Ecosystem Based Management of Shellfish in the Cook Inlet Region

Rock Lobsters

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Abstract

Stretching 180 miles between the Kenai Peninsula and the Alaska Range, Cook Inlet is a stable and diverse area. It is host to many species, but this report looks at the following: the blue mussel (*Mytilus trossulus*), the razor clam (*Siliqua patula*), and the pink shrimp (*Pandorus borealis*), in all of their stages of life. In addition to examining these organisms, we will also examine the ecological conditions and formulate an economic-influenced management system for the area, to ensure future stability and prosperity of the ecological conditions. This management plan is going to include environmental factors and ways to compensate them, such as over-sedimentation, and harmful effects of human activities in the area, including natural resource exploitation and human expansion. Our proposed system will take into account all of these risks and possible harmful circumstances, and list methods of prevention and recovery. This plan will require cooperation between the various agencies that oversee the area, mainly the Homer-based Alaska Department of Fish and Game sector and the National Marine Fisheries Service. With the combined efforts of these agencies, the possibility of damaging events occurring on a scale large enough to impair the local industries will be severely reduced, to the benefit of all.
Introduction

This management plan pertains to the Cook Inlet marine fishery region of south-central Alaska, and also looks at three different species; the razor clam, pink shrimp, and blue mussel. Cook Inlet encompasses 180 square miles and is marked as an estuary. Named after the British Naval commander Captain Cook, the Cook Inlet is known for its central importance in native Alaskan tribes’ history. Cook Inlet has been a staple of life for the tribes that emerged from the area, and supplies the region with fresh sources of salmon, shrimp, shellfish and many more aquatic species. The warm waters in the summer and the steady freezing during the winter makes it difficult to keep annual fishing industries in business, but it is a popular location for sports fishing events and provides subsistence fishing sources for native Alaskan communities.

Biology

Pacific Razor Clam

The Pacific razor clam, or *Siliqua patula*, is a bivalve mollusk which lives primarily along surf-swept, gently sloping, and somewhat protected areas of the shore, found in depths which range from four feet to thirty fathoms. It can be found along the west coast of the United States, from Pismo Beach, California, to Alaska. Their shells are long and thin, with shiny, delicate valves–unusual for a surf-inhabiting creature. While on the surface of the sand, the clam is in a vertical position exposing nothing but their siphons. As water is drawn into the inhalant valve by the waves, and are set up by the action of cilia lining the mantle cavity, and passed over the gills, the razor clam's food–planktonic organisms–are guided by cilia and two
palps to the mouth. The clam breathes as water passes over the gills. Waste products are passed out through a smaller exhalant valve.

The razor clam is an excellent digger, and it depends on this to protect itself from wave shock as well as predators. Individual clams lying on top of the sand have been known to bury themselves completely in less than seven seconds. Diggers fishing for these clams must dig quickly before the clam burrows itself too deeply in hard to reach depths.

The razor clam's life cycle is like that of most clams: there are separate sexes, mating is done externally, and larvae are able to develop after three to four days. It takes roughly eight weeks for the larvae to settle into the sand and begin their juvenile phase of life. Sexual maturity is more closely related to size then age, with most clams reaching maturity at four inches. The usual spawning time for Alaska is August, although it is earlier in other places, and it is believed a water temperature of 55 degrees Fahrenheit is the ideal temperature for spawning. Razor clams reach their maximum rate of growth in the first year, and growing slows within their second and third years. In Alaska, the clams can live to be as old as 18- to 19-years-old, although most specimens are younger.

Blue Mussel

For the blue mussel, or *Mytilus trossulus*, development is partially based on the temperature of the water they are living in. Usually they develop the best in water from 15-20 degrees Celsius. The amount of time that the blue mussel stays open is dependent on the water temperature that it is exposed to during its growth and development. Around 5-6 degrees
Celsius, the clams start to go into hibernation. The food that they eat goes through two labial pulps that are liked rigid organs and they separate the food two different parts of the body. They live in habitats such as flat shores that drain onto a vertical surface. They can sometimes still develop in salinities as low as 14 ppt if there are collected from a more estuarial population. A lot of the eggs that are spawned by the blue mussel may not even be fertilized. There is a large possibility that the larva may be eaten before metamorphosis stage. The mussels don’t have a specific mortality rate. It all depends on the site that that specific blue mussel is living. The temperature of the water, the salinity, and the predators cause a big difference. The most amount of pressure is placed on the blue mussel within the first three weeks of life. There predators are jellyfish, larval, and adult fishes. You can tell how old a blue mussel is by the number of bands on its shell for farming purposes.

**Pink Shrimp**

The *Pandalus borealis* can be found along the coasts of New Foundland, Alaska, the California coast, areas of Micronesia, and in the north-west areas of Europe. *Pandalus eous* was officially recognized in 1992 and is found in the north-east Pacific between the Bering Sea and western Oregon, and can be found in inlets and coastal regions. They can be found on or in silt beds and soft mud floors anywhere from 50 meters to 100 meters below the surface, but they have also been found in depths as low as 4,500 feet. The temperature of water ranges between 32 degrees Fahrenheit and 41 degrees Fahrenheit, but they have been known to inhabit areas with a temperature of up to 54 degrees Fahrenheit.
Pandalus borealis eous can grow up to 15cm in length, with their carapace sizing up to 3cm. Feeding on a diet of algae and small crustaceans, they are also known to ingest detritus as their common food supply. They fear birds and large fish as their predators, but as they exist in highly populated groups they do not necessarily have too many hunters.

Pink shrimp hatch from eggs in the spring months, generally during late April. They swim constantly during their first summer of life, molting the whole time. At the end of the summer, usually in late August/September, they finish their larvae state and settle at the bottom of the water bed. Then during the following summer, they molt again and can begin their ‘male’ phase. They mate a number of times as a male, and then their bodies will develop slowly into a female form. This change generally (but not always) occurs during their fourth year of life and takes the majority of the summer. There are rare occasions however where the shrimp may start out its life as a female. Northern shrimp breed in the fall, as to coincide with the conclusion of the female’s completed gender change. While a female may produce up to 4,000 eggs, not all of them may hatch. The shrimp live up to five or six years, and their growth rate is fast early on but slows down the more mature they are.

Major threats to the species are climate changes, positive changes in the ocean’s acidity, and overfishing. Warmer climate seasons will hurt the shrimp population. More carbon dioxide dissolving from the air into the water will upset the balance of other values in the water, lowering the amount of calcium carbonate available for shellfish such as the shrimp. Overfishing is less of a problem in the Cook Inlet for the shrimp population, but a negative
change to the shrimp population by other natures may cause overfishing to present a more potent threat. (www.adfg.alaska.gov/index.cfm?adfg=northernshrimp.main)

Area of Interest

The area that these organisms are fished for slightly varies. The clams are fished for on shorelines and are buried within the ground. On the other hand if you were to find blue mussels, you would best find them in estuaries because the filter the water there. Also the pink shrimp is something you usually catch by net but you never have to big of a problem until it come to the problem of by catch. The area for the shellfish is soft ground so it is easier for them to burry themselves into the ground to have as a habitat. Blue mussels on the other hand stick to rocks and to the sea floor in places. Not all places but you can find them there. It is hard to give a definite description of the area. They are all slightly spread out into different areas. You don’t find them all together in the same general area and yet they all play a role in the production of one another. The water temperature of their area changes as well. Such as clams and blue mussels have certain temperatures that they live in to determine when they open and when they close. When they mate and when they don’t. But for shrimp, they don’t open or close like organisms with shells so there temperature would obviously be slightly different. Overall, they all live in waters that are somewhat close to a shoreline if not actually physically on one. They stay close to the shore but not necessarily right next to it. It all depends on the migration pattern, the time of year, whether they are shelled or not. And also what kind of shell
they have. Their area will always be changing but for the most part is all around the same general area. They have many common characteristics in their living environment.

History

Development of the Area

Cook Inlet is a 180-mile long estuary that has been a central region to many fishing communities and was named for the British naval commander Captain Cook. Located in south-central Alaska from 59 degrees North to 61 degrees North, many local native tribal groups have relied on it for centuries for its constant supply of aquatic life. With semi-diurnal tides that exceed 10m and its tidal current exceeding 4 knots, the inlet maintains a fresh supply of fish and other marine plants and animals. The Dena'ina Athabaskans were some of the most popularly recorded natives in Cook Inlet area, and relied on the refreshing supply of salmon and clams to feed them. At the end of the 18th century, sailors from the new world, namely Captain James Cook, had explored the inlet. They found the land rich in marine life and many streams and rivers which empty into it. Cook Inlet area has been a focal point for Alaskan history for the south-central tribes and groups, and the land has been used for living for many centuries. No history is accurately recorded of the physical changes of the land prior to the seventeenth century, as not only did no noted explorers traverse the area but the native peoples did not describe changes in the area. Most of the marine life from Cook Inlet travel through the inlet on routes and migratory trails long practiced by their kind, and many shellfish species live permanently in the Cook Inlet. Lately, more pollution has been released into the Inlet from the
neighboring cities, such as Anchorage, which has negatively effected the populations. Development of fishing charters and sporting events has also negatively impacted the species, though not as badly as expected.

**Economic History**

Cook Inlet is a very popular hub for fishing and sports, but the economic values for the Cook Inlet is mainly focused on the people in the area by personal fishing vessels and public fishing charters. Cook Inlet is not heavily fished by corporations or companies. Most of the seafood in the country is actually imported from places such as India. In the mid-1900's, fishing did start providing small flows of money, but the Cook Inlet has never truly been a large area for economic growth. Most fishing in the Cook Inlet is for subsistence.

The Cook Inlet razor clam fishery is very small, thus possessing little economic value to the area. In 2010, 380,000 pounds of clams (in their shells, the average size of which averaged at 5.6 inches) over a course of 56 days spanning from May 13 to June 27 were caught, with a total of 22 diggers being paid $0.62 per pound of clams. This resulted in an overall fishery value of $235,000. While just barely over a quarter of a million U.S. dollars, this total looks of little importance compared to other Alaska fisheries. This number does not, however, include the amount of money needed to pay plant workers to process the clams, nor does it include any other local economic value for what it takes to run the plant.

Intensive marketing efforts are making them become a big part of restaurant menus throughout the United States. Since mussels can attach to surfaces, (including ropes), cages and
pots aren’t required to collect them as they would be for other shellfish, such as crabs or shrimp. This makes it easier and cheaper to catch them. Currently the economics of the fishery are better because costs are only a third of those for off-bottom fisheries. Most people still use mechanical water graders to get them off the bottom of the ocean floor, although that can be dangerous for the blue mussel and cause them to have injuries and possible cause more bacteria and infections to get into the meat when eaten. The blue mussel has a faster growth rate than the traditional shellfish species. It also has a higher ratio of meat to the actual weight. Plus it is nutritionally superior. The fisheries are thinking about thinning wild stocks and moving stocks between areas to improve meat quality. Certain blue mussels that are grown in different areas are better. For instance, the ones managed in bottom culture only take about 2-5 years to be completely grown and good, compared to ones that take seven years to attain the market size.

**Habitat Encroachment**

In the Cook Inlet, habitat encroachment does not pose a significant risk to the marine wildlife of the region. Many rules, laws, and enactments are in place to prevent corporations from destroying much of the habitats, and as much of the hunting force is for sustenance they do not have a need to develop further into the living areas of marine life. If habitat encroachment were to happen in the future and threaten the wildlife of the Cook Inlet, there would mainly be an impact on the subsistence fishing community, and this could disrupt the life patterns of the species in the region. If habitat encroachment were to expand even further, this
could pose a severe risk life patterns of a majority of the species in the region and would need to be monitored and reversed if the marine species were to be preserved.

**Overfishing**

For the razor clam fishery down in the Cook Inlet, there has not been a problem with overfishing. They are dug up using only a shovel and pulled from the sand. There are many people who fish for them at the same time but there still isn’t enough. You can’t just use a large net. Meaning, there really isn’t ever a problem with overfishing, and of right now, there really never has been. They have increased the amount they fish for but the population has also been increasing. It’s hard to give an exact example or definition of what would happen if there was a constant problem with overfishing because there has never been a problem with it. At the moment there isn’t much that needs to be done about the fishing. The fishery has been safely working with the population and doing well on the amount of clams they get and around the time they are harvested.

**Environmental Changes**

There were reports that previous governors wanted to put an oil drill in the Cook Inlet, not taking into consideration the environmental impacts on the area, and thus on ourselves. If oil were to be released into the Cook Inlet around our fishing grounds, one of two things would occur. One, the oil would kill the clams in the Cook Inlet, or two, if they had survived, then it would be in our food supply when we bought it from the market. This problem also leads to there being a large amount of pollution on the Cook Inlet. Some companies are dumping their
pollution into the ocean starting at the Cook Inlet. Certain companies are getting the permission of the state and others are not. Pollution can cause death to the clams of release the toxins. Although with more types of chemicals being released as pollution, there is a higher risk that when we buy the products of clams, we could end up having toxins and chemicals being put directly into our body. If it were to happen, the production of clams and their fishery will have a tremendous decrease. We have to be very careful about the things we put into our water, especially around where we are fishing. By doing this, we are not only causing a problem with the organisms living there but to us. Some organisms can filter things, but then the pollutants which are filtered are still able to get stuck in their system and they will not be able to get it out, which can lead to a decrease in the razor clams' overall population if we continue with this trend. We propose a protocol be established so that the dumping of chemicals, toxins, and waste into the waters is strictly prohibited. There will be no dumping of these around our fishing grounds and where we go to get our food supply. All dumping should be disposed of properly and never dumped around main fishing grounds anywhere throughout the whole Alaskan border of coastlines.

**Natural Changes**

A large storm in 2008 caused thousands of clams to be washed up onto the beaches, covering a large amount of shoreline on Cook Inlet. The storm caused waves to have enough momentum that when they hit the shoreline, it pushed the sand and dirt up causing razor clams to be uprooted. The waves' dangerously fast movements and the weight during the moment of
impact killed most of the clams on contact; the ones that were able to survive died shortly thereafter from being so far up the shore, unable to bury themselves back into the ground. The amount of clams affected by this made it hard for Cook Inlet fishery to have a profit for a short amount of time. The fishery production dropped drastically within the next few months. Storms like this happen almost once a year. Each time it happens, the fishery suffers due to the time taken to be able to continue with normal production.

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**Problems in the Fishery**

Cook Inlet fisheries face the amount of pollution being dumped into the inlet. The state is allowing certain companies to dump toxic wastes into Cook Inlet waters, without caring about the pollution going into the environment. Not only is it hazardous to the clams, shrimp, and mussels living there, but it is also endangering all other species inhabiting the area, including humans, as there is a large amount of fishing going on in Cook Inlet. Whatever gets put into the organisms we harvest, will end up being given to us when the animals are caught, sold, and consumed. This will cause a great risk to the consumers getting poisoned or possible catching diseases.

There are questions about oil drilling around Cook Inlet. The oil could be released into the water and cause a large problem with the pollution. Oil is a very toxic thing for the razor clams to be inhaling and being around. It could cause a decrease in the fishery business because they cannot sell oil covered clams. Also, the oil will kill them and start infecting the areas around them. We need to stop all dumping of anything into waters. No oil tapping in the waters where we fish for as well. If you want to tap for oil, it needs to be in area less populated by any organisms. There should be absolutely no tapping of oil in an area highly fished for by our own fisheries here. Besides these few things Cook Inlet is not in any large danger for anything at the moment. The fishery is doing well with keeping their fishing to a minimal so that they will not
have an overfishing problem. They now do not, nor probably ever will have a problem with by-catch. At the moment, the biologists around Cook Inlet area said that there is nothing that needs to drastically be changed, though. Although the pollution should be put under control so that there will not be a problem at any point, the assistant biologists of the area said that they are expecting less pollution and oil drilling to be happening in the area. The oil industry is doing what it can to get its products where there won’t be harm to the environment. As of the storm problem, she isn’t too worried because the natural environmental changes won’t cause to large of a problem. If these problems get fixed then an increase in the fishery production and the amount of razor clams that are going to be in production each year can be expected.

**Methods/Management Plan**

Razor clams in Cook Inlet are managed by the ADF&G in Homer. Currently, the population is very healthy. The age and size of clams has been managed since 1965, after the devastating 1964 earthquake. The number of clams is estimated and the program has been in effect since 1965 when a study was issued to evaluate the effects of the earthquake and the sudden increase in clam diggers. As bivalves, razor clams (and mussels) may only be harvested from Alaska Department of Environmental Conservation-certified areas. According to Charlie Trowbridge, Homer-based shellfish biologist, these certifications include “regular water sampling as well as ‘lot’ sampling of product to ensure it doesn’t cause paralytic shellfish poisoning.” Alaska complies with the National Shellfish Sanitation Act. Some of the mariculture
farms in Kachemak Bay either grow mussels for market or are permitted to retain and sell mussels that grow on their culture gear (normally for oysters).

Pink shrimp and blue mussels have little to no effect economically in the local area. Since mussels filter feed and pink shrimp are most commonly detritivores, they are primarily prey species for other organisms. Because most successful predators are not completely prey-specific, there are likely other resources that could replace lost shrimp or mussel opportunity. It would be difficult to speculate effects from over or under fishing besides the obvious effects on abundance stemming from too many removals.

In our management plan, it is our goal to rectify the problems within the fishery, starting with the previously stated target species. Our plan can be divided easily into three main components: the Loss Prevention section will monitor the amount of organisms being lost from the ecosystem, due to either environmental or human-based factors. The Environmental Safety section will make sure that all efforts made are working towards a better, healthier ecosystem and environment of the area. The final section, Ecosystem Overview, will look at the changes surrounding the management plan, and show areas where adaptation and changes in the plan may be needed.

Loss Prevention will deal with the overall number of organisms, and stand to stop any excess from being lost to the area so that a diverse ecosystem may be maintained. One of the problems seen in Cook Inlet fishery was highlighted previously, mainly being storms in the area uprooting clams. To fix this problem, we propose the fishery install barriers into the sand, just
deep enough to ensure that should another storm occur like the one in February of this year and in November of 2010, when thousands of clams were scattered among the beaches, and the fisheries lost money due to the amount taken from the beaches. When the waves come in from a storm, they will be slowed down enough so they will not be able to uproot all the clams. The barrier can be buried under the beach shoreline. The waves will come over the barriers and travel above where the clams bury themselves. The waves won’t be able to lift up all the sand and pull up the razor clams. It will help prevent the already small Cook Inlet fisheries from losing their production and their annual salary of money made each year to keep up with all their expenses.

Environmental safety will look after the health of organisms and the environment within the ecosystem. The goal of this section is to make sure the environment is not harmed in any unnecessary ways. One of the threats to this environment currently is the debate over whether or not to begin drilling for oil in Cook Inlet. The oil could be released into the water and cause a large problem with pollution. Oil is a very toxic thing for the razor clams to be ingesting and being around it would cause a decrease in the fishery business as they cannot sell oil-covered clams. Also, the oil will kill the organisms and start contaminating the areas around them. No oil tapping will be allowed in the waters where these fisheries are prominent. If oil is to be tapped, it needs to be in areas less populated by organisms. There should be absolutely no tapping of oil in an area highly fished by our own people. Besides these few things the Cook Inlet is not in any large danger for anything at the moment. The fishery is doing well with keeping their fishing to a minimum so that they will not have an overfishing problem.
Ecosystem overview will be our way of checking in on the targeted area for changes in the ecosystem balance. We will monitor the given species, as well as the other organisms in the area to be sure that no harm is coming to any of them. In order to have a complete view of the health of the target species, we need to know what is happening around them. This section will be monitored by looking in on the acidity of the water, measure fishing of any and all organisms in the area, and being sure that the entire system is kept in its prime condition.

**Conclusion**

The ultimate goal of this management plan is to sustain a long-term healthy, balanced, and diverse marine ecosystem. An understanding of these changes will allow for a better outlook on our ecosystem’s future. We will monitor the proposed plans for both the long-term and short-term effects on the environment. Short-term observations will show the community variations in the distribution and diversity of the Cook Inlet razor clams, blue mussels, and pink shrimp. Long term observations of this data will stand to show us a larger picture of the effects this plan may have on the overall health of the ecosystem. In the end, this plan isn’t just about fisheries or economics of an area: it’s about maintaining and preserving a healthy environment not only for ourselves, but for generations to come.
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