A Retrospective of Rasmuson Fishery Fellows

Rasmuson Fisheries Research Center
School of Fisheries and Ocean Sciences

UNIVERSITY OF ALASKA
FAIRBANKS

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Cover

Rasmusan Fellow Susan McNeil (right) and Greg Carpenter (left), Alaska Department of Fish and Game, work on a core sample from Coghill Lake, Prince William Sound (see research abstract).

A Retrospective of Rasmuson Fishery Fellows 1994 to 2000

Rasmuson Fisheries Research Center
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
Fairbanks, Alaska 99775-7220

Mission

To promote excellence in research related to fisheries, and to develop young fishery scientists.

Research Goals

Selected research areas identified as high priorities by the Advisory Board:

1. Interaction of forage species with marine mammals, marine birds and fishery species;
2. Genetic stock identification of salmonids and salmonid survival studies;
3. Studies using an ecosystem approach focusing on fluctuations of fishery stocks and life history responses to physical and biotic conditions.

The Center was founded in 1994 by Elmer E. Rasmuson with a million dollar endowment, and since then Mr. Rasmuson has made several additional, substantial contributions. Ward's Cove Packing Company has contributed $100,000. The Center will grow through the contributions of industry and individuals to its endowment which is managed by the University of Alaska Foundation.

Research is oriented toward findings with a potential for continued development of scientific or applied value. The work will be distinctive and make an original contribution to existing knowledge. Results will have the potential of adding to the economic and social value of fish and shellfish resource utilization, and will contribute to long-term benefits for Alaska. Awards are for fellowships and are contingent on the student's ability to secure a funding match to meet the actual research costs. ❖

Advisory Board
1994–2001

Elmer E. Rasmuson, *Founder*
Albert V. Tyler, *Director*

Board Members

D. Lee Alverson (2000–)
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Robert Brophy (1994)
Donald D. O'Dowd (1994–1997)
Steven Pennoyer (1994–2000)
Edward B. Rasmuson (2001–)

Original Rasmuson Fisheries Research Center Advisory Board with Elmer Rasmuson, Founder, University of Alaska President Jerome Komisar, and UAF Chancellor Joan Wadlow, March 1994. Left to right: Don O'Dowd, Clem Tillion, Jerome Komisar, Bob Brophy, Elmer Rasmuson, Jim Branson, Joan Wadlow, Al Tyler, Al Burch. ❖

From the Director, Al Tyler

Twenty-one University of Alaska Fairbanks graduate students have been awarded fellowships from the Rasmuson Fisheries Research Center since its formation. These students have worked on degrees at the Institute of Marine Science in Fairbanks, the Alaska SeaLife Center in Seward, and through the Fisheries Division in both Fairbanks and Juneau. Their research has contributed valuable knowledge to fisheries as identified by the Center's research goals. The purpose of this retrospective is to introduce you to the Center and its founder, Elmer E. Rasmuson, and to describe briefly the many research projects that have been supported since it was established in 1994.

The group of people who make up the Advisory Board come from various walks of fishery life, including industry, fishery management councils, the state legislature and government agencies. All have a thorough understanding of science as a critical element in fisheries management.

The conferring of the Rasmuson Fisheries Fellowship represents one of the distinctions offered by the University of Alaska Fairbanks and the School of Fisheries and Ocean Sciences. The Fellowship is not just a source of funds for a graduate assistantship, but an award for scholastic achievement. By this award we recognize outstanding scholarship in selected areas of fisheries research. The Fellows are chosen by the Center's Advisory Board on the basis of their academic record and their potential to contribute to the frontiers of knowledge for fishes of economic importance to Alaska. Rasmuson Fellows who have been supported the previous year give oral presentations of their research to the Board at its annual meeting.

Working with these outstanding people has been a joy for me. By serving as a mentor, discussing their research aspirations with them, I believe I have helped them in some small way on their paths of professional development.

It is with sadness that we have to continue now without Mr. Rasmuson, who passed away on 8 December 2000. The University and the Advisory Board of the Center will carry on the tradition that Elmer started with this fellowship program. He was a generous, principled man, and an example for us all to look up to. ❖

Development of the Rasmuson Fisheries Research Center

as told by
Elmer E. Rasmuson

at the
Rasmuson Fisheries Research Center Annual Meeting
Anchorage, Alaska, 18 March 1998

We're all a fraternity here. We've been tied together for a long time. I was born in Yakutat and grew up in Alaska. I got interested in the fishery business because I was a banker and, as we all know, fishing has always—and still does—employ more people than any other single industry in Alaska. Since I was into the banking business and am identified with the whole inauguration of branch banking in Alaska, I knew that fishing is very important in all our communities. Some of the communities are almost entirely fishing, others are predominately that. I know the strong economic and social issues. If you are going to be concerned with the loaning of money for homes and for small businesses, you necessarily have to get involved and be interested in the fishing business. Probably what tied me in and focused my interest here, was that I was on the Board of Regents of the University of Alaska for 19 years. For most of that time, I was Chairman. I was appointed by Governor Gruening, the governor who stressed the development of the University from a standpoint of what was best for the University. I'm quite critical because I am an outspoken person. Since I know all the governors, I don't hesitate to tell them that the trouble with them is that they use the Board of Regents as a dumping ground for appointments for political reasons and that's one of the problems that the University has at the present time. But being on that Board, all that time, I was interested in what the University was doing. I was with the Board during territorial times when we got a $50,000 grant, which was a lot of money in those days, to study whether we should get into oceanography and fisheries and so on. We asked the top fishery people from places like Woods Hole and Texas. They were all up here. They were all very interested in serving on our committee. Well, frankly, their recommendation at that time was to stay out of fisheries because that was an area reserved for the government—a decision which had to be revised later on because, particularly when we got more into fisheries management, there was a demand for people like yourselves. If you go back 50 years, there weren't many biologist jobs. Now, there are various coastal states and there are the various other universities that are all interested in the area. So I acquired my interest in oceanography and fisheries management when I was with the University.

I served on the INPFC [International North Pacific Fisheries Commission] I don't know how many years. I guess I was on that 15 years anyway, that's how I met all these gentlemen now on the Fisheries Research Board. The reason that our North Pacific Management Council is regarded as being the top council for the U.S. comes from the fact that we all worked together in the INPFC. I was the first Chairman of the Council and so we borrowed from INPFC. I hired Jim Branson to be the Director, which was a very fortunate step in developing the Council. We adopted the committee system we had in INPFC. We adopted

We adopted advisory groups of both statistical/scientific and the general public. We learned how to work together and I think, in general, we can say that we had the confidence of the fishermen, too. I had found that the fishermen in Alaska are very responsive to regulatory discipline if they are sold on the idea that it is honestly applied and fairly so and to everybody. And so I think we had a combination of good support of the fishermen and the scientific community. Well, one of the things that I concluded and talked over with others too, was that we needed a sharper focus in our research. I watched the other universities, not only in this country, but also in Japan, and I felt that the research of the graduate students was so scattered depending upon their interests and the interests of their advisors, that we needed to pull it together. So we decided to form this Fisheries Center which I think has proven to be successful in sharpening the focus. I think the secret of this is our outside panel who are not in the academic line at all, as you know, but they listen to the academics and they all know something about it. When you're dealing with fisheries you start out with the biological, obviously, but you have to know the legal side, you have to know the international side, you have to know the economic side of it and the environmental side, too. It's becoming more and more important because no single group has a monopoly on the ocean. So we developed a Board that had very broad interests. I hope that our student fellows in their own pursuit of professions will keep this broad interest. You all start out in biology but—and while I agree that is basic, that's part of it—you can't divorce these other parts from it or else you get too slanted. Well, I think that by having this focus on certain fields, which is going to be a moving target, it doesn't mean that most of you will never study anything except what you've been asked to study in the last few years. Nevertheless, by sharpening your focus, getting more objective, I think we will have a better result.

Now, to pull this all together, I think we need to have as a connecting link—management. Even if you can't manage El Niño and you can't manage the weather, if you know the impact of that weather you will be better advised and prepared in the harvesting and in the marketing and in the environmental aspects of it. You need to have a very broad scope. That's what we're trying to do here. I am not a biologist, but I believe that the thing that I brought to the INPFC was that I insisted that the biologists be listened to. So we developed a very fine cadre of scientists and the people who supported them. That's what we have for fishery management in Alaska. As you go on in your fields, I think you will find that the North Pacific Fishery Management Council has a high standing because of this synergy of management and science. I'm doing a little rambling here, but I hope that you see what we were trying to do and that you are part of it. I'm very encouraged by the presentations that I have heard of what you are doing. We intend to expand it—I don't make any secret of the fact that all of my estate is going to charitable organizations and one of them, of course, is the University of Alaska, although I get a little worried about who's going to run the University here in the future with it not getting the support that I think it should out of the Legislature. Well, anyway, as my friend Lowell Thomas once said, "Don't ever ask a man over 80 to speak because he remembers too much." Thanks very much. ❖

Rasmuson Fellows

Grace E. Abromaitis

Major Professors: Donald M. Schell and Michael A. Castellini
M.S. – Marine Biology

"A Retrospective Assessment of Primary Productivity on the Bering and Chukchi Sea Shelves Using Stable Isotope Ratios in Seabirds"

Gretchen H. Bishop

Major Professor: Thomas C. Shirley
M.S. – Fisheries

"Sea Otter Predation on Dungeness Crabs in the Icy Straits–Glacier Bay Area"

Thomas A. Bunch

Major Professor: Raymond C. Highsmith
M.S. – Marine Biology

"Genetic Differentiation of Commercially Important Alaskan Tanner Crab (*Chionoecetes bairdi*) Populations"

Dmitri Y. Churikov

Major Professor: Anthony J. Gharrett
M.S. – Fisheries

"Mitochondrial DNA Haplotype Genealogies and Population Histories in the Late Pleistocene: Contrasts of Pink Salmon Broodyears"

Ph.D. – Fisheries

"Evolutionary History and Contemporary Structure of North Pacific Pink, Chum, and Sockeye Salmon Populations Derived from Allozyme, Mitochondrial DNA, and Microsatellite DNA Anaysis"

Sherri C. Dressel

Major Professor: Brenda L. Norcross
Ph.D. – Fisheries Oceanography

"Habitat-Focused Surveys and Analysis Measures for the Assessment of Interannual Fluctuations in Juvenile Flatfish Abundances"

Brian S. Fadely

Major Professor: Michael A. Castellini
Ph.D. – Marine Biology

"Investigations of Harbor Seal (*Phoca vitulina*) Health Status and Body Condition in the Gulf of Alaska"

Masami Fujiwara

Major Professor: Raymond C. Highsmith
M.S. – Marine Biology

"Harpacticoid Copepods: Potential Link Between Inbound Adult Salmon and Outbound Juvenile Salmon"

Michio Fukushima

Major Professor: William W. Smoker
Ph.D. – Fisheries

"Effects of Density-Dependence, Environment and Species Interaction During Spawning and Incubation on Population Dynamics of Pink and Sockeye Salmon in the Auke Lake System, Southeast Alaska"

Patrick L. Goddard

Major Professor: Anthony J. Gharrett
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"Quantitative Genetic Analysis of a Fitness Related Life-History Character, Development Rate, in Odd- and Even-Year Populations of Pink Salmon *(Oncorhynchus gorbuscha)*"

Amy C. Hirons

Major Professor: Donald M. Schell
Ph.D. – Biological Oceanography

"Trophic Dynamics of Pinniped Populations in Alaska Using Stable Carbon and Nitrogen Isotope Ratios"

Julia Mabry

Major Professor: Lewis J. Haldorson
M.S. – Fisheries

"Condition and Food Availability to Pacific Sand Lance *(Ammodytes hexapterus)* in Prince William Sound, Alaska"

Patrick W. Malecha

Major Professor: William W. Smoker
M.S. – Fisheries

"Survival of Pink Salmon Embryos and First Feeding Fry Related to Size of Eggs"

Susan L. McNeil

Major Professor: Bruce P. Finney
M.S. – Geological Oceanography

"The Paleoproductivity of Sockeye Salmon: Assessment by Sediment Core Analysis"

John J. Piccolo

Major Professor: Nicholas F. Hughes
Ph.D. – Fisheries

"Modeling the Mechanisms Linking Stream Habitat Characteristics to the Distribution, Growth, and Abundance of Juvenile Coho Salmon and Steelhead Trout"

Gregg E. Rosenkranz

Major Professor: Albert V. Tyler
M.S. – Fisheries
"Statistical Modeling of Tanner Crab Recruitment in Bristol Bay, Alaska"

Franklin R. Satterfield IV

Major Professor: Bruce P. Finney
M.S. – Marine Biology
"A Comparison of Sockeye Salmon (*Oncorhynchus nerka*) in Two Climate Regimes in the North Pacific Ocean Using Stable Carbon and Nitrogen Isotope Ratios"

Karen A. Scheding

Major Professor: Thomas C. Shirley
M.S. – Fisheries
"Bathymetric Distribution of Dungeness Crabs in Bays with and without Sea Otters"

Zhenming Su

Major Professor: Milo D. Adkison
Ph.D. – Fisheries
"Optimal In-Season Management of Pink Salmon Given Uncertain Run Sizes and Declining Economic Values"

Stephen J. Trumble

Major Professor: Michael A. Castellini
Ph.D. – Marine Biology
"Assessing the Dietary Significance of Commercially Important Fishery Species on the Health Status of Captive and Free-Ranging Pinnipeds in Alaska"

Steven R. Whitney

Major Professor: Alan M. Springer
M.S. – Biological Oceanography
"Jellyfish Impact on Food Web Production and Ecosystem Structure in the Southeastern Bering Sea"

Erik H. Williams

Major Professor: Terrance J. Quinn II
Ph.D. – Fisheries
"Interrelationships of Pacific Herring, *Clupea pallasi*, Populations and Their Relation to Large-Scale Environmental and Oceanographic Variables"

Research Abstracts

from

Rasmuson Fellows

who

have completed

their degrees

A Retrospective Assessment of Primary Productivity on the Bering and Chukchi Sea Shelves Using Stable Isotope Ratios in Seabirds

Grace E. Abromaitis

December 2000

Recent declines of marine mammal and seabird populations in the Bering Sea have raised the question of whether the changes are caused by fishing pressure or from a decrease in ecosystem carrying capacity. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios in Thick-billed Murre muscle and feathers were used as indicators of changing seasonal primary production. $\delta^{13}C$ values in phytoplankton vary directly with growth rates and are passed up the food web to consumers. Muscle and feather $\delta^{13}C$ values decreased over the period 1976–1998, suggesting a decline in Bering/Chukchi continental shelf primary production. Carbon isotope ratios in murres correlated with bowhead whale baleen isotope ratios and with some climate indices. In contrast, $\delta^{15}N$ values in birds showed no significant change, indicating no concurrent shifts in trophic status. ❖

Genetic Differentiation of Commercially Important Alaskan Tanner Crab (*Chionoecetes bairdi*) Populations

Thomas A. Bunch

May 1997

I compared 413 nucleotides of subunit I of the mitochondrial cytochrome oxidase *c* gene among 52 Tanner crabs, *Chionoecetes bairdi*, from four coastal locations in Alaska. Cook Inlet Tanner crabs possessed the largest genetic diversity, while southeastern Alaska Tanner crabs possessed the smallest genetic diversity, based upon number of haplotypes and genetic distance.

The data suggest larval Tanner crabs are transported from east to west along the southern coast of Alaska by westwardly flowing currents. Consequently, declining western stocks may be partly the result of problems in eastern, upstream populations. Southwestern populations are apparently a mixture of both local and upstream haplotypes. The population in southeastern Alaska is probably genetically isolated with one haplotype (A) predominating (85%).

Populations of *C. bairdi* from southeast Alaska, Kodiak, Cook Inlet and Bristol Bay clustered together in phylogenetic analyses. Snow crab, *C. opilio*, was the next closest known taxon. Species of *Telmessus* and *Hapalogaster* clustered intermediately between *Chionoecetes* and the outgroup, *Calantica villosa*. ❖

Mitochondrial DNA Haplotype Genealogies and Population Histories in the Late Pleistocene: Contrasts of Pink Salmon Broodyears

Dmitri Y. Churikov

December 2000

Seven segments of mtDNA, comprising 97% of the mitochondrial genome, were PCR [polymerize chain reaction]-amplified and examined for restriction site variation using 13 restriction endonucleases in three *Oncorhynchus* species: pink *(O. gorbuscha)*, chum *(O. keta)*, and sockeye *(O. nerka)* salmon. Multiple haplotypes, but shallow mtDNA trees were observed for each species. "Star-like" structures indicating historical population explosions were observed in haplotype genealogies. Given reasonable rates of mtDNA sequence evolution, this may reflect recolonization of vast areas in Alaska after the last (Wisconsonian) or preceding (Illinoian) glacier retreats. The phylogeographic survey of 18 Alaskan and eastern Asian pink salmon populations revealed a distinct break between Alaska and Asia in even-year, but continuous distributions of the mtDNA linkages throughout the same range in the odd-year broodline. A nested cladistic analysis of geographical distances indicates that spacial distribution of mtDNA lineages in both broodlines resulted from interplay between historical range expansions and isolation by distance. ❖

Investigations of Harbor Seal *(Phoca vitulina)* Health Status and Body Condition in the Gulf of Alaska

Brian S. Fadely
December 1997

Harbor seal *(Phoca vitulina)* declines during the past 20 years in the Kodiak Island and Prince William Sound regions contrast with stable or slightly increasing populations in southeastern areas of Alaska. Aspects of health status and body condition were investigated to test hypotheses that these declines were driven by nutritional limitation, and to determine whether recent differential population trajectories among Kodiak Island, Prince William Sound, and southeast Alaska could have health-related components. For comparisons between 1992–96 three aspects of health status were examined: blood chemistry, blubber distribution and quantity, and blubber quality. Clinical ranges of plasma chemistries and hematologies were established for free-ranging seals in the Gulf of Alaska. Significant handling, individual, and seasonal effects were found on many blood parameters that could bias interannual and interregional comparisons if not incorporated in models. Based on statistical modeling, some seals showed more clinically aberrant values than expected by chance, but these were not clumped among regions or years. Differences existed in interannual blood chemistry and hematology patterns between juveniles and adults. Likewise, there were regional differences in blood chemistries of unknown significance. Morphometric indices were poor indicators of condition, defined as size-at-age or blubber content. This was related to patterns of blubber distribution and variability, which differed between males and females. Blubber quality, measured as lipid content, did not substantially vary seasonally or between geographic regions, but blubber from Prince William Sound was less hydrated than blubber from non-declining areas. There were no detectable differences in body condition of seals from the Gulf of Alaska sampled during 1963/64 (pre-decline), 1976–78 (during decline) and 1995–96. However, sample sizes were small and patchily distributed throughout locations and years. Thus, the liklihood of detecting body condition changes in response to environmental conditions was poor. Body condition was not substantially different among seals from Prince William Sound, Kodiak Island and southeast Alaska measured during 1993–96. However, interannual blood chemistry and body condition patterns were evident among Prince William Sound seals that may have been associated with environmental conditions. ❖

Harpacticoid Copepods: Potential Link Between Inbound Adult Salmon and Outbound Juvenile Salmon

Masami Fujiwara
May 1997

Stable isotope ratios ($\delta^{15}N$ and $\delta^{13}C$) of estuarine organisms were measured monthly within two field seasons in Seldovia Bay, Alaska to assess the impact of salmon carcass decomposition on estuarine productivity. A hypothesized trophic link between adult and juvenile salmon, with estuarine harpacticoid copepods acting as an intermediate link, was supported by the data. Data show a strong influence of nutrients derived from salmon carcasses on estuarine primary production, as nitrogen stable isotope ratio values of *Ulva*, an estuarine macroalga, were elevated in late summer following the salmon run. The isotope data also indicate that harpacticoids depend on *Ulva*. Stomach content data for juvenile chum salmon (*Oncorhynchus keta*) show they depend primarily on harpacticoids. Therefore, there is a nutrient link between adult and juvenile chum salmon in Seldovia Bay. Because harpacticoid production in an estuary is thought to control survival of chum fry, the nutrient link may function as a feedback mechanism driving population fluctuation. ❖

Effects of Density-Dependence, Environment and Species Interaction During Spawning and Incubation on Population Dynamics of Pink and Sockeye Salmon in the Auke Lake System, Southeast Alaska

Michio Fukushima
May 1996

Mechanisms that regulate or influence fry and smolt production of pink and sockeye salmon in the Auke Lake system, southeast Alaska, were studied with special emphases on effects of: 1) density-dependence, 2) environmental effects, and 3) species interaction. There has been an increasing trend in the residuals of spawner-recruit models for pink and sockeye salmon since the late 1970s. A strong positive influence of precipitation was found in sockeye smolt production. Estimated spawner capacity of pink salmon was 15 times greater than sockeye salmon in the system.

Pink salmon spawners varied in stream life (5–11 days), spawning efficiency (30–70% of daily cohorts of females retained less than 500 eggs at death), and habitat selection (30–70% spawned in Auke Creek rather than Lake Creek, the inlet stream). Variation of these attributes in female pink salmon was explained by several environmental variables using generalized linear models.

Repeated use of limited spawning grounds by Pacific salmon, i.e., redd superimposition, can cause density-dependent mortality. Pink salmon egg loss from part of Auke Creek, estimated by a series of mark and recapture experiments, was roughly proportional to spawner abundance and not related to discharge. The maximum daily egg loss was estimated to be 300,000–400,000 eggs. Eggs in samples were more advanced in development later in the season. Eggs were washed out from the streambed due to redd superimposition; eggs spawned by early pink salmon spawners suffered higher mortality than eggs spawned by later spawners.

The peak sockeye spawning preceded the peak pink spawning by approximately one week in Lake Creek, and the major spawning areas of sockeye salmon occurred approximately 250–350 m upstream from those of pink salmon. Microhabitat selection measured by four variables differed significantly between the species, but discrimination between the species was impossible because of large overlaps. Habitat variation was greater among different runs of sockeye salmon than between the two species. Sockeye salmon shifted spawning sites from riffles to pools as the season progressed. ❖

Quantitative Genetic Analysis of a Fitness Related Life-History Character, Development Rate, in Odd- and Even-Year Populations of Pink Salmon *(Oncorhynchus gorbuscha)*

Patrick L. Goddard
December 1995

Genetic and environmental determinants of a fitness related life-history character, development rate, were investigated in two brood years of pink salmon *(Oncorhynchus gorbuscha)*. Differences in development rate between years revealed the genetic isolation of the two broods. Significantly different rates of development between embryos derived from early-spawning adults and from late-spawning adults within each year's population are evidence of temporal structures within the brood years. Quantitative genetic parameters for development rate to three embryonic stages were estimated from a hierarchical experimental design using 20 paternal half-sib families from each subpopulation. Embryos were incubated in four different temperature regimes. Additive genetic variation accounted for a significant proportion of the observed phenotypic variation only for development rate to hatching, and not for development rate during gastrulation or organogenesis. However, genetic variation in phenotypic plasticity was found for development rate during all three of the embryonic stages. Variation in reaction norms to incubation temperature suggests adaptive differentiation of development rate. ❖

Trophic Dynamics of Pinniped Populations in Alaska Using Stable Carbon and Nitrogen Isotope Ratios

Amy C. Hirons

May 2001

Trophic changes in populations of Steller sea lions (*Eumetopias jubatus*), northern fur seals (*Callorhinus ursinus*) and harbor seals (*Phoca vitulina*) in the eastern Bering Sea and Gulf of Alaska were studied using stable isotope analysis. Declining populations of all three species of pinnipeds prompted this study in an effort to determine if changes in diet, likely resulting from food limitation, contributed to the declines. Stable carbon and nitrogen isotope ratios were analyzed in the vibrissae (whiskers) and body tissues of pinnipeds from 1993–1998 and compared with muscle tissue from prey species during the same time period in an effort to determine pinniped trophic dynamics. Vibrissae growth rate studies revealed harbor seal vibrissae are only retained for one year then replaced, while Steller sea lions maintain their vibrissae for several years. Isotopic data from all three pinniped species are consistent with diets comprised of walleye pollock (*Theragra chalcogramma*) at various times and locations throughout the year. Steller sea lion and northern fur seal vibrissae revealed regular oscillations along their lengths in both carbon and nitrogen isotope ratios that likely corresponded to regional isotopic differences. As these animals moved or migrated from one region to another during the year, they metabolically incorporated the different isotope ratios from these regions through their prey. Because these animals return to their rookery to pup, breed and molt each year, the isotope ratios in the vibrissae showed a regular pattern of enrichment and depletion. Harbor seals, which tend to stay in one geographic location, had relatively static isotope ratios in their vibrissae, while seals that moved into offshore waters had fluctuating isotope ratios that corresponded to regional differences. No trophic shifts, as evidenced by major changes in nitrogen isotope ratios, were present in any tissues from the three species over the period 1975–1998. Stable isotope ratios of bone collagen for all three species from 1950–1997 indicated no change in trophic level but did reveal a decline in the carbon isotope ratios. These data are supportive of evidence that the seasonal primary production in the north Pacific Ocean has declined and may have contributed to a decreased carrying capacity impacting these top trophic level organisms. ❖

Condition and Food Availability to Pacific Sand Lance *(Ammodytes hexapterus)* in Prince William Sound, Alaska

Julia Mabry
May 2000

Pacific sand lance *(Ammodytes hexapterus)* is a common forage fish for seabirds in Prince William Sound, Alaska (PWS). The objectives of this study were to determine if condition of young-of-the-year (YOY) sand lance varies within PWS, and if variation in condition is related to temperature and food availability. Fish were collected in 1996, 1997, and 1998 and assayed for energy content. Zooplankton samples were collected concurrently. SeaWiFS [Sea-viewing Wide Field-of-view Sensor] ocean color satellite images and AVHRR [Advanced Very High Resolution Radiometer] temperature images were analyzed for chlorophyll biomass and temperature history. Standard lengths of YOY sand lance ranged from 47 to 97 mm, and their energy content ranged from 4490 to 5670 cal/g, with significant differences among stations. Sand lance in southern PWS were in better condition than those in other areas. Surface chlorophyll concentration and zooplankton abundance were not related to energy content; however, there was a positive and significant relationship between energy content and SST [sea surface temperature]. ❖

The Paleoproductivity of Sockeye Salmon: Assessment by Sediment Core Analysis

Susan L. McNeil

May 1997

The paleoproductivity of three Alaskan sockeye salmon nursery lakes was studied using stable isotope ratio analysis of lake sediments to trace the input of marine-derived nutrients from returning adult salmon. Greater input of marine-derived nutrients from salmon results in a greater $\delta^{15}N$ in the lake, and thus in lake sediments, because adult salmon ($\delta^{15}N$ = 11–12‰) are enriched in ^{15}N compared to other sources of nitrogen (atmospheric N_2, $\delta^{15}N$ = 0‰). In Karluk and Frazer Lakes, Kodiak Island, a strong positive correlation exists between downcore changes in sedimentary $\delta^{15}N$ and the historical changes in sockeye escapements. In Coghill Lake, Prince William Sound, this correlation is not as evident. Karluk and Coghill Lakes show evidence for higher average escapement prior to the impacts of commercial fishing. ❖

Statistical Modeling of Tanner Crab Recruitment in Bristol Bay, Alaska

Gregg E. Rosenkranz

December 1998

Effects of environmental conditions on recruitment of Tanner crabs, *Chionoecetes bairdi*, in Bristol Bay, Alaska were investigated through correlation analysis and linear modeling. Recruitment was indexed by estimates from a length-based model developed by the Alaska Department of Fish and Game. Water temperatures and northeast winds were statistically related to the recruitment estimates. Possible effects of commercial fishing on recruitment could not be evaluated due to lack of data and confounding between recruitment, abundance, and fishing effort. The statistical results supported the hypotheses that bottom water temperature affected reproductive success of the spawning stock, sea surface temperature and winds affected food availability for crabs during the larval stage, and winds caused advection of larval crabs to favorable or unfavorable habitats for survival. Autocorrelation in the recruitment and temperature time series and lack of knowledge on Tanner crab growth added uncertainty to the biological interpretation of the statistical results. ❖

A Comparison of Sockeye Salmon *(Oncorhynchus nerka)* in Two Climate Regimes in the North Pacific Ocean Using Stable Carbon and Nitrogen Isotope Ratios

Franklin R. Satterfield IV

December 2000

This study explores how the climate shift in the late 1970s impacted sockeye salmon feeding. Stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) of recent muscle and scale tissues from five mature salmon species are highly correlated ($R^2 = 0.96$ and 0.91, respectively), validating the use of archived scales for retrospective analysis. These data suggest a trophic separation by species with chinook occupying the highest level, followed by coho with some degree of overlap among sockeye, pink and chum at the lowest level. Archived scales from four different sockeye stocks from Kodiak Island and the southeast region were analyzed over the last 34 years to investigate changes relative to the 1976–77 climate regime shift. Most stocks show no statistical differences before and after the regime shift in either isotope. Despite recorded differences in sockeye abundance and size between these two regimes, these data suggest only minor changes in prey items. ❖

Interrelationships of Pacific Herring, *Clupea pallasi*, Populations and Their Relation to Large-Scale Environmental and Oceanographic Variables

Erik H. Williams

December 1998

Recruitment estimates for Pacific herring, *Clupea pallasi*, populations in the Bering Sea and northeast Pacific Ocean are highly variable, difficult to forecast, and crucial for determining optimum harvest levels. Age-structured population models for annual stock assessments of the sac-roe fisheries rely on fishery and survey of composition data tuned to an auxiliary survey of total biomass. The first age-structured model for Norton Sound herring was developed similarly to existing models.

Estimates of variability from age-structured stock assessment models for Pacific herring are often not calculated. A parametric bootstrap procedure using a fit of the Dirichlet distribution to observed age composition data was developed as a quick and easy method for computing error estimates of model estimates. This bootstrap technique was able to capture variability beyond that of the multinomial distribution. This technique can provide estimates of variability for existing population models with age composition data, requiring little change to the original model structure.

Recruitment time series from Pacific herring stock assessment models for 14 populations in the Bering Sea and northeast Pacific Ocean were analyzed for links to the environment. For some populations, recruitment series were extended backward in time using cohort analysis. Correlation and multivariate cluster analyses were applied to determine herring population associations. There appear to be four major herring groups: Bering Sea, outer Gulf of Alaska, coastal southeast Alaska and British Columbia.

These associations were combined with an exploratory correlation analysis of environmental data. Appropriate time periods for environmental variables were determined for use in Ricker type environmentally dependent spawner-recruit forecasting models. Global and local scale environmental variables were examined in forecasting models, resulting in improvements in recruitment forecasts compared to models without environmental data. The exploratory correlation analysis and best fit models, determined by jacknife error prediction, indicated temperature data corresponding to the year of spawning resulted in the best forecasting models. The Norton Sound age-structured model, parametric bootstrap procedure, and recruitment forecasting models serve as enhancements to the decision process for managing Pacific herring fisheries. ❖