

FISH & INVERTS :: Bycatch Reduction

Comparing Electronic and Human Observers in the Halibut Longline Fishery

Project 712

THE MAJORITY OF VESSELS OPERATING IN THE Pacific halibut fishery are not required to have observers, and their bycatch rates are not well estimated. Previous research documented successful electronic monitoring efforts of Pacific halibut longline fishing on chartered research vessels, yet the technique was not tested in the commercial halibut fishery, where a much broader range of environmental and physical factors affects the vessel operations.

Project 712 is evaluating and comparing electronic video monitoring and human observers of bycatch in a commercial halibut longline fishery by conducting a cooperative study with the commercial fishing industry with various vessel configurations. The resulting information will be key in determining the most cost-effective, efficient, and precise bycatch monitoring methods for this fishery.



Carwyn Hammond

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Bycatch Crab Survival

Project 711

PROJECT 711 ADDRESSES THE ISSUE OF UNOBSERVED Bering Sea crab injury and mortality after seafloor trawl encounters. Bycatch that comes aboard can be enumerated and included in assessment calculations, but some species suffer injury or mortality without ever being observed and counted. To tackle this problem, researchers are designing a recapture net as well as developing handling and holding procedures onboard commercial vessels. They will standardize reflex impairment observations (a method to tell how well a crab is doing) in the lab, then combine these developments to assess the mortality probabilities of crab that have passed the sweeps, wings, and central footrope of a commercial groundfish trawl.

Causes of Major Species Decline

UNDERSTANDING WHY SOME MAJOR SPECIES POPULATIONS HAVE DECLINED ARE AMONG THE HIGHEST PRIORITY ECOSYSTEM RESEARCH NEEDS. SOME SPECIES, LIKE CRAB, SHRIMP AND POLLOCK, ARE PARTICULARLY IMPORTANT OWING TO THEIR HIGH ECONOMIC VALUE WHILE OTHERS, LIKE WESTERN ALASKA SALMON, HAVE CULTURAL SIGNIFICANCE AND LOCAL VALUE.

Still others, including sharks and arrowtooth flounder, play important roles in restructuring the ecosystem. Understanding the role of natural and human causes on declines of crab, shrimp, western Alaska salmon, Greenland turbot, walleye pollock, and halibut and increases in arrowtooth flounder, other flatfish, sharks, and skates is important to developing management strategies that reflect their causes. The Board has funded six projects in this category focused on crab and salmon for just under \$1.4 million.

Crab research projects focused on diseases affecting snow and tanner crab, as well as on the mysterious disappearance of the populations of red king crab near Kodiak that once supported the largest king crab fishery in the world. Salmon projects looked at the dramatic decline of Kvichak sockeye salmon runs, the distribution of sockeye and chum salmon in the Bering Sea, and life histories of Copper River salmon.

CRAB

Much research has focused on climate variability impacts on recruitment and growth for groundfish and salmon, but relatively little work has been done in this respect with crab stocks. Yet their high commercial value makes it important to better understand the effects of fishery management and environmental processes on crab abundance.

FISH & INVERTS :: Causes of Decline of Major Species :: Crab

Bitter Crab Syndrome in Snow and Tanner Crab

Projects 306, 623

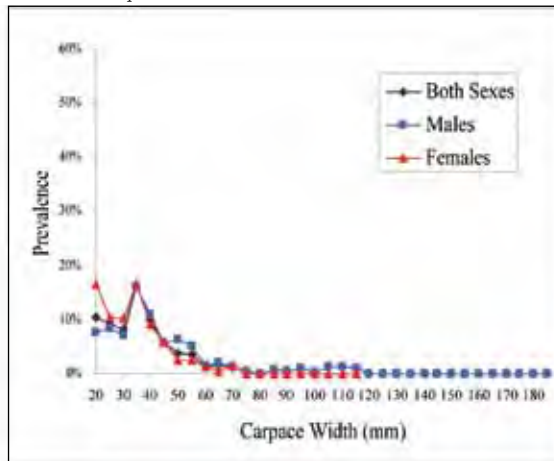
SNOW AND TANNER CRAB WERE DISCUSSED PREVIOUSLY under projects 508 and 814. Project 306 studied the causative agent of bitter crab syndrome in these two species as a possible key player in increased natural mortality and poor recruitment. A parasitic dinoflagellate (*Hematodinium* spp.) causes bitter crab syndrome, which is fatal in snow and Tanner crabs. Infections occur in crustaceans of all sizes and ages, but juveniles are particularly susceptible. Although the parasite causes death, researchers know little about its life history, or how crabs become infected, yet our understanding is critical for commercially important crabs in the Bering Sea.

Using a series of molecular techniques, researchers identified two species of this parasite: one infects the blue king crab, and one that appears to infect all other decapod hosts studied. Investigators identified an assay to better detect the presence of *Hematodinium*, which is the current focus of bitter crab syndrome monitoring efforts. Scientists

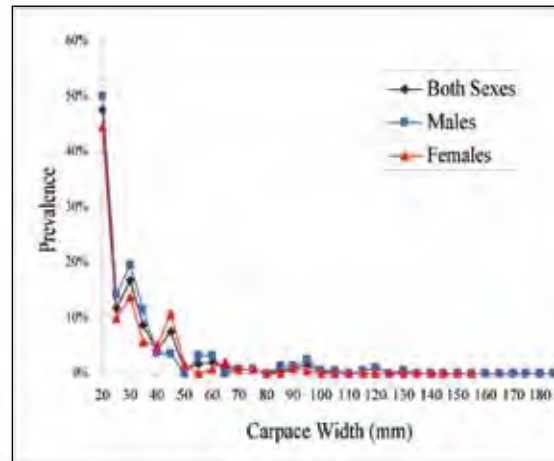
are unable to get parasite samples from the environment, even though they targeted areas of known high infestation prevalence. Whether free-living life history stages exist or at what densities, and which environmental parameters are influencing their abundance, remain to be studied.

Project 623 followed up on these problems and is developing an even more precise, quantitative molecular monitoring tool (quantitative real-time polymerase chain reaction) for *Hematodinium*. Researchers hope this improved technique will not only detect the presence, but let us monitor the effects on Tanner crab size frequencies and general population trends, as well as identify potential infection vectors or reservoirs of the parasite, thereby providing key life history parameters that have eluded us so far. Assessing these disease dynamics would greatly aid managers in developing alternative harvest strategies to minimize losses due to *Hematodinium* infections.

Chionoecetes opilio



Chionoecetes bairdi



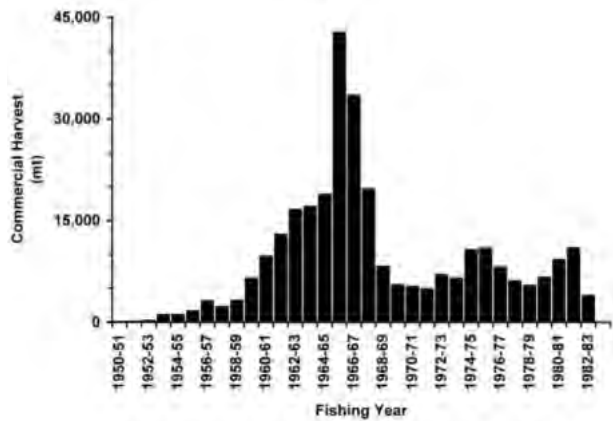
Prevalence of BCS in eastern Bering Sea snow and Tanner crabs, 1988-1998.

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Red King Crab Mystery

Project 509

KODIAK ONCE SUPPORTED THE LARGEST RED KING CRAB fishery in the world, with peak landings at 94.4 million pounds (43,000 metric tons) in 1965, worth \$12.2 million at the time. After 15 years of declines, the fishery closed in 1983, but despite the closure, the red king crab population never recovered. The reasons for the collapse and failure to recover remain a mystery that Project 509 set out to solve.



Annual harvests (metric tons) of red king crab from the Kodiak Management Area during 1950-1982.

To create prospects of recovery and to learn about future sustainability, researchers constructed a population dynamics model using historical fishery and survey data to estimate abundance, recruitment, and fishing and natural mortality over the years 1960 to 2004. They also used geographical analyses to explore potential fishery and ecological factors in the crab decline.

The study found that during a critical time of fishery development in the late 1960s, a period of strong recruitment promoted fishery overcapitalization, resulting in unsustainable harvest rates, particularly from 1981 to 1982. Recruitment failed, resulting in extremely high fishing mortality rates on a declining population of mature males, and producing sex ratios skewed toward females. Adverse environmental and ecological changes likely magnified these problems.

The stock has remained low, at less than one million males and has been stable since 1985, suggesting that predation may be preventing stock recovery. This new analysis will contribute to setting appropriate harvest strategies, and also help evaluate proposed stock enhancement activities. Scientists will next look in more detail at the effects of ecological and environmental factors on recruitment for this species.



SALMON

Salmon are another species of special interest, particularly concerning some of their regional declines and their implication on commercial and subsistence use, but also concerning their ocean migrations and intermingling of stocks on the high seas, effects of fisheries and environmental conditions on ocean survival, and the issue of overall ocean rearing capacity which is being stressed by increasing releases of young salmon from hatcheries around the Pacific Rim.



Greg Fluggenone

Sockeye salmon.

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Kvichak Salmon Declines

Project 321

KVICHAK SOCKEYE SALMON, ONCE THE LARGEST sockeye stock in the world with up to 50% of the world's sockeye production, declined by 73% between 1991-1999 from 1990 stock levels. To find out what caused this dramatic decline, Project 321 examined external human and environmental factors, as well as possible changes in biological characteristics of this species.

Researchers found no evidence to support the previously postulated idea that the decline was due to a regulatory change in the mid-1980s that led to more stable escapement levels. Indeed, specific cyclical spawning escapements do not seem necessary to achieve high productivity of Kvichak salmon. A detailed look at patterns in smolt abundance and survival at sea indicates that the decline was driven by factors influencing marine survival and ocean conditions influencing subsequent processes in freshwater. Several other Bristol Bay stocks also declined during these years, although not as deeply. Those declines

were associated with the ocean age structure of the populations, with age-2 salmon experiencing greater declines as compared to age-3s, likely due to their smaller size.

The authors of the study hypothesize that Kvichak salmon may have declined because of reduced at-sea growth during late marine stages, which produces the highest percentage of ocean age-2 sockeye in Bristol Bay. In addition to the impacts of these environmental conditions, the study also examined the possible role of beluga whale predation on smolts migrating out to sea. The analysis estimated that approximately two million smolts are consumed by belugas in the Kvichak each year, thus reducing the run by less than 2% per year. The absolute effect of these predation rates on smolts on the subsequent return of adult sockeye salmon was estimated to be an average of 180,000 fish, or about 2%. Given these results, it is unlikely beluga whales could have played an important role in the decline of salmon returning to the Kvichak River.

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Distribution of Sockeye and Chum Salmon in the Bering Sea

Project 303

PROJECT 303 EXTENSIVELY ANALYZED THE INTERPLAY between ecological and oceanographic factors influencing the distribution and abundance of Asian and North American sockeye and chum salmon in the Bering Sea. Researchers looked at stock composition at different stations as well as seasonal migration routes and timing.

The study was carried out under the auspices of the Bering-Aleutian Salmon International Survey (BASIS) developed by the North Pacific Anadromous Fish Commission (NPAFC), and included researchers from the U.S., Japan, and Russia, who shared access to a common, comprehensive database on salmon distribution and environmental conditions in the Bering Sea.

Because of the large number of collaborators from the three different nations, the coordination and exchange of ecological data proceeded slowly, and while substantial progress was made, this project was not able to fully investigate the factors affecting the oceanic distribution and abundance of each regional stock. Through the genetic analysis of juvenile salmon captured at stations throughout the Bering Sea, however, researchers did determine that Asian and North American chum stocks were not randomly distributed. Japanese salmon roamed the central Bering Sea, similar to Russian salmon which also spread into the North Pacific Ocean. Northwestern Alaska salmon,

including fall chum salmon from the Yukon River, were distributed mainly in the eastern North Pacific Ocean.

Researchers hypothesize that fish migrate from hatcheries through the Sea of Okhotsk, seasonally through the Bering Sea and northwestern Gulf of Alaska, then back to Japan. For sockeye salmon, U.S. investigators identified a broader distribution of North American stocks than suggested by historical tagging studies. Bristol Bay salmon were the most widely-distributed, accounting for more than half the mixtures in all areas except the southwestern Bering Sea. Russian salmon were primarily detected in the western Bering Sea, and differences were detected in the distributions between the eastern- and the western-Kamchatka Peninsula populations. Salmon from the Gulf of Alaska were also widely distributed throughout much of the Bering Sea, although at low proportions relative to the Pacific Ocean production estimates.

Data from this project have provided the foundation for continuing studies by NPAFC scientists, Pacific Salmon Commission studies by the National Ocean and Atmospheric Administration and Alaska Department of Fish and Game, and are being used by Fish and Game to improve harvest management in Southeast Alaska, Cook Inlet, and Bristol Bay.



FISH & INVERTS :: Causes of Decline of Major Species :: Salmon

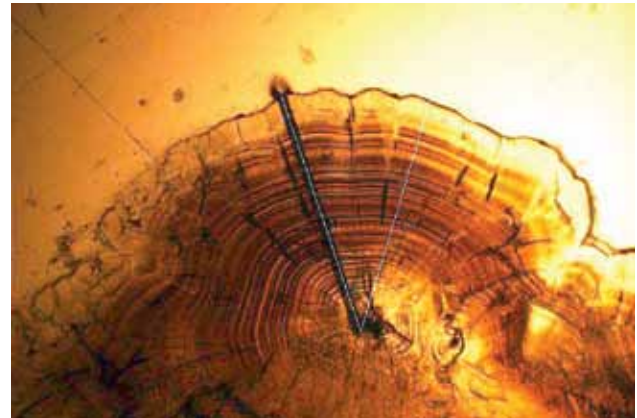
Copper River Salmon

Project 310

SALMON ARE AN INTEGRAL COMPONENT OF THE socioeconomic and ecological landscape of the North Pacific. Most species live part of their lives in fresh water, in estuaries and in the open sea. The amount of time that they spend in these habitats varies greatly in the early life histories and migratory behaviors of coho and sockeye salmon, both on local and regional scales.

For sea-going sockeye salmon, time growing up in estuaries may be critical for survival. Project 310 aimed to quantify the spatial and temporal variability in the age that they migrate to sea and the relative contribution of different freshwater and marine residence strategies to the surviving spawners in the Copper River watershed.

Scientists estimated the time coho and sockeye salmon spent in estuaries using traditional fisheries sampling techniques—mid-water trawls, fyke nets, and seine samples. They also used micro-chemical analysis of strontium concentration in otoliths of juvenile and adults within the Copper River Delta.



Mary Bishop

Otoliths lay down daily growth rings that take into account the chemical concentrations of ambient water chemistry.

Both species spent only a relatively brief period in estuarine waters, an average of 30 days, but during that time ingested substantial quantities of food, clearly pointing to the critical role of these estuarine habitats to ensure subsequent marine survival. The authors point out that natural or human-caused alterations to these vital habitats may have serious consequences for sustainable harvest of salmonids.



Deborah Mercy

Researchers sample for coho and sockeye salmon in the Copper River Delta.