Alaska FISHERIES SCIENCE CENTER

Quarterly Report
July August September
2014

NOAA FISHERIES

Genetic Research Provides Insight Into the Production and Behavior of Western Alaska Chum Salmon

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

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The Alaska Fisheries Science Center (AFSC) *Quarterly Report* is produced by the Center's Communications Program.

NOAA FISHERIES

REFM continued

Genetic research provides insight into the production and behavior of western Alaska chum salmon

Chris Kondzela, Jeffrey R. Guyon, and Jim Murphy

Introduction and objectives

In western Alaska, chum salmon (*Oncorhynchus keta*) are critical for subsistence, commercial, and cultural reasons. Over the last few decades, declines in chum salmon returns in some western Alaskan drainages prompted various disaster declarations by the State of Alaska and federal agencies. In addition, chum salmon fisheries on the Yukon and Kuskokwim Rivers, two of the largest chum salmon production drainages in western Alaska, have been complicated in recent years by various restrictions designed to limit the take of Chinook salmon, which are currently at very low abundance.

Sorting juvenile salmon from trawl haul. SECM Project

Little is known about the survival of juvenile Yukon River chum salmon in their freshwater or saltwater environments.

The two distinct Yukon River chum salmon life-history types, an earlier and typically more abundant summer run and a later fall run, are managed by the Alaska Department of Fish and Game (ADF&G) to provide escapement and maximize harvest opportunity. Summer-run chum salmon generally spawn in the lower to middle reaches of the Yukon drainage, whereas fall-run chum salmon are typically larger and generally spawn in spring-fed regions of the middle to upper reaches in Alaska and Canada. The summer run of chum salmon has averaged 1.8 million fish between 2000 and 2012, and the fall run has averaged 864,000 fish over the same time period, although there is variation in the two run strengths between years. Concern about low fall-run chum salmon abundance in some years has resulted in reduced subsistence fishing opportunities and has created challenges in fulfilling treaty obligations with Canada that specify escapement objectives.

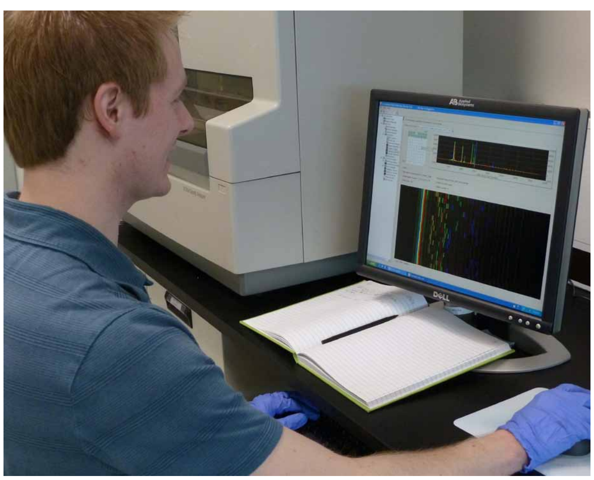
Little is known about the survival of juvenile Yukon River chum salmon in their freshwater or saltwater environments. Juvenile chum salmon out-migrate from the Yukon River in the spring and are found in the pelagic waters on the eastern Bering Sea shelf during summer and fall months. Juvenile chum salmon have been collected as part of annual U.S. Bering-Aleutian Salmon International Surveys (BASIS) in the eastern Bering Sea since 2002. A previous genetic analysis of the 2002 juvenile chum salmon based on allozyme markers determined that a substantial proportion of juvenile chum salmon samples collected in this area were from the Yukon River; however, samples from other years remained unanalyzed.

With support from the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative and the Alaska Sustainable Salmon Fund, we genetically analyzed juvenile chum salmon samples collected on the 2003–07 BASIS cruises. Our study had three objectives. First, with genetic mixed-stock analyses, determine the extent of stock contributions of juvenile chum salmon on the eastern Bering Sea shelf off the mouth of the Yukon River and compare the distribution across years. Second, develop a relative abundance index of summer- and fall-run Yukon River juvenile chum salmon on the eastern Bering Sea shelf. Third, examine the potential to correlate juvenile relative abundances with adult returns for summer and fall Yukon River chum salmon runs. A full report of this study is available online at http://www.akssf.org/Default.aspx?id=2420).

Methods

Sample and data collection, and mixed-stock analyses

Tissue samples and catch data from the U.S. BASIS cruises were provided by the Alaska Fisheries Science Center's (AFSC) Ecosystem Monitoring and Assessment Program at Auke Bay Laboratories. Juvenile chum salmon samples were collected on the eastern Bering Sea shelf during late summer-early fall from 2003 through 2007 (Fig. 1). Fish were collected with a midwater rope trawl that was towed at or near the surface during daylight hours; all tows lasted 30 minutes and covered 2.8 to 4.6 km. The genetic analysis of the 2003–07 juvenile chum salmon focused on samples collected between approximately lat. 58° and 64°N. This latitudinal range encompasses an area for which juvenile chum salmon are likely to be from the Yukon River, and relative abundances between summer- and fall-run juvenile indices may more likely correlate with adult Yukon River returns. DNA was extracted from 5,002 juvenile chum salmon. Genotypes were obtained for 11 of the genetic markers (microsatellite loci) represented in the coastwide chum salmon genetic baseline. The genotypes were used for stock composition estimates that were determined with a Bayesian algorithm. The stock composition estimates were the proportion of each grouping of baseline populations that contributed to the mixture of juvenile chum salmon samples of unknown origin.



Reviewing Genetic Analyzer results. Chris Kondzela

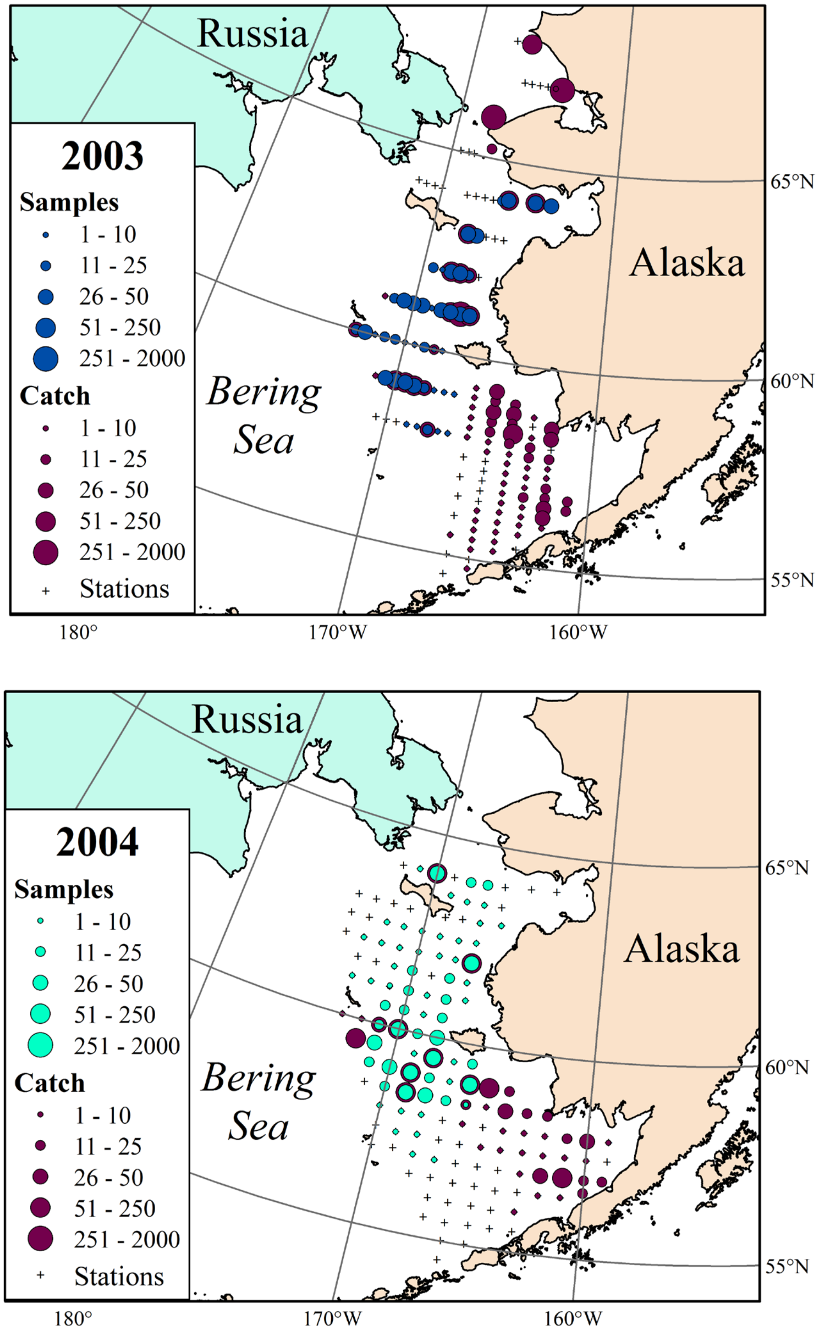
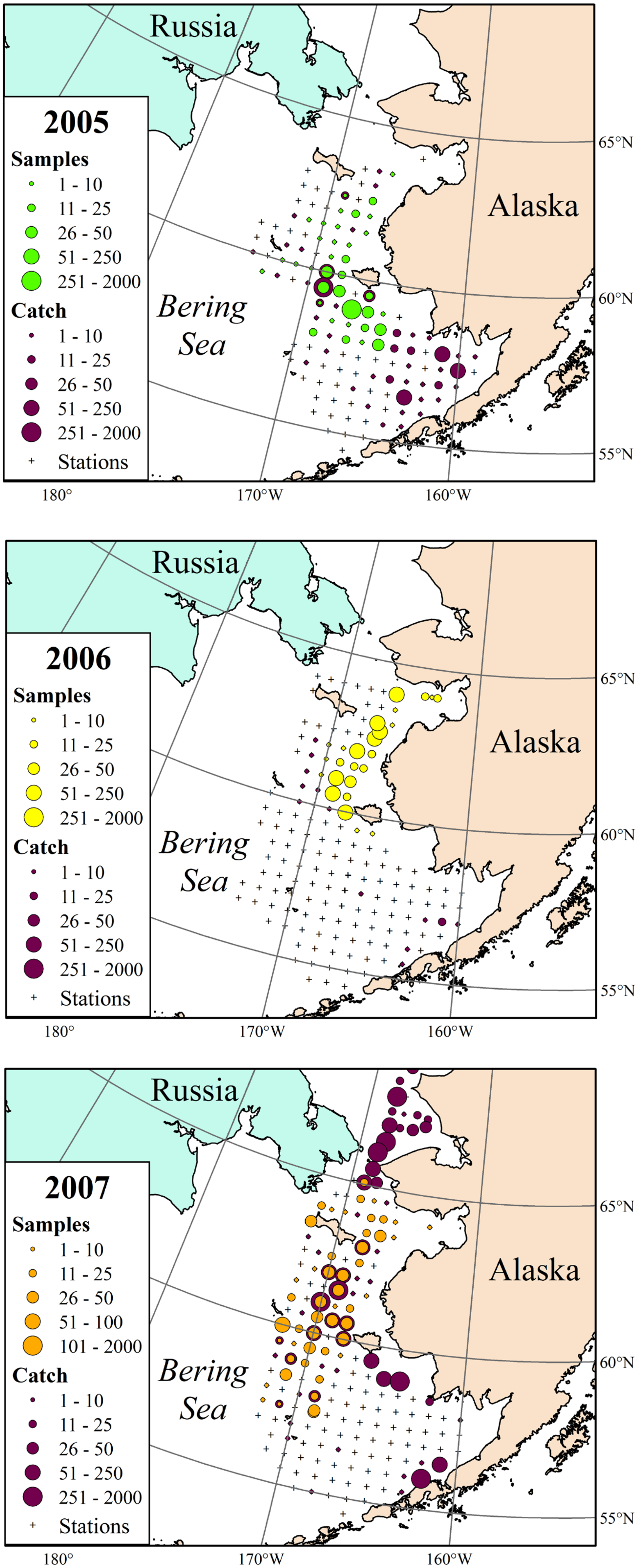


Figure 1. Sample spatial distribution of juvenile chum salmon collected in the eastern Bering Sea from the 2003–07 BASIS cruises. Samples that were genotyped are designated as "Samples" whereas the total catch from the survey is designated as "Catch." Stations surveyed with no juvenile salmon caught in the sample are designated with a "+".

Juvenile chum salmon samples were collected on the eastern Bering Sea shelf during late summer-early fall from 2003 through 2007

Figure 1. Continued.

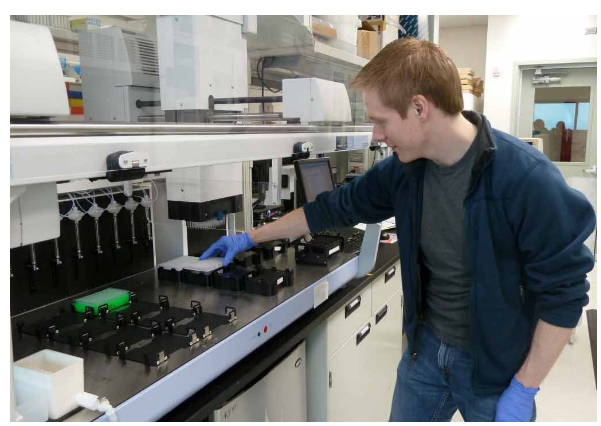


Baseline evaluation

A subset of the coastwide chum salmon baseline was used to develop a western Alaska specific baseline, which was then evaluated to determine finer-scale regional population groupings for stock composition analyses of the juvenile chum salmon mixtures. Population genetic structure of this western Alaska baseline was examined in two ways. First, a principle coordinate analysis (PCO) of genetic distances of baseline populations was completed from genetic marker allele frequencies. Second, baseline simulation analyses were performed to evaluate the effectiveness of the baseline to allocate stocks to the correct regions. Simulation analyses with baseline population resampling were performed by reallocating hypothetical mixtures of 400 fish from a single region to determine the percentage that reallocated back to the correct region.

Yukon River fall-run component

Adult return estimates by age-class for Yukon River chum salmon for years 2000–12 were provided by the ADF&G. To follow brood-year returns, the adult returns were summed for age-3 through age-6 for both summer- and fall-run fish. A relative abundance index for Yukon River fall-run adult chum salmon by brood-year was then computed by dividing the proportion of fall-run chum salmon by the total Yukon River chum salmon return. For the juvenile chum salmon samples collected at sea, the yearly proportions of fall-run fish were determined by dividing the fall-run genetic composition estimate by the total Yukon River genetic composition estimate (summer plus fall). A correlation analysis was performed to determine if there was a relationship between the relative proportion of Yukon River fall-run juveniles collected at sea and 1) the relative proportions of fall-run adults that produced the juveniles, or 2) the relative proportions of fall-run adult brood-year returns.



Loading DNA onto PCR plate with robotic equipment. Chris Kondzela

Results

Genotyping

Most of the juvenile chum salmon samples analyzed were successfully genotyped for 8 or more of the 11 loci (Table 1). Samples genotyped for less than 8 loci were removed from analysis. Quality control of sample handling and genotyping indicated a low discrepancy rate of 0.4%.

Table 1. Number of successfully genotyped juvenile chum salmon samples that were collected in the eastern Bering Sea during 2003–2007 BASIS cruises.

Year	Genotyped number	Collection date
2003	1,069	8/21-10/8
2004	887	8/27–9/28
2005	794	8/15–10/5
2006	1,011	9/3–9/20
2007	1,113	9/5–10/6
Total	**4,874**	

Microsatellite baseline – coastwide groupings

The coastwide chum salmon microsatellite baseline was used to perform stock composition analysis. This baseline consists of 381 populations that we aggregated into six large stock groupings—Southeast Asia, Northeast Asia, Coastal Western Alaska, Upper/Middle Yukon River, Southwest Alaska, and the Gulf of Alaska/Pacific Northwest (GOA/PNW) (Fig. 2). To evaluate the ability of the 11 microsatellite markers to effectively separate the six regional groupings in mixed-stock analyses, simulations were performed with baseline resampling. The baseline reallocated stocks with a high degree of accuracy indicating that stock composition estimates derived from the use of this baseline are highly accurate (Table 2).

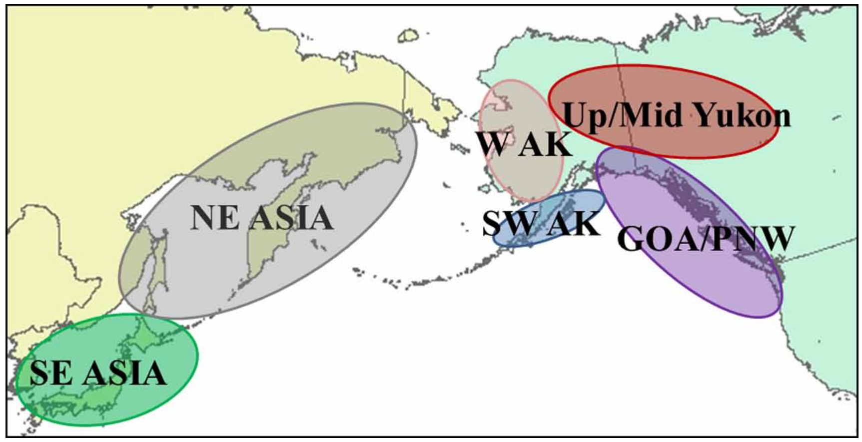


Figure 2. The six large regional groupings of spawning chum salmon stocks from throughout the Pacific Rim: Southeast (SE) Asia; Northeast (NE) Asia; Coastal Western Alaska (W AK); Upper/Middle Yukon River (Up/Mid Yukon); Southwest Alaska (SW AK); and the Gulf of Alaska/Pacific Northwest (GOA/PNW).

Table 2. Coastwide chum salmon baseline evaluation with simulated mixtures in which 100% of the samples were derived from a single regional grouping (read down columns). Correct allocations highlighted in bold font.

Grouping	SE Asia	NE Asia	Coastal West AK	Up/Mid Yukon	SW Alaska	GOA-PNW
SE Asia	**0.873**	0.041	0.004	0.001	0.015	0.003
NE Asia	0.036	**0.835**	0.008	0.002	0.047	0.007
Coastal West AK	0.008	0.055	**0.960**	0.059	0.040	0.002
Up/Mid Yukon	0.000	0.002	0.010	**0.934**	0.001	0.000
SW Alaska	0.002	0.007	0.004	0.000	**0.819**	0.003
GOA-PNW	0.016	0.045	0.010	0.002	0.070	**0.977**

Stock composition estimates – coastwide groupings

Yearly stock composition estimates were made with the coastwide chum salmon baseline and six large regional groupings for samples collected between long. 172.50° and 166.75°W and lat. 58° and 63°N (Fig. 3). More than 95% of the 2003–07 juvenile chum salmon samples were from the Coastal Western Alaska and Upper/Middle Yukon regions. Because most of the fish were from these two regions, a more parsimonious baseline was selected for additional stock composition analyses with finer-scale regional groupings.

The coastwide chum salmon microsatellite baseline was used to perform stock composition analysis.

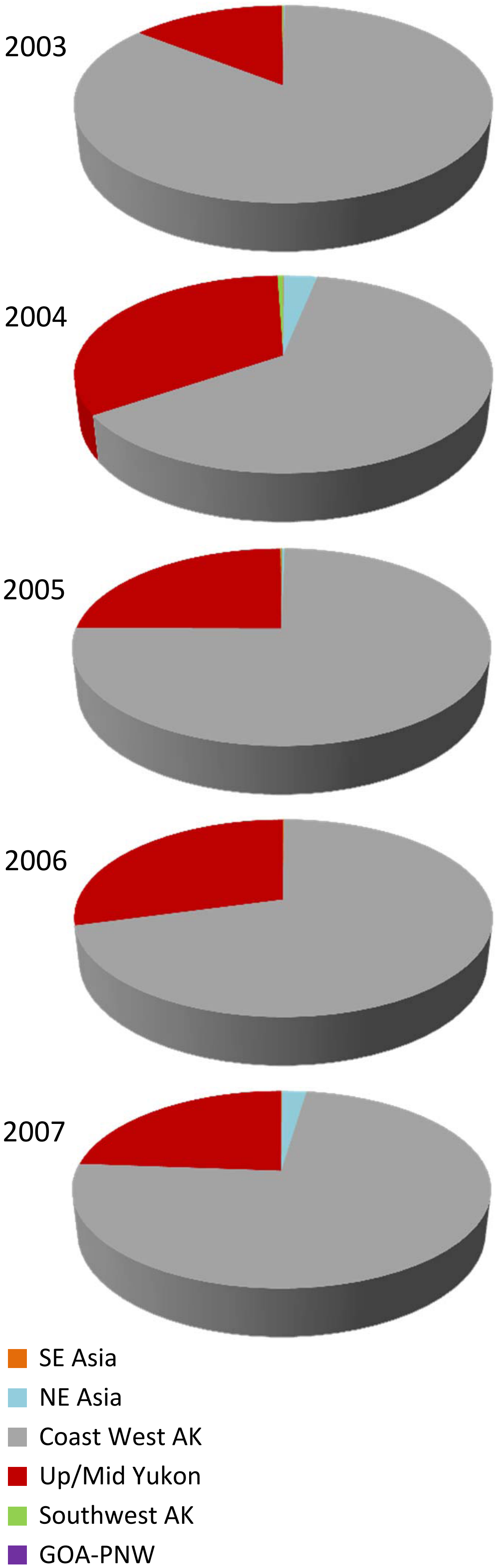


Figure 3. Regional stock composition estimates for juvenile chum salmon collected between lat. 58° and 63°N in the eastern Bering Sea during the summer/fall 2003-2007 BASIS cruises.

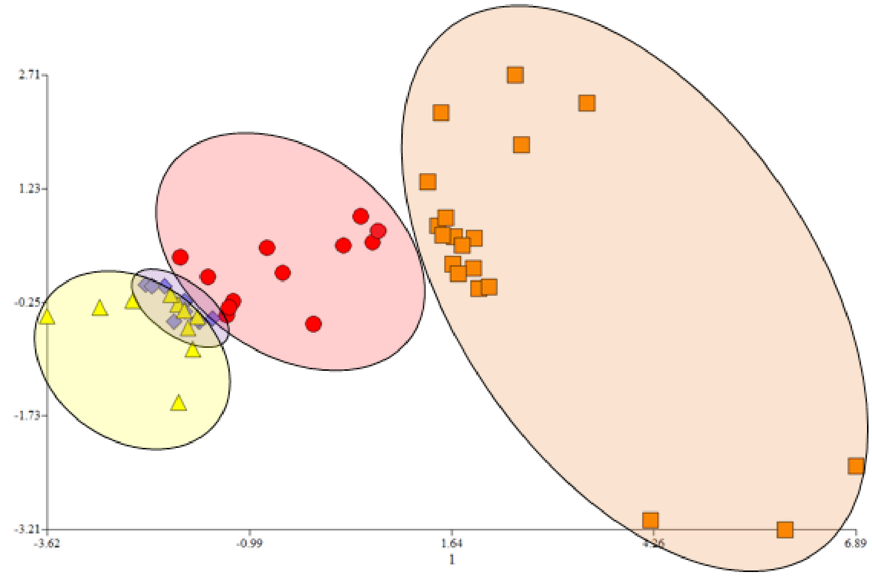


Figure 4. Principal coordinate analysis for the 51 western Alaska and Yukon River populations separated into four temporal-spatial groupings. Yukon Summer (red circles), and Yukon Fall (orange squares), Norton Sound (purple diamonds), and Kuskokwim/NE Bristol Bay (yellow triangles).

Microsatellite baseline – western Alaska/Yukon groupings

The preponderance of juveniles in the eastern Bering Sea of western Alaska origin led to additional analyses to determine the suitable number of stock groupings for the 51 populations in western Alaska between Norton Sound and northeastern Bristol Bay, including the Yukon River drainage. The finer-scale population groupings were determined from principal coordinate analysis based on genetic distances and State of Alaska salmon management areas, and were evaluated with baseline simulation analyses. On the first two principal coordinates, the Yukon River summer-run (red circles) and fall-run (orange squares) chum salmon populations separate (Fig. 4). All of the Norton Sound populations (purple diamonds) clustered tightly together, but the Kuskokwim/NE Bristol Bay populations (yellow triangles) clustered more loosely and many overlap with the Norton Sound populations (Fig. 4). With these four western Alaska chum salmon stock groupings (Fig. 5), baseline simulation analyses showed that the baseline reallocated three of the four groupings (Yukon summer, Yukon fall, and Norton Sound) with a high degree of accuracy, but there was substantial misallocation of the Kuskokwim/NE Bristol Bay grouping to other coastal western Alaska groupings (Table 3). Stock composition analyses performed with these baseline groupings may underestimate the contribution from the Kuskokwim/NE Bristol Bay region.

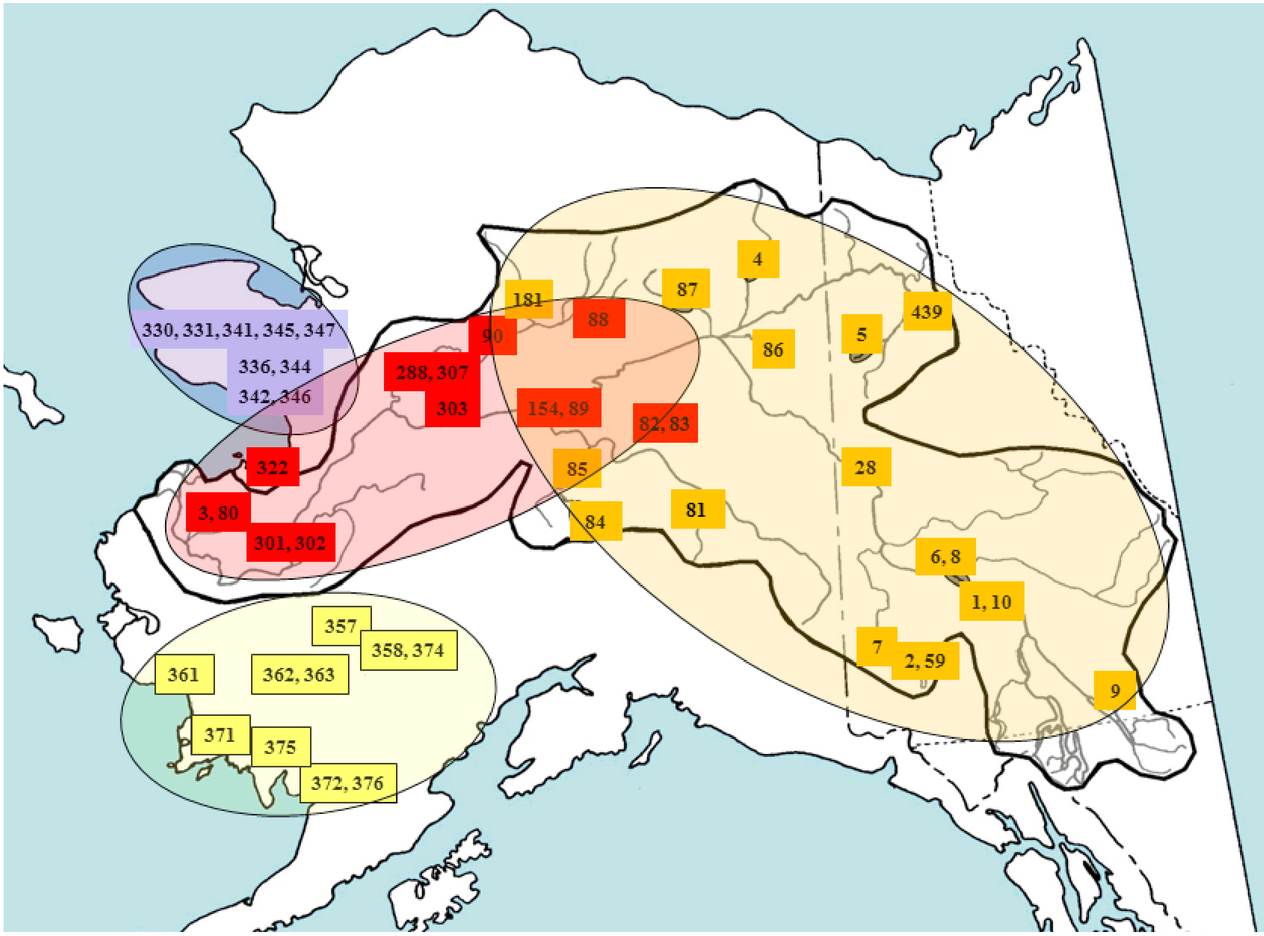


Figure 5. Four finer-scale temporal-spatial population groupings of chum salmon used for mixed-stock analysis: Yukon Summer (red); Yukon Fall (orange); Norton Sound (purple); and Kuskokwim/NE Bristol Bay (yellow). Numbers refer to the population number in the coastwide microsatellite baseline. Base map courtesy of ADF&G.

Table 3. Evaluation of the finer-scale 51-population, 4-temporal-spatial grouping western Alaska/Yukon River chum salmon baseline with simulated mixtures in which 100% of the samples were derived from a single regional grouping (read down columns).

Grouping	Yukon Summer	Yukon Fall	Norton Sound	Kuskokwim/ NEBB
Yukon Summer	**0.846**	0.062	0.073	0.218
Yukon Fall	0.028	**0.923**	0.004	0.005
Norton Sound	0.092	0.006	**0.895**	0.246
Kuskokwim/ NEBB	0.030	0.003	0.023	**0.522**

Stock composition estimates – years pooled

For years 2003 through 2007, samples were aggregated by latitude and longitude to determine the optimal sampling location for estimating proportions of summer- and fall-run Yukon River chum salmon. Samples across years were combined by latitude as follows: 1,244 samples at lat. 58°–59.5°N; 2,736 samples at lat. 60°–63°N; and 296 samples at lat. 63.5°–65°N (Fig. 6). All samples were limited to between long. 166.75° and 172.5°W. First, stock composition estimates were made for all three locations with the 381-population coastwide baseline for six regional groupings (Table 4). Nearly half the fish from the most northern samples were from Coastal Western Alaska with most of the remaining fish from Northeast Asian populations. Two-thirds to three-quarters of the fish from the two locations between lat. 58° and 63°N were from Coastal Western Alaska. Nearly all of the remaining fish were from the Upper/Middle Yukon region.

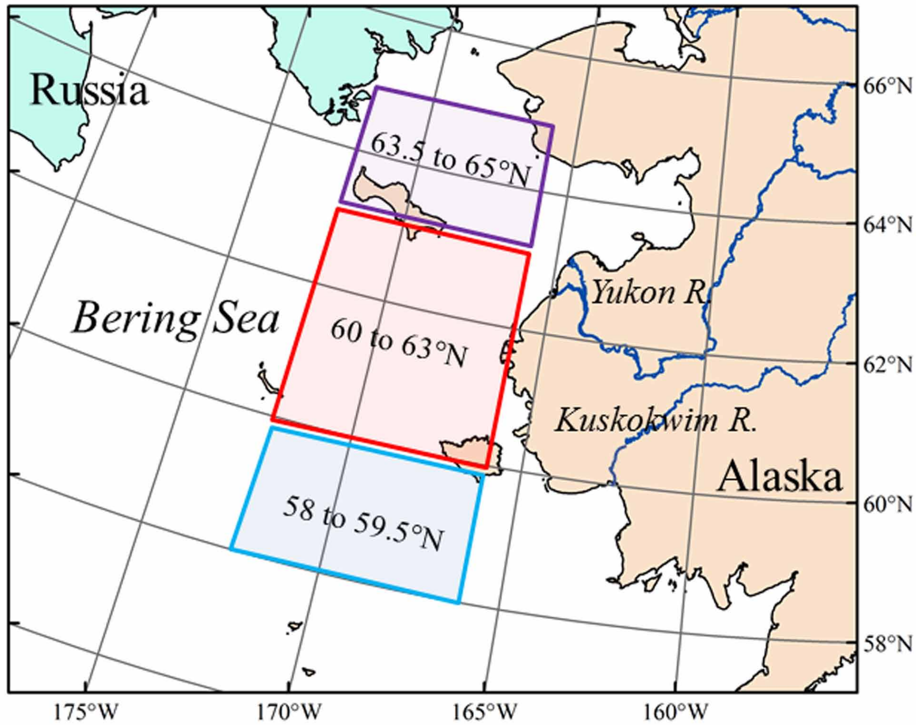


Figure 6. Sampling locations in the Bering Sea. Juvenile chum salmon were collected at stations between approximately lat. 58° and 65°N as part of the annual BASIS cruises in 2003–07.

Second, stock composition estimates were made for the two more southern locations with the finer-scale 51-population western Alaska/Yukon River baseline with four temporal-spatial groupings. Given the large proportion of Northeast Asian fish and the small sample size of the most northern dataset, it was not analyzed with the finer-scale baseline. The contribution of Kuskokwim River fish was low in both areas (Table 4). Because the Yukon Fall fish are identified with high accuracy (Table 3) and because the relative proportion of fall-run fish did not change appreciably between the lat. 58°–59.5°N and 60°–63°N areas, we focused on the samples collected between lat. 58° and 63°N to investigate potential correlations between the relative abundance of fall-run juvenile chum salmon and 1) the parents of the juveniles and 2) the future adult returns of the juveniles.

Table 4. Stock composition estimates of juvenile chum salmon samples collected during 2003–07 for the three spatial areas identified in Figure 6. Estimates with lower credible interval values >0 are identified in bold font. NEBB = northeastern Bristol Bay.

Spatial areas					
Lat. 63.5-65°N, N=296		**Lat. 60-63°N, N=2,736**		**Lat. 58-59.5°N, N=1,244**	
381-population coastwide baseline					
Grouping	**Proportion**	**Grouping**	**Proportion**	**Grouping**	**Proportion**
SE Asia	0.001	SE Asia	0.000	SE Asia	0.000
NE Asia	**0.408**	NE Asia	**0.004**	NE Asia	**0.019**
Coast West AK	**0.479**	Coast West AK	**0.752**	Coast West AK	**0.673**
Up/Mid Yukon	**0.111**	Up/Mid Yukon	**0.244**	Up/Mid Yukon	**0.307**
SW Alaska	0.001	SW Alaska	0.000	SW Alaska	0.001
GOA-PNW	0.001	GOA-PNW	0.000	GOA-PNW	0.000
51-population western Alaska/Yukon baseline					
Grouping	**Proportion**	**Grouping**	**Proportion**	**Grouping**	**Proportion**
Yukon Summer	—	Yukon Summer	**0.407**	Yukon Summer	**0.444**
Yukon Fall	—	Yukon Fall	**0.205**	Yukon Fall	**0.238**
Norton Sound	—	Norton Sound	**0.311**	Norton Sound	**0.186**
Kuskokwim/NEBB	—	Kuskokwim/NEBB	**0.077**	Kuskokwim/NEBB	**0.132**
Proportion Yukon fall-run relative to total Yukon	n/a		0.34		0.35

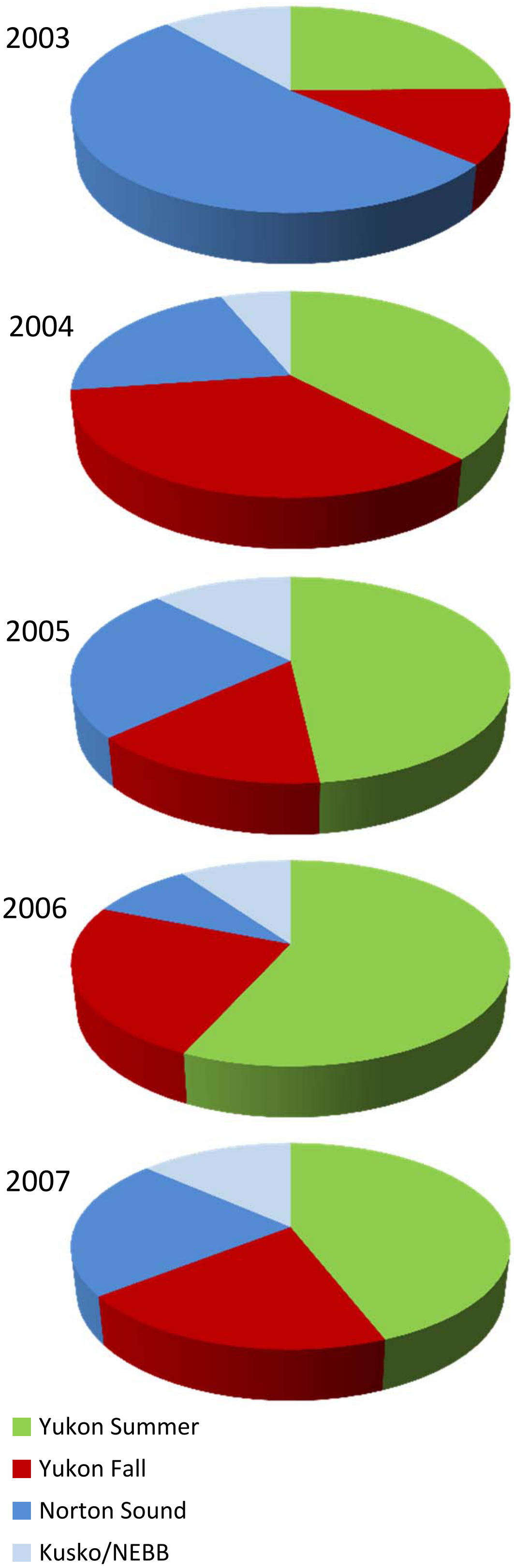


Figure 7. Stock composition estimates for juvenile chum salmon collected during 2003–07 summer/fall BASIS cruises. A 51-population baseline was used to estimate contributions from four western Alaska/Yukon River reporting groups.

The Yukon Summer contribution was always higher than the Yukon Fall contribution.

Stock composition estimates – western Alaska/Yukon groupings

With the 51-population western Alaska/Yukon River chum salmon baseline comprised of four temporal-spatial groupings, stock composition estimates were made for each year for samples collected between lat. 58° and 63°N (Fig. 7). Except in 2003 when approximately 50% of the juvenile chum salmon collected on the eastern Bering Sea shelf were from Norton Sound populations, most of the juvenile chum salmon originated from the Yukon Summer populations. The Yukon Summer contribution was always higher than the Yukon Fall contribution. Typically about 10% of the juvenile chum salmon samples originated from the Kuskokwim River/northeastern Bristol Bay populations.

Yukon River chum salmon: abundance estimates and correlation of juvenile and adult fall-run proportions

Across years, the proportion of fall-run adult returns of Yukon River chum salmon based on the ADF&G abundance estimates varied inter-annually (Fig. 8). On average, 32% of the annual return between 2000 and 2012 was classified as a fall stock, with a high of 47% in 2005 and a low of 22% in 2006. A large return of age-3 and age-4 fish sometimes corresponded to a large return of age-4 and age-5 fish, respectively, the following year (Fig. 9).

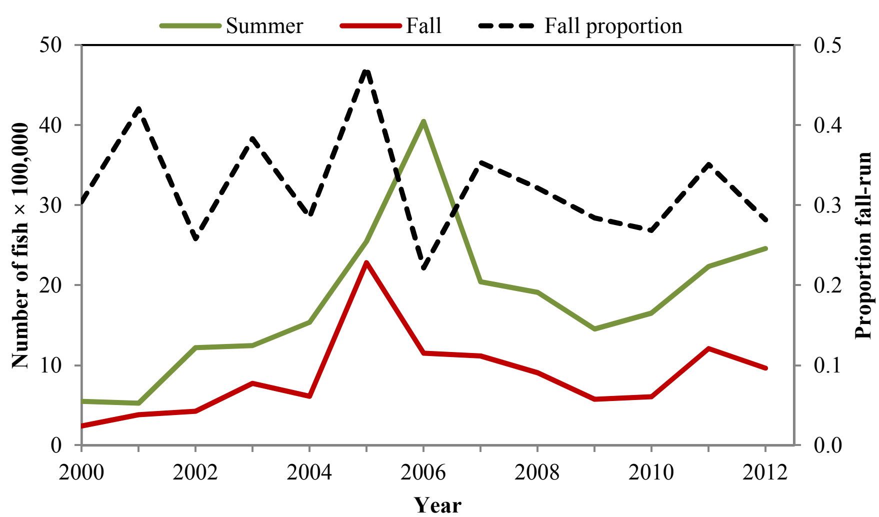


Figure 8. Annual summer- and fall-run adult returns of chum salmon to the Yukon River drainage. Estimates of return are on the left y-axis and proportions of fall-run chum salmon are on the right y-axis.

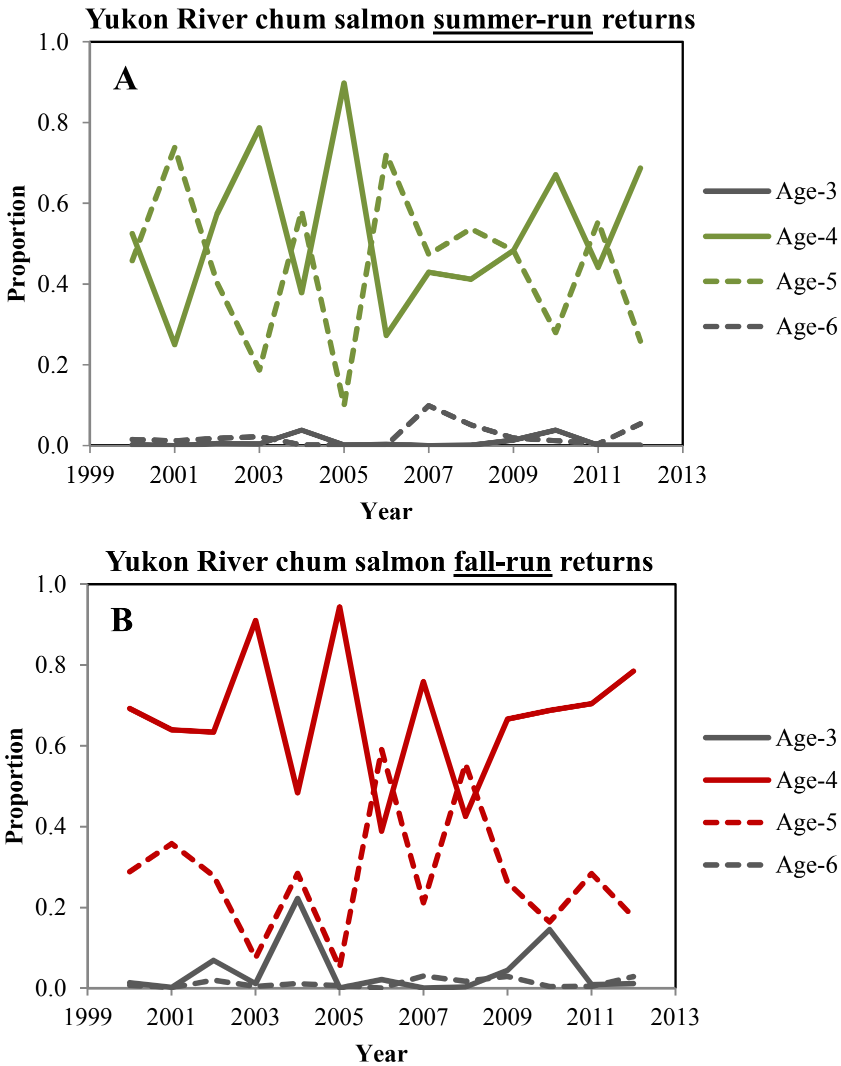


Figure 9. Proportion of age-3 to age-6 chum salmon adult returns to the Yukon River for A) summer-run fish, and B) fall-run fish.

A correlation was found between the proportions of fall-run juveniles estimated from genetic analysis and the adult brood-year returns calculated from abundance estimates. This relationship was further supported by data for the 2002 sample year that was produced from an earlier study with allozyme markers

To determine the proportion of fall-run adults that produced the juveniles collected in 2003–07, the abundance estimate for the fall-run from the year previous to each year of juvenile sampling was divided by the total Yukon River return (summer + fall). For example, the 2003 juveniles sampled at sea were spawned by the 2002 adult returns (Table 5). To determine the proportion of each juvenile year-class that returned as fall-run adults across four years, the abundance estimates that tracked ages 3–6 were summed for each run component and then the fall-run abundance was divided by the total return (summer + fall). For example, some of the 2003 juveniles would have returned as age-3 adults in 2005, as age-4 in 2006, as age-5 in 2007, and finally as age-6 in 2008 (see Table 5). A correlation was found between the proportions of fall-run juveniles estimated from genetic analysis and the adult brood-year returns calculated from abundance estimates. This relationship was further supported by data for the 2002 sample year that was produced from an earlier study with allozyme markers (Fig. 10). There was no correlation between the proportion of fall-run juveniles and the parents that produced those juveniles.

Processing juvenile salmon catch. EMA Program

Table 5. Matrix of juvenile collections and adult returns of Yukon River chum salmon. The blue cells identify the juveniles collected at sea. The yellow cells identify the parent year of the juveniles. The orange cells identify the age of the adult brood-year returns in relation to year of juvenile collections.

		Adults										
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Juveniles	2003		Age-1	Age-2	Age-3	Age-4	Age-5	Age-6				
	2004			Age-1	Age-2	Age-3	Age-4	Age-5	Age-6			
	2005				Age-1	Age-2	Age-3	Age-4	Age-5	Age-6		
	2006					Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	
	2007						Age-1	Age-2	Age-3	Age-4	Age-5	Age-6


Eastern Bering Sea, August 2011.
Chris Kondzela

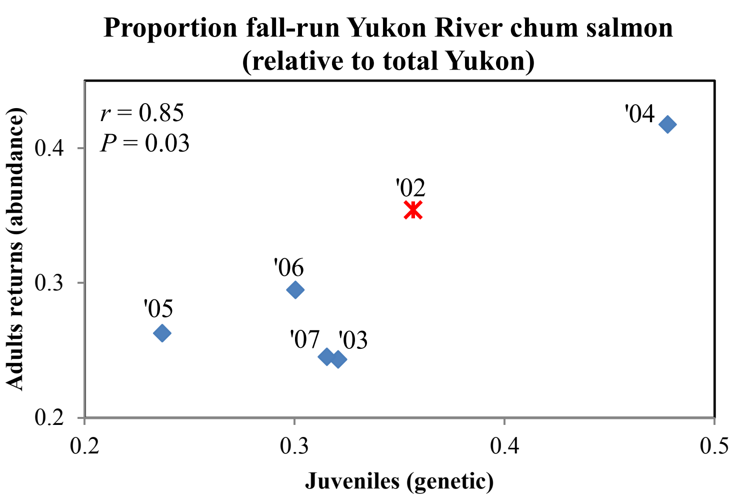


Figure 10. The yearly relative proportion of fall-run Yukon River juvenile chum salmon collected in the eastern Bering Sea between lat. 58° and 63°N during 2003–07, versus the brood-year adult returns. Microsatellite marker data indicated with blue diamonds and allozyme marker data with a red star.

Summary

The availability of multi-year collections of juvenile chum salmon from the eastern Bering Sea and the comprehensive genetic information of chum salmon populations throughout their geographic distribution provided an opportunity to examine the distribution of western Alaskan chum salmon during their first summer/fall at sea. For the first time that we are aware of, our study investigated the relationship of the stock compositions of juvenile chum salmon collected at sea and the Yukon River adult chum salmon returns. Because the genetic diversity of coastal western Alaska chum salmon populations (summer-run) is low and therefore challenging to apply to mixed-stock analyses, we focused on the Yukon River, which has fall-run populations that are genetically distinct from the summer-run populations. Estimates of the proportions of the two life-history types in mixtures of juveniles were used to examine year-to-year differences in distributions in the Bering Sea during early marine residence, and to investigate the potential association of juvenile abundances with Yukon River adult returns.

The estimated stock proportions of juvenile chum salmon caught in the eastern Bering Sea during late summer/fall over a 5-year time period adds to our understanding of the distribution of western Alaska chum salmon during their first year in the ocean. Our results support a migration model whereby western Alaska juvenile chum salmon head primarily west and south across the eastern Bering Sea shelf during the summer/fall season. With both the full coastwide baseline and the finer-scale western Alaska baseline, the contributions from each stock grouping of this highly migratory species were remarkably similar from year-to-year, especially given the inter-annual latitudinal shifts in juvenile chum salmon distribution across the eastern Bering Sea shelf (Fig. 1), as well as the variation in the date that stations were sampled across years. Nearly all of the juvenile chum salmon were from the Coastal Western Alaska and Upper/Middle Yukon River stock groupings (Fig. 3), as was found in an earlier genetic analysis of samples from 2002. Except in 2003, the highest proportion of juvenile chum salmon caught in the surveys was from the Yukon Summer populations. In all years, the Yukon Summer component was higher than the Yukon Fall component. The contribution from Norton Sound varied annually, but in general, increased with latitude (Table 4). Given the low abundance of many Norton Sound chum salmon populations in some years, surveys in the northeastern Bering Sea might help provide insight into the early marine residence of these populations. Previous analyses indicated that samples collected below lat. 60°N contained Kuskokwim origin fish, although our analysis suggests that Kuskokwim/NE Bristol Bay origin fish were only a minor component as far south as lat. 58°N and did not migrate northward during their first summer. This difference may simply reflect inter-annual variation of migration routes or an effect of sampling west of long. 166.75°W, an area potentially outside the migration route of the Kuskokwim origin chum salmon during the 2003–07 surveys.

On average, across the 5-year dataset, about one-third of the Yukon River juvenile chum salmon were from fall-run populations based on genetic stock estimates, much like the adult returns based on abundance estimates. Although no correlation was found between the estimated proportion of fall-run Yukon River juvenile chum salmon in the sample sets and the adult year-classes that produced them, a significant correlation was found between the juveniles and the brood-year returns. In 2004, the departure of the relative survival of the two life-history types in the Yukon River provided contrast in the correlation analysis of the proportions of fall-run juveniles and brood-year returns. The significant correlation suggests that differences in the production and survival of the summer- and fall-run populations occur during the period of freshwater and early marine residence.

For the first time that we are aware of, our study investigated the relationship of the stock compositions of juvenile chum salmon collected at sea and the Yukon River adult chum salmon returns.

In most years, the abundance of fall-run fish is usually well-correlated with the abundance of summer-run fish (Fig. 8), but infrequently, the fall-run proportion is substantially higher or lower than expected, e.g., higher in 2005. The relative proportions of fall-run juvenile chum salmon provide insight into the relative strength of fall-run adult returns. For example, juvenile chum salmon produced from the 2001 and 2002 year-classes have different impacts on the 2005 adult returns. There were few age-3 fall-run Yukon River chum salmon returns in 2005, so the juveniles produced from the 2002 year-class did not contribute significantly to the 2005 adult returns. However, 94% of the fall-run component in 2005 was comprised of age-4 fish (Fig. 9) that were produced from the 2001 year-class of juveniles (sampled in 2002), which from our earlier study based on a different set of genetic markers had a relatively high proportion of fall-run fish (Fig. 10).

The proportion of fall-run juveniles that return as adults is spread across multiple years due to the age structure of chum salmon. Thus, the high proportion of fall-run juveniles from the 2003 year-class (collected in 2004) contributed to adult returns in 2006 as age-3, in 2007 as age-4, in 2008 as age-5, and in 2009 as age-6. The age-3 and age-6 contributions were only 2%-3% of the fall-run return in 2006 and 2009, but the high proportion of fall-run juveniles caught in 2004 is evident as age-4 fish, which comprised 76% of the 2007 fall-run return, and as age-5 fish, which comprised 56% of the 2008 fall-run return (Fig. 9), the second highest proportion of age-5 fall-run returns in years 2000–12.

Conclusions

The results of our study indicate that by the time juvenile chum salmon are caught on the continental shelf of the eastern Bering Sea in late summer/early fall, the relative proportion of summer and fall fish appears to have been determined for that brood year.

The juvenile fall-run proportions may be useful in managing the Yukon River fall-run stock group. Chum salmon are currently managed with the assumption of a constant ratio of fall and summer abundance. The stock proportions of juveniles could improve this strategy by forecasting the relative strength of fall and summer runs to the Yukon River.

Future investigations should incorporate ongoing advances in the genetic baselines, which may improve the accuracy of the stock composition estimates in the western Alaska region, particularly for the summer coastal stocks. Analyses of samples collected during more recent years (2009–12) may further clarify the relationship between the juvenile and adult chum salmon from the Yukon River.

Acknowledgements

We are grateful to Emily Fergusson for coordinating sample processing, to Wei Cheng and Hanhvan Nguyen for the DNA extraction of many of the juvenile chum salmon samples, to Colby Marvin for laboratory analyses, and to Jackie Whittle for exploratory data analyses. Yukon River chum salmon adult abundance estimates were provided by Katie Howard from ADF&G. Discussions with Katie and Bill Templin from ADF&G are greatly appreciated. Funding was provided by Alaska Sustainable Salmon Fund (Project 44619) and the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (Project 1002/SAF-336).

Ecosystem Monitoring and Assessment Program

Use of Shelf, Slope, and Basin Habitat by Age-0 Walleye Pollock and Pacific Cod in the Gulf of Alaska

Walleye pollock and Pacific cod are widely distributed across the Gulf of Alaska (GOA) and are commercially and ecologically important species. Recruitment estimates based on the latest stock assessments for both species are highly variable. Prior to the mid-1980s, pollock recruitment in the GOA was correlated with larval mortality, which is believed to have been largely influenced by environmental conditions. However, this relationship deteriorated following a major environmental shift in the mid-1970s, and it appears that the critical stage for recruitment of pollock is now largely dependent on conditions experienced during the post larval, juvenile life stage. AFSC scientists are in the process of developing a new, long-term monitoring survey designed to assess the health, abundance, and distribution of age-0 pollock and P. cod and other marine species with the goal of providing information to aid stock assessment and resource management efforts in the GOA.

Individuals inhabiting slope waters in the eastern GOA on average contained higher energy stores relative to those over the shelf and basin as well, although statistically significant differences in somatic energy density were not detected.

Age-0 pollock (Fig. 1) and P. cod were collected in surface trawls with other species during July and August 2012 as part of the North Pacific Research Board's GOA Project. This survey sampled stations along a series of 128-km long transects located west of the Alaska panhandle and 300-km long to the east of Kodiak Island, Alaska (Fig. 2) and was designed to compare processes occurring in two

Figure 1. **Age-0 walleye pollock captured in a surface trawl.** Photo by John Eiler.

distinctly different regions of the GOA. Age-0 pollock and P. cod inhabiting continental slope waters of the GOA during summer acquired higher energy stores than those occupying the shelf and basin, suggesting that individuals remaining over the slope were better conditioned to survive winter. Individuals inhabiting slope waters in the eastern GOA on average contained higher energy stores relative to those over the shelf and basin as well, although statistically significant differences in somatic energy density were not detected.

Increased energy reserves and overwinter survival of age-0 pollock and P. cod in the Bering Sea have been directly related to cool ocean conditions caused by late ice retreat which support the production of large, energy-rich Calanus spp. copepods during late summer. Mechanistic explanations of how climate and temperature may affect copepod production in the GOA are limiting; however, zooplankton guilds are believed to be segregated according to ocean (offshore) habitat in the northern GOA.

Previous investigations report that the ocean zooplankton community contains larger copepod species such as *Neocalanus christatus* and *Eucalanus bungii* whereas the shelf community contains smaller species such as *Calanus marshallae* and *Pseudocalanus spp.*, and the transition zone separating these communities commonly crosses the shelf break, allowing for the incursion of oceanic species up onto the shelf. Thus, age-0 pollock and P. cod located over the slope may have more opportunities to forage on larger, more energy-rich copepods.

P. cod were longer and heavier than pollock across all habitats in the GOA, and their life history strategy appears to favor the allocation of energy toward increasing body size. Larger fish are better conditioned to avoid starvation, have an improved immune response, and a greater thermal tolerance. Age-0 pollock inhabiting shelf and slope waters of the GOA are likely allocating energy toward storage during summer months in order to limit foraging explorations and exposure to predators during winter.

Pollock and P. cod were equally abundant in the central GOA and overlapped substantially in their distribution. Pollock were also widely distributed and abundant in the eastern GOA where P. cod were seldom encountered. Density-dependent interactions may occur in areas with spatial overlap of juvenile fish occupying similar guilds, and given the large dietary and spatial overlap, density dependence may be an issue in the central GOA during summer months.

By Jamal Moss, Marilyn Zaleski, and Ron Heintz

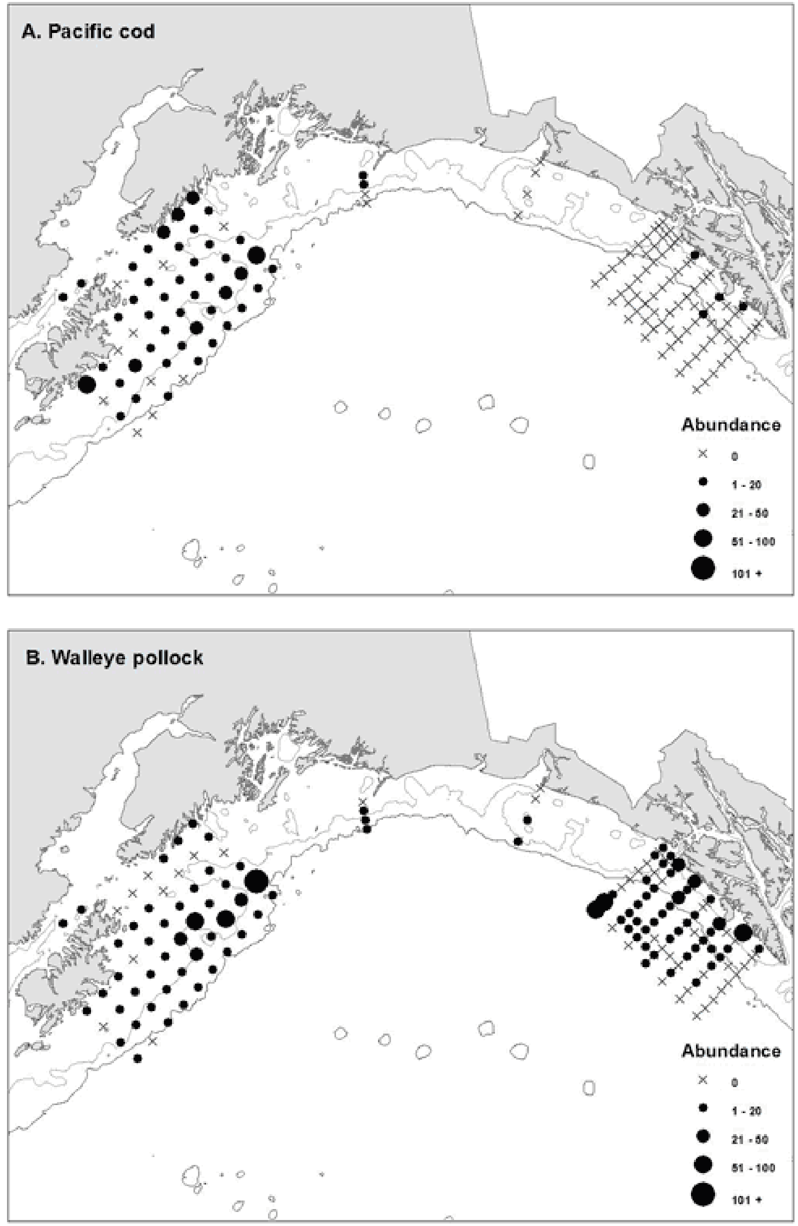


Figure 2. Abundance of catch during the summer 2012 Gulf of Alaska survey for (A) Pacific cod and (B) walleye Pollock.

North Pacific Groundfish and Halibut Observer Program Recommendations

In January 2013 the North Pacific Groundfish and Halibut Observer Program (Observer Program) was restructured to reduce the potential for bias in observer data, authorize the collection of observer data in previously unobserved sectors, and assess a broad-based fee to more equitably distribute the costs of observer coverage[1]. Restructuring also established an iterative process of reviewing and revising the program on an annual basis. In June of each year the National Marine Fisheries Service (NMFS) provides an annual report to the North Pacific Fishery Management Council (Council) on the previous year's Observer Program performance. Based on the analysis and recommendations in the report, a proposed annual deployment plan for the coming year is provided to the Council in October. This process allows fishery managers to adapt and respond to management needs of North Pacific fisheries.

In May 2014, NMFS provided its first Annual Report to the Council on observer deployment under the restructured observer program. The report, North Pacific Groundfish and Halibut Observer Program 2013 Annual Report (Annual Report) assesses the degree to which the objectives of the observer program restructuring have been met and includes recommendations to improve the program. Chapter 3 of the report, Deployment Performance Review, was formalized as a separate NOAA Technical Memorandum.

As part of the annual review process, a set of performance metrics were used to assess the efficiency and effectiveness of observer deployment into the trip-selection (vessels > 57.5 ft in length) and vessel-selection (vessels 40-57.5 ft in length) strata of the partial coverage category. There was a marked difference in the relative performance of the two deployment methods in 2013. In the vessel-selection stratum, coverage levels were less than expected during five of the six 2-month selection periods. Coverage shortages in vessel-selection were due to a lack of a proper sampling frame and NMFS granting conditional releases. In total, 52% of the vessels and 50% of the trips resulting from these vessels were not observed due to conditional releases from observer coverage. This high level of release from coverage coupled with a low sample size resulted in systematic spatial coverage issues, most notably in NMFS Reporting Area 650. In contrast, the trip-selection stratum met the anticipated coverage goals throughout the year.

Based on the results presented in the Annual Report, at the June 2014 Council meeting NMFS recommended, and the Council agreed, that NMFS should consider placing participants who were in the vessel selection category in 2014 into the trip selection category for 2015. This recommendation was further analyzed and formally proposed in the 2015 Draft Annual Deployment Plan (ADP) provided to the Council in October 2014. In addition, the Draft ADP proposed maintaining coverage rates of 12% for vessels 40-57.5 ft in length, but increasing observer coverage from 16% to 24% for vessels >57.5 ft. This was based on the Council's June recommendation to consider higher coverage rates for all trawl vessels and fixed gear vessels over 57.5 ft. The ADP also proposed limiting the conditional release policy for vessels 40-57.5 ft only for life raft capacity in order to improve the sampling efficiency within this stratum.

Photo NMFS, North Pacific Observer Program.

At its October 2014 meeting, the Council unanimously approved the Draft ADP with the caveat that if vessels in the small vessel trip selection stratum are selected randomly three trips in a row, the third selected trip be released from coverage. The proposed changes to observer coverage will take effect in January 2015 and remain in effect for the calendar year.

The review of observer deployment during 2014 will begin early next year culminating in the Annual Report to the Council in June 2015 and another ADP in October 2015. This non-regulatory, iterative approach of reviewing and recommending changes to observer coverage on an annual basis provides a streamlined approach for the Council and NMFS to adapt to changing needs of the fishery. For more information on the North Pacific Groundfish and Halibut Observer Program, visit our Fisheries Monitoring and Analysis webpage. Detailed information on the ADP or Annual Report process can be found on the Alaska Regional Office or the Council's webpages.

By FMA staff

[1] The changes applied primarily to the partial coverage fisheries. Full coverage fisheries continued to operate under a separate pay as you go process, although some catcher processor vessels previously under partial coverage were added to the full coverage sector in 2013.

Cetacean Assessment and Ecology Program

Fifth Annual International Whaling Commission POWER Cruise

Sally Mizroch, from the National Marine Mammal Laboratory's (NMML) Cetacean Assessment and Ecology Program (CAEP), participated in the fifth annual Pacific Ocean Whale and Ecosystem Research (POWER) cruise this summer, from 2 July to 30 August 2014, surveying the vast North Pacific Ocean to study the distribution and abundance of baleen whales in areas where populations were depleted by 20th century commercial whaling. The POWER cruises are a collaboration between the International Whaling Commission (IWC) and the Government of Japan. Cruise plans and line-transect tracklines have been developed with the participation of the National Research Institute of Far Seas Fisheries (Research Agency of Japan) and the Alaska Fisheries Science Center, under the guidance of the IWC-POWER Steering Group established by the IWC Scientific Committee.

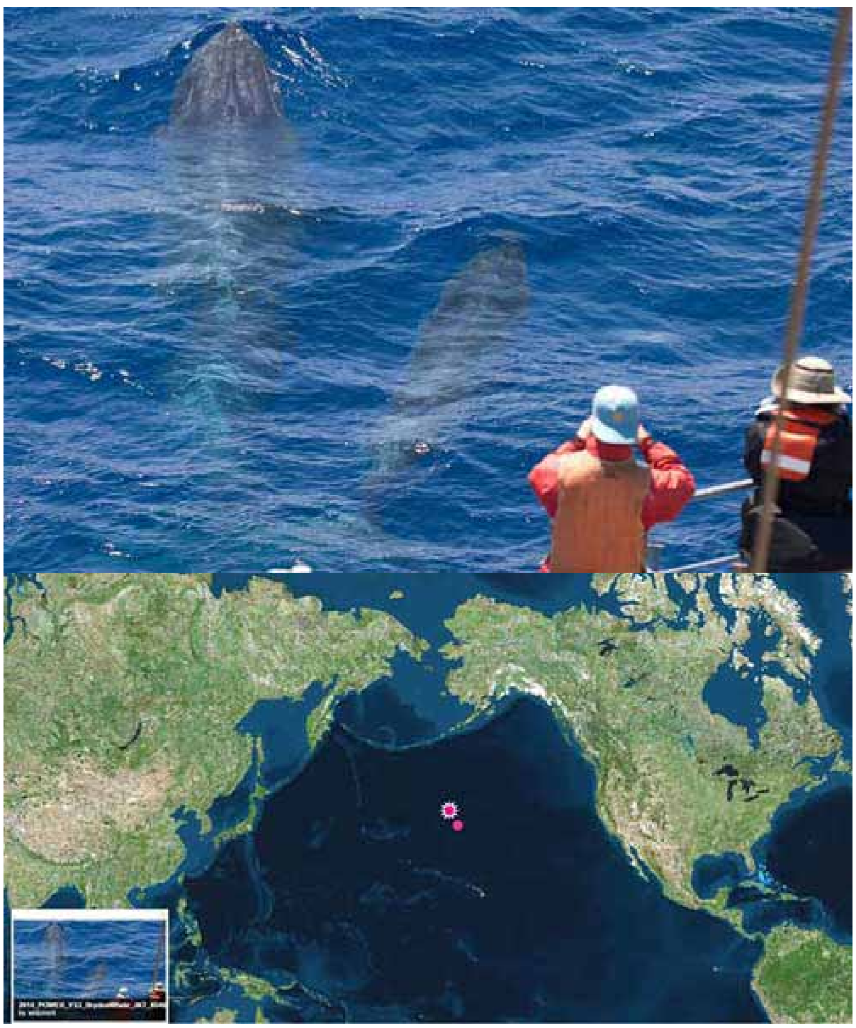


Figure 1. (Top) Photo of a Bryde's whale mother and calf taken from one of three different heights on the ship: a platform above the upper bridge. Photo by Jess Taylor. (Bottom) A map showing the location where the Bryde's whale mother and calf were photographed, using GPS data in the photos' EXIF metadata; the photo was uploaded to Flickr and the map is a snapshot of the Flickr screen image.

POWER cruises have been conducted each year from 2010 through 2014, and plans are underway to continue the surveys at least through 2016. This year's survey area was the central North Pacific Ocean from 30°N to 40°N latitude, between 170°E and 160°W longitude. A total of 21 people were on board the Yushin Maru No. 3, including cruise leader Koji Matsuoka (Institute of Cetacean Research); researchers Mizroch (CAEP), Isamu Yoshimura (Kyodo Senpaku), and Jess Taylor (IWC); and crew.

During POWER cruises, all baleen whales sighted within 3 nautical miles (nmi) perpendicular distance to the trackline are approached for species confirmation. During these close approaches, all efforts are made to collect biopsy samples if conditions permit.

Directed photo-identification approaches are conducted for priority species, such as blue whales, North Pacific right whales, and humpback whales. However, photo-ID data are collected opportunistically for all baleen whale species approached, including fin whales, sei whales, and Bryde's whales (Fig. 1). Data are also collected opportunistically for toothed whale species, including sperm whales, beaked whales, killer whales, pilot whales, and any dolphin species that come into view.

With very good weather conditions during the 2014 cruise, survey coverage in the study area was 83.4% of the planned tracklines for a total of 3,233 nmi of trackline surveyed on effort.

Sightings included: blue whales (1 group/1 individual); sei whales (1/1); Bryde's whales (118/140); sperm whales (78/155); Cuvier's beaked whales (6/13); unidentified *Mesoplodon* species of beaked whales (8/19); unidentified *Ziphiid* species of beaked whales (39/86); killer whales (1/3); southern form of short-finned pilot whales (2/12); Risso's dolphins (8/140); bottlenose dolphins (3/69); spotted dolphins (6/436); striped dolphins (5/420); and short-beaked common dolphins (4/1,747).

Photo-ID data were sufficient to catalog 1 blue whale, 69 Bryde's whales, 2 sperm whales (a mother and calf), all the individuals in a pod of 3 killer whales, 1 pilot whale, and 14 Risso's dolphins.

A total of 80 biopsy (skin and blubber) samples were collected. Biopsy samples were collected from 78 individual Bryde's whales, including six mothers and calves: samples were collected from both the mother and calf in four encounters, the mother only in one encounter, and the calf only in one encounter. A solitary blue whale was sampled, as well as one killer whale (the male in the pod of three individuals).

Figure 2. Bottlenose dolphins in the pelagic North Pacific. Photo by Sally Mizroch.

Figure 3. Common dolphins: normal pigmentation (right) and a color morph described by Perrin in 1995 (left). Photo by Sally Mizroch.

Figure 4. Sperm whale mother and calf. Photo by Sally Mizroch.

In 2014, three photographers photographed each close approach: Mizroch photographed from the bow deck and shot at 10 frames per second to try to capture the exact "hit" position of each biopsy dart and to opportunistically capture any photo-ID shots; Jess Taylor photographed from a platform above the upper bridge to capture photo-ID shots and document biopsy hit positions; and Koji Matsuoka photographed from the crow's nest to capture full body shots of whales, as well as biopsy hit locations and photo-ID shots.

In 2014, as in 2011 and 2012 (surveys in which Mizroch also participated), all of the POWER photos were geotagged; however, in 2014, the photos were geotagged automatically using a GPS logger attached directly to each camera.

At the end of each survey day, photos from all three cameras were integrated and transferred to folders labelled with the day's date and line-transect sighting number. An informative encounter number that included information abouth the cruise (POWER) and the ship (YS3) plus the sighting number, for example, 2014_POWER_ YS3_20140731_23, was batch edited into the "Image Description" EXIF metadata field of each photo in each folder.

Photographs were evaluated each evening to determine if there was sufficient detail to assign a catalog number to individual whales. All cataloged photographs were labelled with an annual catalog number in the "Artist" EXIF metadata field, and the body part used to identify the individual (e.g., LD for left dorsal) was typed into the "Copyright" EXIF metadata field. For each successful biopsy encounter, photos of the biopsy hit were labelled with the biopsy sample number and shooter name, and then the photos were evaluated jointly with the biopsy sample manager to determine the "hit position" to enter on the biopsy data form.

When all the photo labelling was complete, the daily photographs were backed up each night to three hard drives using a high-speed, hard-drive dock (155 Mb/sec). Each photographer was able to review all of the integrated photos each day and then adjust camera settings (ISO, shutter speed, zoom level) in subsequent photos, if necessary, to complement photos taken by the other photographers.

In addition to the many thousands of spectacular Bryde's whale photos taken during the survey (Fig. 1), a number of other interesting species were documented in the middle of the North Pacific: for example, three groups of bottlenose dolphins in a pelagic region far from other known sightings of this species (Fig. 2); a number of common dolphin groups, including some of the classic color morphs described by Perrin in 1995 (Fig. 3); and a sperm whale mother and calf (Fig. 4).

Resource Ecology and Ecosystem Modeling Program

Fish Stomach Collection and Lab Analysis

During the third quarter of 2014, the stomach contents of 5,066 groundfish were analyzed in the Resource Ecology and Ecosystem Modeling (REEM) program's food habits laboratory and out at sea. Data were error-checked and loaded into the AFSC's Groundfish Food Habits database, resulting in 8,677 added records. The majority of the samples analyzed during the quarter were core predator species – walleye pollock, Pacific cod, arrowtooth flounder, Pacific halibut, Atka mackerel, and Pacific ocean perch – analyzed at sea during the AFSC's groundfish trawl survey in the Aleutian Islands. The stomach contents of 32 species from the northern Bering and Chukchi Seas were analyzed in the laboratory. Stomach samples from core predator species were collected in the eastern Bering Sea during the groundfish trawl survey (5,817) and by fisheries observers during commercial fishing operations (722).

By Troy Buckley, Geoff Lang, Mei-Sun Yang, Richard Hibpshman, Kimberly Sawyer, Caroline Robinson and Sean Rohan

Ecosystem Considerations

Stephani Zador completed the first public version of the 2014-15 Ecosystems Considerations for the Ground Stock Assessment and Fisheries Evaluation Report (SAFE) and presented results to the North Pacific Fisheries Management Council's Bering Sea/Aleutian Islands, Gulf of Alaska, and Crab Plan Teams in September. Thirty-one indicator updates were received and published in this report. North Pacific climate conditions were reported along with biological indicators for the eastern Bering Sea (EBS) and Gulf of Alaska (GOA).

The North Pacific showed a weak Aleutian low last winter, with positive sea surface temperature (SST) anomalies south of Alaska and a transition of the Pacific Decadal Oscillation (PDO) to positive. A weak to moderate El Niño is also forecast. A "blob" of warm water in the North Pacific led to the warmest SST anomalies for the GOA on record. The Transition Zone Chlorophyll Front was 240km north of normal, which impacts the distribution of subarctic animals. However, conditions were also anomalously upwelling-favorable in the GOA, which kept the coasts of the GOA from experiencing the higher temperatures.

During the EBS groundfish survey, average bottom and surface temperatures were warmer than average. A wind-drift model shows unfavorable indications for flatfish recruitment from 2012 to 2014, although that relationship has broken down a bit in recent years. Euphausiid abundance was lower in 2014 (similar to 2004 levels). A new regime shift indicator shows the salmon indicator shifting to negative in 2009.

Zooplankton in Southeast Alaska and Icy Bay were anomalously low throughout the summer in 2013. Continuous Plankton Recorders in 2013 yielded smaller copepods, larger mesozooplanton biomass, and greater abundance of large diatoms in warm waters in the Alaskan Gulf. Small mesh trawl surveys along the south coast of the Alaska Peninsula and near Kodiak Island resulted in low catches of herring and pink salmon; juvenile pollock were found in the greatest numbers seen since 1979. Herring biomass peaked in 2011 and has declined since. The strong 2013 year-class of pink salmon indicates a projected increase in sablefish numbers. The fish stock sustainability index shows that no stocks are currently subject to overfishing in the GOA or EBS. For non-target catch, jellyfish show alternating high and low years; seabird bycatch has declined from historic levels and has leveled off to much lower levels in the past 5 years. Total discards in the pollock trawl fisheries appear to be decreasing as well.

By Kerim Aydin and Stephani Zador

Seabird Bycatch Monitoring

In September 2014, there was an incidental take of an endangered short-tailed albatross in the hook-and-line groundfish fishery of the Bering Sea/Aleutian Islands, and the take of a second unidentified albatross in the same haul, the identity of which will be evaluated after the fishery observer debriefing. The last three documented short-tailed albatross takes in Alaska were in August 2010, September 2010, and October 2011. Shannon Fitzgerald coordinated the response to this incident with the NMFS Alaska Regional Office, the North Pacific Groundfish Observer Program, and the U.S. Fish and Wildlife Service. The confirmed short-tailed albatross had a leg band identifying its natal breeding colony in Japan and was 5 years old.

By Kerim Aydin and Shannon Fitzgerald

Multispecies Modeling

Kirstin Holsman attended the International Council for the Exploration of the Sea (ICES) Annual Science Conference on 15-19 September 2014 in A Coruña, Spain, to present her talk titled "Reading the crystal ball: using climate-specific multispecies models to evaluate future harvest." At the meeting she also met with scientists from other countries and universities, as well as NOAA regional offices, to discuss climate change, multi-species stock assessment models, and integrated ecosystem assessments. She will continue these collaborations through participation in ICES working groups, including remotely attending the ICES multispecies stock assessment working group meeting (chaired by Daniel Howell) in October.

By Kirstin Holsman

Economics & Social Sciences Research Program

Gulf of Alaska Trawl Fishery Social Survey: Preliminary Results

The North Pacific Fishery Management Council is considering implementing a new bycatch management program for the Gulf of Alaska groundfish trawl fishery. Any change in how the fishery is managed will likely affect the people and communities participating in the fishery. In anticipation of such changes, the Alaska Fisheries Science Center developed a survey to collect baseline information about the social dimensions of the fishery. Data were collected before program implementation in order to provide a baseline description of the industry as well as to allow for analysis of changes the bycatch management program may bring for individuals and communities once implemented. Having a detailed baseline description will allow for a greater understanding of the social impacts the program may have on the individuals and communities affected by the new management program. When combined with data to be collected in planned post-program implementation follow-up surveys, this information will inform changes in the social characteristics over time and assist in a more comprehensive program evaluation and more informed consideration of potential post-implementation modifications of the program, if needed. Additionally, the survey asked for opinions on a range of elements that may or may not be included in the final bycatch management program to assess different participant's preferences for various management options, which may change over time as well.

Data were collected using a multiple methods approach in order to obtain the highest response rates possible and to make the survey available to a wide variety of respondent types. Fieldwork was completed in Kodiak, Sand Point, King Cove, Seattle, and Petersburg in an attempt to maximize the use of in-person survey administration, given budget constraints. The survey was conducted with participants in the Gulf of Alaska groundfish trawl fishery, including vessel owners, vessel operators, groundfish vessel crew, catcher/processor owners, catcher/processor crew, shoreside and inshore floating processors, and tender owners and operators. The study also included other individuals who are stakeholders in the trawl fishery including any businesses that are directly tied to the groundfish trawl industry through the supply of commercial items, including but not limited to gear suppliers, fuel suppliers, and equipment suppliers. The results of the survey highlight the differences in the people, sectors, and communities engaged in the fishery. Data from the survey demonstrate how different individuals and sectors depend on the Gulf of Alaska groundfish trawl fishery to sustain their businesses and families and how they may be interconnected with one another. We will be presenting preliminary results of the 2014 survey at the October North Pacific Fishery Management Council (NPFMC) meeting. The full preliminary analysis report can be found on the NPFMC's October 2014 agenda, item C-7.

By Amber Himes-Cornell and Stephen Kasperski

A Unified Framework to Estimate Fish and Crab Prices

The Economic and Social Sciences Research (ESSR) program is developing new methods to estimate fish and crab prices. Primary economic data for Alaska fisheries consists of revenues and quantities from a census dataset (e.g., fish tickets). These data are used for a variety of purposes including the calculation of "standard" ex-vessel prices to assess observer fees. The standard method is non-statistical; it simply adds up revenues and quantities and uses the ratio of these totals to define the standard price. We extended the standard method to calculate statistics such as the standard ratio-of-means (RoM), mean-of-ratios (MoR), and ordinary least-squares (OLS) estimates of the price. All three are quantity-weighted averages but there are non-trivial differences in the prices calculated depending on the procedure. For example, the RoM and MoR are not equal except if complete symmetry prevails and all production units are equal, which is not realistic. When the dataset is a census of the population, what does the application of these ratio-based calculations (and others) imply about the relationship between aggregate value and quantity? These and other estimators can be compared within the context of a statistical framework by hypothesizing a super-population. An advantage of a statistical framework is that we can determine the statistical properties of price estimates. For example, if the assumptions for OLS regression are satisfied then the coefficient on quantity is an unbiased estimate of the marginal change in revenues with respect to quantity, i.e., the price. In addition, a statistical framework gives us tools to evaluate uncertainty in price estimates. In this case, the notion that the actual price paid in the market is random with a distribution is more consistent with Bayesian framework, in contrast to classical regression where quantity is related to value through a constant but unknown price. We are currently developing methods of Bayesian price estimation.

By Mike Dalton and Ben Fissel

Status of Stocks & Multispecies Assessment Program

REFM Staff Participate in the American Fisheries Society Annual Meeting

REFM staff traveled to Quebec City, Canada, 18-21 August 2014 to give presentations and engage in discussions at the American Fisheries Society (AFS) annual meeting. Carey McGilliard (Status of Stocks & Multispecies Assessment (SSMA) program) gave a talk titled "Accounting for Scientific Uncertainty in Stock Assessments: an Exploration using Management Strategy Evaluation" in the session "The Next Generation of Stock Assessments." In her presentation Carey explained that quantifying scientific uncertainty is a key part of providing scientific advice in fisheries management. She reported that management systems increasingly require that catch limits account for scientific uncertainty by specifying a buffer such that the catch limit is lower than that determined based on an assumption of perfect information. She described a "P* approach," which is a method whereby a catch limit is specified such that the probability that a future fishing mortality rate (F) exceeds the F corresponding to maximum sustainable yield (MSY) (FMSY) remains at or below a pre-specified value (P*). She developed a management strategy evaluation to examine the performance of a "P* approach" that included accounting for model configuration uncertainty, with application to Alaska groundfish. Her results showed that including model configuration uncertainty about natural mortality better accounts for uncertainty in limit reference points, such as FMSY and FOFL. In addition, she found that accounting for even a small amount of model configuration uncertainty about natural mortality substantially changed the probability of overfishing associated with a given catch level.

Mei-Sun Yang (REEM program) presented the poster "Digital Images, a Stomach Examiner's Tool (SET) on Line" in the symposium "Community Ecology and Trophic Interaction of Fishes." The poster showed that after 30 years of stomach contents processing, the REEM program has accumulated abundant taxonomical information that is useful for the stomach contents analysis. In addition, REEM program scientists have recorded the taxonomical information of whole specimens with digital cameras, as well as partially digested specimens, gill arches, vertebrae, postcleithrum, otoliths, telson of crustaceans, subopercle and preopercle of fish, and setae of polychaetes. With this information soon online , stomach examiners will be able to access taxonomical information fast and easily. The objective of the Stomach Examiner's Tool (SET) website is to provide comprehensive information as a guide for stomach content examiners to identify items in fish stomachs. To date, there are 552 pictures on the SET online.

Liz Conners and Libby Logerwell (SSMA program) made presentations in the symposium "Marine Mammal and Fisheries Interactions : Management Challenges in a Changing World." Liz's talk was "Spatial Scale and Fish Movement As Key Factors for Interaction Between Marine Mammals and Commercial Fisheries." She presented new results of simulation modeling of differing levels of spatial overlap between fish concentrations, fisheries, and a central-place predator (such as Steller sea lion) foraging. For static prey populations, she showed that localized depletions from fishing can affect predator foraging. With mobile prey populations, however, there were many conditions where no interaction occurs. Libby's talk was titled "The Fishery Interaction Team (FIT): A Decade of Research on the Indirect Interactions Between Fisheries and Marine Mammals". She described FIT's major field efforts to investigate the localized impacts of commercial fishing on walleye pollock, Pacific cod and Atka mackerel. She explained that FIT field research to date indicates that competition between fisheries and higher trophic level predators such as Steller sea lions can occur but that issues of scale, fish movement, fish behavior, and experimental methodology need further attention. Furthermore, explicit links between fishing, predator foraging behavior and predator population parameters are lacking.

By Libby Logerwell

Age & Growth Program

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 30 September 2014. Total production figures were 30,871 with 7,380 test ages and 407 examined and determined to be unageable.

Species	Specimens Aged
Alaska plaice	539
Arctic cod	2,032
Arrowtooth flounder	904
Atka mackerel	1,019
Blackspotted rockfish	538
Dusky rockfish	73
Flathead sole	1,735
Greenland turbot	493
Harlequin rockfish	255
Kamchatka flounder	686
Northern rock sole	1,330
Northern rockfish	880
Pacific cod	1,351
Pacific ocean perch	1,615
Saffron cod	1,004
Walleye pollock	11,908
Yellowfin sole	1,481

By Jon Short

A 200-Year Archeozoological Record of Pacific Cod Life History as Revealed Through Ion Microprobe Oxygen Isotope Ratios in Otoliths

Pacific cod is an abundant marine fish species inhabiting the Alaska continental shelf whose importance for food spanned centuries from modern industrial fisheries back to traditional subsistence use by Alutiiq communities. Alutiiq residents of the remote Kenai coast settlements were referred to as *Unegkurmiut* or "people out that way" by the other more densely settled inhabitants around the Kodiak archipelago. Subsistence artifacts recovered at the Early Contact Village (~1785-1820) and Denton (~1850-1890) Kenai archeological sites consisted of arrowheads and darts, shouldered lance points, adzes, and fish hooks. Archeological recovered fish hooks, museum examples of fishing equipment, and ethnohistoric records indicate that the Alutiiq subsistence effort focused on adult Pacific cod in waters approximately 30-50 m deep. Large samples of bone and otoliths confirm the importance of Pacific cod in their diet. Intact fossilized Pacific cod otoliths found at archeological sites in the Gulf of Alaska (GOA) provided a unique opportunity to explore the interactions between climate and fish populations on temporal scales not typically available to modern ecologists. Using otoliths recovered from the Early Contact Village and Denton archeological sites dated from 200+ and 100+ years before present (YBP) along with modern collections in Aialik Bay, Alaska (Fig. 1), we analyzed oxygen isotope ratios ($\delta^{18}O$) to reconstruct the near-shore temperature regime and Pacific cod habitat use in the GOA since the Little Ice Age (1350-1850).

Nine Pacific cod otoliths (3 from 200+ YBP sites, 3 from 100+ YBP sites, and 3 from modern caught (2004) fish in Aialik Bay) were thin sectioned, polished, and gold coated in preparation for microsampling using the WiscSIMS (University of Wisconsin, GeoSciences) ion microprobe (Fig. 2). The Ion Microprobe-Secondary Ion Mass Spectrometer (SIMS), funded by the National Science Foundation, was used to explore new applications of *in situ* analysis of stable isotope geochemistry. The advantage offered by the IMS-1280 ion microprobe coupled with the SIMS over conventional isotope mass spectrometry is the dramatic reduction in analysis spot sizes; from 1 to 10 micrometers. In particular, recent developments in the analytical capabilities of the WiscSIMS ion microprobe, a focused ion beam coupled with a double-focusing mass spectrometer, have allowed *in situ* analysis of otoliths on sub-annual, even daily, time scales. The ion microprobe can analyze discrete samples (~ 2 ng) that are thousands of times smaller than those required by conventional acid digestion/gas-source mass spectrometry (10-100 µg). The increased spatial resolution (sample diameter = 10 µm with depth of ~1 µm) allows for finer temporal resolution of measurements while maintaining high accuracy and precision.

Full life-history transects comprising between sixty to eighty 10-micron spot samples from the otolith core (juvenile stage) to edge (adult stage) were sampled with the ion microprobe (Fig. 2) and values $\delta^{18}O$ measured from a secondary ion mass spectrometer were plotted as ‰ relative to Vienna PDB standard. Measured $\delta^{18}O$ was converted to temperature using a fractionation equation developed from ion microprobe analysis of seven modern Pacific cod otoliths from which *in situ* bi-hourly temperature and depth records were recorded in electronic archived tags (Fig. 3). Specifically, spot samples of measured $\delta^{18}O$ that were sampled near the outer edge of the otolith representing the aragonite material accreted during the period at liberty were regressed with average monthly *in situ* instrumental temperatures. The fractionation equation was used to predict the thermography of Pacific cod's life history from spot samples over the entire transect and to reconstruct near shore Gulf of Alaska temperatures from spot samples taken within the otolith core.

We obtained sample densities along a linear transect that were at least 2 to 3 times greater than micromilling/conventional mass spectrometry techniques with high spot-to-spot analytical precision ($\delta^{18}O$ ±0.3‰). Measured values of $\delta^{18}O$ were typically lower near core samples

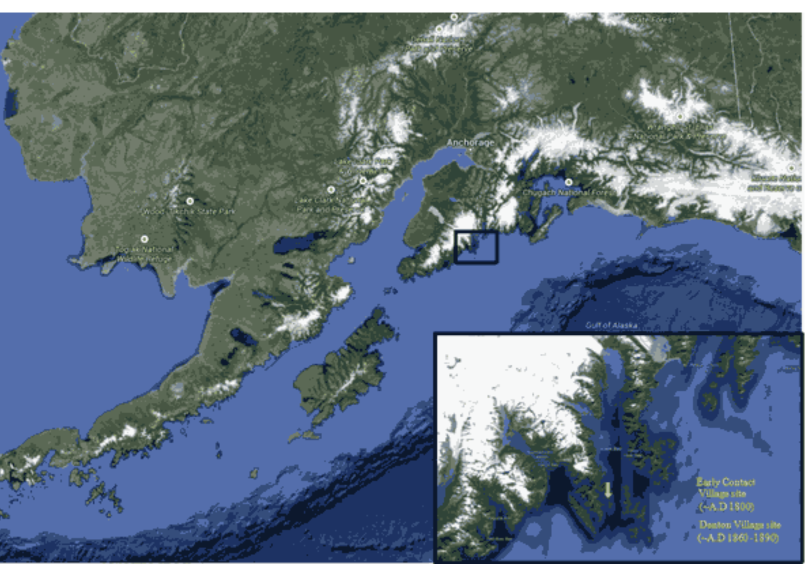


Figure 1. Location of recovered Pacific cod otoliths at two archeological sites in Aialik Bay, Alaska.

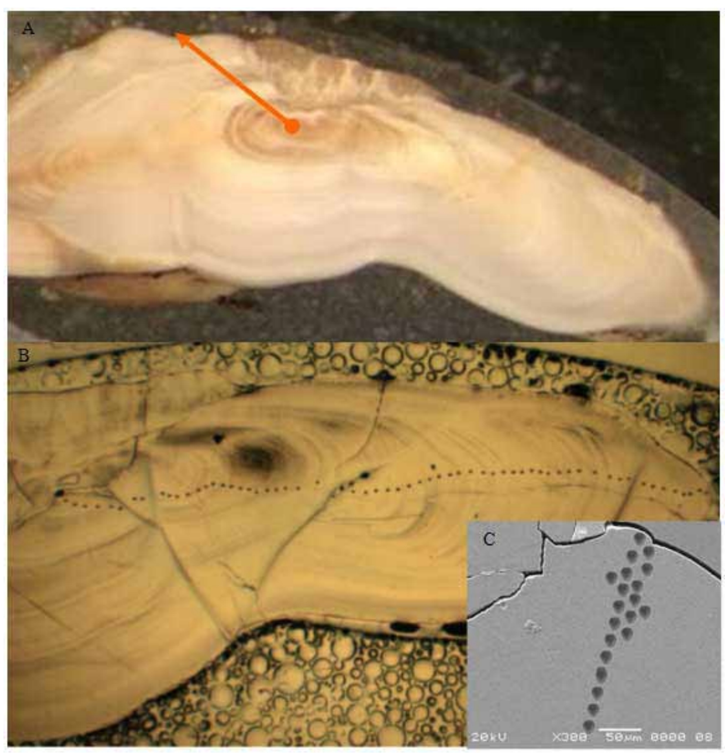


Figure 2. Thin sectioned Pacific cod otolith (A) recovered from 200+ year old archeological site in Aialik Bay, Alaska. WiscSIMS ion microprobe spot samples from otolith core to edge (B). Electron micrograph (C) shows high spatial sampling resolution of spot samples.

(-4.08 to -2.21 ‰ PDB) than spot samples near the otolith edge (0.52 to 1.44 ‰ PDB) (Fig. 4). Rapid rise in of $\delta^{18}O$ after the first year of life followed by higher but cyclical $\delta^{18}O$ concentrations reflect ontogenetic migratory behavior from warmer near-shore habitat during the first year of life to cooler deeper waters at later ages (Fig. 4). Predicted temperature of Pacific cod habitat use, estimated from the fractionation equation from archive tagged Pacific cod (Fig. 3; r=0.75, p<0.001), show a thermography consistent with what is known about migratory behavior. A decline in the average $\delta^{18}O$ of core spot samples from archeological (200+, 100+ YBP) to modern otoliths suggest increasing sea surface temperatures from the late Little Ice Age to present. Temperatures calculated from the $\delta^{18}O$ in aragonite suggest a 2°-3°C rise in coastal marine sea surface temperatures in the Gulf of Alaska over the last 200 years (Fig. 5).

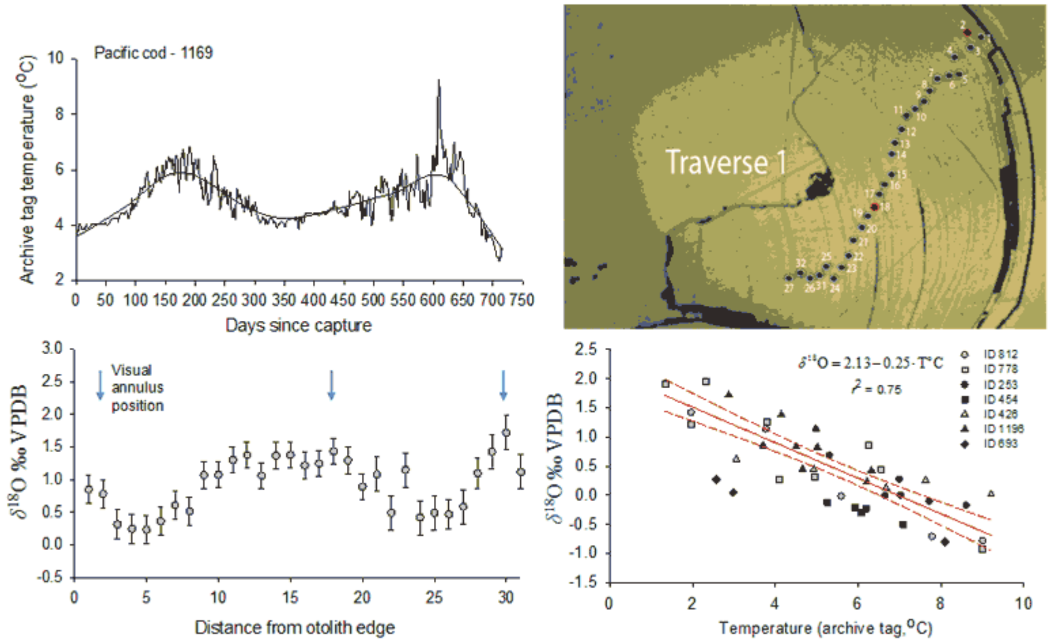


Figure 3. Sequence of ion microprobe spot samples measuring stable oxygen isotopes $\delta^{18}O$ (‰ VPDB, ±2 S.D.) made at WiscSIMS from a traverse sectioned Pacific cod tagged with an electronic data logger (temperature and depth) and at liberty for 716 days. Spot samples 1-31 were sampled near the outer edge of the otolith and represented the aragonite material accreted during the period at liberty. As expected, relationship between Pacific cod otolith aragonite ($\delta^{18}O$) and bottom temperature showed an inverse, statistically significant linear relationship (r=0.75, p<0.001).

High resolution sampling for $\delta^{18}O$, using tools such as the ion microprobe, provides a unique perspective on Pacific cod biogeography and migratory behavior, showing habitat preference for warmer near-shore water during early life stages followed by migration to cooler deeper water. This life history strategy has not appeared to have changed over the past 200 years. Near-shore temperatures in the Gulf of Alaska, inferred through archeological and modern $\delta^{18}O$ samples from Pacific cod otoliths, appeared to have increased since the late Little Ice Age. The difference of about 2°-3°C cooler around the decade 1800 A.D. from otolith $\delta^{18}O$ is consistent with tree-ring derived estimates of cooler air temperature during the same period. Next steps will be to conduct microprobe sampling on Pacific cod otoliths recovered from even deeper strata at the Kenai archeological sites dating to over 1,000 YBP. Studies of fish otoliths recovered from archeological sites and analyzed with innovated tools such as the ion microprobe, provide a window into the past that opens our understanding of climate change, fish populations, and human resource utilization of the Alaska region over the past thousand years.

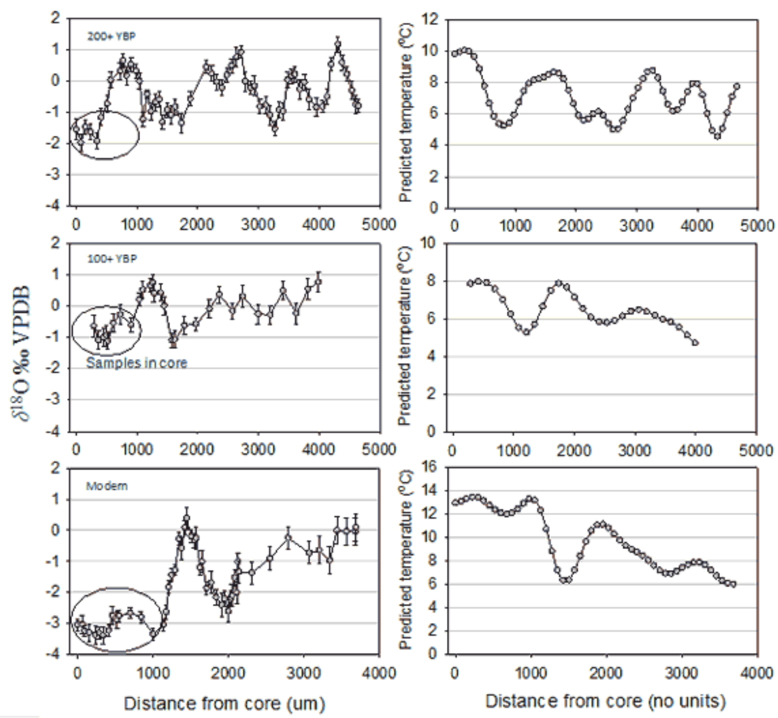


Figure 4. Sequence of ion microprobe spot samples from otolith core to edge measuring stable oxygen isotopes $\delta^{18}O$ (‰ VPDB, ±2 S.D.) made at WiscSIMS with predicted temperatures estimated from fractionation equation. Circles show spot samples within the otolith core used to reconstruct near shore temperature change since Little Ice Age.

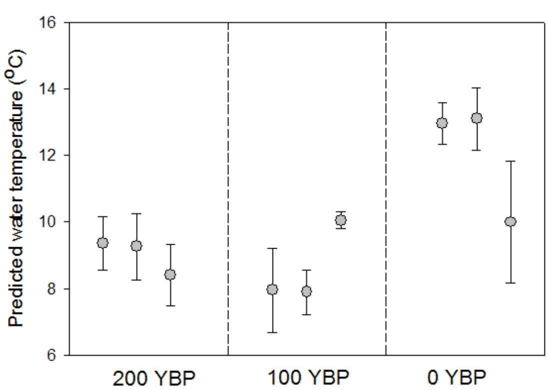


Figure 5. Predicted near shore water temperature since the Little Ice Age (200+ YBP) to modern times from 9 Pacific cod otoliths (six of which were recovered from archeological sites and dated to 200+ and 100+ YBP) sampled for stable oxygen isotopes $\delta^{18}O$. Temperature was reconstructed from fractionation equation.

By Thomas Helser and Craig Kastelle

Otolith Sclerochronology Reveals Effects of Climate on Growth of Pacific Ocean Perch

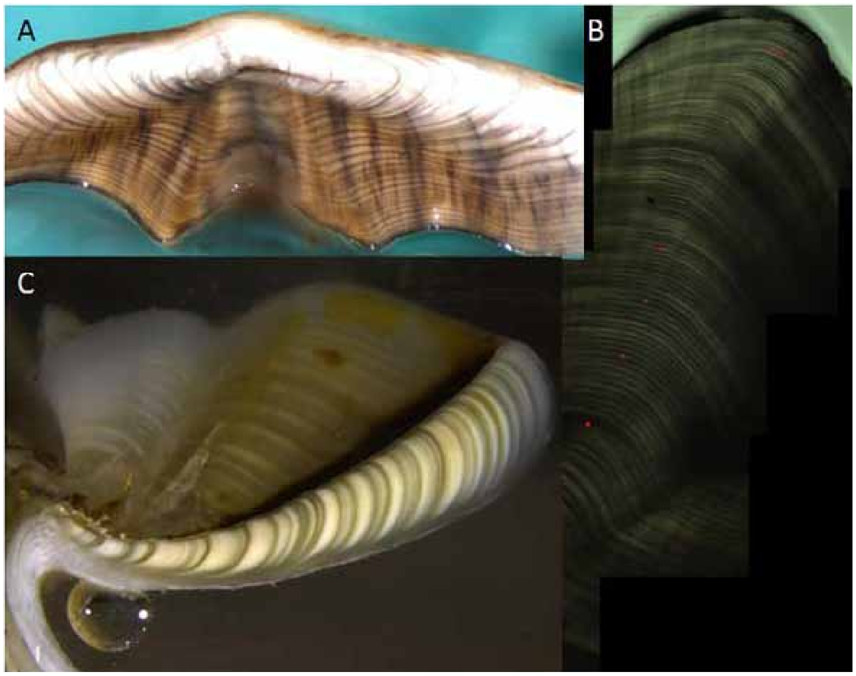


Figure 1. Thin sections of otoliths from yellowfin sole (A) and Pacific ocean perch (B) and shells of Arctic surf clam (C) showing annually resolved growth increments. These increment widths are being measured and used to develop chronologies of growth (sclerochronologies) as a measure of ecosystem productivity.

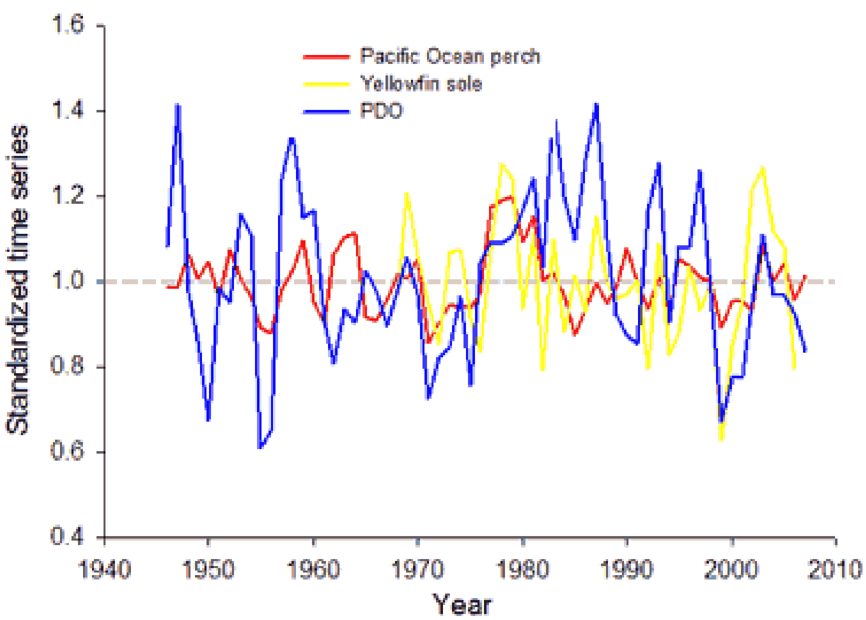
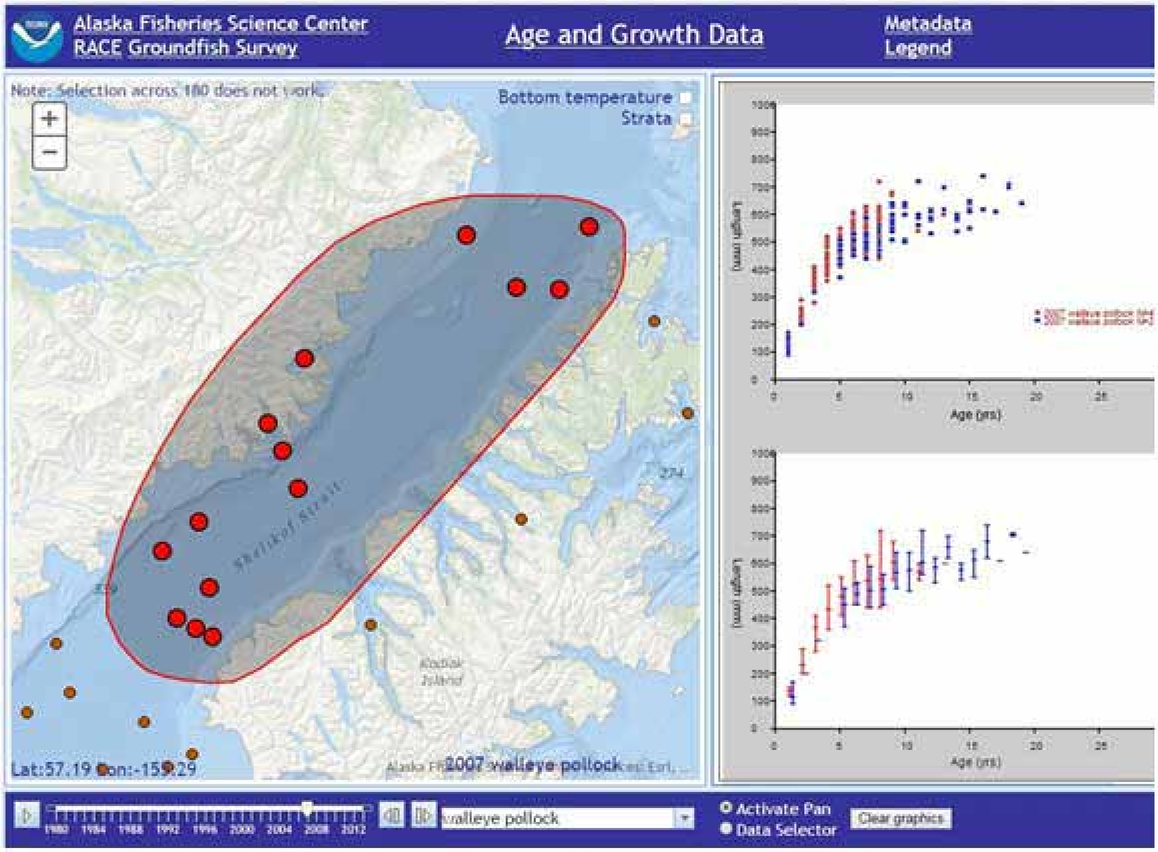


Figure 2. Standardized time series of annually resolved yellowfin sole (yellow line) and Pacific ocean perch (red line) growth increments in the Bering Sea along with the Pacific decadal oscillation (PDO, blue line). Deviations above unity indicate growth is better than average suggesting that growth of these species is generally coherent with the PDO.

Time series datasets of growth derived from otoliths and other hard parts have become an increasingly important tool to describe impacts of climate on marine ecosystems. Borrowing methods from the tree-ring science of dendrochronology, these marine sclerochronologies can provide insight into the effects of climate change on interannual variation in growth as well as act as proxies for environmental variables such as temperature, for which long-term instrumental records are often unavailable. The AFSC's Age and Growth Program in collaboration with researchers at the University of Texas are developing a new multi-species sclerochronology based on growth-increment measurements of Bering Sea species at different functional levels in the ecosystem. Our goal is to develop climate indicators based on otoliths from yellowfin sole (Fig. 1a) and Pacific ocean perch (Fig. 1b), as well as shells from Arctic surf clams (Fig. 1c), and "measure" the sensitivity of these sentinels to climate variability and ecosystem forcing. Each species' chronology (time series) is annually resolved and provides a "down looking" integration of ecosystem productivity as it cascades up through multiple trophic levels.

Published results of the Bering Sea yellowfin sole (YFS) chronology, which span half a century (Fig. 2), reveal accelerate growth of this species during years of significant ice retreat and warmer bottom temperatures. Building upon these findings, we have developed a biochronology for Pacific ocean perch (POP) which currently spans the years 1946 to 2006 (Fig. 2) and is by far the oldest sclerochronology developed to date in Alaskan waters. Significant positive correlations were detected between the POP chronology and the Multivariate ENSO Index (MEI), the Pacific Decadal Oscillation (PDO), and sea surface temperature, and negative correlations were detected between the chronology and spring sea ice cover, all indicating that warm conditions are important for growth. Climate regime shifts, such as the well documented events in 1976-77 and 1988-89 were strongly evident in the growth increment widths of both YFS and POP. Our next steps are to extend the YFS and POP chronologies back to the turn of the century using archived otolith specimens, develop a chronology for Arctic surf clams (which appear to live 50-60 years), and integrate these with other indicators such as seabird productivity in the Bering Sea.

By Beth Matta
and Thomas Helser



New Age and Growth Program Mapping Tool is Online

Ever wonder if walleye pollock born during the Carter administration have the same average length-at-age as pollock born during the Bush administration? Do southern rock sole grow faster than northern rock sole? Do pollock from Shelikof Strait live longer than pollock from Nagai Strait? These questions and more can be answered on the AFSC Age and Growth Interactive Mapping Application. Draw circles around haul locations and have an age-length scatterplot and a mean length-at-age automatically graphed. Multiple areas and years of collection can be selected and color coded for comparing fish growth. Data collected over 30 years is available for 40 different species of groundfish from the Bering Sea, Aleutian Islands, and Gulf of Alaska. New age data is added semiannually, typically in April and October.

By Jon Short

Data collected over 30 years is available for 40 different species of groundfish from the Bering Sea, Aleutian Islands, and Gulf of Alaska.

Age and Growth Program Uses Otolith Shape to Identify Blackspotted and Rougheye Rockfish

Black spotted (*Sebastes melanostictus*) and rougheye rockfish (*Sebastes aleutianus*) are large, red, viviparous rockfish found in the North Pacific Ocean with a contiguous distribution along the west coast from California up around the Gulf of Alaska and across the Aleutian Islands and eastern Bering sea. They were considered to be one species until recently when they were genetically identified as two.

In 2009 and 2013 NOAA scientists collected tissue samples (i.e., fin clips) and otoliths from field-identified blackspotted and rougheye rockfish. The tissue samples were genetically analyzed to test the accuracy of field identification. The otoliths were used by Age and Growth scientists to determine if otolith shape could separate the two species.

A logistic regression model was developed to discriminate the two species based on six otolith shape measurements and estimated age. The measurements were length, width, major axis, minor axis, perimeter, and area. The otoliths were aged as part of the Age and Growth program's regular production ageing process. It was noticed that the size-at-age of the two species differed, and this was incorporated into the model.

The effect of age was found to be a significant factor in accurately identifying each species as seen in Figure 1. Using these parameters, a statistical model assigned a probability to each otolith that was used to determine whether it was a rougheye or blackspotted rockfish (Fig. 2). The model was then applied to a separate dataset to test its efficacy, and was found to still yield accurate results (Fig. 3).

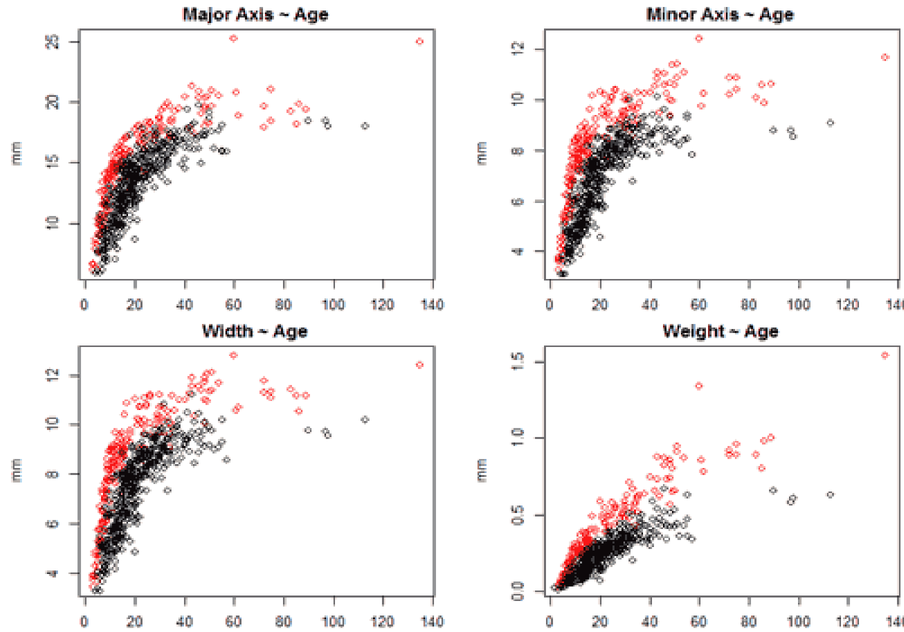
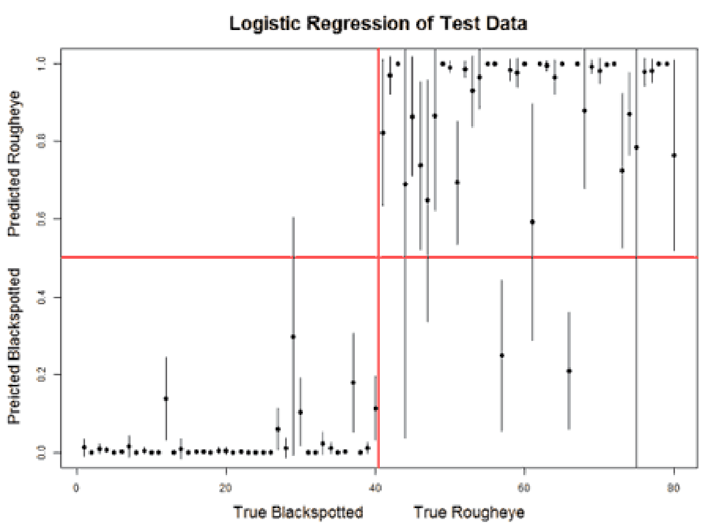


Figure 1. Plots showing several otolith metrics with respect to increasing age. Black circles represent blackspotted rockfish otoliths & red circles represent rougheye rockfish otoliths.

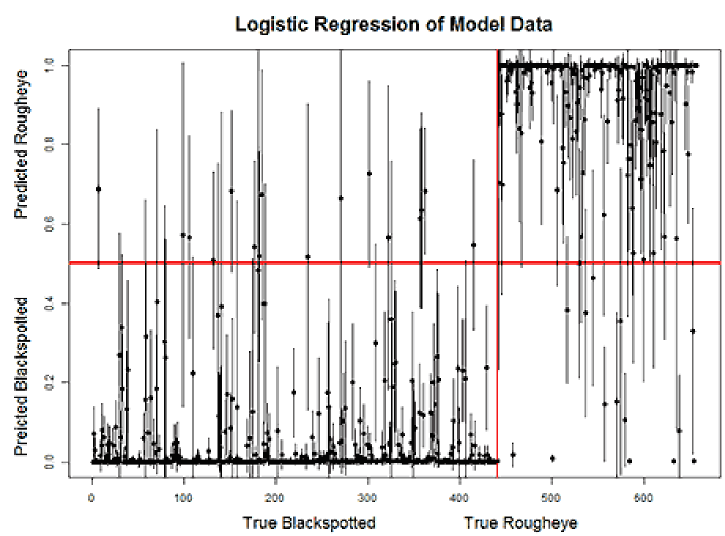
The Age and Growth program will implement otolith shape distinction for the following situations: to use as quality control with ongoing NOAA otolith collections; to separate the species from AFSC fishery observer collections; and to separate archived collections when the species were identified as one.

By Charles Hutchinson and Jeremy Harris



	N	Correct	Incorrect	Uncertain	Accuracy	Mis-IDed
Blackspotted	40	39	0	1	97.5%	0
Rougheye	40	34	2	4	85.0%	5.0%

Figure 2. Graph showing estimates for each otolith. Otoliths with a probability less than .5 are assigned to blackspotted and those above .5 are identified as rougheye. If the 95% confidence interval around an estimate crosses the .5 threshold, then the otolith is classified as uncertain. The true genetic identity of each specimen is shown on the horizontal axis, with blackspotted rockfish to the left of the vertical line, and the identity predicted by the model is shown on the vertical axis.



	N	Correct	Incorrect	Uncertain	Accuracy	Mis-IDed
Blackspotted	441	409	1	31	92.7%	0.2%
Rougheye	216	188	9	19	87.0%	4.2%

Figure 3. The same procedure from figure 2 is applied to a new data set to independently validate the results.

Age Validation of Northern Rockfish and Yellowfin Sole with Bomb-Produced ^{14}C

Accurately ageing fish is often a difficult task. The routine method used to estimate fish age is by counting presumed annual growth zones in cross sections of fishes' otoliths (Fig. 1). Otoliths are small, calcium carbonate stone-like structures in the inner ear of fish. The interpretation and counting of otolith growth zones is not always clear and can require subjective decisions. The impacts of systematic errors in counting growth zones include difficulty in estimating stock-recruitment relationships, unrealistic fish growth estimates, and population forecasting inaccuracy. Therefore, validating the accuracy of estimated fish ages is a critical step in determining the reliability of age data used in stock assessments.

Northern rockfish (*Sebastes polyspinis*) has one of the most northerly distributions among the 60+ species of *Sebastes* in the North Pacific Ocean and are important to the commercial fishery in the Gulf of Alaska, where about 4,000 metric tons are caught by trawlers each year. Yellowfin sole (*Limanda aspera*) is one of the most abundant flatfish species in the eastern Bering Sea and is the target of the largest flatfish fishery in the United States. The Center's Age and Growth program routinely estimates age for these species by growth zone counts from an otolith cross section (Fig. 1). The maximum age is about 71 and 31 years of age for northern rockfish and yellowfin sole, respectively. Both species are assessed using age-structured population models. But how accurate are the age data?

To validate the ageing methods of growth-zone counts, we used a technique known as the bomb-radiocarbon assay. This method is based on the increase of in the atmosphere and surface layer of the ocean caused by above-ground testing of nuclear bombs during the late 1950s and 1960s. To apply this validation method, first a ^{14}C "reference chronology" (a time series of ^{14}C measurements from otoliths of known-age fish) is developed from 1-year-old juvenile fish collected during the era of marine ^{14}C increase (1950s to 1960s). The ^{14}C reference chronology is then compared to ^{14}C measured in otolith cores from adult test fish.

The otolith core is material deposited in the first year of life. If the bomb-produced increase of $\Delta^{14}C$ in both the reference and test chronology is synchronous, the growth zone ages are considered validated. This comparison assumes that the test and reference chronologies are based on biologically similar species that are from the same geographical area. Our goals were to 1) validate the accuracy of ages determined from otolith growth zone counts in northern rockfish and yellowfin sole and 2) expand our fish age validation abilities to species from the eastern Bering Sea (EBS) by developing a new reference chronology from EBS juvenile Pacific halibut.

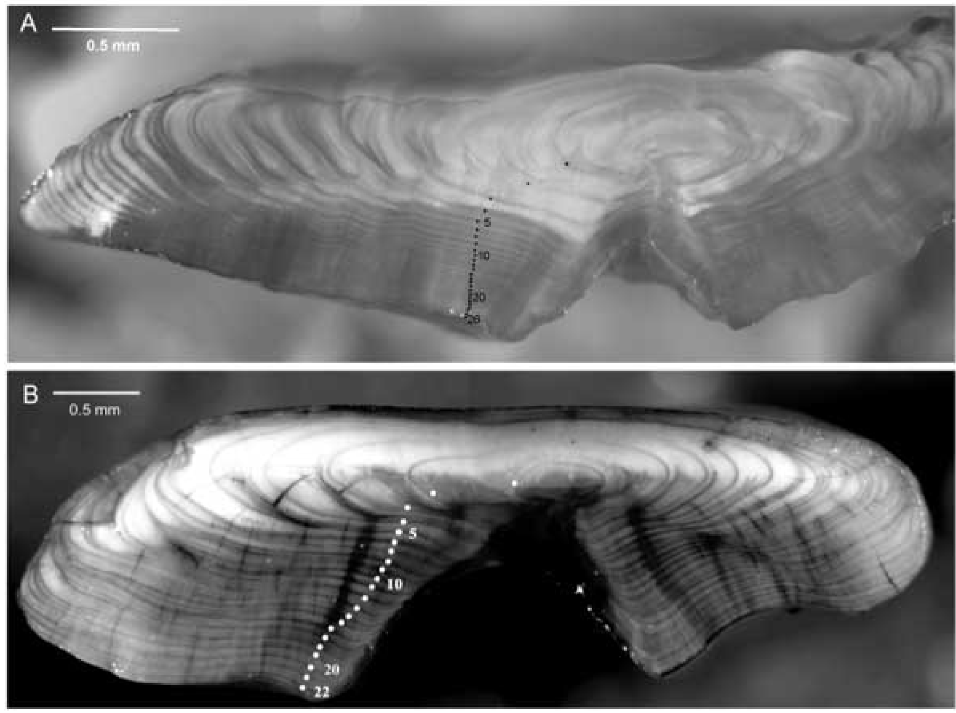


Figure 1. Northern rockfish otolith cross sections with presumed annual growth zones indicated (A). Yellowfin sole cross sections with presumed annual growth zones indicated (B).

Our test samples, northern rockfish and yellowfin sole otoliths, were collected during AFSC scientific trawl surveys or by NMFS fishery observers aboard commercial vessels. Specific specimens were chosen such that their posted birth years (based on catch year and estimated growth-zone age) were during the era of $\Delta^{14}C$ increase. The otolith's cores were removed, analyzed for ^{14}C, and reported here as $\Delta^{14}C$ ‰ (a standardized method of presenting radiocarbon results).

Two reference chronologies were used, one developed prior to our study using juvenile Pacific halibut collected in 1954–81 from the Gulf of Alaska (GOA) by the International Pacific Halibut Commission (IPHC), and second, our new reference from EBS juvenile Pacific halibut otoliths collected by the IPHC between 1956 and 1980 in our study (Fig. 2).

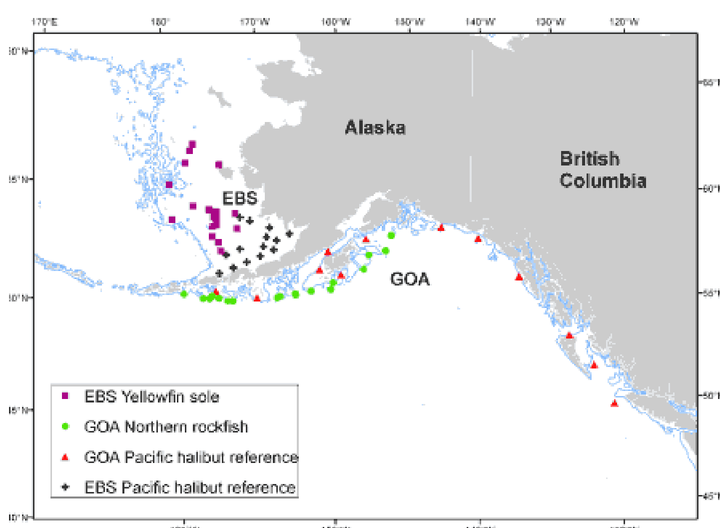


Figure 2. Map of collection locations for northern rockfish, yellowfin sole, eastern Bering Sea halibut reference, and Gulf of Alaska halibut reference.

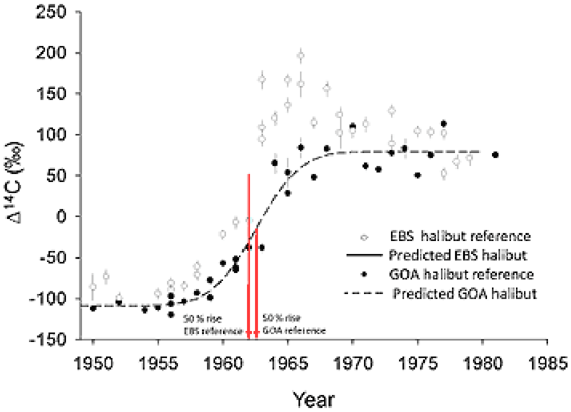


Figure 3. Eastern Bering Sea halibut reference, individual samples and predicted model, and eastern Bering Sea yellowfin sole test samples, individual samples and predicted model (A). Gulf of Alaska halibut reference, individual samples and predicted model, and Gulf of Alaska northern rockfish test samples, individual samples and predicted model (B).

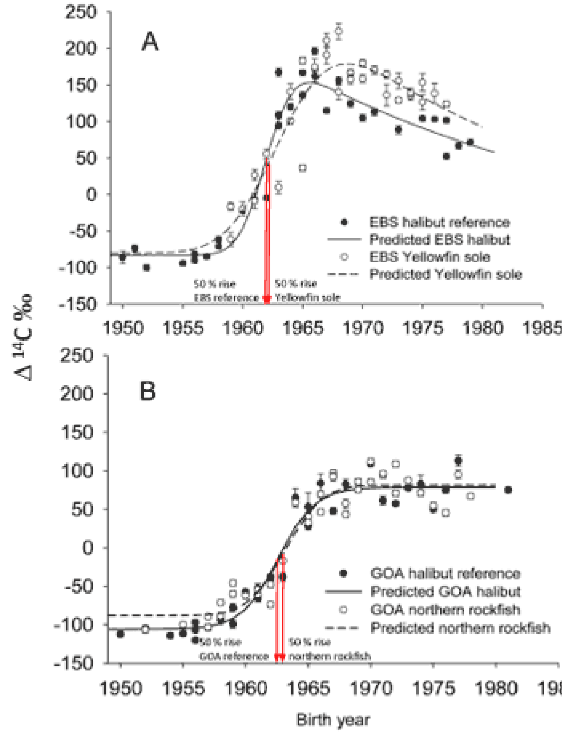


Figure 4. Eastern Bering Sea halibut reference, individual samples and predicted model, and eastern Bering Sea yellowfin sole test samples, individual samples and predicted model (A). Gulf of Alaska halibut reference, individual samples and predicted model, and Gulf of Alaska northern rockfish test samples, individual samples and predicted model (B).

To validate the northern rockfish and yellowfin sole ages and estimate any potential ageing bias, we quantitatively compared the test Δ14C ‰ datasets to the reference curves from each basin using a 4-parameter logistic function. The logistic function was modified to account for a post-peak decay in Δ14C ‰ levels after 1970 to more realistically reflect the Bering Sea data (Figs. 3 and 4). Bayesian inference and Markov Chain Monte Carlo (MCMC) simulations were used to estimate all parameters and derive a probablistic framework for estimating bias. Bias was approximated as the difference between the parameter that describes the year at 50% rise of Δ14C curve.

We found a difference in the rate of increase and amount of bomb-produced Δ14C in the GOA and EBS; also we found that ages determined for the two species were accurate. The estimated year at 50% rise in the GOA reference chronology was 1962.6, while in the new EBS reference chronology it was 1962.0 (Fig. 3). The difference between these parameters appears small; however, the other estimated parameters clearly indicated that the two references were different, as demonstrated by the two predicted references chronologies seen in Figure 3.

In the EBS, the Δ14C increased at a faster rate, rose slightly earlier, increased to a greater level, and decreased faster than in the GOA. The validation of accurate estimated ages for yellowfin sole was demonstrated by a year at 50% rise of 1962.2, which is comparable to the EBS reference of 1962.0. This was further demonstrated by the similarity of the other parameters, as seen in the nearly identical predicted model fits (Fig. 4).

The validation of accurate estimated ages for northern rockfish was demonstrated by a year at 50% rise of 1963.0, which is comparable the GOA reference of 1962.6. Again, this was further demonstrated by the similarity of the other parameters, as seen in the predicted model fits (Fig. 3).

For northern rockfish, the probability of under-ageing by 1 or more years (ageing bias) is about 10%, and the probability of over-ageing by 1 or more years is only about 1% (Fig 5).

For yellowfin sole, the probability of under-ageing by 1 or more years is about 1% (Fig. 5). For yellowfin sole, and especially for northern rockfish where the average age in the population exceeds several decades, these results indicate a very small likelihood of age inaccuracy.

In addition, the comparison of the two reference chronologies indicate that different geographic areas and unique oceanographic conditions may led to differences in the assimilation and incorporation of 14C in fish otoliths. Therefore, future age validation studies need to make careful choices in the reference chronology used. Historically, there has been a lack of available reference chronologies; here we developed a new one for a region where none existed before.

By Craig Kastelle, Thomas Helser, and Steve Wischniowski

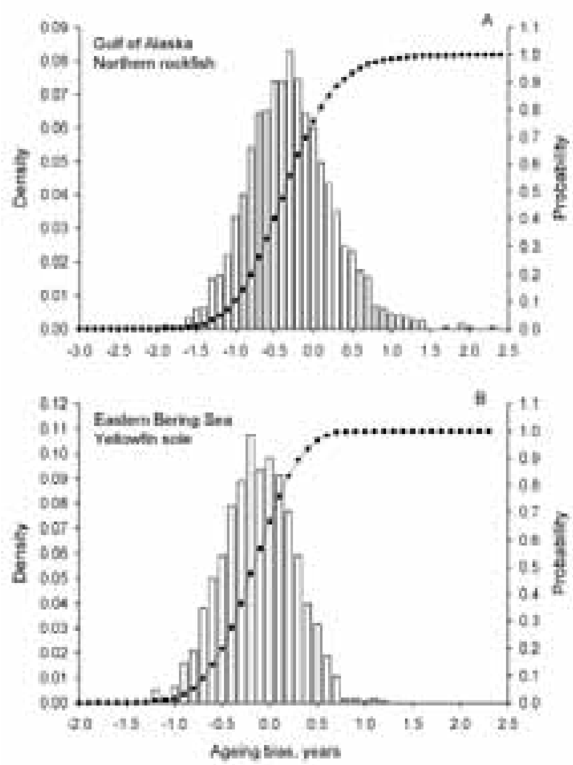


Figure 5. Probility of under or over ageing by one or more years for northern rockfish is about 10% and 1% respectively (A). Probility of under or over ageing by one or more years for yellowfin sole is about 1% respectively (B).

International Affairs and Research Collaboration

U.S.-Russia Intergovernmental Consultative Committee on Fisheries

Pursuant to the 1988 Agreement on Mutual Fisheries Relations, representatives of Russia and the United States conducted the 25th Session of the Intergovernmental Consultative Committee (ICC) on Fisheries in Vladivostok, Russia, on 10-12 September 2014. The meeting was lead by the U.S. Department of State and the Fisheries Agency of the Russian Federation.

Science issues discussed included:

- Status of Bering Sea pollock and groundfish stocks. Both parties updated their exchanges on status of the stocks.
- Walruses. The U.S. Fish and Wildlife Service proposed to conduct a joint survey with Russia in 2015 to collect skin biopsy samples from Pacific walruses.
- Status of Steller sea lion stocks, interactions with fisheries, and protection measures around rookeries and haul-outs. Tthe parties updated their exchanges of information on these issues.
- Ice seal research. The parties agreed to undertake synoptic aerial surveys of ice seals in the Chukchi Sea in spring 2016.
- Status of crab species: *Opilio*, Blue and Red King Crab, and *Chionoecetes baird*. The parties updated their exchanges on status of the stocks.
- Status of joint research planning, data exchanges, and surveys. This year (2014) marks the third year of a U.S.-Russia coordinated survey on pollock in the transboundary area of the northern Bering Sea. We agreed on survey gear and techniques and exchange of survey data. This ICC forum enables the NOAA ship *Oscar Dyson* to survey in the Russian EEZ and the Russian R/V *TINRO* to survey in the U.S. EEZ. Going forward, TINRO and the AFSC agreed to analyze the data from these surveys jointly and continued to coordinate their surveys.
- Potential opportunities for cooperative research and data exchange relating to fisheries, habitat, and ecosystem processes in the Chukchi and Northern Bering Sea: the parties discussed potential opportunities for cooperative research in the near future that may include ice seal surveys, walrus research, a general data sharing plan, and expansion of the salmon-integrated ecosystem BASIS survey into the Chukchi Sea. Russia has agreed to send their survey planners to the AFSC in Seattle in early 2015 to plan a cooperative program with the United States under this ICC arrangement.
- Special topic for discussion. Both parties agreed that salmon would be the focus of discussion at the 2015 ICC meeting.

By Loh-Lee Low

NOAA-Korea Joint Project Agreement

Representatives of the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Republic of Korea Ministry of Oceans and Fisheries (MOF) convened the 13th joint working group meeting of the NOAA-MOF Joint Project Agreement for Scientific and Technical Cooperation in Integrated Coastal and Ocean Resources Management (JPA) on 26-27 August 2014 in Busan, Korea. At the meeting, NOAA and MOF identified cooperative activities of mutual interest to be pursued by four panels in 2015. The fisheries panel is one of the four panels. Korea will fund the fisheries panel to enable scientists to meet and run their projects while NOAA will contribute in-kind services.

The fisheries panel approved 14 projects under three research themes: 1) surveys and monitoring; 2) climate change, stock assessments, and ecosystems research; and 3) applications of JPA research. The specific projects are i) observer training; ii) fisher collected ocean data; iii) survey gear technology; iv) habitat research; v) extension of "NOWCAST" – a model for tracking recruitment of fishery species; vi) snow crab assessment; vii) integrated fisheries risk analysis method for ecosystems and management strategy evaluation; viii) CPUE standardization; ix) stock structure of Pacific cod; x) status of pollock stock off Korea; xi) fishing impacts of fishing on corals and vulnerable marine ecosystems; xii) training on fisheries management practices; xii) Arctic research; and xiv) fisheries panel meeting.

By Loh-Lee Low

Publications and reports for July, August, September 2014.
Authors citing affiliation with the AFSC are denoted in **boldface**.

Baker, C.S., D. Steel, J. Calambokidis, E. Falcone, U. Gonzalez-Peral, J. Barlow, A.M. Burdin, **P.J. Clapham**, J.K. B. Ford, C.M. Gabriele, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urban, **P. R. Wade**, D. Weller, B.H. Witteveen, and M. Yamaguchi.

2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306.

Burns, J., H. Aderman, T. Askoak, and **D. Withrow**

2012. Local and scientific knowledge of freshwater seals in Iliamna Lake, Alaska, p. 211-227. In C. Carother, K. R. Criddle, C. P. Chambers, P. J. Cullenberg, J. A. Fall, A. H. Himes-Cornell, J. P. Johnsen, N. S. Kimball, C. R. Menzies, and E. S. Springer (editors), Fishing People of the North: Cultures, Economies, and Management Responding to Change. Alaska Sea Grant, University of Alaska, Fairbanks, Fairbanks, AK.

Castellote, M., T.A. Mooney, L. Quakenbush, **R. Hobbs**, C. Goertz, and E. Gaglione.

2014. Baseline hearing abilities and variability in wild beluga whales (Delphinapterus leucas). J. Exp. Biol. 217:1682-1691.

Copeman, L.A., **B.J. Laurel**, and C.C. Parrish.

2013. Effect of temperature and tissue type on fatty acid signatures of two species of North Pacific juvenile gadids: a laboratory feeding study. J. Exp. Mar. Biol. Ecol. 448:188-196.

Donnelly-Greenan, E.L., J.T. Harvey, H.M. Nevins, M.M. Hester, and **W.A. Walker**

2014. Prey and plastic ingestion of Pacific northern fulmars (Fulmarus glacialis rogersii) from Monterey Bay, California. Mar. Pollut. Bull. 85:214-224.

Douglas, A.B., J. Calambokidis, L.M. Munger, M.S. Soldevilla, **M.C. Ferguson**, A.M. Havron, D.L. Camacho, G.S. Campbell, and J.A. Hildebrand.

2014. Seasonal distribution and abundance of cetaceans off Southern California estimated from CalCOFI cruise data from 2004 to 2008. Fish. Bull., U.S. 112:198-220.

Duncan, C.G., R. Tiller, D. Mathis, R. Stoddard, G.J. Kersh, **B. Dickerson**, and **T. Gelatt**.

2014. Brucella placentitis and seroprevalence in northern fur seals (Callorhinus ursinus) of the Pribilof Islands, Alaska. J. Vet. Diagn. Invest. 26:507-512.

Felthoven, R., and **S. Kasperski**.

2013. Socioeconomic indicators for United States fisheries and fishing communities. PICES Press 21(2):20-23.

Felthoven, R., J. Lee, and K. Schnier.

2014. Cooperative formation and peer effects in fisheries. Mar. Resour. Econ. 29:133-156.

Hawkyard, M., **B. Laurel**, and C. Langdon.

2014. Rotifers enriched with taurine by microparticulate and dissolved enrichment methods influence the growth and metamorphic development of northern rock sole (Lepidopsetta polyxystra) larvae. Aquaculture 424-42:151-157.

Hollowed, A., and S. Sundby.

2014. Change is coming to the northern oceans. Science 344:1084-1085.

Howard, J., E. Babij, R. Griffis, B. Helmuth, A. Himes-Cornell, P. Niemier, M. Orbach, L. Petes, S. Allen, G. Auad, R. Beard, M. Boatman, N. Bond, T. Boyer, D. Brown, P. Clay, K. Crane, S. Cross, M. Dalton, J. Diamond, R. Diaz, E. Duffy, D. Fauquier, W. Fisher, M. Graham, B. Halpern, L. Hansen, B. Hayum, S. Herrick, **A. Hollowed**, D. Hutchins, E. Jewett, D. Jin, N. Knowlton, D. Kotowicz, T. Kristiansen, P. Little, C. Lopez, P. Loring, R. Lumpkin, A. Mace, K. Mengerink, J.R. Morrison, J. Murray, K. Norman, J. O'donnell, J. Overland, R. Parsons, N. Pettigrew, L. Pfeiffer, E. Pidgeon, M. Plummer, J. Polovina, J. Quintrell, T. Rowles, J. Runge, M. Rust, E. Sanford, U. Send, M. Singer, C. Speir, D. Stanitski, C. Thornber, C. Wilson, and Y. Xue.

2013. Oceans and marine resources in a changing climate, p. 71-192. In R. N. Hughes, D. J. Hughes, and I. P. Smith (editors). Oceanography and Marine Biology: An Annual Review, Vol. 51. CRC Press.

Kuhn, C.E., J.D. Baker, **R.G. Towell**, and **R.R. Ream**.

2014. Evidence of localized resource depletion following a natural colonization event by a large marine predator. J. Anim. Ecol. 83:1169-1177.

Lew, D.K., and **C. Seung**.

2014. On the statistical significance of regional economic impacts from changes in recreational fishing harvest limits in southern Alaska. Mar. Resour. Econ. 29:241-257.

Marsh, J.M., **N. Hillgruber**, and **R.J. Foy**

2012. Temporal and ontogenetic variability in trophic role of four groundfish species—walleye pollock, Pacific cod, arrowtooth flounder, and Pacific halibut—around Kodiak Island in the Gulf of Alaska. Trans. Am. Fish. Soc. 141:468-486.

Matkin, C.O., **J.W. Testa**, G.M. Ellis, and E.L. Saulitis.

2014. Life history and population dynamics of southern Alaska resident killer whales (Orcinus orca). Mar. Mammal Sci. 30:460-479.

Monnahan, C.C., T.A. Branch, K.M. Stafford, **Y.V. Ivashchenko**, and E.M. Oleson.

2014. Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. PLOS ONE 9(6):e98974. doi: 10.1371/journal.pone.0098974

Morrison Paul, C.J., **R.G. Felthoven**, and M. de O. Torres.

2010. Productive performance in fisheries: Modeling, measurement and management. Aust. J. Agr. Resour. Econ. 54:343-360.

Punt, A.E., D. Poljak, M.G. Dalton, and **R.J. Foy**

2014. Evaluating the impact of ocean acidification on fishery yields and profits: the example of red king crab in Bristol Bay. Ecol. Model. 285:39-53.

Russell, D.J.F., S. Brasseur, D. Thompson, G.D. Hastie, V.M. Janik, G. Aarts, **B.T. McClintock**, J. Matthiopoulos, S.E.W. Moss, and B. McConnell.

2014. Marine mammals trace anthropogenic structures at sea. Curr. Biol. 24:R638-R639.

Schnier, K., and **R. Felthoven**.

2011. Accounting for spatial heterogeneity and autocorrelation in spatial discrete choice models: Implications for behavioral predictions. Land Econ. 87:382-402.

Som, N.A., P. Monestiez, **J.M. Ver Hoef**, D.L. Zimmerman, and E.E. Peterson.

2014. Spatial sampling on streams: Principles for inference on aquatic networks. Environmetrics 25:306-323.

Stachura, M.M., T.E. Essington, N.J. Mantua, **A.B. Hollowed**, M.A. Haltuch, **P.D. Spencer**, T.A. Branch, and M.J. Doyle.

2014. Linking Northeast Pacific recruitment synchrony to environmental variability. Fish. Oceanogr. 23:389-408.

Thompson, K.A., S.S. Heppell, and **G.G. Thompson**.

2014. The effects of temperature and predator densities on the consumption of walleye pollock (Theragra chalcogramma) by three groundfish in the Gulf of Alaska. Can. J. Fish. Aquat. Sci. 71:1123-1133.

Torres, M., and **R. Felthoven**.

2014. Productivity growth and product choice in catch share fisheries: the case of Alaska pollock. Mar. Policy 50:280-289.

Vulstek, S. C., T.P. Linderoth, **J.R. Guyon**, and D.A. Tallmon.

2013. Spatio-temporal population genetic structure and mating system of red king crab (Paralithodes camtschaticus) in Alaska. J. Crustacean Biol. 335:691-701.

Tech Memos[1]

Allen, B.M., and **R.P. Angliss**.

2014. Alaska marine mammal stock assessments, 2013. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-277, 294 p.

Goddard, P., **R. Lauth**, and **C. Armistead**.

2014. Results of the 2012 Chukchi Sea bottom trawl survey of bottomfishes, crabs, and other demersal macrofauna. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-278, 110 p.

Fissel, B.E.

2014. Economic indices for the North Pacific groundfish fisheries: Calculation and visualization. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-279, 47 p.

Himes-Cornell, A., and **K. Kent.**

2014. Involving fishing communities in data collection: a summary and description of the Alaska Community Survey, 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-280, 170 p.

Faunce, C., J. Cahalan, J. Gasper, **T. A'mar**, **S. Lowe**, **F. Wallace**, and R. Webster.

2014. Deployment performance review of the 2013 North Pacific Groundfish and Halibut Observer Program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-281, 74 p.

Processed Reports[2]

Orr, J.W., **D.T. Drumm**, **G.R. Hoff**, and **D.E. Stevenson**.

2014. Species identification confidence in the Bering Sea Slope surveys (1976-2010). AFSC Processed Rep. 2014-05, 71 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

[1] The NOAA Technical Memorandum series NMFS AFSC (formerly F/NWC) is a Center publication which has a high level of peer review and editing. The Technical Memorandum series reflects sound professional work and may be cited as publications. Copies may be ordered from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161 or at *www.ntis.gov*.

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