Ecosystem Functions of Habitats

THE ROLE OF HABITAT IN THE MARINE ECOSYSTEMS OFF ALASKA IS THE BROADEST AND PERHAPS MOST COMPLEX TOPIC WITHIN THE OVERALL FISH HABITAT RESEARCH CATEGORY OF THE *SCIENCE PLAN*.

Some of Alaska's marine habitats are home to a diverse assemblage of species, such as corals and sponges, and may or may not support species of commercial interest. Regardless, as a hub of biodiversity, we need to know where they are, their role in the ecosystem, and whether they need to be protected.

Investigations of this nature address the "marine ecosystems information needs" priority in NPRB's enabling legislation. Yet we also need to shed light on how fish depend on particular types of habitat so resource managers may use the information for sustainable fisheries management. And managers need to know more than the rudimentary presence or absence of particular fish species. They must also consider growth, reproduction and survival rates, and to the extent possible, production rates as they relate to different types of habitats.

Our ultimate goal in funding this research is to determine which habitats are necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem. Ecosystem functions of habitat include:

- fish-habitat relationships
- ecological value of habitat types
- the role of benthic invertebrates
- identification of potential refugia
- vulnerability of habitat to natural disturbances
- identification of important nursery areas, and
- linking habitat to species population dynamics.

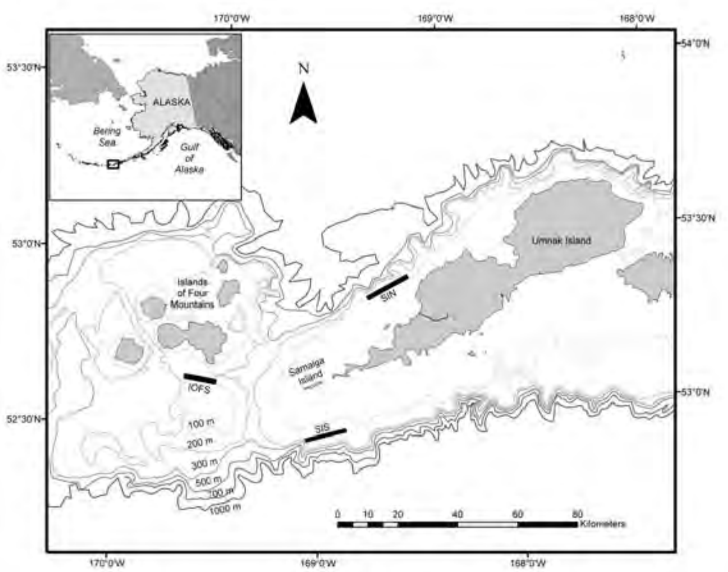
NPRB has focused most of its fish habitat research on the ecosystem functions of habitat, funding 12 studies of which nine have been completed so far.

FISH HABITAT :: Ecosystem Functions of Habitats

Shelter for Young Pacific Ocean Perch in the Aleutians

Project 416

USING SONAR GROUNDTRUTHED WITH UNDERWATER video, Project 416 examined the ecological value of habitat to juvenile Pacific ocean perch at five study sites in the Aleutian Islands. Researchers found juveniles mainly in mixed sand and boulder substrate, to the exclusion of most other habitats, and usually within one body length of boulders, corals, sponges, or other complex structures. The study also looked at the condition of the fish and why it varied between sites, perhaps due to differences in prey quality, predator abundance, and/or habitat quality, possibly as mediated through the abundance of zooplankton, especially large copepods. Scientists concluded that climate forcing and its effects on wind forcing could influence the intensity of upwelling in different areas, affecting zooplankton production and quality, which could in turn affect the condition of juvenile Pacific ocean perch. Also, the amount and type of habitat available to juveniles could influence their ability to avoid predators.



Map of islands of Four Mountains and Samalga Pass area showing three of the five sites (black strips) where acoustic mapping was completed.

FISH HABITAT :: Ecosystem Functions of Habitats

Tube Worm Bed Nurseries for Flatfish

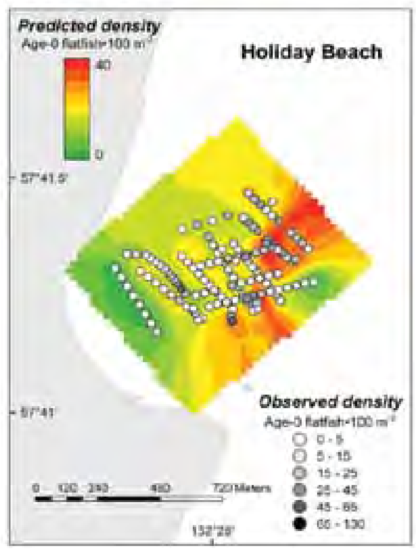
Projects 301, 710

THE CENTRAL GULF OF ALASKA AROUND KODIAK HAS supported a commercial flatfish fishery for many years, beginning with foreign fisheries that worked the area starting in the early 1960s. South of Kodiak, emergent structures created by polychaete tube worms dominate the low-relief benthic region. This tube worm habitat provides a nursery area for age-0 juvenile flatfish, particularly northern rock sole and Pacific halibut, which are both commercially important species. Project 301 set out to evaluate these emergent structures to better estimate the distribution and abundance of juvenile flatfishes around Kodiak.


Cliff Ryer

Using video camera sleds, researchers assessed fish densities, habitat features, and fish-habitat associations on a fine spatial scale. They found juvenile flatfish associated with low to moderate worm tube densities, where fish may aggregate to feed on the worms or associated fauna. The structural complexity created by the tubes may also reduce the predation threat for flatfish. Yet when worm tube densities were too high and created a continuous turf, juvenile flatfish were nearly absent because they could not bury themselves and thus were more vulnerable to predation. If shell material was added to the seafloor to enhance structural complexity, juveniles were attracted only when larger adult flatfish were scarce.

Scientists concluded that differential predation pressure may make two seemingly similar areas of seafloor vastly different in quality as perceived by juvenile flatfish. The study also showed how species react to predation pressure. Rock sole minimize activity and bury themselves, while English sole become more active to avoid predation. Pacific halibut had an intermediate reaction. Knowing how individual species relate to different habitat types, and the vulnerability or resilience of particular bottom types helps managers make better decisions on how to protect it. Fishing impacts on these habitat types are being studied under Project 710.



Density of age-0 northern rock sole predicted for Holiday Beach based upon video-acquired field variables identified for the combined nursery grounds. Circles show the actual densities of rock sole observed in the video record. The study site covers a gently sloping bottom with a depth range of 5-17 meters at mean low water.

FISH HABITAT :: Ecosystem Functions of Habitats

Where Flatfish Live in the Eastern Bering Sea

Project 709

SCIENTISTS ARE ALSO STUDYING FLATFISH HABITAT IN THE EASTERN BERING SEA UNDER PROJECT 709. THAT retrospective study examines the spatial distribution of yellowfin sole, Alaska plaice, and arrowtooth flounder on the eastern Bering Sea shelf over 25 years, from 1982 to 2005. In this ongoing study, researchers expect to analyze fish distributions relative to small-scale environmental features, climatic indices, demographic state of the population, and human harvest activities.

FISH HABITAT :: Ecosystem Functions of Habitats

Skate Nurseries Near Deepsea Canyons

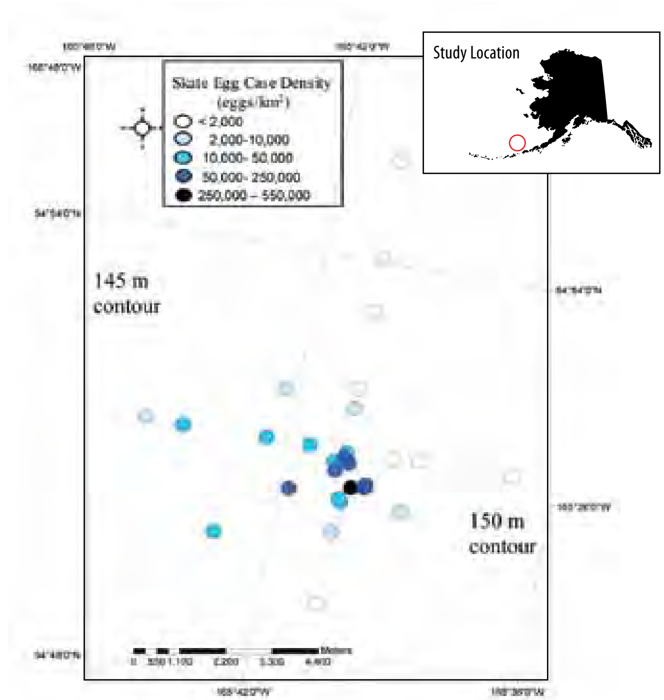
Projects 415, 808

AT THE HEAD OF BERING CANYON, NEAR WHERE THE shallow shelf meets the slope at 150 meters, Alaska skates deposit eggs in a highly productive nursery covering about one to two square kilometers. Project 415 set out to study this relatively flat, sandy, muddy bottom habitat that had no detectable abiotic or biotic structure or diversity, yet which supported more than 500,000 skate eggs per square kilometer.

Skates reproduce in Alaska throughout the year, peaking in fall and winter. Embryos develop slowly, hatching more than 3.5 years after being deposited in the nursery. Skate survival is a gamble—gastropods, particularly the Oregon triton, cruise the nurseries preying on the egg cases, while Pacific cod and halibut feed on newly hatched skates.

Skate nurseries seem to be located in highly productive upwelling areas near canyons. Having a ready supply of food allows skates to remain within the nursery site and minimize foraging excursions during reproductive cycles. Currents supply oxygen and remove metabolic wastes from the egg cases. The shelf-slope interface may provide the delicate balance of these critical elements that ensure the highest production and survival of adults and developing offspring.

Sensitive to disturbances, these nursery sites are important habitat for successful skate reproduction, the study concluded, and may need to be protected from disturbance by fishing activities. Project 808 continues work on skate nursery sites in the eastern Bering Sea, gathering detailed information on nursery habitat and benthic associations and providing annual production estimates for each site. These estimates will be used to develop a model that predicts the importance of each site and its relative contribution to the estimated young-of-the-year population for the Alaska skate.



Trawl locations and egg case density estimates in the Alaska skate nursery site during the July 2004 investigation and all seasonal sampling periods combined.

Dave Ebert

FISH HABITAT :: Ecosystem Functions of Habitats

Rocky Reef Habitat for Yelloweye and Lingcod

Project 616

THE CHISWELL RIDGE SOUTH OF SEWARD, ALASKA supports high densities of yelloweye rockfish and lingcod. Project 616 estimated the density and abundance of these species based on new habitat delineations and compared those to previous estimates. More precise mapping of rocky reef habitat and evaluating the associated fish densities demonstrated that abundance estimates should be decreased by about 48% for the southern Chiswell area, compared to earlier estimates. Applying these new estimates would require more conservative management, especially considering the low inherent productivity of yelloweye rockfish populations. *(For more about the habitat mapping aspect of this study, see page 50: Mapping the Chiswell Ridge in the Gulf of Alaska)*

Terrance Fidler

FISH HABITAT :: Ecosystem Functions of Habitats

Home Ranges for Copper Rockfish and Lingcod in Prince William Sound

Project 729

FURTHER NORTH AND EAST, IN PRINCE WILLIAM SOUND, Project 729 studied residency and movements of copper rockfish and lingcod in nearshore areas using acoustic telemetry. Researchers surgically implanted acoustic transmitters in 45 fish captured in three habitats: artificial reef, low-relief natural reef, and patch high-relief rock reef. The homing experiment demonstrated that rockfish have the ability to return to capture sites following a four kilometer displacement. Rockfish and lingcod appear to exhibit very high site fidelity and long periods of residence at the sites studied. Fish on the artificial reef moved least, while those in low-relief natural reef areas maintained the largest home range. The artificial reef also attracted fish from the other habitats and appears to have the potential to provide refuge habitat in the event of physical disturbances such as oil spills and coastal development.

FISH HABITAT :: Ecosystem Functions of Habitats

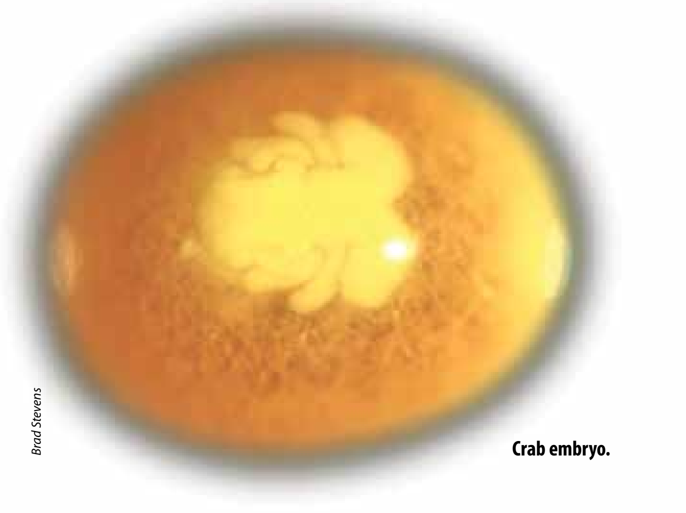
Forage Fish in Nearshore Habitats

Project 642

A SECOND PRINCE WILLIAM SOUND STUDY, PROJECT 642, examined seasonal distribution, habitat use, and energy density of forage fish in the nearshore areas of eel grass beds, bedrock outcrops, and kelp. Scientists most frequently encountered Pacific herring, saffron cod, pink salmon juveniles, and capelin, which used the nearshore habitat for about six months. Pink salmon were most abundant in spring, herring in summer and capelin in fall. These areas serve as nursery habitat and are particularly susceptible to oil spills or other shoreline disturbances.

NOAA-NMFS

Because nearshore habitats are vulnerable to human disturbance, a better understanding of how the nearshore environment supports ecologically important forage fish species is needed to help managers conserve forage fish populations and protect essential habitats.



Brad Stevens

Crab embryo.

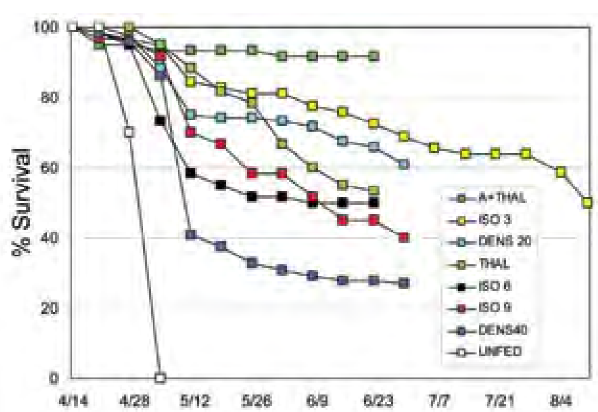
FISH HABITAT :: Ecosystem Functions of Habitats

Essential Habitat for Declining Crab Species

Project 316

THE MAIN OBJECTIVE OF THIS PROJECT WAS TO determine if, and under what conditions, the larvae of blue crab, once the basis of thriving commercial fisheries around the Pribilofs and St. Matthews Island, could be cultivated at the National Marine Fisheries Service Lab in Kodiak. The longer-term goal, through subsequent research, would be to use laboratory experiments to help characterize essential fish habitat for declining or depleted crab species.

Researchers tested the effects of diet, temperature, and rearing density, but density did not appear to have a significant effect on survival. A diet of *Artemia* nauplii plus diatoms produced significantly higher survival and the colder the temperature, the longer it took for the first juvenile crab stage to develop. Results showed that blue king crab larvae can be cultivated with high survival. Using the proper diet, and that swimming larvae need to feed, but settling larvae do not feed. These results may be used to produce larger numbers of juvenile crab for laboratory research and stock enhancement.



Percent survival of blue king crab *(P. platypus)* larvae at weekly intervals, from hatching to stage C1, under different culture conditions.

FISH HABITAT :: Ecosystem Functions of Habitats

Crab Survival in Warming Seas

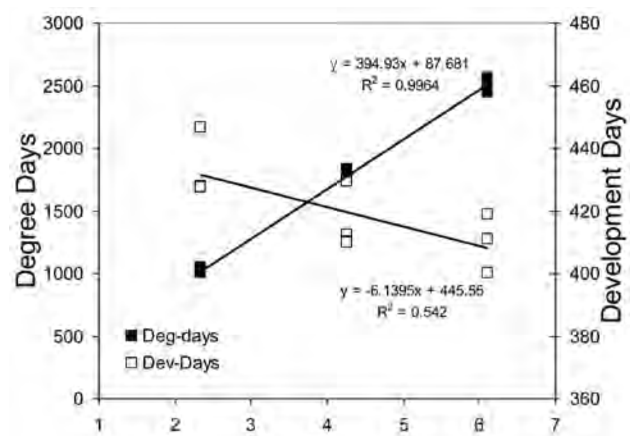
Project 507

A FOLLOW-UP STUDY, PROJECT 507, LOOKED AT juvenile blue king crabs, looking at environmental effects on hatching, habitat selection and survival, particularly the role that water temperature plays in embryonic development rates, hatch timing, and oxygen consumption. As in Project 316, embryo development and hatching times are slower at lower temperatures, although development times differed by only 24 days over the 4°C range of temperatures tested. Increases in temperature of up to 4°C caused adult females to increase their oxygen consumption, but had little effect on embryos or larvae. After metamorphosis, blue king crab post-larvae settle immediately on suitable habitat.

Brad Stevens

Blue king crab embryo.

In a warming Bering Sea, earlier hatching by king crab could put them out of synchrony with plankton blooms, resulting in poor survival and small, weak subsequent year-class survival. Laboratory data from this study showed that crabs may be able to compensate somewhat for changing temperature regimes by adjusting development rates, allowing limited reproductive success in years of warm conditions, thus preventing complete reproductive failure.



Mean total degree-days and development days for blue king crab larvae.

FEATURE PROJECT

FISH HABITAT :: Ecosystem Functions of Habitats

Biodiversity in Aleutian Coral Gardens

Project 304

PROJECT 304 EXAMINED DEEPSEA CORAL DISTRIBUTION AND HABITAT IN the central Aleutian Islands. Funded at $1.3 million, this was the largest individual study ever supported by the Board. While primarily a mapping study using submersibles, scientists also wanted to assess the importance of coral and sponge habitat for commercially important species of fish, crab, and octopus, as well as assess any impacts of fishing gear.

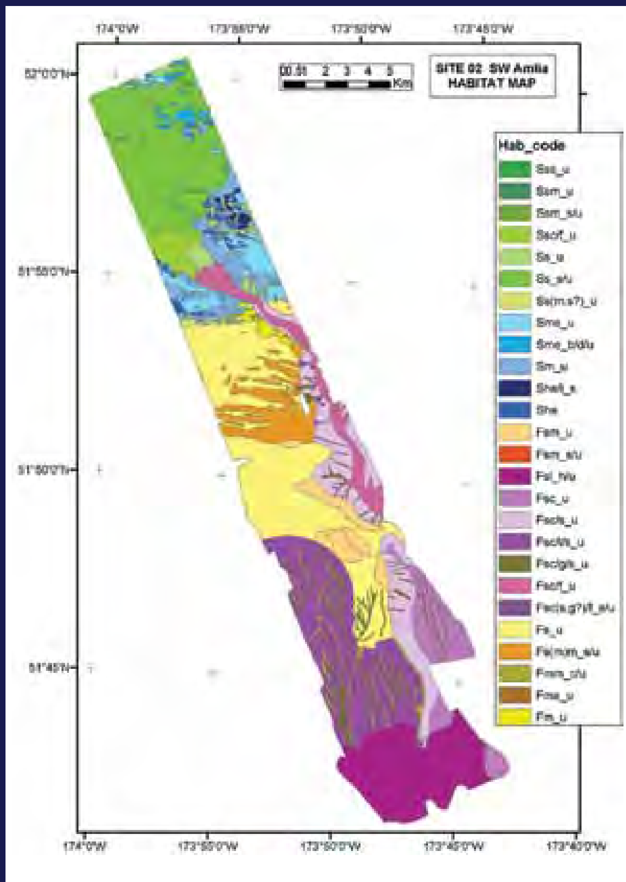
Associated Species

The study found that 64-72% of commercially important fish species in the Aleutians were associated with corals or sponges. Juvenile rockfish were the most abundant fish, followed by grenadiers and Pacific ocean perch. Crabs were not as abundant as fishes and among the eight species identified, deepsea Tanner crabs were the most abundant. Most shallow-water fishery management plan species (those living at depths of less than 1,000 meters) appear to frequently associate with sedentary, structure-providing invertebrates, such as hydroids, actiniarians, bryozoans, and tunicates, and there is evidence that their presence may be essential to some species.

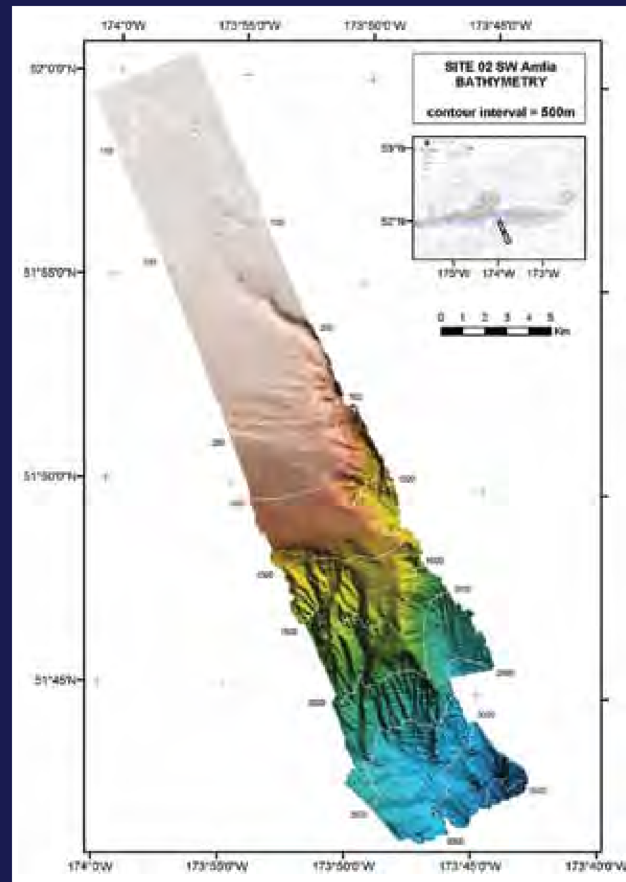
Chris Rooper

The study found that 64-72% of commercially important fish species were associated with corals or sponges.

Bob Lauth, NOAA



Project 304: Habitat map of site 02.



Project 304: Bathymetric map of site 02.

Mapping Corals and Sponges

Scientists mapped 17 sites with dual frequency multibeam sonar systems, covering 2,600 square kilometers down to depths of 3,800 meters, coupled with visual observations to 2,950 meters. They collected biological information and developed a predictive model to relate coral and sponge distribution to environmental characteristics. They also used bathymetry and backscatter data, combined with geologic interpretation, to create habitat classification maps.

The new data showed details of the substrate variations within sites, proportions of different types of substrates, and the interplay between substrates and geologic and oceanographic processes. Habitats dominated by bedrock and cobble supported the highest densities of corals, while coral and sponge diversity increased from deep to shallow water. For predictive modeling, explanatory variables included depth, slope, and roughness, with depth and slope being the most important factors. Models of coral and sponge presence or absence were more successful to the north of the Aleutian archipelago than to the south. The study reported over 60 sponge species that had not been known previously in the Aleutians, and more than 25 new species that are being formally described.

Assessing the Impact of Fishing Gear

Scientists examined video footage of the seafloor for damage and disturbance in relation to observed fishing intensity in the central Aleutian Islands. They classified corals and sponges as damaged if skeletons were broken, if organisms had missing or broken branches, were torn or had other evidence of injury, were detached from the seafloor, or were attached but overturned and lying in contact with the seafloor. Overall, 11% of the corals and 21% of the sponges were damaged. Disturbance was widespread and evident on most video transects, with the most damage in heavily trawled areas. This study helped provide significant background information to the North Pacific Fishery Management Council when it approved closing large areas to trawling to protect the coldwater coral and sponge habitats in the Aleutians.