientific Review Group Meeting

The Alaska Scientific Review Group (SRG) met in Juneau on 4-5 March to provide advice to NMFS regarding the science behind the management of Alaska marine mammals. Major topics discussed included the status of the Alaska sea otter, the research and conservation plans for Cook Inlet beluga whales, and new abundance estimates for Alaska harbor seals. Final minutes of recent SRG meetings are now posted on the NMML website at http://nmml.afsc.noaa.gov/AKSRG.htm; the final minutes of the March 2002 meeting will be posted when they are available.

By Robin Angliss.

## RESOURCE ASSESSMENT & CONSERVATION ENGINEERING (RACE) DIVISION

### Groundfish Assessment : Data Storage Tags Show Vertical Movement Patterns of Atka Mackerel and Pacific Cod

The RACE Division, in collaboration with the Center's Resource Ecology and Fisheries Management (REFM) Division and the Alaska Department of Fish and Game, has been conducting research on the vertical movement patterns of Atka mackerel (*Pleurogrammus monopterygius*) and Pacific cod (*Gadus macrocephalus*) using externally attached data storage tags. The archival tags collect depth and temperature information from 2 to 60 minute intervals.

In July 2000, 117 Atka mackerel were released with data storage tags in Seguam Pass. Thus far, 13 tags have been recovered from fish at liberty from 42 to 407 days. All movement away from the bottom occurred approximately between sunrise and sunset. At night, fish apparently remained on bottom (Fig. 1). Due to the shorter day-length during winter, Atka mackerel spent longer periods on the bottom than at other times of the year (Fig. 2). During summer months (July-September), fish often returned to the same depth each night, indicating that fish likely maintained a homesite. Daytime vertical movements were correlated with light intensity, time of day, and current velocity. Vertical movements increased with increasing light during the morning and decreasing light during the early afternoon, but then decreased over time. The currents in Seguam Pass, which reach velocities in excess of 4 knots, affected the magnitude or distance of vertical excursions away from the bottom. Surface-directed excursions were reduced in magnitude during periods of greater current velocities (spring-tide periods), whereas slope-directed excursions increased in magnitude (Fig. 3). These observations suggest that the diel behavior of Atka mackerel should be taken into account when conducting resource assessment surveys. Current bottom-trawl surveys are conducted only during daylight hours when Atka mackerel are often above the bottom (A manuscript on Atka mackerel behavior has been submitted to *Marine Ecology Progress Series*).

In November 2001, 224 Pacific cod were released with data storage tags off Kodiak Island. Thus far, 143 tags have been recovered (64% return rate). The high return rate resulted from the combination of very limited horizontal movements of cod and concentrated fishing by commercial longline and pot fisherman on the location where

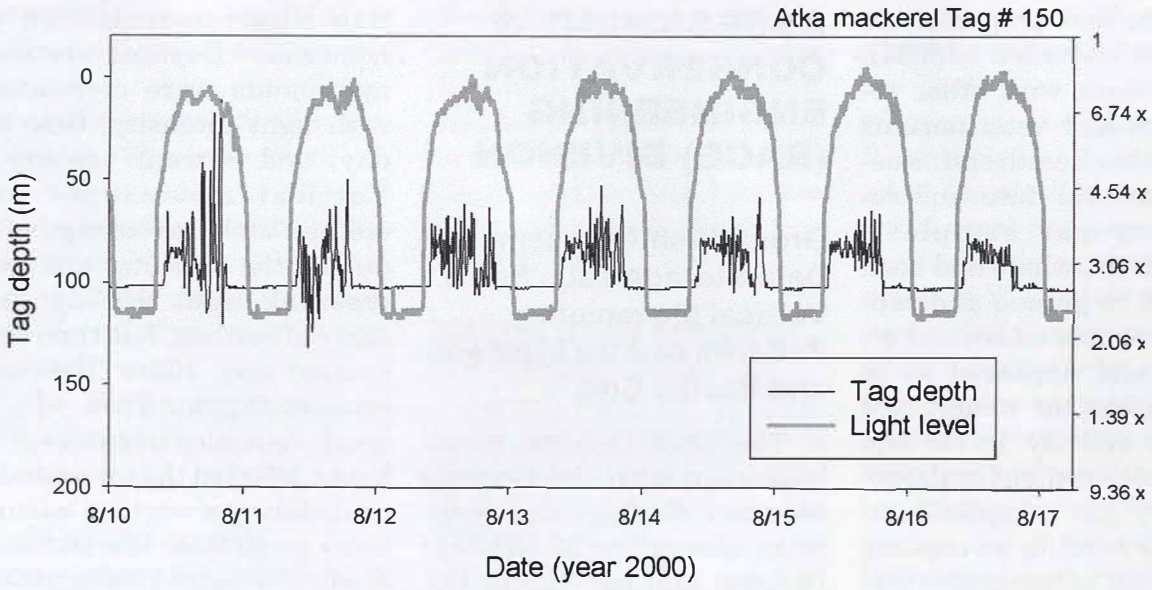


**Figure 1. Diel vertical movement pattern of Atka mackerel for a 1-week period.**

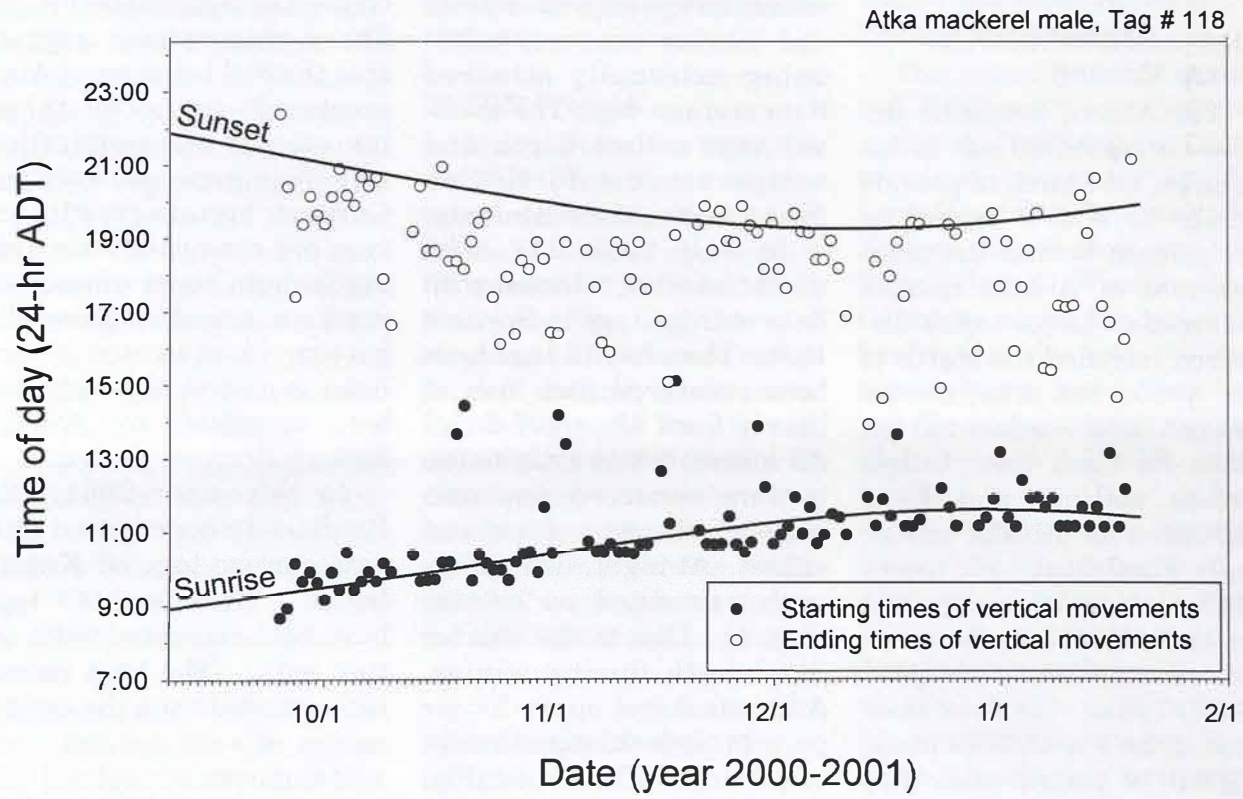


**Figure 2. Starting and ending times of Atka mackerel vertical movements within a 24-hour period.**

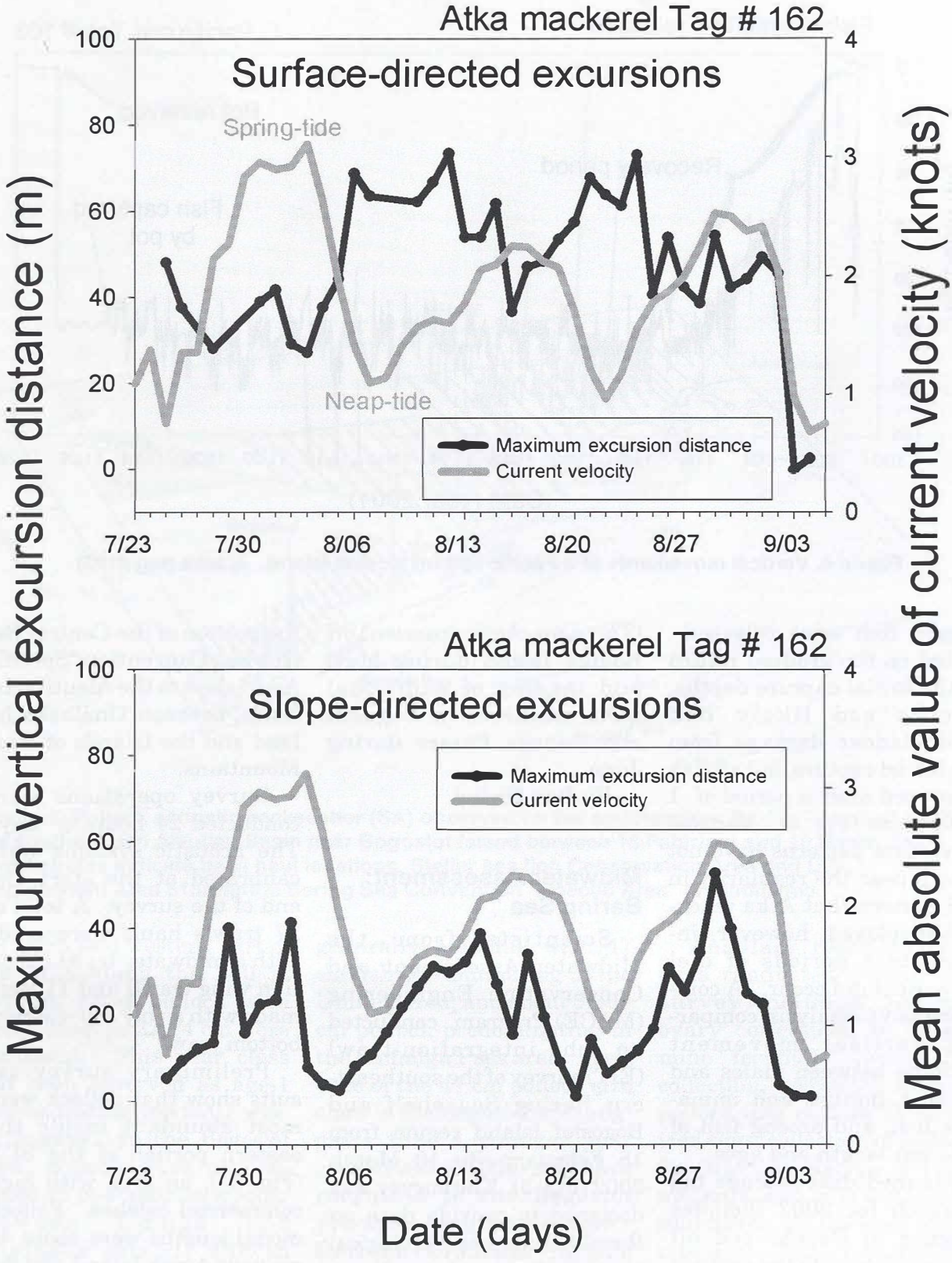


**Figure 3. Maximum surface-directed (top graph) and slope-directed (bottom graph) vertical excursions of Atka mackerel as related to current velocity.**

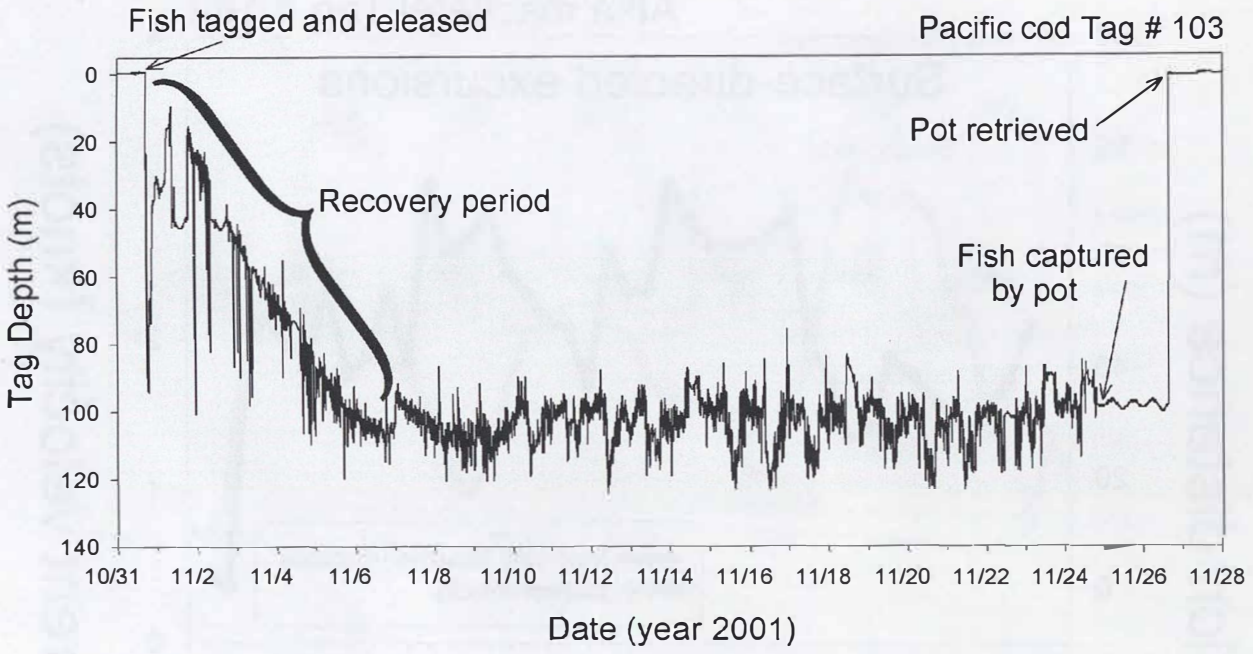


**Figure 4. Vertical movements of a Pacific cod off Kodiak Island, Alaska (tag #103).**

tagged fish were released. Based on the gradual return to the initial capture depths, Pacific cod likely had swimbladder damage from the initial capture, but all fish recovered after a period of 1 to 3 weeks (Fig. 4). Vertical movement patterns have not shown near the regularity in diel pattern that Atka mackerel displayed; however, intermittent periods of diel movement did occur. A comprehensive analysis comparing vertical movement patterns between males and females, mature and immature fish, and among fish of different length and ages .

Planned data storage tag research for 2002 includes tagging of Pacific cod off Unimak Island in the eastern Bering Sea during April, tagging of walleye pollock (*Theragra chalcogramma*) off Kodiak Island during May, and tagging of additional Atka mackerel in Seguam and Tanaga Passes during June.

By Dan Nichol.

## Midwater Assessment: Bering Sea

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted an echo integration-trawl (EIT) survey of the southeastern Bering Sea shelf and Bogoslof Island region from 18 February to 10 March 2002 (Fig. 5). The survey was designed to provide data on the abundance and biological composition of walleye pollock in the Steller sea lion Conservation Area (SCA) and the portion of the Central Bering Sea Convention "Specific Area" close to the Aleutian Islands, between Unalaska Island and the Islands of Four Mountains.

Survey operations were conducted 24 hours a day. The acoustic systems were calibrated at the start and end of the survey. A total of 27 trawls hauls were made with a midwater trawl (Aleutian wing trawl) and 11 were made with a poly Nor-eastern bottom trawl.

Preliminary survey results show that pollock were most abundant inside the eastern portion of the SCA (Fig. 5 ), an area with high commercial catches. Pollock modal lengths were about 49 cm near Amak Island and decreased gradually towards the west and north. On the

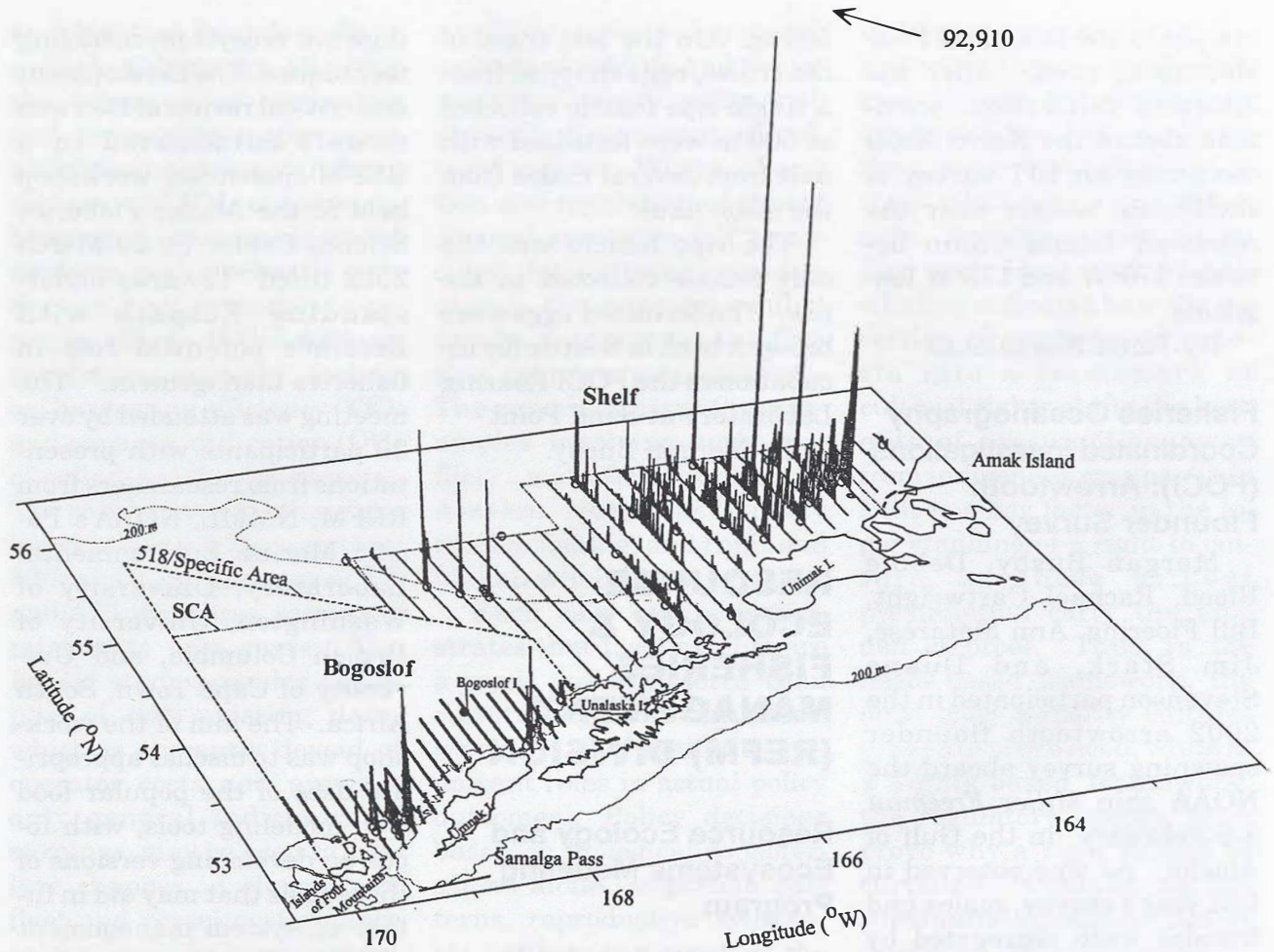


**Figure 5. Pollock acoustic backscatter (SA) observed on the southeastern Bering Sea shelf and in the southeastern Aleutian Basin near Bogoslof Island between 18 February and 10 March 2002. Small circles indicate trawl haul locations. Steller sea lion Conservation Area and U.S. Management Area 518/Central Bering Sea Convention "Specfic Area" are indicated.**

northern and western part of the SCA along the 200 m isobath, age-2 pollock with modal lengths 22-24 cm were abundant. This year class had been observed as age-1 pollock during the 2001 winter survey. In the Bogoslof area, pollock were concentrated in two main locations: between Umnak and Unalaska Islands and in Samalga Pass adjacent to the Islands of Four Mountains. The size distribution was generally bimodal, with 47 cm fish predominating in the Umnak area, and about 57-60 cm pollock predominating in the Samalga Pass area. Presence of the 47 cm pollock size class in the Bogoslof area suggests that a younger year class (1995 or 1996) may have recruited to the Bogoslof pre-spawning population. Pollock biomass in the Bogoslof area was about the same as that observed during the 2001 survey.

Ancillary research projects conducted during the survey included: pollock ovary collections to determine fecundity , whole fish collection, spawning mature pollock and culture of fertilized eggs, collection of pollock fin clips for analysis of DNA markers, and whole stomach collections. At the start of the cruise, the NOAA ship *Miller Freeman* and the Japan Fisheries Agency ship *Kaiyo Maru* conducted an intership cali-

bration in the Islands of Four Mountains area. After the intership calibration, scientists aboard the *Kaiyo Maru* conducted an EIT survey of shelf/basin waters near the Aleutian Island Chain between 170°W and 176°W longitude.

By Taina Honkalehto.

### Fisheries Oceanography Coordinated Investigations (FOCI): Arrowtooth Flounder Survey

Morgan Busby, Debbie Blood, Rachael Cartwright, Bill Floering, Ann Matarese, Jim Stark, and Duane Stevenson participated in the 2002 arrowtooth flounder spawning survey aboard the NOAA ship *Miller Freeman* 3-9 February in the Gulf of Alaska. As was observed in last year's survey, males and females were segregated by depth indicating that peak spawning had not yet begun. Bottom trawls conducted at 200 and 400 m depths on the outer shelf and upper slope west of Kodiak Island were dominated by females with most mature and running ripe individuals occurring at 400 m. Tows conducted at 500 and 600 m depths contained nearly all males with numerous ripe individuals found at 500 m. Toward the end of the cruise in the area off the Shumagin Islands, eggs stripped from two ripe females collected at 400 m and held in a live well were successfully fertilized with milt from males collected at 500 m. On the last trawl of the cruise, eggs stripped from a single ripe female collected at 500 m were fertilized with milt from several males from the same haul.

The ripe female was the only female collected in the tow. The fertilized eggs were brought back to Seattle for incubation in the FOCI Rearing Laboratory at Sand Point

By Morgan Busby.

## RESOURCE ECOLOGY & FISHERIES MANAGEMENT (REFM) DIVISION

### Resource Ecology and Ecosystems Modeling Program

Laboratory analysis was performed on 4,872 groundfish stomachs from the eastern Bering Sea, 404 from the Gulf of Alaska, and 541 from the Washington-Oregon-California region. No observers returned stomach samples during the quarter.

### Development and Extension of Food Web Modeling Techniques

REFM scientists, in collaboration with NMML scientists and the National Center for Ecological Analysis and Synthesis (see contribution by Sarah Gaichas is this section) continue to develop and improve ecosystem modeling techniques. The development and critical review of food web models culminated in a REFM-sponsored workshop held at the Alaska Fisheries Science Center on 29 March 2002 titled "Towards understanding Ecopath with Ecosim's potential role in fisheries management." The meeting was attended by over 20 participants with presentations from researchers from REFM, NMML, NOAA's Pacific Marine Environmental Laboratory, University of Washington, University of British Columbia, and University of Cape Town, South Africa. The aim of the workshop was to discuss appropriate uses of the popular food web modeling tools, with focus on developing versions of these tools that may aid in future ecosystem management efforts. The discussion covered model methodology and data requirements, preliminary results, and possible uses in investigating trophic interactions with respect to fisheries management. The creation of an extended version of these models with improved statistical capabilities is under way by REFM staff.

By Pat Livingston.

### Economic and Social Sciences Research Program: Measuring Capacity, Utilization, and Economic Performance

The American Fisheries Act (AFA) of 1998 significantly altered the Bering Sea

and Aleutian Islands walleye pollock fishery by allowing the formation of harvesting and processing cooperatives and defining exclusive fishing rights. REFM economists have used data envelopment analysis and stochastic production frontier models to examine effects of the AFA on the fishing capacity, technical harvesting efficiency (TE), and capacity utilization (CU) of pollock catcher/processors. The results indicate that fishing capacity fell by more than 30% and that harvesting TE and CU measures increased relative to past years. The REFM study provides examples of how existing data, which is currently devoid of operator costs and provides only general indicators of earnings, may be used to analyze changes in elements of fleet and vessel performance in response to management actions. Results of this research are summarized in a paper titled, "Effects of the American Fisheries Act on Capacity, Utilization, and Technical Efficiency in Alaskan Pollock Fisheries" by Ron Felthoven. The paper has been accepted for publication in the journal *Marine Resource Economics*.

## Subsistence Harvests and Cultural Rights

"Treaty Rights and the Right to Culture: Native American Subsistence Issues in U.S. Law" by Jennifer Sepez examines the history and framework of several conflicts over subsistence harvest of wildlife and the interplay of treaty rights with an inchoate concept of cultural rights. Where allocation and regulation of shared natural resources fail to account for cultural considerations, the ensuing conflict can be detrimental to effective resource management. The paper discusses three examples involving such conflict: waterfowl hunting in Alaska, Northwest treaty salmon fishing, and Inuit and Makah whaling.

Each case study demonstrates that treaty rights are a more powerful force than cultural rights in the courtroom, but that both play important roles in actual policy outcomes. Policy decisions based on biological considerations alone (migration patterns, reproductive seasons, etc.) at best can overlook the legitimate concerns of minority cultural groups, and at worst can be employed intentionally as cover for inequitable distribution schemes. Examples discussed in the paper include the 80-year history of conflict in Alaska over the Migratory Bird Treaty Act, which by banning waterfowl hunting during nesting season effectively banned all Inuit harvests of these birds yet permitted hunting in the lower 48 states. Also examined are examples from pre-Boldt Decision conflicts over Native American salmon fishing in which gear-type and escapement restrictions were deployed as covert allocation measures. Until the Supreme Court noted that, even though the regulations appeared facially neutral, they were invalid because their effect was to discriminate. An examination of conflict over Inuit and Makah whaling indicates how the insertion of needs-based criteria into a framework of cultural rights shifts the benefits of presumption away from indigenous groups. This shift is a key factor in the legal standing of a right to culture, as those without presumption carry the burden of proof. Thus, in the needs-based framework, the onus is on minority cultural groups to prove need, while in a rights-based framework, the regulatory agency must prove why a right should be curtailed. Considering the substantial changes to Native American cultures under the processes of colonization, any contemporary discussion of a right to culture must also include issues of cultural revival. The paper uses Makah whaling to explore the issues involved in cultural revival, indicating how conflicting notions of tradition, authenticity, morality, and self-determination complicate the process of producing resource policies that effectively manage biodiversity while recognizing and accommodating cultural diversity. The paper will be published in a special issue of the journal *Cultural Dynamics* devoted to emerging concepts of a right to culture.

## Economic Data Collection Programs

REFM staff continue to represent the AFSC on the Interagency Economic Data Committee. The committee is revising a proposal to increase the availability of fishery economic data for North Pacific Fishery Management Council (NPFMC)-managed fisheries. The committee submitted its report to the Council in February. Joe Terry prepared a discussion paper "Objective Measures and the Data Required to Monitor the Success of the Crab Rationalization Program" for the Council which identifies objective measures that can be used to monitor the success of the crab rationalization program, identifies the data required to support those objective measures, and briefly discusses several issues associated with implementing mandatory reporting requirements for these data. The types of measures discussed in the paper are intended to allow the Council to monitor the success of the crab rationalization program in terms of addressing five problems currently facing the fishery (as identified in the Bering Sea Aleutian Islands (BSAI) crab rationalization problem statement prepared by the Council in February 2002). The five problems and the summary of the problems facing the Council are

- Resource conservation, utilization and management problems;
- Bycatch and its associated mortalities, and potential landing deadloss;
- Excess harvesting and processing capacity, as well as low economic returns;
- Lack of economic stability for harvesters, processors and coastal communities; and
- High levels of occupational loss of life and injury.

In cooperation with the Pacific States Marine Fisheries Commission (PSMFC), Todd Lee has engaged in a project to collect economic data from halibut, charter boat operators. The purpose of this survey is to provide information about the economic performance of the halibut charter fleet. The data from this project has been entered into a database and some preliminary summary analysis has been completed. The final report from this project is expected to be completed by December 2002.

## Regulatory Analysis of North Pacific Groundfish Observer Program Regulations

Program staff assisted developing proposed changes to the regulations that implement the Observer Program and preparing the regulatory analysis of the proposed changes. The regulations that authorize and implement the North Pacific Groundfish Observer Program expire 31 December 2002. The regulatory analysis addressed three alternatives for extending the regulations, which are: 1) allow the regulations and the Observer Program to expire (the no action alternative); 2) extend the regulations indefinitely with the expectation that they would be amended periodically to maintain or increase the effectiveness and efficiency of the Observer Program; and 3) extend the regulations through 31 December 2007.

In addition, two complementary options for improving the existing regulations were addressed. Option 1 would: 1) change the observer certification and decertification process to ensure that it is compliant with the Administrative Procedures Act (APA); 2) change the observer certification criteria and standards of behavior to clarify and strengthen these regulations; 3) replace the observer provider (contractor) certification and decertification process with an APA compliant permitting process similar to that used for other NMFS Alaska Region permits; and 4) change the duties and responsibilities of observer providers in order to eliminate ambiguities and to strengthen the regulations governing the relationship between NMFS and the ob-

server providers. Option 2 would increase the ability of NMFS to interact effectively with observers, fishermen, and processing plant employees by granting to NMFS the authority to place NMFS staff and other qualified persons aboard groundfish and halibut vessels and at groundfish plants.

### Other Activities

A spending plan developed for funds provided by the NMFS Office of Science and Technology provides support for the following projects. The projects are intended to improve the economic data and models that are available both to monitor the economic performance of Federally managed fisheries and to support the economic analysis of fishery management actions.

1. Input price data collection
2. Cost, earnings and employment survey
3. Survey data verification
4. Electronic economic data logbook pilot study
5. Observer Program economic data entry contract
6. Develop supply and demand models for groundfish
7. Improvement of regional economic models
8. Logbook enhancement and data entry
9. Repeat survey for halibut charter boat fishery

By Joe Terry.

### Age and Growth Program

Estimated production figures for 1 January to 31 March 2002.

| | |
|---|---|
| Flathead sole | 724 |
| Dover sole | 434 |
| Northern rock sole | 133 |
| Walleye pollock | 3,831 |
| Atka mackerel | 1,340 |
| Northern rockfish | 1,787 |

Total production figures were 8,249 with 2,015 test ages and 56 examined and determined to be unageable.

### U.S. North Pacific Groundfish Observer Program

During the first quarter of 2002, 233 observers were trained, briefed, and equipped for deployment to fishing and processing vessels and shoreline plants in the Gulf of Alaska, Bering Sea, and Aleutian Islands. They sampled aboard 264 fishing and processing vessels and at 20 shoreline processing plants. The observers were trained or briefed in various locations. The University of Alaska Anchorage (UAA) Observer Training Center trained 29 first time observers, and another 131 observers with prior experience were briefed at this site. The AFSC Observer Program in Seattle briefed another 62 observers who had prior experience. Eleven observers were excused from briefing because they had just completed a cruise successfully and were returning immediately to the field. The first quarter 2002 observer workforce thus comprised 12% new observers and 88% experienced observers.

The program conducted a total of 110 debriefings during the first quarter of 2002. Fifty-four debriefings were held in Anchorage, 1 in Dutch Harbor, 1 in Kodiak, and 54 in Seattle.

### Changes to Observer Program Regulations Undergo Public Review

At the February 2002 meeting, the NPFMC recommended releasing for public review the draft regulatory analysis addressing various program issues. The issues addressed in the regulatory analysis fall under four main areas: 1) extending the program's implementing regulations past their 31 December 2002 expiration date; 2) revising and strengthening the

regulations which outline the duties and responsibilities of the observer providers; 3) granting NMFS the authority to place NMFS staff and other qualified persons, aboard groundfish and halibut vessels and at groundfish plants and 4) changing some aspects of the observer and observer provider certification and decertification process to make them compliant with the Administrative Procedures Act. Final action on the regulatory package is scheduled for the April 2002 meeting.

## Program Database Modernization

The Observer Program is developing an Internet, web-based, client-server application for its NORPAC database. This will speed up connections to the database from remote field office sites in Alaska and will simplify database management and maintenance. In addition, the program is developing a custom-made gear inventory application that utilizes barcode scanning and interfaces with the NORPAC database. The inventory system creates a more accurate and efficient system for purchasing, dispersing, and tracking observer gear.

## Observer Safety at Sea

Program managers met with representatives from the U.S. Coast Guard (USCG) Marine Safety Office to develop ways in which the program and the USCG can work together to increase observer safety at sea. Discussions centered around observer safety training, the USCG vessel safety decal system, and improving communications between observers, program staff, and the USCG. The meeting helped lay the groundwork for a written Memorandum of Understanding between the USCG and the program will outline an interagency working relationship fostering increased safety awareness and protection for observers at sea.

By Bob Maier.

## Status of Stocks and Multispecies Assessment Program

The AFSC continues to study the effect of commercial fishing on walleye pollock abundance and distribution. One method to assess fishery effects on Steller sea lion prey involves using replicated scientific surveys at study and control sites. However, there are logistical constraints to scientific surveys, such as the difficulty of securing sufficient ship time to conduct replicate surveys, the lack of appropriate study and control sites in the eastern Bering Sea (EBS), and the legal obstacles of implementing an adequate survey design under Endangered Species Act (ESA) restrictions.

A novel approach to the study of the pollock distribution, particularly in winter and on spawning grounds, is being developed at the AFSC. The approach is to solicit the cooperation of commercial vessels that carry state-of-the art echo-sounding equipment to log their acoustic data. This was first proposed after the 1999 fishing season when fishing practices changed due to the American Fisheries Act. Under the new regulations, most vessels fishing pollock in the EBS are part of a cooperative with a fixed amount of quota share. This practice has greatly reduced the "race for fish" and has given vessel operators much more time to survey for pollock prior to actually fishing (e.g., Fig. 1). The hope and goal of this project is that by post-processing the raw acoustic data, particularly during a vessel's exploration/searching process, methods can be developed to provide insight on the aggregation characteristics of pollock during different locations and times of year. The strength of the approach is realized by deployment of the system on multiple vessels. Over the course of a fishing season, exploration of potential fishing areas by the catcher/processor fleet is thorough, with many areas revisited multiple times by different vessels.

A viability study began in January 2002 with the cooperation of three vessels. The vessels selected have

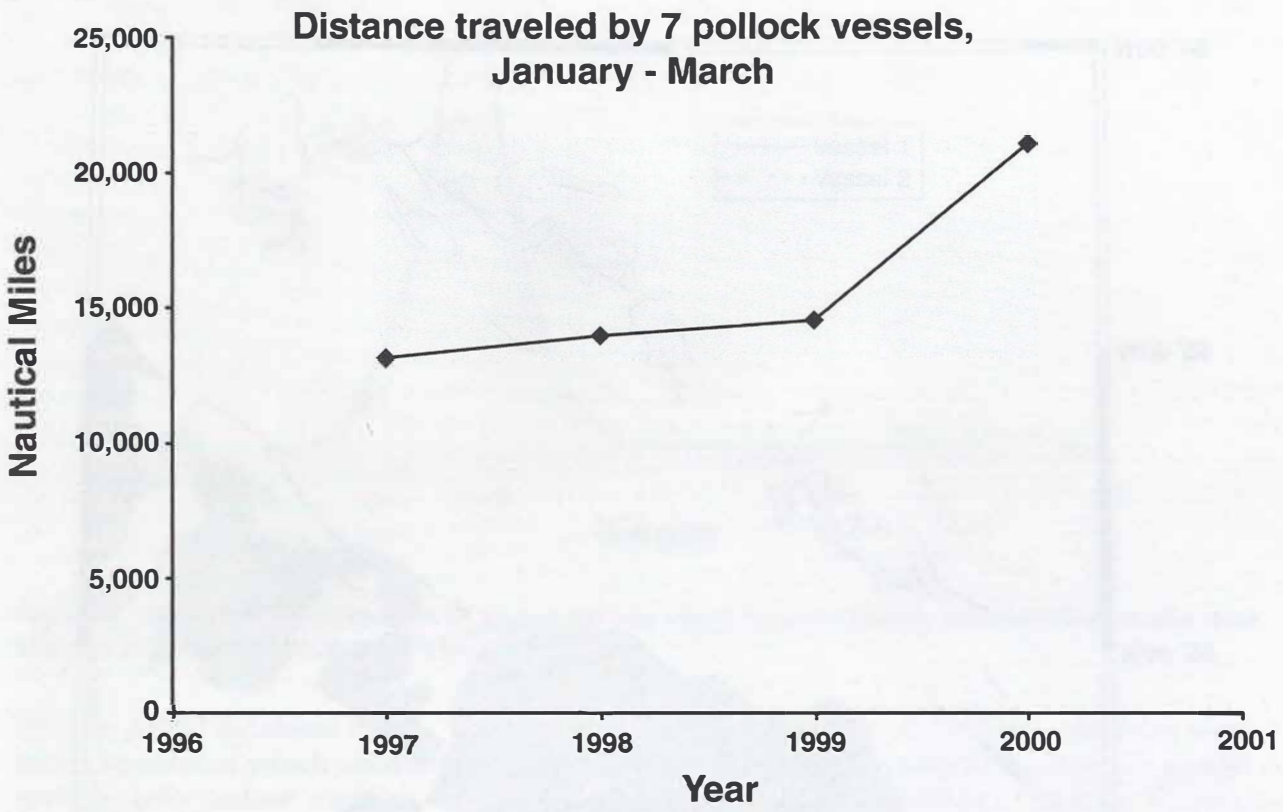


**Figure 1. Total distance traveled, January-March for seven pollock vessels, 1997-2000. The increase in distance traveled is thought to be due to more time available for searching.**

SIMRAD ES60 echosounders, which have the capability of downloading raw acoustic data. The AFSC, with support from NMFS Office of Science and Technology, provided hardware and software upgrades for these echosounders and also provided hardware and software to configure the sounders with removable, high-capacity disk drives (20 gigabyte storage capacity). The drives served to log the data from the echosounders by periodically copying the raw data files directly to the removable storage devices.

Figure 2 shows the relative spatial distribution of two vessels with systems operating during the first week of February 2002. This figure shows that as data from more vessels become available, it will be possible to generate a reasonably comprehensive map of pollock distribution. Even more interesting will be to observe how such maps change over time. We hope that some standardization between different vessels will be possible by matching vessels fishing nearby (and cross-checked with observer data records of actual catch). Other routine analyses of the data include developing methods for categorizing vessel activity. For example, two vessels have very similar modes of operation speeds (Fig. 3).

As of March 2002, one vessel reported technical problems during the first 10 days of the fishery, while another boat had equipment failure during the latter part. Preliminary work indicates that there are also problems on the post-processing side. The size of the data files that the vessels store is very large and we are currently seeking ways to easily process these data into more aggregated formats for easier analysis.

This project is a collaborative effort between the Pollock Conservation Cooper-

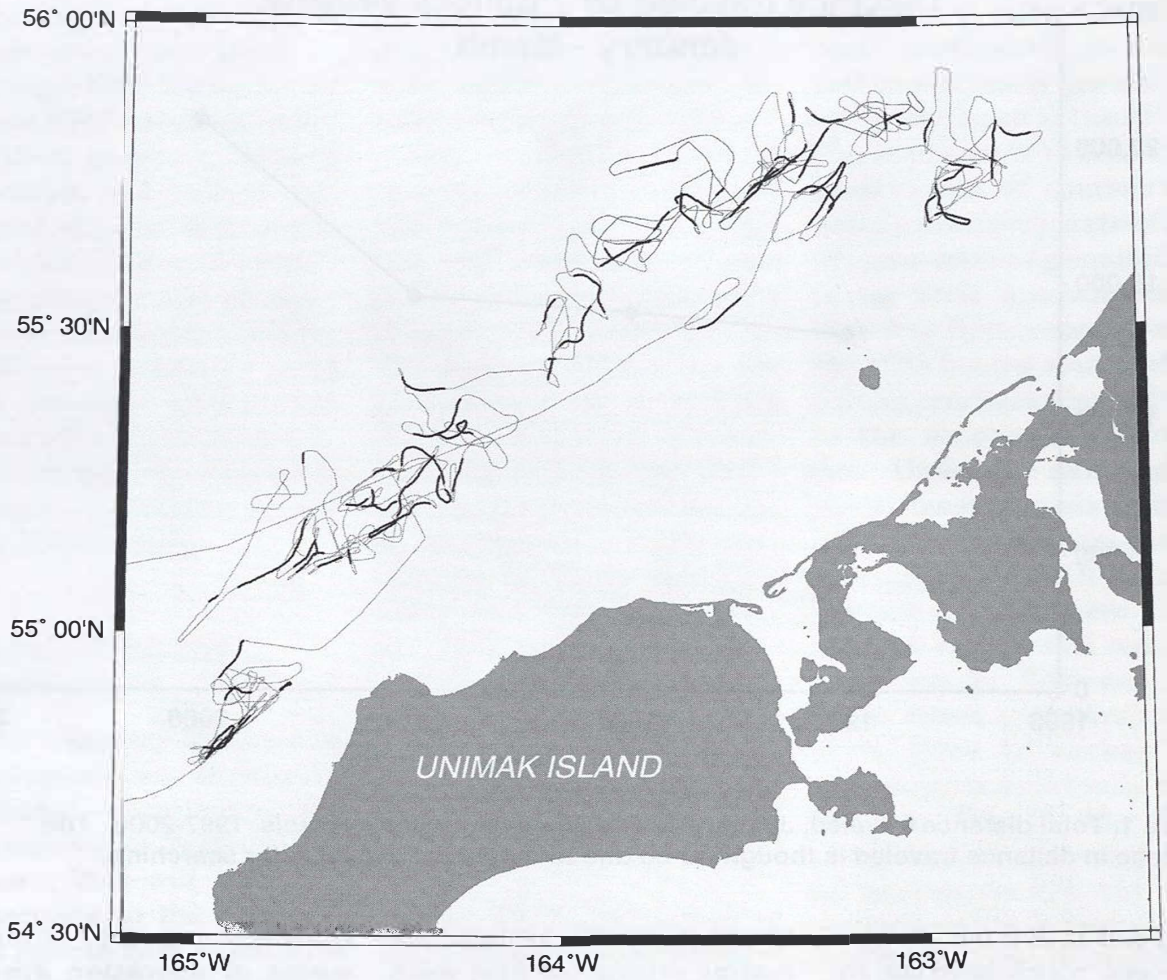


**Figure 2. Cooperative study vessel operation locations in the eastern Bering Sea, 1-8 February 2002.**

ative (PCC), University of Alaska (UAF), and the Alaska Fisheries Science Center (AFSC). The PCC is providing funding for a UAF graduate student and logistical support to the project. The AFSC's contribution to the project is technical support via funding of computer and data storage medium for the project from the NMFS Industry Cooperative Research Program. The AFSC scientists involved in the project—Drs. Ianelli, Dorn, and Karp—are providing scientific support to the PCC and UAF in bringing the project to fruition.

By Jim Ianelli.

## AFSC Database Workshop

The AFSC hosted a workshop in February 2002 to familiarize offsite data users with databases stored at the AFSC. The idea for the workshop evolved from several discussions between participants in Seattle and Anchorage involved in updating essential fish habitat (EFH) descriptions for the EFH Environmental Impact Statement (EIS). As the AFSC becomes more involved with the various National Enviromental Protection Act (NEPA) and ESA documents, more outside users will seek permission to utilize our data. As a result of the workshop, it was recommended

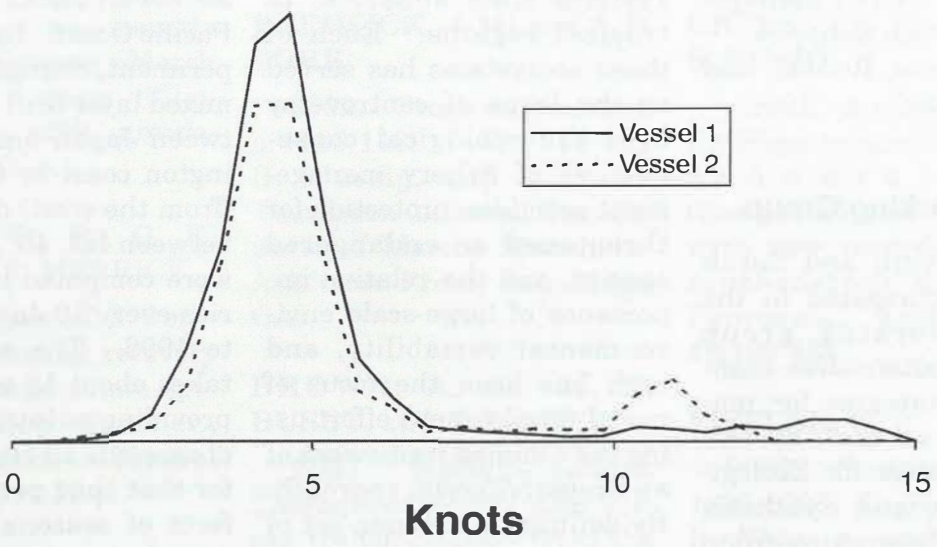


**Figure 3. Frequency distribution of speed for two vessels participating in the EBS acoustic data storage project, 20 January -9 February 2002.**

that an AFSC database users guide be created which would include information such as who to contact with specific database questions. Another consideration at the workshop was to begin discussion among geographic information systems (GIS) users to obtain a consensus on which coverages to use on a regional or Alaska-wide GIS analysis. With several coverages available for Alaskan waters, there is potential for one document to contain maps using different coverages to describe similar features (a caveat to this is each bathymetric coverage, for instance, gives a different resultant map). Thus, analyses using these different coverages for the same document will have results that are different or not comparable. Further discussion of this workshop will be presented in a poster at the GeoHab conference in Moss Landing, California, on 1-3 May 2002.

By Rebecca Reuter.

## Categorizing Habitat

Preliminary results from a cluster analysis of research survey hauls where rockfish occurred were presented at the Western Groundfish Conference held 12-14 February 2002 at Ocean Shores, Washington. The analysis showed that in the Aleutian Islands at least three habitat categories can be described using rockfish assemblages. The species composition of those hauls that clustered together and the depth range of those hauls determined the three habitat categories: shelf (100-200 m); outer shelf (200-300 m); and upper-slope (300+ m). Species associated with those categories were *S. alutus*, *S. polyspinus* and *S. ciliatus* (shelf); *S. alutus* (outer shelf) and *S. aleutianus*; *S. borealis* and *Sebastolobus alascanus* (upper slope). To understand the spatial distribution of these assemblages, the haul clusters were mapped to indicate if any associations were due to geographic location. The next steps in this research are to refine the category definitions by using different size classes by species and to contrast categories between the Gulf of Alaska and Aleutian Islands region. Habitat use along environmental gradients, such as temperature and depth, will be investigated to further analyze habitat associations and species co-occurrence. Results from this study may aid in describing essential rockfish habitat and identify areas potentially

suitable for spatial management of rockfish fisheries.

By Rebecca Reuter and Paul Spencer.

## NCEAS Working Group

Kerim Aydin and Sarah Gaichas participated in the ongoing working group "Models of alternative management strategies for marine ecosystems" at the National Center for Ecological Analysis and Synthesis (NCEAS). The working group includes collaborators from the University of Washington, University of Wisconsin, Duke University, University of British Columbia, the Inter-American Tropical Tuna Commission, and the Pacific Marine Environmental Laboratory. Other collaborators representing management, industry and environmental interests will participate in future meetings.

The goal of the working group is to attempt to identify robust approaches to the exploitation of large marine ecosystems. The group intends to achieve this by employing the comparative approach to identify similarities and differences between five large marine ecosystems in the North Pacific Ocean. The five systems include the eastern Bering Sea, the Gulf of Alaska, the Northern California Current, the Eastern Tropical Pacific, and the Central North Pacific, spanning continental shelf ecosystems and open ocean pelagic ecosystems from subarctic to tropical regions. Each of these ecosystems has served as the focus of controversy over the ecological consequences of fishery management practices, protection for threatened or endangered species, and the relative importance of large-scale environmental variability, and each has been the focus of model development effort using the common framework of an Ecopath/Ecosim approach. By defining a common set of objective criteria for evaluating conservation strategies, economic goals, and ecosystem management objectives, the group will employ these five models as the basis for evaluating policy outcomes, clarify the conflict of alternatives, and provide guidance to realistic expectation from management actions.

The group had its initial meeting 13-15 December 2001 and a second meeting 17-20 March 2002. In the interim, a team of graduate students worked in residence at NCEAS on developing models and making initial model comparisons. A third meeting is scheduled for December 2002, and the project will continue through 2004.

By Sarah Gaichas.

## OSCURS Model

REFM's Ocean Surface Current Simulator (OSCURS) is used to find indexes of year-to-year changes in ocean circulation that may affect fish stocks in the North Pacific Ocean. In a recent experiment, changes in surface mixed layer drift currents between Japan and the Washington coast in the westerly (from the west) drift channel between lat. 40°N and 50°N were computed in a time series every 10 days from 1967 to 1998. The average drift takes about 18 months, thus providing an integrated index of currents all along the track for that time period. The effects of seasonal signals so prevalent on both sides of the Pacific are averaged out.

Looking at a plot of the end points versus time shows more extreme east-west changes in longitudes of the end points, speed of the long drift, than north-south changes in latitude of the end points. Major features include greater speeds in the early 1970s, prior to the regime shift, slower speeds through the early 1980s, a return to normal in the late1980s after the 1983 El Niño, and a recent return to faster speeds in the late 1990s. The recent increase in speed may have contributed to a greater supply of more productive Subarctic Water to the west coast coincident with enhanced salmon runs.

By Jim Ingraham.

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