

A Retrospective of Rasmuson Fishery Fellows 2001-2015



Rasmuson Fisheries Research Center
School of Fisheries and Ocean Sciences



March 2016

A Retrospective of Rasmuson Fishery Fellows 2001 to 2015

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. Ecology, biology, distribution and systematics of species of fish and shellfish affected by fisheries, both target and non-target species;
2. Responses of fish and shellfish and of stocks of fish and shellfish to variations of physical and biotic conditions;
3. Genetic structure of Alaskan fish and shellfish populations;
4. Fluctuations of fish and shellfish stocks, interactions of forage species with consumers including mammals and birds, and the ecosystems in which they occur; or
5. Development of the shellfish aquaculture industry in Alaska.
6. Human dimensions of fishery systems.

The Rasmuson Fisheries Research Center was founded in 1994 by Elmer E. Rasmuson with an endowment to the University of Alaska Fairbanks (UAF). A second major endowment in support of the Center was created through a bequest from Mr. Rasmuson's estate in 2001. The University of Alaska Foundation manages the endowments, and interest on the principal is used to support the research of graduate students that contributes toward the scientific or applied knowledge base of Alaska's marine waters and resources. The fellowships include a graduate student stipend and full tuition. More details on the Rasmuson Fisheries Research Center can be found on the UAF School of Fisheries and Ocean Sciences web site at: www.sfos.uaf.edu/rasmuson.

Rasmuson Fisheries Research Center Advisory Board

Elmer E. Rasmuson, Founder

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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.

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.

Since 2001, thirty-four University of Alaska Fairbanks graduate students have been awarded fellowships from the Rasmuson Fisheries Research Center. These students have worked on degrees in Fisheries, Marine Biology and Marine Sciences throughout the School of Fisheries and Ocean Sciences. Their research has contributed valuable knowledge to fisheries as identified by the Center's research goals. The purpose of this retrospective is to describe briefly the many research projects that have been supported since 2001. A similar document covering the years from 1994 to 2000 is also available.

Rasmuson Fellows

Gregory Albrecht	Major Advisor: Sarah Hardy M.S. – Marine Biology “Defining Genetic Population Structure and Historical Connectivity of Snow Crab (<i>Chionoecetes opilio</i>)”
Alison Banks	Major Advisor: Alan Springer M.S. – Marine Biology “Variability in Population Trends, Life History Characteristics, and Milk Composition of Northern Fur Seals in Alaska”
William Bechtol	Major Advisor: Terry Quinn Ph.D. – Fisheries “Abundance, Recruitment, and Environmental Forcing of Kodiak Red King Crab”
Michael Courtney	Major Advisor: Andrew Seitz M.S. – Fisheries “Dispersal Patterns and Summer Oceanic Distribution of Adult Dolly Varden from the Wulik River, Alaska, Evaluated Using Satellite Telemetry”
Raphaelle Descoteaux	Major Advisor: Sarah Hardy and Katrin Iken M.S. – Marine Biology “Effects of Ocean Acidification on Development of Alaskan Crab Larvae”
Terril Efrid	Major Advisor: Brenda Konar M.S. – Marine Biology “Effects of Environmental Characteristics on the Fish Assemblages of High Latitude Kelp Forests in South-Central Alaska ”
Sonya El Mejjati	Major Advisor: Loren Buck M.S. – Marine Biology “Physiological and Behavioral Responses of Tanner Crabs (<i>Chionoecetes bairdi</i>) to Handling, Emersion and Temperature”
Elena Fernandez	Major Advisor: Lara Horstmann and Katrin Iken M.S. – Fisheries Oceanography “The Effects of Ocean Acidification on Walleye Pollock (<i>Theragra Chalcogramma</i>) Early Life History Stages”

Michael Garvin	Major Advisor: A.J. Gharrett Ph.D. – Fisheries “Identification and Application of Molecular Markers to Chum Salmon (<i>Oncorhynchus keta</i>) Population Genetics”
Georgina Gibson	Major Advisor: David Musgrave Ph.D. – Oceanography “Non-Linear Dynamics of Marine Ecosystem Models”
Christine Gleason	Major Advisor: Brenda Norcross M.S. – Fisheries Oceanography “Physical Environmental and Biological Correlates of Otolist Chemistry of Arctic Marine Fishes in the Chukchi Sea”
Shannon Hanna	Major Advisor: Loren Buck M.S. – Marine Biology “Interrelationship Among Temperature, Metabolism, Swimming Performance and Recovery in Pacific Cod (<i>Gadus macrocephalus</i>): Implications of a Changing Climate”
Katy Howard	Major Advisor: Milo Adkison M.S. – Fisheries “Inter-Decadal Change in Sablefish (<i>Anoplopoma fimbria</i>) Growth and Maturity in the Northeast Pacific Ocean”
Zachary Hoyt	Major Advisor: A.J. Gharrett M.S. – Fisheries “Movement and Habitat Utilization by Golden King Crab (<i>Lithodes aequispinus</i>) Benedict 1895 in Southeastern Alaska”
Brian Knoch	Major Advisor: Robert Foy M.S. – Fisheries “Investigating the Trophic Role of Adult Arrowtooth Flounder (<i>Atheresthes stomias</i>) as a Top Level Consumer, in the Gulf of Alaska Ecosystem”
Emily Lescak	Major Advisor: Andres Lopez and Frank Von Hippel Ph.D. – Fisheries “Contemporary Evolution in Threespine Stickleback from Uplifted Islands in Alaska”

Mary Beth Loewen	Major Advisor: Robert Foy M.S. – Fisheries “Seasonal Abundance and Habitat Characteristics of Nearshore Palagic Fish in Kodiak, Alaska”
Courtney Lyons	Major Advisor: Courtney Carothers and Ginny Eckert Ph.D. – Fisheries “Understanding Place in Fisheries Management: An Examination of Ecological and Social Communities in the Pribilof Islands, Alaska”
Laurinda Marcello	Major Advisor: Franz Mueter M.S. – Fisheries “What drives snow crab recruitment: cod, spawners, or climate”
Joel Markis	Major Advisor: Brenda Konar M.S. – Marine Biology “Essential Larval and Juvenile Fish Habitat in Nearshore Waters of Kachemak Bay, Alaska”
Jennifer Marsh	Major Advisors: Robert Foy and Nicola Hillgruber M.S. – Fisheries “Ontogenetic Considerations in the Trophic Level of Commercial Groundfish Species in the Gulf of Alaska”
Megan M. Murphy	Major Advisor: Katrin Iken M.S. – Marine Biology “Larval Transport of Brachyuran Crab in Kachemak Bay, Alaska”
Julie Nielsen	Major Advisor: Tom Shirley M.S. – Fisheries “Distribution and Movement of Juvenile Tanner Crabs (<i>Chionoectes bairdi</i>) in Glacier Bay National Park”
Olav Ormseth	Major Advisor: Brenda Norcross Ph.D. – Oceanography “Reproductive Potential of Pacific Cod (<i>Gadus macrocephalus</i>) in Alaska”
Katie Palof	Major Advisor: A.J. Gharrett M.S. – Fisheries “Population Genetic Structure of Alaskan Pacific Ocean Perch (<i>Sebastes Alutus</i>)”

Carrie Parris	Major Advisor: Katrin Iken M.S. – Marine Biology “The Influence of Selected Bottom-Up Factors on Intertidal Clam Communities in Kachemak Bay, Alaska”
Megan Peterson	Major Advisor: Courtney Carothers and Franz Mueter Ph.D. – Fisheries “Toothed Whale Interactions with Longline Fisheries in Alaska”
Jonathan Richar	Major Advisor: Gordon Kruse Ph.D. – Fisheries “Recruitment Mechanisms of Tanner Crab in the Eastern Bering Sea”
Cara Rodgveller	Major Advisor: William Smoker M.S. – Fisheries “Effects of Inbreeding and Family Origin on Size of Chinook Salmon (<i>Oncorhynchus tshawytscha</i>) Fry”
Sean Rooney	Major Advisors: Brenda Norcross and Jennifer Reynolds M.S. – Fisheries “Habitat Analysis of Major Fishing Grounds on the Continental Shelf off Kodiak, Alaska”
Ashwin Sreenivasan	Major Advisors: William Smoker Ph.D.. – Fisheries “Nucleic acid ratios as an index of growth and nutritional ecology in Pacific Cod (<i>Gadus macrocephalus</i>), walleye pollock (<i>Theragra chalcogramma</i>), and Pacific herring (<i>Clupea pallasii</i>)”
Cindy Tribuzio	Major Advisor: Gordon Kruse Ph.D. – Fisheries “Life History, Demography, and Ecology of the Spiny Dogfish (<i>Squalus acanthias</i>) in the Gulf of Alaska”
Briana Witteveen	Major Advisor: Terry Quinn M.S. – Fisheries “Abundance and Feeding Ecology of Humpback Whales (<i>Megaptera novaegliae</i>) in Kodiak, Alaska”

Jamie Womble

Major Advisor: Brendan Kelly

M.S. – Fisheries

“Seasonal Distribution of Stellar Sea Lions (*Eumetopias jubatus*)
in Relation to High-Quality Ephemeral Prey Species in Southeast
Alaska”

Research Abstracts
from
Rasmuson Fellows
who completed
their degrees
between 2001 and 2015

Defining Genetic Population Structure and Historical Connectivity of Snow Crab (*Chionoecetes opilio*)

Gregory Albrecht
August 2011

The snow crab (*Chionoecetes opilio*) is a valuable commercial resource within the Bering Sea, as well as other areas in the North Pacific and Atlantic Oceans. Large populations are known to exist within the Chukchi and Beaufort Seas, including recently discovered commercial sized individuals (Beaufort). However, genetic connectivity throughout these regions has not been examined until now. Based on seven polymorphic microsatellite loci, relatively low population genetic structuring occurs throughout the Alaskan region ($G_{ST} = 0.001$). This homogeneity is likely due to long-distance larval dispersal, adult migrations, and a possible recent population expansion following the last glacial maximum. Furthermore, meta-population analysis was conducted for Alaskan and Northwest Atlantic stocks. Although significant genetic divergence characterizes the West Greenland stock in relation to all other populations, low divergence ($G_{ST} = 0.005$) was found between Atlantic Canada crabs and those from the Alaska region. Larval dispersal between regions is highly unlikely due to the transit distance. Therefore, low divergence is likely the result of a recent population expansion into the Northwest Atlantic <5000 years ago.

Variability in Population Trends, Life History Characteristics, and Milk Composition of Northern Fur Seals in Alaska

Alison Banks

December 2012

The northern fur seal population on the Pribilof Islands (Pribilofs) has been declining since the 1960s and is now less than 30% of its former size. Chapter 1 examines numerous factors that might cause a population to decrease to such an extent and concludes that only nutritional limitation caused by climate change or commercial fisheries, predation by killer whales, or a combination of factors that includes conditions in the North Pacific during the winter were possible explanations. Chapter 2 reports on the proximate composition of northern fur seal milk on St. Paul Island (St. Paul, one of the Pribilofs) and Bogoslof Island, where the fur seal population has been growing exponentially since its founding more than 30 years ago. This study was part of a larger project that investigated the factors that may be contributing to the differing population trajectories of northern fur seals in the Bering Sea (Consequences of Fur Seal Foraging Strategies, COFFS). Knowledge of milk composition is essential information for understanding the energy requirements of lactation and the energetics of pup growth and body condition at weaning. Multiple variables were examined to understand potential sources of variability in milk composition. In July, none of the independent variables tested (island, year, female mass and milk volume) had an effect on milk composition. However, in October, the variables days postpartum, time ashore, July milk composition, island and preceding trip duration had an effect on milk lipid content and the variables days postpartum, time ashore and July milk composition had an effect on energy content. The variables rookery, year, female mass and milk volume had no effect. October lipid content averaged $53.8 \pm 1.0\%$ at St. Paul and $57.3 \pm 0.8\%$ at Bogoslof ($p < 0.01$) and energy content averaged 24.0 ± 0.4 kJ/g at St. Paul and 25.3 ± 0.3 kJ/g at Bogoslof ($p = 0.11$). On average, milk lipid content increased 22% from July to October, protein remained relatively stable with averages ranging between 10.0% and 10.5%, and total energy content increased by 20%. COFFS found that pups on Bogoslof were weaned at a significantly greater mass and body condition than pups on St. Paul, but the differences were likely the result of divergent female foraging strategies between the two locations and not because of the difference in milk composition. Females from Bogoslof spent approximately 35% of their time on shore during nursing bouts compared to females from St. Paul that spent approximately 21% of their time on shore. The lipid content of northern fur seal milk near peak lactation is the highest reported among otariid seals and is as high as the highest known for phocid seals, making it among the highest known for all mammals. This is consistent with the short lactation length and long foraging trip durations typical in northern fur seals.

Abundance, Recruitment, and Environmental Forcing of Kodiak Red King Crab

William Bechtol

May 2009

Commercial harvests of red king crab (*Paralithodes camtschaticus*) around Kodiak Island, Alaska increased rapidly in the 1960s to a peak of 42,800 mt in 1965. Stock abundance declined sharply in the late 1960s, moderated in the 1970s, and crashed in the early 1980s. The stock has not recovered despite a commercial fishery closure since 1983. To better understand the rise, collapse, and continued depleted status of the red king crab stock around Kodiak Island, I conducted a retrospective analysis with three primary objectives: (1) reconstruct spawning stock abundance and recruitment during 1960-2004; (2) explore stock-recruit relationships; and (3) examine ecological influences on crab recruitment.

A population dynamics model was used to estimate abundance, recruitment, and fishing and natural mortalities. Three male and four female “stages” were estimated using catch composition data from the fishery (1960-1982) and pot (1972-1986) and trawl (1986-2004) surveys. Male abundance was estimated for 1960--2004, but limited data constrained female estimates to 1972-2004. Strong crab recruitment facilitated increased fishery capitalization during the 1960s, but the high harvest rates were not sustainable, likely due to reproductive failure associated with sex ratios skewed toward females.

To examine spawner-recruitment (S-R) relationships for the Kodiak stock, I considered lags of 5-8 years between reproduction and recruitment and, due to limited female data, two currencies of male abundance as a proxy for spawners: (1) all males 2: 125 mm carapace length (CL); and (2) legal males (2: 145 mm CL). Model selection involved AIC, the Akaike Information Criterion corrected for small sample size. An autocorrelated Ricker model using all males and a 5-year lag, with the time series separated into three productivity periods corresponding to different ecological regimes, minimized AIC, values. Depensation at low stock sizes was not detected.

Potential effects of selected biotic and abiotic factors on early life survival by Kodiak red king crab were examined by extending the S-R relationship. Results suggested a strong negative influence of Pacific cod *Gadus macrocephalus* on crab recruitment. Thus, increased cod abundance and a nearshore shift in cod distribution likely impeded crab stock rebuilding.

Dispersal Patterns and Summer Oceanic Distribution of Adult Dolly Varden from the Wulik River, Alaska, Evaluated using Satellite Telemetry

Michael Courtney
May 2015

In Arctic Alaska, Dolly Varden *Salvelinus malma* is highly valued as a subsistence fish; however, little is known about oceanic dispersal or ecology. This study addresses this knowledge gap, by using a fisheries independent method, pop-up satellite archival tags (PSATs). In spring of 2012 and 2013, we attached 52 PSATs to Dolly Varden in a river in northwestern Alaska, which flows into the Arctic Ocean, to examine the marine dispersal, behavior and habitat occupancy of this species. Tagged Dolly Varden demonstrated two types of dispersal, including offshore and nearshore dispersal. The offshore type was the first documented northwesterly dispersal and occupancy of Outer Continental Shelf (OCS) areas of the Russian Chukchi Sea. While occupying this area, tagged Dolly Varden demonstrated affinity for the first 5 m of the water column, diel patterns in depth occupancy, and dive depths of up to 50 m, while experiencing a thermal environment of generally 3–7°C. During the nearshore dispersal type, Dolly Varden transited in coastal areas of northwest Alaska, likely returning to their natal rivers to spawn. While in nearshore areas, tagged Dolly Varden always occupied shallow waters (< 6 m), and experienced a rapidly changing thermal environment ($\pm 15^{\circ}\text{C}$), including some waters temperatures cooler than -1°C . This study demonstrates that PSATs offer an alternative and effective platform with which to study several aspects of large adult Dolly Varden dispersal and ecology in areas where it is not practical or feasible to capture these fish, such as in coastal and offshore regions of Arctic Alaska. Additionally, the results of this study have increased our knowledge of the summer marine distribution, behavior and thermal environment of Dolly Varden in Arctic regions of Alaska, and this knowledge is important to several stake holders for the conservation of this important subsistence species.

Effects of Ocean Acidification on Development of Alaskan Crab Larvae

Raphaelle Descoteaux

May 2014

The oceans absorb a large proportion of the carbon dioxide gas (CO₂) emitted into the atmosphere. This CO₂ changes the chemistry of seawater to make it more acidic, a phenomenon termed ocean acidification. Ocean acidification can have negative impacts on marine fauna, especially during early life stages, presenting a risk to ecosystems and fisheries. This research tested the effects of ocean acidification on the larval development of three crab species in Alaska: Tanner crab (*Chionoecetes bairdi*), rock crab (*Glebocarcinus oregonensis*) and Dungeness crab (*Metacarcinus magister*). Experiments were undertaken to assess the effects of exposure to low-pH conditions (decrease of up to 0.6 pH units from current levels, range of pH ~8.1 to 7.5) on survival, growth (morphometrics and mass), and carapace mineral composition of larval Tanner, rock, and Dungeness crabs. Results showed a decrease in survival as well as a small but non-significant decrease in size of Tanner crabs. There was a small but complex effect of pH on survival of Dungeness crabs. Rock crabs raised in low-pH conditions (pH 7.5) had higher individual biomass than those raised in ambient conditions (pH 8.1). There was no significant impact of pH on mineralization of any species. Therefore, low pH had a negative effect on development of Tanner crabs, a small effect on Dungeness larval survival and no discernable negative effect on rock crab larvae. Differences in response to ocean acidification may be related to pre-adaptation to variable pH conditions through lifestyle such that species that live in deeper, more stable waters (e.g., Tanner crab) are more vulnerable than species living in shallower, more variable waters (e.g., rock and Dungeness crabs). These observations suggest that ocean acidification will have negative impacts on Tanner and Dungeness crab larval survival with potential implications for recruitment to the adult population and consequently, for their fisheries.

Effects of Environmental Characteristics on the Fish Assemblages of High Latitude Kelp Forests in South-Central Alaska

Terril Efrid

December 2013

Alaskan kelp forests are patchy habitats, varying greatly in size, physical complexity, and biotic and abiotic characteristics, and are important to fish communities. Patchy habitats often support different communities on patch edges versus interiors, while patch size and physical complexity are typically correlated to the resident community structure. This study quantified the biological and physical heterogeneity within different sized kelp forests and identified which factors are important in structuring the associated fish communities. Fish and habitat surveys were conducted at ten kelp forests of varying sizes. Significantly different fish communities were found at edge compared to interior locations. The relative abundance of seven species explained 91.4% of the variability in the fish community. Fish community structure was not correlated with kelp forest size or the species composition of canopy forming kelps. Instead, it related to the abundances of two understory kelps, bottom rugosity, and water depth. Together these benthic attributes correlated with 53.6% of the fish community variability. These findings suggest that within patchy systems that are spatially and structurally non-uniform, associated fish species composition and abundance may be more directly linked to location within the patch and year-round habitat complexity rather than habitat patch size or foundational species composition.

Physiological and Behavioral Responses of Tanner Crabs (*Chionoecetes bairdi*) to Handling, Emersion and Temperature

Sonya El Mejjati
December 2006

Commercially harvested Tanner crabs (*Chionoecetes bairdi*) are exposed to physical stressors during capture and sorting including changes in temperature and oxygen availability. This study characterizes the physiological and behavioral responses of Tanner crabs exposed to air (emersion) at 8 and -15°C for various durations. Concentrations of glucose and lactate in hemolymph measured between 30 and 120 min following emersion for 45 min differed between animals exposed to 8 or -15°C. Glucose concentrations were higher among animals emersed at 8°C than those exposed to -15°C within the intervals sampled. Lactate concentrations were unchanged at intervals following emersion at 8°C, while they were elevated at 120 min following emersion at -15°C. Rates of oxygen consumption (VO_2) increased immediately following 15, 30, and 45 min emersion at 8°C, whereas 30 and 45 min emersion at -15°C resulted in depressed VO_2 . All crabs survived handling and emersion at 8°C, while exposure to -15°C resulted in increased mortality. Thus, differences among physiological parameters corresponded with differences in percentage survival between the two temperature treatments. While not providing a causal relationship between survival and physiology, the metabolic responses of Tanner crabs following a simulated capture protocol provide a predictive index of subsequent survival.

The Effects of Ocean Acidification on Walleye Pollock (*Theragra Chalcogramma*) Early Life History Stages

Elena Fernandez

May 2015

Since the Industrial Revolution of the late 1700's, atmospheric and marine carbon dioxide levels have drastically increased. Ocean acidification is the result of the shift in the marine carbon cycle caused by the increase in marine and atmospheric carbon dioxide. Changing environmental conditions caused by ocean acidification have been shown to have adverse effects on different marine species as well as life history stages. As a result, ecologically and economically important teleost fish species such as walleye pollock (*Theragra chalcogramma*) could be adversely affected by ocean acidification conditions. This study explores the responses of walleye pollock eggs and larvae incubated under different projected levels of ocean acidification, looking at hatch timing and growth parameters to examine potential adverse responses to more acidic conditions. Older walleye pollock juveniles (age 1+) were used to uncover potential physiological responses to ocean acidification pertaining specifically to stress, overall body condition indices, and blood chemistry. I found that while the two early life history stages of walleye pollock could survive under ambient, high, medium, and low pH conditions (pH 8.1, 7.9, 7.6, and 7.2, respectively), there were some physiological responses to projected levels of ocean acidification. Hatch timing was not delayed in the lowest pH treatment as expected. In addition, size at hatch, yolk area, and eye diameter did not differ among pH treatments. Walleye pollock juveniles reared under projected levels of ocean acidification demonstrated shifts in blood gas levels and blood pH. However, exposure to a lower pH environment of pH 7.9, 7.6, or 7.2 did not induce a response for either the stress indicators or body condition indices that were measured. To uncover the mechanism for their resilience, more testing is needed to gain further insight into underlying compensatory mechanisms of various life history stages and populations.

Identification and Application of Molecular Markers to Chum Salmon (*Oncorhynchus keta*) Population Genetics

Michael Garvin
December 2012

I developed a new technique, DEco-TILLING (an adaptation of Eco-TILLING), to discover useful single nucleotide polymorphisms (SNPs) rapidly and inexpensively. Some chum salmon (*Oncorhynchus keta*) populations have declined in Western Alaska and in other areas of their geographic range. Possible reasons include climate shifts, by-catch in fisheries, and other perturbations. Genetics offers powerful tools that can be used to monitor this species on the high seas in stock mixtures aiding management of by-catch identification and other contributors to declines. Single nucleotide polymorphisms are a genetic marker that can be easily and rapidly surveyed on many individuals. Tools like SNPs offer advantages in discriminating stocks in mixtures. However, tens or hundreds of informative SNPs must be discovered from among the million in the chum salmon genome. Available discovery methods introduce ascertainment bias into this process, which can result in uninformative SNPs or the failure to identify useful ones. I incorporated and improved a genotyping assay to screen SNPs in thousands of individuals for a tenth of the cost of the standard available assay, and improved an assay to resolve the phase of linked SNPs. I show that the SNPs that I discovered are useful and can be used for mixed stock analysis.

Non-Linear Dynamics of Marine Ecosystem Models

Georgina Gibson
December 2004

Despite a rapid trend towards more realistic Nutrient-Phytoplankton-Zooplankton (NPZ) models, in which zooplankton are presented with multiple nutritional resources, investigations into the fundamental dynamics of these newer models have been limited. The objective of this dissertation was to explore the dynamical behavior of such NPZ models parameterized for the coastal Gulf of Alaska. With alternative stationary forcing regimes and zooplankton grazing functions, the dynamics of one-dimensional NPZ models were investigated for a range of specific predation rates (h) and predation exponents (q), which together define the form of the predation (model closure) function. Oscillations in state variables are shown to be an intrinsic property of the NPZ models, not dependent on variable seasonal forcing for their existence. Increasing mixed layer diffusivity or reducing mixed layer depth increased model excitability; it is hypothesized that this is due to the resultant increase in flux of utilizable nutrient. Model behavior was also strongly influenced by the form of both the grazing and predation functions. For all of the grazing functions implemented, Hopf bifurcations, where the form of the solution transitioned between steady equilibrium and periodic limit cycles, persisted across the q - h parameter space. Regardless of the values of h and q , with some forms of the grazing function steady equilibrium solutions that simultaneously comprised non-zero concentrations for all model components could not be found. The inclusion of sinking detritus in the model had important implications for the composition and excitability of model solutions, generally increasing the region of q - h space for which oscillatory solutions were found. Therefore, in order to correctly simulate the depth-explicit concentrations of model components, or to have an accurate understanding of the potential excitability of the system, inclusion of this component is valuable. This dissertation highlights the importance of understanding the potential impact that choice of functional response may have on the intrinsic oscillatory nature of a model prior to interpreting results from coupled bio-physical simulations. As we come to rely more on ecosystem models as a tool to interpret marine ecosystem functionality it will be important to improve our understanding of the non-linear behavior inherent in these models.

Physical Environmental and Biological Correlates of Otolith Chemistry of Arctic Marine Fishes in the Chukchi Sea

Christine Gleason

August 2012

Life history movement patterns in marine fishes can be determined by otolith chemistry if environmental variables are reflected in the otoliths. Arctic cod (*Boreogadus saida*), Arch staghorn sculpin (*Gymnocanthus tricuspis*), and Bering flounder (*Hippoglossoides robustus*) are abundant Arctic fishes in the Chukchi Sea with overlapping distributions. Physical environmental data, demersal fishes, bottom seawater, and sediment interface seawater samples were collected from the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) cruise on July 30, 2009 and the Russian American Long-term Census of the Arctic (RUSALCA) cruise from September 3 to 30, 2009 in the Chukchi Sea. Magnesium (Mg), strontium (Sr), barium (Ba), and Calcium were measured with an inductively coupled plasma mass spectrometer (ICP-MS) on the most recent growth edge of otoliths and in whole fish blood, as well as Ba in bottom and sediment interface seawater. Environmental variables and fish age correlated with Arctic cod and Arctic staghorn sculpin otoliths while only environmental variables correlated with Bering flounder signatures. Elemental correlations were not always consistent for the variable tested among species. The complexity of this multi-element tool suggests otolith chemistry may not be useful to determine life history movement patterns of these demersal Arctic fishes in offshore waters.

Interrelationship Among Temperature, Metabolism, Swimming Performance and Recovery in Pacific Cod (*Gadus macrocephalus*): Implications of a Changing Climate

Shannon Hanna

May 2009

Physiological constraints are suggested to contribute to the observed changes in relative abundance of Pacific cod (*Gadus macrocephalus*) seen in association with interdecadal changes in sea surface temperatures. To examine this concept, two experiments were conducted to determine critical swimming speed (Ucrit) rates of oxygen consumption and recovery post-exhaustion of adult cod acclimated to different temperatures. In addition, hematocrit and plasma concentrations of cortisol, metabolites and ions from resting and exhausted fish were measured to assess the impact of swim trials on fish condition. In experiment one, fish acclimated to 4° C had similar mean Dent (1.07 BL/s) and resting metabolic rates (35.34 mg Oz/kg 0.8/hr) compared to fish acclimated to 11° C fish (1.07 BL/s; 49.43 mg O₂/kg 0.8/hr). Similarly, concentrations of blood constituents differed little between temperature treatments; each exhibited increases in plasma cortisol and metabolites from pre- to post-swim. Experiment two illustrated few differences in rates of recovery between temperature groups (2 and 7°C). After four hours of recovery there was no evidence of plasma cortisol or metabolites returning to pre-swim concentrations in either temperature group. It seems unlikely that physiological constraints on the metabolic performance of adult Pacific cod contribute to changes in their relative abundance.

Inter-Decadal Change in Sablefish (*Anoplopoma fimbria*) Growth and Maturity in the Northeast Pacific Ocean

Katy Howard
August 2008

Errors in growth and maturity estimates can drastically affect the spawner-perrecruit threshold used to recommend commercial fish catch quotas. Growth and maturity parameters for Alaskan sablefish, *Anoplopoma fimbria*, have not been updated for stock assessment purposes for 20 years, even though sablefish aging has continued. In this study, the old length-stratified data set (1981- 1993) was updated and corrected for bias. In addition, newer, randomly collected samples (1996- 2004) were analyzed, and new length-at-age, weight-at-age, and maturity -at-age and length parameters were estimated. A comparison of the two datasets showed that in recent years, sablefish are growing larger and maturing later and that growth and maturity differ somewhat among regions. The updated growth information improves data fits in the sablefish stock assessment model. It also provides results that are biologically reasonable. These updated and improved estimates of sablefish growth and maturity help ensure the continued proper management of this commercially important species in Alaskan waters.

Movement and Habitat Utilization by Golden King Crab (*Lithodes aequispinus*) Benedict 1895 in Southeastern Alaska

Zachary Hoyt
December 2003

Movements and habitat use of golden king crabs (GKC) (*Lithodes aequispinus*) were investigated with a manned submersible and ultrasonic telemetry in Frederick Sound, Alaska. Crabs were collected with commercial crab pots and ultrasonic transmitters were attached to the carapaces of 26 crabs; movements and depth distribution of male and female crabs were monitored bi-monthly from May 11, 2000 to April 12, 2001. Crabs preferred steep, complex habitat with hard substrate; few were on flat, soft substrate. Male and female GKC were not segregated by depth in mid-May. Seventeen pairs of courting crabs were observed during dives; 14 of these pairs were associated with either intermittent or continuous boulder fields and 3 with wall substrates. Crabs did not have seasonal site fidelity. Crabs had seasonal changes in depth distribution, moving to deeper water during late fall and winter and returning to shallower depths during spring. Crabs moved as far as 39 km over one year. No evidence of spatial fidelity was observed; golden king crabs may be moving greater distances or site fidelity maybe on a longer temporal scale than our study, or golden king crabs may be nomadic in nature.

Investigating the Trophic Role of Adult Arrowtooth Flounder (*Atheresthes stomias*) as a Top Level Consumer, in the Gulf of Alaska Ecosystem

Brian Knoth
December 2006

The arrowtooth flounder (*Arheresthes stomias*) (ATF) population in the Gulf of Alaska has increased dramatically over the past 25 years and the resulting ecosystem impacts are unclear. Arrowtooth flounder diet and prey consumption was studied to more accurately assess the predator-prey relationships of this key predator near Kodiak Island, Alaska. Temporal and ontogenetic diet trends were quantified from the analysis of 742 ATF stomachs sampled from annual bottom trawl surveys conducted in May and August from 2002 to 2004. Several significant dietary trends were found, most notably: 1) euphausiids decreased in dietary importance from May to August whereas the importance of capelin (*Mallotus villosus*) increased and 2) smaller ATF consumed more capelin and larger ATF consumed more walleye pollock (*Theragra chalcogramma*) and Pacific sand lance (*Ammodytes hexaprerus*). A bioenergetics model was used to estimate ATF prey consumption. Within the study area, the ATF population was dominated by large individuals (≥ 50 cm total length) that accounted for > 75 % of the population's total prey biomass consumption. Arrowtooth flounder were significant predators and consumed an estimated 339 t of fish prey including Pacific sand lance and walleye pollock and 222 t of invertebrate prey such as euphausiids and shrimps.

Contemporary Evolution in Threespine Stickleback from Uplifted Islands in Alaska

Emily Lescak
August 2015

How rapidly can evolution occur in the wild? Threespine stickleback (*Gasterosteus aculeatus*) fish are a prime model organism to address this question because we can study post-glacial populations that are only about 13,000 years old. During this relatively short period of time, oceanic stickleback have repeatedly and independently colonized newly available freshwater habitat, giving rise to resident freshwater populations that exhibit repeated patterns of phenotypic and genetic divergence. However, it is currently unknown whether it actually takes thousands of years for resident freshwater populations to diverge from the ancestral form. To address this question, we have identified phenotypically variable stickleback populations in freshwater sites formed on islands in Prince William Sound and the Gulf of Alaska as a result of uplift from the 1964 Alaska Earthquake. Population genomics analyses support the hypothesis of ongoing independent colonization of freshwater habitats by oceanic ancestors. Despite recurrent gene flow between oceanic and freshwater stickleback, we find that the magnitude of phenotypic and genetic divergence between the ancestral and derived populations is comparable to what has been observed in populations that were founded thousands of years ago. Our data implicate natural selection as the major driver of phenotypic diversification and support the hypothesis that the metapopulation organization of this species helps maintain a large pool of standing genetic variation available for selection when oceanic stickleback colonize fresh water. We propose that the greatest amount of phenotypic evolution occurs within the first few decades after stickleback colonize novel freshwater environments.

Seasonal Abundance and Habitat Characteristics of Nearshore Pelagic Fish in Kodiak, Alaska

Mary Beth Loewen
August 2007

The importance of Alaskan embayments as adult walleye pollock and Pacific herring habitat is unknown. Seasonal hydroacoustic and trawl surveys were conducted in three oceanographically distinct bays to correlate abiotic and biotic habitat factors with nearshore fish distributions around Kodiak Island. Relationships between fish densities and sea surface temperature and salinity, bottom depth, zooplankton density and diversity, bottom temperature and salinity, and water column stratification were analyzed through General Additive Models (GAMs). Bathymetry and temperature were consistently included as important habitat variables. Relationships between fish density and habitat variables differed by season and location, suggesting factors defining preferred habitat vary seasonally. Herring appear to prefer warmer, fresher surface waters associated with the Alaska Coastal Current. Mean pollock density increased between February and August, indicating the nearshore area is important summer habitat, while it is less important for herring after winter spawning. Pollock and herring utilize different horizontal and vertical areas of the bays, with pollock in deeper waters. Pollock separated vertically by size class, but no vertical separation was found for herring of different size classes. The range of size classes and high densities of both species suggest these previously unsurveyed areas are important pelagic fish habitat.

Understanding Place in Fisheries Management: An Examination of Ecological and Social Communities in the Pribilof Islands, AK

Courtney Lyons
August 2015

Holistic approaches toward fisheries management are widely considered a more sustainable option than standard single-species frameworks. This project uses the holistic frameworks of ecosystem-based fisheries management (EBFM) and place-making to examine the ecological and social systems of the Pribilof Islands and the ways in which fisheries management decisions have structured these systems. In Chapter 1, we sought to understand potential ecological constraints of temperature, fish predation, and interactions with congener (red king crab; *Paralithodes camtschaticus*) on blue king crab (*Paralithodes platypus*) recovery. These examinations suggest that blue king crab juveniles switch strategies from predator avoidance to a strategy of predator deterrence in situations where predation is more likely. In addition, this research suggests that predatory interactions between crab congeners may be more likely than fish predation to inhibit blue king crab recovery. In Chapter 2, we sought to understand local place-making efforts and how they differed between the two Pribilof Island villages, as well as, how these place-making efforts articulated with development programs. We found that place-making efforts in both communities were based on maintaining residence in the islands and an appreciation of the way-of-life that residence provided. The way place-making efforts articulated with development programs, however, differed between the communities. In St. George, Alaska, residents selectively embraced development, only supporting initiatives that would help realize the goal of maintaining residence in the community, as opposed to integrating into a regional economy. Residents of St. Paul, Alaska, in contrast, had more autonomy and were able to control development projects in their community, as opposed to integrating into a regional economy. Residents of St. Paul, Alaska, in contrast, had more autonomy and were able to control development projects in their community to support local place-making efforts. In Chapter 3, we used these data to develop a framework for assessing the vulnerability of fishing communities based on holistic, ethnographic understandings of local social systems. This framework showed St. George to be a highly vulnerable community, while St. Paul was only moderately vulnerable. These assessments challenged previously published, quantitative vulnerability assessments. The results of our investigations into the social and ecological systems of the Pribilof Islands support the idea that holistic perspectives provide important information that can drastically alter management understandings of both fish resources and the people who depend upon them.

What drives snow crab recruitment: cod, spawners, or climate?

Laurinda Marcello

December 2011

Snow crab (*Chionoecetes opilio*) are found in many subarctic ecosystems where they are important components of marine food webs and support large commercial fisheries. Snow crab abundance is highly variable, but what causes large changes in year-class strength is poorly known. I will present results from a regression study that examined the effects of snow crab spawning stock biomass, environmental conditions, and predation by cod on snow crab recruitment or abundance in each of three ecosystems; the eastern Bering Sea, the Newfoundland-Labrador Shelf, and the southern Gulf of St. Lawrence. Cold ocean conditions during early life history were associated with increased snow crab recruitment or abundance in all three ecosystems. However, there was no consistent evidence that spawning stock biomass or cod predation were significantly related to subsequent recruitment. These results underscore the value of comparing multiple ecosystems and demonstrate the importance of ocean conditions in driving variability in snow crab populations.

Essential Larval and Juvenile Fish Habitat in Nearshore Waters of Kachemak Bay, Alaska

Joel Markis
May 2007

Complex kelp and rocky habitats can be beneficial to fishes, however, their use of these habitats is poorly understood in northern latitudes. This study examined nearshore kelp habitats to examine the potential effects of kelp density and substrate topography on nearshore fish communities in Kachemak Bay, Alaska. Fish were collected from multiple sand, understory kelp, and understory and canopy kelp sites, along with kelp and substrate complexity measurements. Standard Monitoring Units for the Recruitment of Fish (SMURFs), light traps, shrimp pots, and SCUBA visual surveys were all employed in these collections. Relative fish abundance and community composition varied temporally in all habitats. The dominant fish families were gadids, pleuronectids, hexagrammids, and sebastids. Habitat use differed significantly temporally and spatially in relation to size class. These differences were family specific. Community analysis of the dominant fish families showed that different habitat complexities supported distinct fish assemblages. Low complexity sand habitats were particularly important for juvenile pleuronectids in this region and complex nearshore kelp habitats may be essential fish habitat for juvenile Pacific cod. Although these high complexity nearshore environments may be challenging to sample, they support large fish assemblages and may be essential to a variety of fish families and species.

Ontogenetic Considerations in the Trophic Level of Commercial Groundfish Species in the Gulf of Alaska

Jennifer Marsh
December 2010

Trends in trophic level (TL) estimates of commercial fishery catches are used as ecosystem-based indicators for sustainability, but these estimates often do not incorporate species-specific interannual and ontogenetic feeding patterns. This study provides a finer resolution of ontogenetic and temporal variations in the trophic position of four groundfish species in the central Gulf of Alaska (GOA), walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), arrowtooth flounder (*Atheresthes stomias*), and Pacific halibut (*Hippoglossus stenolepis*), using stable isotope analysis to assess TL and diet source. Samples were collected from the northeastern side of Kodiak Island, Alaska, from 2000-2004. Several Analysis of Covariance models were tested, allowing TL to co-vary with length, to detect possible variation among years and seasons and to estimate TL of catch for each study species. For each species, TL increased with length. Significant annual differences in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were detected for all groundfish, indicating a lower TL, pelagic diet in 2003 and a higher TL, benthic diet in 2001. Overall, TL of GOA commercial catches appeared to remain stable over 1990-2009, with the exception of walleye pollock after 1999. This study shows that including length data could lead to an earlier detection of decline in TL estimates.

Larval Transport of Brachyuran Crab in Kachemak Bay, Alaska

Megan M. Murphy
August 2010

This study's primary goal was to understand the oceanographic effects on larval crab transport and distribution between an estuarine inner and more oceanic outer bay in the subarctic estuary of Kachemak Bay, Alaska. Plankton tows and hydrographic measurements (temperature and salinity) were taken along the boundary between the two bay parts from March – October on spring and neap tides. Summer water flow and stratification in Kachemak Bay is predominantly freshwater-driven and density patterns vary inter-annually with the amount of freshwater supplied to the inner bay. Larvae of seven crab species occurred in a seasonal sequence and the crab larval assemblage was closely correlated to temperature in the upper 20 m. The influence of tidal forcing on larval transport was not clear even though most species exhibited peak abundances at spring tides. Larval distribution patterns across the inner/outer boundary indicated that *Oregonia gracilis* larvae may be transported into inner Kachemak Bay; however, late larval stages of the two commercially relevant species, *Chionoecetes bairdi* and *Cancer magister*, were never observed and may be exported from the inner estuary. These observations provide an important baseline for further studies to understand Kachemak Bay's role as a source or sink for larval crab.

Distribution and Movement of Juvenile Tanner Crabs (*Chionoecetes bairdi*) in Glacier Bay National Park

Julie Nielsen
December 2005

Spatial segregation of adult and juvenile Tanner crabs was observed in conjunction with glacial landscape features during a comprehensive systematic survey of Glacier Bay National Park, Alaska, in 2002. Hot spots (clusters of high values) of catch per unit effort for juveniles occurred mainly in two narrow glacial inlets, whereas most adult hot spots occurred in the central portion of the bay. Overall, juveniles were associated with shallower depths and warmer temperatures than adults. However, in juvenile hot spot areas, where adults were rare, juveniles were associated with greater depths and colder temperatures than adults. Glaciated landscapes may provide spatial refuges from predation and nursery areas for juveniles. Tagging methods with high trans-molt retention need to be developed for direct measurement of ontogenetic movement. A laboratory study was conducted to determine trans-molt survival and retention of Floy T-bar tags in juvenile Tanner crabs. Approximately half of crabs in all tagging treatments survived and retained tags through a molt. Trans-molt retention of Floy tags is hindered by complex morphology of the Tanner crab carapace.

Reproductive Potential of Pacific Cod (*Gadus macrocephalus*) in Alaska

Olav Ormseth
December 2007

The reproductive potential of female fishes, which results from the number of eggs they produce and the quality of individual eggs, is a critical factor in fisheries biology. Reproductive potential is important to individuals because maternal fitness is the product of the number of offspring produced and how many offspring survive. The growth rate of populations and their capacity for supporting commercial fisheries also depend on the number of viable offspring that females produce. I studied the reproductive potential of female Pacific cod (*Gadus macrocephalus*) in the North Pacific Ocean. Pacific cod is an important ecological and economic resource, yet much of its reproductive biology remains unexplored. I used several different approaches to investigate whether egg number or egg size are more important in determining reproductive potential, and to evaluate factors that influence reproduction. An analysis of life history variation among Pacific cod in Canada and Alaska demonstrated that despite differences in life history strategies, females from different populations had similar lifetime reproductive success (a proxy for individual fitness). I also collected Pacific cod in the Gulf of Alaska, eastern Bering Sea, and western Aleutian Islands from 2002 to 2005. Biochemical analyses of Pacific cod eggs revealed that Pacific cod produce low energy eggs that are adapted for rapid development on the seafloor. Larger females produce eggs with less arachidonic acid (a fatty acid that has been linked to egg quality) than smaller females, suggesting that they may sacrifice egg quality to maintain fecundity. Determination of fecundity and egg size in 590 females from different areas and years revealed that maternal length and weight are excellent predictors of fecundity, but that variability in egg size is not related to the age or size of females. The greatest difference in reproductive potential among years and areas was reduced egg size in the eastern Bering Sea in 2003, which may have been due to changes in ocean temperature or prey availability that impacted the ability of females to store energy. These results suggest that female Pacific cod maximize their fitness through increased egg production, not egg quality, and that their reproductive success is under strong environmental control.

Population Genetic Structure of Alaskan Pacific Ocean Perch (*Sebastes Alutus*)

Katie Palof
May 2008

Knowledge of the population structure of a species is essential for its effective management and sustained production. Although Pacific ocean perch (*Sebastes alutus*, POP) is an important species both economically and ecologically, little is known about its population structure and life history in Alaskan waters. The objectives of this study were to describe the population structure of POP in terms of the numbers and geographic scale of local populations, their connectivity, and the compatibility of that structure with current management. Fourteen microsatellite loci were used to characterize the population structure genetically in eleven geographically distinct collections from sites along the continental shelf from the Queen Charlotte Islands to the Bering Sea. In spite of the many opportunities for most life stages to disperse, there was strong geographically related genetic structure ($F_{ST} = 0.0123$, $p < 10^{-5}$). Adults appear to belong to neighborhoods that exchange genetic information at relatively small spatial scales (14 to 90 km). Although this suggests limited movement, connectivity is evidenced by the isolation-by-distance relationship, the apparent northwestward movement of gene flow in the Gulf of Alaska (GOA), and the break in gene flow in the central GOA. The observed population structure has a finer geographic scale than management areas, which suggests that current fisheries management should be revisited.

The Influence of Selected Bottom-Up Factors on Intertidal Clam Communities in Kachemak Bay, Alaska

Carrie Parris
May 2008

Intertidal clams are an important ecological and economic component of coastal areas in Alaska, but local depletions in some areas have increased the concern about this resource. Intertidal clams were sampled in 2004 and 2005 at four sites along a gradient of estuarine conditions in Kachemak Bay to investigate the influence of selected bottomup factors (food concentrations and sediment grain-size) on clam communities. I hypothesized that clams would be less abundant in the more estuarine than in the more marine regions. Clam abundance was highest at both the most estuarine site (Bear Cove, mean 320 ± 166 ind./m²) and at the most marine site (Duncan's Slough, mean 255 ± 10 ind./m²), and was lowest at the two intermediate sites (approximate mean 70 ind./m²). Biomass (shell-free wet weight, SFWW) decreased from Bear Cove (mean 1336 ± 338 g SFWW/m²) to Duncan's Slough (mean 332 ± 25 g SFWW/m²). Most clam species in Kachemak Bay fed mainly on benthic microalgae; however, the distribution of intertidal clams did not have any relationships to benthic chlorophyll-a concentrations. Sediment size had little influence on community structure. Bottom-up conditions encountered in Kachemak Bay may not be in a range that is limiting for intertidal clam communities.

Toothed Whale Interactions with Longline Fisheries in Alaska

Megan Peterson

May 2014

Killer whale (*Orcinus orca*) and sperm whale (*Physeter macrocephalus*) depredation occurs when whales damage or remove fish caught on longline gear. This project used a mixed methods approach incorporating Generalized Linear and Additive Modeling techniques and social research methods, such as semi-directed interviews and written questionnaires, to evaluate: 1) spatio-temporal depredation trends, 2) depredation effects on groundfish catch rates, and 3) socio-economic implications of depredation avoidance and changing fishing practices due to whale interactions. The occurrence of killer whale depredation varied by target species and area based on National Marine Fisheries Service longline survey data and observer commercial fishery data collected from 1998 to 2012 in the Bering Sea, Aleutian Islands, and Western Gulf of Alaska. The percentage of commercial fishery sets affected by killer whales was highest in Bering Sea fisheries for: sablefish (*Anoplopoma fimbria*; 21.4%), Greenland turbot (*Reinhardtius hippoglossoides*; 9.9%), and Pacific halibut (*Hippoglossus stenolepis*; 6.9%). Killer whale depredation was more common on the standardized longline survey (9.2-34.6% skates impacted) than the commercial sablefish fishery (1.0-21.4% sets impacted) in all three management areas. Catch reductions were consistent across data sets. Average commercial fleet catch reductions ranged from 35-69% for sablefish, Pacific halibut and Greenland turbot ($p < 0.001$); survey catch reductions ranged from 51-73% ($p < 0.001$). Sablefish catch per unit effort, gear haul time and location significantly impacted the proportion of sets depredated. Fishermen reported changing their fishing practices in response to depredating whales by soaking gear longer to “wait the whales out” or moving to different fishing sites. These avoidance measures resulted in increased operation costs and opportunity costs in lost time. In a follow-up analysis based on data collected by fishermen in 2011 and 2012, it was found that killer whale depredation avoidance measures resulted in an average additional cost of \$494 per vessel-day for fuel and crew food. Opportunity costs of time lost by fishermen averaged \$486 per additional vessel-day on the grounds. These results provide insight into the potential impacts of whale depredation on fish stock abundance indices and commercially important fisheries in Alaska and will inform future research on apex predator-fisheries interactions.

Recruitment Mechanisms of Tanner Crab in the Eastern Bering Sea

Jonathan Richar

August 2014

Influences of biophysical conditions on survival of zoeal and early stages of eastern Bering Sea Tanner crab, *Chionoecetes bairdi*, were investigated using simple linear regression modeling, and a combination of hydrodynamic modeling and spatial and geostatistical methods. Linear regression analyses indicated that estimated reproductive female crab abundance, age 3-7 Pacific cod (*Gadus macrocephalus*) abundance and flathead sole (*Hippoglossoides elassodon*) total biomass were statistically related to estimates of recruitment to the 30-50 mm carapace width size interval of juvenile crab. Analysis of output from a Regional Ocean Modeling System simulation model indicated considerable capacity of the Bering Sea oceanography to retain zoeae at regional and local scales. Major transport patterns corresponded to long-term mean flows, with a northwesterly vector. Retention may be a significant recruitment process, particularly in Bristol Bay, which is effectively oceanographically isolated from other source regions of crab larvae. Periods during which conditions may have favored juvenile crab survival were observed at the model-estimated larval endpoints during the early 1980s and mid to late 1990s. While environmental conditions at model-estimated endpoints were highly variable, crab recruitment was positively correlated with endpoint locations either within the periphery of the cold pool, or outside of it, and SST >2° C after allowing for autocorrelation in the juvenile recruitment series. However, limitations of the model, gaps in knowledge of Tanner crab life history and ecology, and the possibility of spurious correlations complicate interpretation of these results.

Effects of Inbreeding and Family Origin on Size of Chinook Salmon (*Oncorhynchus tshawytscha*) Fry

Cara Rodgveller
May 2004

We cultured separate lines of chinook salmon fry of Chickamin River, Southeast Alaska, ancestry in seven common garden enclosures. A parentage analysis based on variation of microsatellite alleles showed that within these lines seven brothersister matings created 35 inbred fish from 7 families ($F = 0.25$) and 37 outbred fish resulted from 10 matings between segregated lines. Outbred and inbred fish did not differ in length ($P = 0.42$), weight ($P = 0.86$), or condition factor ($P = 0.16$). There was significant variation among families for length ($P = 0.01$) and weight ($P < 0.01$), but not for condition factor ($P = 0.48$). Because variation among families can be large, it can potentially confound the effects for which a study was designed. To avoid drawing improper conclusions, studies should estimate the amount of variation that can be attributed to family origin, or be certain that many families are sampled.

Habitat Analysis of Major Fishing Grounds on the Continental Shelf off Kodiak, Alaska

Sean Rooney
December 2008

The continental shelf and upper slope of the Gulf of Alaska support diverse and commercially important communities of demersal fishes. Twenty-eight video-strip transects conducted from a research submersible, together with habitat maps based on interpreted multibeam sonar data, were used to classify distribution and abundance patterns of fishes relative to seafloor substrate type and water depth on Albatross and Portlock Banks on the Kodiak Shelf in the Gulf of Alaska. These associations were examined across spatial scales: ranging from tens of kilometer centimeters in size. A total of 5, 778 fishes were recorded from 33 taxa. Fish community distribution patterns were largely correlated with depth and to a lesser extent with substrate type. Individual fish species habitat associations were also influenced by depth and substrate type; however, the spatial scale at which these factors were relevant varied by fish species. There was strong regional concordance among observed fish species habitat associations and those previously documented in studies from central California to the northern Gulf of Alaska. Although integrating substrates classified at different scales was challenging, the resulting information of scale specific habitat associations provides a more comprehensive understanding of how demersal fishes utilize benthic habitats.

Nucleic acid ratios as an index of growth and nutritional ecology in Pacific Cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), and Pacific herring (*Clupea pallasii*)

Ashwin Sreenivasan

December 2011

Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), and Pacific herring (*Clupea pallasii*) are among the most ecologically and commercially important species in the North Pacific Ocean. In spite of their importance, little is known about larval and juvenile growth strategies in these fish. Since larval and juvenile fish growth may determine future growth, possibly affecting recruitment success, assessments of growth strategies might improve predictive growth models. Nucleic acid ratios (RNA/DNA) can have applications as a sensitive growth index in larval and juvenile Pacific cod, walleye pollock, and Pacific herring, and can potentially be used to determine growth responses and energetic assessments at the cellular level. Determining physiological growth responses in these fish after exposure to different temperatures and nutritional states can help in understanding growth strategies and condition. Nucleic acid ratios from white muscle of juvenile Pacific herring and whole-body Pacific cod and walleye pollock larvae were used as a cellular growth index to provide energetic assessments in these species. Growth responses were studied in these fish across a range of temperatures and nutritional states. Growth was compared between fed, starved/fed and terminally starved Pacific herring cultured at 6.5°C, 8.5°C, and 12.5°C. Relative to fed controls, starved/fed fish showed similar RNA/DNA ratios and soluble protein concentration, but reduced mass. Nucleic acid ratios in starved/fed fish during the starvation phase, and in terminally starved fish, indicated incipient terminal starvation. Also, a seasonal variation of RNA/DNA, protein concentrations and total body lipid concentrations was seen in fed fish, reflecting changes in resource allocation. Early growth was compared in yolk-sac Pacific cod and walleye pollock larvae cultured at 5°C and 8°C, and in yolk-sac Pacific cod larvae cultured in two nutritional states (fed and starved). Growth responses in Pacific cod and walleye pollock larvae were affected by small differences in temperature. Exposure to the lower temperature resulted in higher RNA/DNA in both Pacific cod and walleye pollock larvae. Based on nucleic acid patterns with larval development, it was possible to identify distinct growth stanzas in Pacific cod larvae.

Life History, Demography, and Ecology of the Spiny Dogfish (*Squalus acanthias*) in the Gulf of Alaska

Cindy Tribuzio
August 2010

The spiny dogfish (*Squalus acanthias*) is a small, cosmopolitan shark species, common in sub-tropical and sub-arctic waters. The species is often targeted commercially in most areas of the world throughout its range, and in some cases it is overfished or the subject of conservation concern. In the Gulf of Alaska, spiny dogfish are not targeted and not generally retained, but incidental catch can be high for this schooling species. Previously, biological parameters for spiny dogfish in the Gulf of Alaska were assumed from estimates for this species neighboring areas, including British Columbia and Washington State. The purpose of this study was to examine spiny dogfish in the Gulf of Alaska and estimate important parameters for stock assessment in four stages: (1) general biology, distribution and life history; (2) modeling age and growth; (3) population demographic modeling; and (4) ecological interactions revealed by diet analysis. Spiny dogfish are similar in length in the Gulf of Alaska to neighboring regions, but mature at larger sizes and have a greater fecundity than reported elsewhere. There is high natural variability in estimated ages for the species, which is reflected in the poor fit of the growth models, possibly owing to measurement error from using the dorsal fin spine as the aging structure. A two-phase growth model provided the statistical best fit. However, questions were raised about the biological interpretation of the model and whether more traditional models (e.g., von Bertalanffy and Gompertz) may be more appropriate. Using the life history and growth data, Leslie matrix type age- and stage-based demographic models were created to estimate sustainable fishing mortality rates and to examine the risk of harvest scenarios. Female Gulf of Alaska spiny dogfish can support up to a 3% annual harvest rate; fisheries that target juveniles have the greatest risk of population decline below threshold levels. Spiny dogfish are generalist opportunistic feeders that feed on whichever prey is available, however shrimp are the most important prey type, followed by cephalopods. Results of this study will be used in future ecosystem modeling and stock assessments for this species.

Abundance and Feeding Ecology of Humpback Whales (*Megaptera novaegliae*) in Kodiak, Alaska

Briana Witteveen
August 2003

A feeding aggregation of humpback whales (*Megaptera novaeangliae*) in the Kodiak Island region has received little previous study. A mark-recapture experiment was conducted in 2001 and 2002 to estimate its abundance. Historical abundance was back-calculated from this estimate, whaling records, and suspected survival and productivity values within a population model. The current population was estimated at 157 whales and the pre-whaling population at 343 whales. Prey consumption by humpback whales was modeled using three methods for two hypothetical diets based on prey availability surveys conducted within the study area and stomach contents of commercially caught whales. By assuming current consumption is proportional to prey availability, the current population removes an estimated 9,600 tons of prey annually. Historical populations may have removed over 19,000 tons of prey annually.

Seasonal Distribution of Stellar Sea Lions (*Eumetopias jubatus*) in Relation to High-Quality Ephemeral Prey Species in Southeast Alaska

Jamie Womble
August 2003

Energetic demands are high for sea lions during spring when females are pregnant and lactating and males are preparing for extended fasting during the breeding season. Therefore, I predicted that the distribution of sea lions in spring would be influenced by the distribution of spring-spawning aggregations of high-energy Pacific herring (*Clupea pallasii*) and eulachon (*Thaleichthys pacificus*) in southeastern Alaska. Monthly aerial surveys at 23 Steller sea lions haulouts revealed that haulout use was seasonally dynamic. Some sea lion haulouts were only occupied during spring. Other haulouts exhibited pronounced increases in the number of sea lions during certain seasons. Sea lion haulouts with peak numbers of sea lions in spring were significantly closer to forage fish aggregations than haulouts with peak numbers of sea lions at other times of year. From March through May 2002, I used aerial surveys to monitor the number of Steller sea lions at spring spawning aggregations of Pacific herring and eulachon. The maximal numbers of sea lions observed were 949 at a eulachon-spawning site and 252 at a herring spawning site. Seasonal pulses of high-energy food resources may be critical to the reproductive success of individual Steller sea lions.

Where are they now?

Gregory Albrecht
Alison Hayden (Banks)
William Bechtol
Michael Courtney
Raphaelle Descoteaux
Terril Efrid
Sonya El Mejjati
Elenda Fernandez
Michael Garvin
Georgina Gibson
Christine Gleason
Shannon Hanna

Katie Echave (Howard)
Zachary Hoyt
Brian Knoth
Emily Lescak
Mary Beth Loewen
Courtney Lyons
Laurinda Marcello
Joel Markis
Jennifer Marsh
Megan Murphy
Julie Nielsen
Olav Ormseth
Katie Palof
Carrie Parris

Megan Peterson
Jonathan Richar
Cara Rodgveller
Sean Rooney

Ashwin Sreenivasan
Cindy Tribuzio
Briana Witteveen
Jamie Womble

ADF&G- Habitat Biologist II, Douglas AK
University of Alaska System Coordinator
Retired from ADF&G, Private Consultant
Research Technician,UAF
Looking for a PhD Position
NOAA Commissioned Officer Corp
ADF&G- Shellfish Biologist, Kodiak
ADF&G- Field Biologist, Cordova
Postdoctoral- Israel
Research Assistant Professor, UAF
Research Technician, UAF
Research Biologist-Material Measurement
Laboratory
NOAA-Auke Bay Laboratory
PhD Candidate- Fisheries Program,UAF
Idaho Fish and Game
Postdoctoral- UAA
ADF&G-Fishery Biologist II, Kodiak, AK
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ADF&G- Fish Tech II, Sitka, AK
Assistant Professor of Fish. Tech.,UAS
PhD Candidate- Fisheries Program, UAF
National Estuarine Research Reserve
PhD Candidate- Fisheries Program, UAF
NOAA- Resource Ecology and Fish. Management
PhD Candidate- Fisheries Program, UAF
Consultant for Logistic Firm for Arctic Olgoonik
Fairweather, Albuquerque New Mexico
NOAA- NRC Post Doctorate
ADF&G- Fish Tech II, Petersburg, AK
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