Module 3
Fisheries

Developed by Dr. Scott Smiley, Director of the Fishery Industrial Technology Center of the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, and Associate Professor at the University of Alaska Fairbanks; and Dr. Peter J. Bechtel, a USDA Agricultural Research Service scientist and an Adjunct Professor in the School of Fisheries and Ocean Sciences, at the University of Alaska Fairbanks[1]

Key Terms and Concepts

- adductor muscle
- Alaska Department of Fish and Game (ADF&G)
- artifact
- beam
- bladder buoy
- bottom trawl
- brailing net
- bridle
- by-products
- cannonball
- carrick bend
- chafing gear
- checker
- cherry picker
- circle hook
- clip-on gear
- cod end
- commercial fishing
- cork line

[1] The authors wish to acknowledge the contributions of Dr. Robert Foy, Dr. Alexandra Oliveira, Dr. Sathivel Subramaniam, and Dr. William Smoker of the University of Alaska Fairbanks.

- Cryoprotectants
- decanter centrifuge
- docosahexaenoic acid (DHA)
- dredge
- drift gill net
- Dungeness pot
- ecosystem-level management
- eicosapentanoic acid (EPA)
- essential amino acids
- essential fish habitat
- factory trawler
- fat-soluble vitamins
- fish trap
- fish meal
- flasher
- foot rope
- gaff
- gangion
- gelatin
- gill net
- ground line
- gurdy
- hand troll
- hold
- holding skiff
- hoochies
- hook
- hydraulic pot launcher
- individual fishing quota
- International Pacific Halibut Commission
- jig
- jigging machine

- land bridge
- lead line
- limited entry
- limited entry commission
- live tank
- longline
- long term monitoring of stocks
- middens
- moratorium permits
- National Marine Fisheries Service (NMFS)
- National Oceanic and Atmospheric Administration (NOAA)
- North Pacific Fishery Management Council (NPFMC)
- observer
- observer program
- omega-3 fatty acids
- *Oncorhynchus*
- otter trawl
- outrigger
- overharvesting
- oxidative rancidity
- Pacific salmon
- pelagic trawl
- picking skiff
- pot
- pot door
- power troll
- power block
- purse seine
- rake
- reel
- regime shift
- retort

- rockhopper gear
- seamer
- seine
- seine skiff
- seiner
- set line
- set net
- set net lead
- set net roller gear
- shots of line
- skate
- spoilage bacteria
- sports recreational fishery
- sterilization
- stuck gear
- subsistence fishery
- surimi
- sustainability
- tender
- tickler chain
- trawl
- trawl roller gear
- trigger guard
- troll
- value-added products
- variable climactic conditions
- vessel monitoring system (VMS) program
- water-soluble vitamins
- weir
- wet pump

Learning Objectives/Outcome

Upon completion of this module, you should be able to

1. describe various methods of seafood harvesting.
2. define limited entry permits.
3. define individual fishing quotas (IFQs)
4. explain how limited entry permits and individual fishing quotas have affected the overcapitalization of the salmon and halibut fisheries.
5. list the nutritional benefits of having marine fish in your diet.
6. describe the processes involved in making fish meal from fish by-products.
7. explain the meaning of “regime shift” and give an example.

Overview

This module outlines the history of fishing in Alaska from prehistoric to modern times. There are detailed descriptions of modern harvesting methods including trawling, seining, longlining, pots, and others. Fish is an excellent food and provides many nutrients that are identified and described. How fish are transformed into food and how they are stabilized against degradation through freezing or canning is described, as is the fate of the by-products of seafood processing. There are many rules and regulations by which harvesters and processors must abide. Discussions of these, as well as of sustainable harvesting and the effective monitoring of fish stocks, are also included.

Lecture

Fisheries of Alaska

Pre-European Fisheries in Alaska

Humans first colonized Alaska about 13,000 years ago. Using the land bridge connecting Asia with North America across the Bering Sea, or in small watercraft—and in multiple waves of migration—these people moved from eastern Siberia into Alaska. From there they moved southwards, colonizing what is now Canada and the United States, and eventually Central and South

America. Prior to the European discovery of Alaska in the seventeenth and eighteenth centuries, the indigenous populations of Alaska fished for a variety of different species in local marine and fresh waters. Seafood was an important component of the diet for these people. Indigenous peoples of Alaska still speak of the phrase attributed to their ancestors, the pre-European settlers of Alaska, “When the tide is out, the table is set.” Alaska’s indigenous peoples ate a wide variety of marine organisms, including kelps, crabs, shrimp, barnacles, clams, rock oysters, snails, chitons, octopus, numerous different fish species, marine mammals, and birds, as well as their eggs. Ancient middens or refuse piles have been excavated in many locations across Alaska. The bones, shells, and other artifacts found in middens reveal a diverse diet for these people.

Among the most important fish to these people were the five species of Pacific salmon, fish that returned yearly from their migrations in the north Pacific to their natal streams—the streams where they were born. Today, these five species of Pacific salmon are all taxonomically located in the genus *Oncorhynchus*. The type species for the genus *Oncorhynchus* is the rainbow trout, also known in its sea-run form as the steelhead. The scientific name for this species is *Oncorhynchus mykiss*. (See table 3.1.)

Table 3.1 Species in the genus *Oncorhynchus* found in Alaska

Scientific Name	Alaskan Name	Canadian Name
Oncorhynchus clarkii	cutthroat	---
*Oncorhynchus gorbuscha**	pink	humpy
*Oncorhynchus keta**	dog	chum
*Oncorhynchus kisutch**	silver	coho
Oncorhynchus masou	cherry	---
Oncorhynchus mykiss	rainbow	(sea-run) steelhead
*Oncorhynchus nerka**	red	sockeye
*Oncorhynchus tshawytscha**	king	chinook

* The five species of Pacific salmon

Prior to contact with Europeans, Alaska’s indigenous peoples probably encountered many if not all of these species. The most abundant were probably the five Pacific salmon species, with fewer cutthroat and rainbow (also called steelhead) trout caught. The cherry salmon is native to the Japanese islands and probably was only caught occasionally.

The amount of time each species characteristically spends at sea prior to returning to their natal stream varies. Pink salmon are generally smaller fish that return after two years. Dog, red, and silver salmon generally return after four years, but they can spend a varying amount of time in freshwater lakes before they become smolt and run to sea. King salmon can delay their return as much as eight years after they were spawned, perhaps accounting for some of their amazing size.

Fish will spoil because of microbial action if they are not effectively treated in short order after death. To preserve the salmon they caught, America's indigenous peoples either smoked or dried them on racks protected from the rain in open-walled roofed structures. The drying agent was largely the wind and not the fickle sunshine encountered in coastal Alaska. Salting the fish may well have joined these methods, although information on the use of this process by Alaska's indigenous peoples is limited.

Pre-European indigenous peoples of Alaska probably used a number of different techniques and technologies to harvest salmon and other fish species. We know they caught Pacific halibut (*Hippoglossus stenolepsis*) by hook and line because hooks too large for most species other than halibut have been found at archaeological sites. Evidence of ancient weirs suggests these were used for salmon, but wicker traps and natural fibre nets were also used. Other indigenous peoples of America used spears in rivers to capture salmon, and it seems likely spears were probably used in Alaskan rivers as well. Fish wheels were not used by the early Alaskans; they were an invention that reached Alaska long after European contact.

Historical Development of Fisheries in Alaska

Russian visitors to Alaska undoubtedly fished from time to time to provide fresh food. Initially, they probably used the same methods to preserve their fish as did the indigenous peoples of Alaska—smoking and drying—but also it seems likely they used considerably more salting. Their exploitation of Alaska's fish continued after they established permanent communities in Kodiak and Sitka. Things were not to change substantially until the later half of the nineteenth century, when the methods for canning food became well established. Among the first major commercial uses of Alaska's marine bounty, other than the rendering of whales into oil and meat products by Yankee whalers, included the canning of salmon, which commenced in the l880s.

Canning

The first large commercial canning plants were built by salmon processors whose main operations were in the Pacific northwest. Most of the fish for these early canneries were captured in fish traps. Fish traps were permanent structures built from pilings driven into the sea bottom. The traps included a long line of pilings extending from the shore out into the sea. The line of pilings ended with a rectangular trap structure, also made from pilings, and often a shack for a watchkeeper to prevent petty theft. Nets were hung from the pilings, preventing the salmon from continuing along the coast towards their natal stream. The line of pilings led to the trap, which was constructed in such a way as to make escape difficult. Nets also lined the inner side of the trap and, in addition, a sheet like brailer net was attached to bents (timber caps extending over several pilings) on one side. By lifting the brailer net, live salmon were delivered from the trap to a waiting tender vessel, tied alongside the trap and which transported the fish to the nearby cannery for processing.

In the cannery, the fish were killed then sent to a mechanical device that removed the head, tail, and fins and also eviscerated the fish. The salmon then passed along a line of workers who cut the fish into appropriately sized portions and stuffed these sections of salmon—together with skin and bones—into metal cans to a certain weight. The only ingredients placed in the cans were salmon, water and salt, but often the salmon was topped off with salmon oil derived from boiling the removed salmon heads. Salmon oil was added because it was exceptionally healthful and also it produced a product prized by consumers for its mouth feel. To this day, the only ingredients found in Alaskan canned salmon are salmon, water, and salt, but unfortunately the salmon oil has been left out since the early 1970s.

The cans were inspected and then sent to the seamer, where the top of the can was carefully and tightly seamed to prevent any leaks that might allow air into the can. Once packed in the can, it was important that the fish be sterilized quickly. Workers placed the seamed cans in racks; when a sufficient number of racks were filled, these were loaded into a retort cooker (a large commercial pressure cooker). Once the retort was filled with racks, the doors were shut and steam was introduced to the retort, heating up the retort and expelling any residual air. Workers monitored the temperature in the retort and the valve where air escaped; when all the air had been expelled, the valve was shut. Steam pressure raised the temperature in the retort to around 270^{o} F for sterilization. The cans were cooked for 80–90 minutes and then cooled before being packed onto pallets for shipping to Seattle. Individual salmon packers produced hundreds of thousands of cases of canned Alaskan salmon each year between 1890 and 2000. During the late 1930s, the Second World War, and into the early 1950s, American families often ate canned salmon on average once a week.

Other Species, Other Methods

Several marine organisms other than salmon were also canned in Alaska. Early on, in the 1910s and 1920s, a number of razor clam canneries opened up. Meat from various species of crab was also preserved in cans. After the Second World War, however, freezing technology, offering a much more versatile method of processing, became available in Alaska. Primary processing—the preservation of the catch from microbial degradation—was now accomplishable using different methods. Many of the fish now harvested are primary processed and frozen prior to being shipped to distant locations, including not only North America, but Europe and Asia as well.

Current Status of Commercial Fisheries in Alaska

A significant majority of the wild fish caught for human consumption in the United States are landed and processed in Alaska. For years, wild Pacific salmon were the largest component of Alaskan seafood landings, but more recently, groundfish such as pollock and cod have been of increasing importance. The exact number of species harvested commercially in Alaska changes from year to year, but it is somewhere upwards of 100 different species. The seafood industry is the largest employment sector in Alaska. Many of the small coastal communities in Alaska have at least one local fish-packing plant that has been the major source of revenue for their economies. The most plentiful finfish species harvested and processed includes the following in table 3.2.

Table 3.2 Species harvested, and harvests (metric tonnes)

Species Harvested	Harvests
Alaska pollock (*Theragra chalcogramma*)[a]	1,165,007
Pacific cod (*Gadus macrocephalus*)[a]	255,155
pink salmon (*Oncorhynchus gorbuscha*)[b]	120,668
yellowfin sole (*Limanda aspera*)[a]	101,201
dog salmon (*Oncorhynchus keta*)[b]	64,309
Atka mackerel (*Pleurogrammus monopterygius*)[a]	56,277
red salmon (*Oncorhynchus nerka*)[b]	53,890
Pacific herring (*Clupea harengus pallasi*)[b]	39,608
rock sole (*Lepidopsetta bilineata*)[a]	33,645
Arrowtooth flounder (*Atheresthes stomias*)[a]	28,216
Flathead sole (*Hippoglossoides elassodon*)[a]	26,139
Pacific halibut (*Hippoglossus stenolepis*)[c]	20,068
Pacific ocean perch (*Sebastes alutus*)[a]	19,029
silver salmon (*Oncorhynchus kisutch*)[b]	10,704
Greenland turbot (*Reinhardtius hippoglossoides*)[a]	8,875
sablefish, or black cod (*Anoplopoma fimbria*)[a]	8,542
northern rockfish (*Sebastes polyspinis*)[a]	3,639
rex sole (*Glyptocephalus zachirus*)[a]	2,669
Dover sole (*Microstomus pacificus*)[a]	2,286
TOTAL	**2,019,927**

Source of data: [a] NMFS 1997, harvest statistics
[b] ADF&G 1998, harvest statistics
[c] IPHC 1998, harvest statistics

This adds up to about 2 million metric tonnes of fish processed into seafood each year in Alaska. Of this harvested biomass, approximately 35% is converted into human food, while the remaining 65% is processing waste or by-products.

Economic Importance of the Alaskan Fisheries

Today, the commercial seafood industry is Alaska’s largest employment sector, outstripping even the petroleum industry. In terms of revenue generated, the Alaskan seafood industry ranks second in the state, after petroleum. Tourism is also a large employment sector, and a lucrative one as well, but it is not as economically significant to Alaska as is seafood. The commercial seafood industry, however, is not the only business involved in harvesting and processing Alaska’s marine bounty. Traditional subsistence fisheries have existed in Alaska since well before the European colonization. These subsistence fisheries are important both culturally and nutritionally to the people engaged in them. Another sector involved in the commercial exploitation of marine resources in Alaska is the sports commercial fisheries or charter fleet. The amount of fish harvested by the sports commercial fleet has grown over the years and is now being recorded, as are the landings of commercial harvesters. Finally, sports recreational fisheries constitute a significant use of these resources. In a study conducted in the early 1990s, more than 80% of people who were driving into Alaska along the Alaskan highway intended to purchase a sports fishing licence and to catch Alaska freshwater and marine fish.

Student Activity

1. Where is the fishery nearest to your community? Find out what kind of fish are harvested and in what numbers.

2. Where are the fish processed? What method of processing is used, and where is the processed fish shipped? What percentage of the harvest is waste or by-product?

Harvesting and Processing

Modern Methods of Commercial Harvesting

Rules and regulations governing the fishing industries in Alaska are usually made upon the recommendation of three separate agencies. The North Pacific Fishery Management Council (NPFMC), working with National Marine Fisheries Service (NMFS) sets the rules and regulations for federal waters fisheries, roughly 3–200 miles (4.827–321 km) offshore. The Alaska Board of

Fish and Game, working with the Alaska Department of Fish and Game (ADF&G), sets the rules and regulations for fisheries in state waters, less than three miles (4.827 km) from shore. Together, these agencies collaborate on the crab fisheries in the Bering Sea. Finally, by treaty, the Pacific halibut fishery in Alaska is managed by the International Pacific Halibut Commission (IPHC). Enforcement of fishing rules and regulations for the fisheries in Alaska is dependent on the location where the putative violation occurred, the type of putative violation involved, and other factors.

Trawl

The greatest portion of the more than 2,000,000 metric tonnes of harvested fish in Alaska's seafood industry is caught by trawling. Trawlers catch more fish than other fishing methods. The largest fishery, accounting for the landing of more than 1,100,000 metric tonnes, is for Alaska pollock (*Theragra chalcogramma*); but Pacific cod (*Gadus macrocephalus*), Pacific ocean perch (*Sebastes alutus*), black rockfish (*Sebastes melanops*), and flatfish of a variety of species are also taken by trawl. In this method, a net is slowly towed behind the harvesting vessel. Fish enter the net and are caught. After the net has captured a certain amount of fish, it is hauled back on board and the catch is removed from the net. Trawl nets are built for specific purposes, and there are significant differences in the mechanisms used to hold a trawl net open. Otter trawl is the most commonly employed method in Alaska's fisheries. Here, the net is held open in its lateral aspects by doors that provide an outwards force as they are pulled through the water. The top of the net is held up by floats and the bottom is held down by weights. Doors for trawling in the mid-water zone—that is, pelagic trawling—are different from doors used for bottom trawls, as are the nets and several other features.

Trawl nets do not plunge to the bottom when towed; they fly down towards the bottom, depending on how fast the vessel is moving and how the winches are operated. Skippers do not want to hang their nets up on rocks or other obstructions on the bottom and the more skilled ones are able to exert little downward pressure on the substrate with the net. Generally, only the doors, the tickler chains, and the foot ropes encounter the bottom. Replacing a trawl net can cost more than $50,000. Flatfish and other species are encouraged to swim up and lift off the bottom by means of the tickler chain, which rattles along the bottom, hanging down from the lower front of the net near the foot rope. Often, when trawling along uneven bottoms, a variety of aids are employed to keep the nets from hanging up on obstructions. Among these is the chafing gear, which is a protective mat-like device made of fibre and sewn into the bottom of the trawl net that prevents the net from meeting with the obstructions. The front of the net is often protected by roller and rockhopper gear that includes wheels and rubbery wheel-like discs that allow the front of the net to roll over smaller obstructions.

Fish often will swim in front of the net unless they are overtaken or they tire out. As they enter the net, some provisions are used to allow for the escape of certain species depending on regulations. Separator panels allow Pacific halibut to escape through special openings provided in the net; grates can prevent larger fish from gaining access to the front of the net; and differential mesh sizes can allow the escape of smaller fish. Eventually, the fish all congregate in the back of the trawl net, a portion called the *cod end,* or bag. This is closed at the extreme posterior of the net with a cinch and a release lock of some kind.

The trawl is set out and retrieved by means of powerful winches that reel out and reel in wire rope (warps) attached to the doors and the net. The tension in the wire ropes can be extreme, and the parting of one can be a deadly event on deck. Once the wire rope has been hauled in and the doors stabilized, the cod end can be brought on board by means of a variety of booms and winches. If the cod end can be lifted above the deck, this is often done. Then a crew member will release the lock on the cinch and the contents of the net will spill onto the deck for sorting. Once the trawl is emptied, the release lock is reset. The net and doors are swung over either the side or the stern of the trawl vessel, and the wire rope is paid out by the main winches. Sorting the catch usually occupies part of the time while the emptied net is fishing. Target species fish are put into the hold, where they are kept in refrigerated sea water until they are delivered to the processing plant. Non-target species bycatch are discarded according to regulation.

A beam trawl is used for shrimp fishing, particularly in southeast Alaska. The beam is a large steel structure that is fastened to the net, laterally, at the front. The beam provides support for keeping the front of the net open and also the weight to take the net down to the appropriate depth for fishing. No doors are used with beam trawls. Generally, beam trawls are smaller than otter trawls and are used where smaller nets are required; for example, in fisheries pursuing shrimp around rocky substrate and pinnacles characteristic of southeast Alaskan inshore waters. Otherwise, the fishing of beam trawls is similar to that described for otter trawls. Factory trawlers are used in the Bering Sea. These are large vessels that can both harvest the fish and process them on board. Their operations in terms of the trawl gear are essentially the same as described for otter trawls of smaller size.

Longline

This is a hook and line method of commercial fishing. Predominantly employed in fisheries with higher value per pound (or kilogram), the catch for longline is lower than that for trawl. Traditionally caught with longline in Alaskan waters are Pacific halibut (*Hippoglossus stenolepis*), black cod or sablefish (*Anoplopoma fimbria*), and Pacific cod (*Gadus macrocephalus*). The term *longline* refers to the 3/8” to 1/2” thick sinking ground line that is the fishing unit employed. The set line is usually made up of ten skates, each 300 fathoms

(1,800 ft., or 548.64 m) long. The skates are tied together and anchored at both ends to keep the gear on the bottom. Two principal schemes are used for attaching the hooks to the ground line: stuck gear and clip- or snap-on gear.

In stuck gear, gangions—similar in function to a leader in sports fishing—are sections of stiff, smaller-diameter line that are spliced into the ground line. At the end of each gangion, there is a hook. The length of the gangions, their separation along the skate, and the size of the hooks vary, depending on the species being targeted.

Stuck gear is generally kept in tubs with the hooks and gangions lain outside the tub and the ground line within until the gear is set. With clip- or snap-on gear, the ground line is wound on a large reel that is hydraulically controlled. The gangions, with a clothespin-like metallic clip-on device at one end, and the hook at the other, are stored on racks to prevent tangling. Hooks are generally of the self-setting type called circle hooks. The crew keeps these hooks extremely sharp with a file.

Baiting the gear is generally delayed until the gear is set. An anchor and buoys are attached to one end of the longline. The ground line is paid out through a baiting machine where the hooks encounter a mass of bait. Drawn through the bait by the forward motion of the vessel, the hooks "self-bait," exit the vessel, and travel down to the bottom. Clip-on gear is snapped onto the ground line as it is paid out. The hooks in this method are sometimes baited using the self-baiting technology; at other times, the hooks are baited by hand. Hand baiting is generally reserved for baits that are either more expensive or tougher. Octopus is frequently used as bait for halibut, and its reputation is excellent; but octopus can be tough to put on a hook with baiting machines and is sometimes hand baited. When the last of the ground line in a set is exiting the vessel, another anchor and buoy set is attached. Often harvesters will set parallel sets of gear while fishing, each up to three miles long (4.827 km).

Longlines are usually allowed to soak for 12–24 hours before they are retrieved, depending on how well they are fishing. To haul in the line, the buoys are caught and brought aboard and the ground line is pulled through a power block or attached to the reel's drum. When a fish is brought up, the crew will see it broach the surface and will gaff it before it is pulled over the rail by the power block or reel. During the landing of fish, careful control of the uptake speed on the ground line is essential to prevent injuries to the crew. The gaff is a sharpened, unbarbed steel hook at the end of a shaft. Fish are gaffed to prevent losing them and to ease bringing them aboard. The fish is then passed to the checker, where it is quickly dressed (bled, eviscerated, and the gills removed); then it is passed to the hold, where it is stored in ice before delivery to the processing plant.

Pots

A variety of pots are used in commercial fisheries in Alaska. Some are quite large, like those used for king crab (*Paralithodes kamchatika*), tanner crab (*Chionoecetes bairdi*), queen crab (*Chionoecetes opilio*), Dungeness crab (*Cancer magister*), and Pacific cod (*Gadus macrocephalus*). Besides crab, fish are also caught in pots, and harvesters often get a better price for pot-caught cod than they do for trawl-caught cod because the fish are generally delivered to the processor in better condition. The most common pots in Alaska are the 6 x 6 steel-frame king crab pots. Called “six by six” because they are 6 feet by 6 feet (by about 3 feet deep) (roughly 1.8 m x 1.8 m x 0.9 m), the pots generally weigh about 700 lbs. (317 kg). By regulation, the netting covering the pot is degradable. An entrance, formed from a rounded, rectangular-shaped piece of rod, is held in place on one face of the pot by twine, which is tied, under tension, to the frame. When the pot is used for fishing cod, a trigger guard, consisting of a plastic piece that prevents crabs from entering, is locked into the entranceway. The pot is baited by opening a door that is formed from one end of the pot. This is hinged, usually with twine, and is kept closed by hooks attached to heavy-duty rubber band, which are usually made by cutting up inner tubes. Baiting the pot requires opening the door, crawling into the pot, and using metal clips (indistinguishable from the snap-on ones used for longlining), and clipping the bait container to the netting so that it hangs free in the pot.

Other kinds of pots that are frequently in use in pot fisheries in Alaska include round Dungeness pots, which are roughly 3 feet (0.9 m) in diameter and are often covered with stainless steel mesh wire rather than netting. A stackable Japanese pot is also sometimes used for Dungeness crab and shrimp. Other types of pots have been used as well. The depiction below of how pots are used is consistent with most types of pot fishing, although sometimes pots are strung together in a line and used that way. This is often true for pots used to fish cod. Small pots similar in size to the lobster pots of New England have also been used to fish for prawns (*Pandalopsis dispar*) in Alaska. The bait for these is rich in fat, and the pots are often strung together in a long line. The pots are then draped over the edge of an underwater cliff, where the prawns are likely to be found.

The usual bait for crab is herring. Bait herring is generally caught in the fall of the year during the “food and bait” opening. Herring harvested at this time of the year has a high lipid content, 16%–30%, compared to the lipid content of herring caught for the roe fishery that occurs during the spring, 1%–3%.

Pots have a rope bridle, to which is tied many shots of floating line and the buoys. The buoys and line are kept in the pot while they are stored on land and when stacked on board. The bridle allows the pot to be picked up by a hook, without tearing the netting, and stacked, unstacked, or loaded into the launcher. The amount of line attached to a pot differs depending on the depth of water being fished, the tidal range, and current velocity. Sufficient shots of line must be added to the pot to allow the buoys to remain above water when the tide changes. Buoys can be dragged under by current velocity in certain conditions. Additional shots of line can be attached to the pot using a carrick bend. This is a strong knot that can be readily released.

Pots are sent over the side from a hydraulic pot launcher on the vessel. The pot is loaded into the launcher, the door is opened, and the line and buoys are removed. Additional appropriate shots of line are added between the bridle and the buoys while another crew member baits the pot. The door is closed and latched and the pot is flipped overboard by the hydraulic launcher. The line is then tossed into the water in coils followed by the buoys.

When a pot is to be retrieved, a four-pronged drag hook on a throwing line is tossed over the buoy line and that line is brought aboard. The buoy line is run through a power block and the pot is brought in. This drags the pot from the bottom and, because the vessel is making forward progress all the time, the pot moves through the water as it rises to meet the boat. While this is happening, the line shoots from the power block and a crew member coils it as it comes aboard, making separate coils for each shot of line. The pot is brought to the vessel by the power block; then the hook from a cherry picker captures the bridle and the pot is hoisted into the launcher. The door is opened and the crabs spill onto a sorting table. Extra shots of line are added or removed, old bait jars are retrieved and new ones installed, and the pot is sent back to the bottom to continue fishing. If it is the last pull of the pot in that specific fishing location, the buoys and line are stored in the pot and it is stacked on deck. The crew sorts the crabs. Those meeting the appropriate sex and size requirements are put in a live tank with continuously running sea water until they are delivered to the processing plant. Undersized or non-target species of crab are sent back to the sea via a chute. Sea lions can be a problem for crab fishers; they are known to frolic with the buoys and deflate them. For this reason, it is not uncommon to see a smaller hard plastic buoy accompanying the larger, more visible bladder buoys on Alaskan crab gear.

Dredge

A dredge, in contrast to a trawl net, is designed to dig into the ocean bottom to ensure that sessile marine invertebrates are not missed. This gear is used in Alaska to harvest weathervane scallops (*Pecten caurinus*) in certain restricted areas as per regulations developed by the Alaska Department of Fish and Game The dredge is manoeuvred on the bottom by hydraulic winches aboard the harvesting vessel. These take up and pay out wire rope connected to the dredge. The dredge consists of a rake that disturbs the bottom and is attached to a metal rectangular frame that carries the bag. The bag is made of interconnected metal rings or various types of stout chicken or pig wire. Since the dredge collects rocks and hard, sharp objects, the bag needs to be quite hardy.

Fishing involves putting the dredge over the side and paying out the wire rope until the dredge contacts the bottom. The dredge is then slowly dragged along the bottom to collect the scallops. Weathervane and other types of scallops can swim in response to the presence of danger by rapidly clapping their valves together, “biting” at the water. Usually, the swimming is not sufficient to get them out of the way of the dredge, but occasionally scallops do manage to avoid the gear. Once it is retrieved, the dredge bag is opened and the contents are dumped onto a sorting table. Scallops are immediately processed on board. The twin valves of the scallop are separated, and the scallop meat (the adductor muscle that holds the valves together) is cut free from the shell and packed on ice or immediately frozen at sea.

Seine

A seine is a long net that is attached to a seine vessel or seiner. Seines are used in Alaska to harvest Pacific salmon and herring. The seine net can be several hundred fathoms (or several hundred metres) long and 4–5 fathoms (24–30 ft., or roughly 7 x 9 m) deep, depending on the preferences of the harvesters and regulations. The top of the seine is kept at the surface by floats attached to the main line. The bottom of the seine is kept deep in the water column by means of a lead line at the bottom. The amount of weight used is a function of the kinds of current conditions expected to be encountered. The seine mesh comes in sheets and is sewn to the main line and the lead line. Most seines used in Alaska are purse seines. The purse refers to the ability to close up the bottom edge of the seine by pulling a purse line taught. The purse line is held in place at the bottom of the seine with metal rings and is locked with a special device or knot.

Usually, the seine is paid out off the seiner by means of a seine skiff. These are powerful and open small craft, often employing high-powered inboard diesel engines and jet drives. Upon reaching the appropriate position for making a set, the seine skiff will pull the seine off the deck of the seiner and directly away from the seiner. The most common set has the shape of a *j*, with the open side of the *j* facing into the current and the skiff located at the end of the *j* and the seiner at the top. Salmon will encounter the seine and sweep towards the end of the *j*, circling around and concentrating in the end of the *j*. The skiff operator will often make loud noises with a special plunger at the end of the *j* to scare the fish back towards the net. When the set has held for a sufficient time, the seine skiff will tow the end of the seine back to the seiner. Usually, only the seiner has sufficient pulling power to tow the entire seine and not the seine skiff; but if the end of the seine is not too far from the seiner and the current is amenable, seine skiffs can often do the job. There, the end of the seine will be tied off and the seine will be retrieved by means of a power block. As the seine spills back down onto the deck, it is laid out with corks on one side and leads on the other so that it will not tangle when being paid out again.

Pursing the seine requires coordination and careful timing. As the seine is brought on board by the power block, the end of the purse section is reached. The two ends of the purse line are pulled together until the net has formed the purse. A special quick release knot, or locking device, holds the purse closed as the seine continues to be brought aboard by the power block. Gradually, the fish are concentrated in the purse until they can be brought aboard.

In herring seining, once the catch is surrounded by the purse, it can be pumped aboard tender vessels with a wet pump. This is a large hydraulic vacuum pump that is designed not to bruise or harm the fish and is operated at low-flow rates. Seined salmon can be handled the same way or, when the pursed bag contains relatively few salmon, it can easily be lifted aboard by winches and a boom articulating with the mast. When the purse is filled and too heavy for the boom to lift, the fish can be brailed out by means of a winch-activated brailing net, circular in shape with a long stout metal handle. Alternatively, if there is a roll to the sea, the skipper can manoeuvre the seiner parallel to the swell and use the energy of the wave's roll to assist in moving the fish-filled bag on deck. As fish spill out on the deck, it lessens the load that must be borne by the boom and the bag is quickly brought aboard. The fish are sorted to species and loaded into the hold to be kept on ice or in refrigerated sea water until they are delivered to the processor's dock or to a tender.

Seiners are not large vessels, and if they had to travel long distances to their processing plants, much fishing time would be lost. Processors, therefore, employ the services of tenders to take delivery of freshly caught fish from seiners and to transport these to the processing plant. Tender vessels are usually crab boats, trawlers, or larger longliners. Tenders also provide gas and groceries for their seine vessels. Crew members of seiners may shower on the tender, given the limited freshwater holding capacity of seiners.

Gill Net

Until now, all the netting we have discussed has been the same: square mesh netting made from assorted twisted fibre materials, in different sizes and with varying decomposition rates. Gill nets are distinct from these in that they are diamond, not square, mesh; and gill net mesh is made from several strands of degradable synthetic fibre. The diamond allows fish to poke their nose through the mesh and get entangled. Gill nets are used to harvest Pacific salmon and herring. The anatomy of fish is such that the head can be pushed forward into the netting, which forms a taught circle around the fish's body. But if the fish tried to back out of this, the gill plates covering the gills will not allow the mesh to slip forward off the head. The fish are caught and cannot escape.

Gill nets are composed of a main line that has the gill netting and floats sewn onto it. The gill netting can be of varying depths, depending on the harvester's choice, or regulations, as can be the length of the net. At the bottom of the net, the mesh is sewn onto a lead line, again of potentially different weights, depending on local current conditions. The size of the diagonally stretched mesh opening varies with the kind and size of the fish sought.

There are two applications for gill nets: drift gill net fishing, and set netting. In drift gill netting, the net is stored on a hydraulically activated reel and paid out by moving the boat away from the free end of the net. Harvesters will drift with the currents, waiting for a school of salmon to reach the net. Under the best conditions, the gill net hangs straight downward, and fish that encounter the net will try to poke their heads through because of the limited visibility of the strands of monofilament. When fish are entrapped in a gill net, they cause the floats holding the net at the surface to submerge. This is one sign harvesters look for while tending their nets.

When a drift gill net is retrieved, the hydraulic reel pulls in the net. Crew segregate the cork line from the lead line to prevent tangling as the net is wound around the reel drum. Fish that are gilled have to be removed from the net and placed in the fish hold with ice or refrigerated sea water until they are delivered to the processor or tender. In many areas, the size of the drift gill net vessel is regulated by the state. For instance, drift gill net vessels fishing in Bristol Bay cannot exceed 32 feet (9.7536 m) long.

Not all regions of Alaska allow drift gill netting. On parts of Kodiak Island and the shores of Bristol Bay, set nets are the allowed form of gill net fishing. In set netting, a set line is anchored to the shore and run out roughly perpendicular to the current. At the terminus of the set, the set line is directed into an arrowhead shape, forming the hook. On Kodiak Island, the maximum length of a set net is 150 fathoms (900 ft., or 274.32 m). About 25 fathoms (150 ft., or 45.72 m) are required to form the hook, leaving about 125 fathoms (750 ft., or 228.6 m) of gill net to attach to the set line. The gill net used in set netting is similar to that used for drift gill netting, with a cork line to which is sewn the gill net mesh and the corks or floats. At the bottom is the lead line, again with the gill net mesh sewn onto it. The gill net is tied to the set line, starting at the end of the hook and proceeding back towards shore. In many cases, a non-gill net lead is tied onto the set line from the end of the gill net to the point where the set line enters the water. The lead is used to prevent fish from swimming around the shoreward side of the gill net.

Fishing a set net is different from fishing a drift gill net in that the gear is in the water fishing from the time of the opening (set by ADF&G) until it closes—except in very bad weather. At regular intervals, or when many of the corks are submerged, the crew will use picking skiffs to travel along the net and remove the captured fish. Newer skiffs have roller gear attached to the front of their skiffs. This allows the set line and gill net to roll over the front of the skiff while crew, standing in the body of the skiff, removes the fish. As the gill net and set line exit the stern of the skiff, they are often cleaned with high-pressure washers to remove jellyfish and seaweed. Operated with outboard motors of either the two- or four-cycle variety, Alaskan set net skiffs are a remarkable creation in their utilitarian design, flexibility, and stability.

The set net hook is the place where the greatest concentration of fish is generally found. This is because after a few fish have become entangled, the gill net is made visible to the newly arriving fish. These fish will run along the net towards the offshore or hook end until they can turn the corner on the net. This is where the hook is, and by turning that corner, the fish are effectively trapped in the hook. Set netters will sometimes plunge the entrance to the hook before they pick there. This will frighten any fish caught in the trap of the hook and drive them into the gill net to become entangled.

When the fish have been harvested from the set nets they are taken in the picking skiff to a holding skiff where they are sorted by species and placed in ice or in refrigerated sea water until they are collected by the tender. Tenders in these set net fisheries serve the same function as they do in the seine or some drift gill net fisheries: they collect fish, distribute fuel and groceries, and convey the catch to the processor’s dock.

Troll

Trolling involves hook and line fishing by dragging a baited hook through the water, usually at a specific depth. Trolling is used to capture Pacific salmon, particularly the more valuable species such as silvers and kings, although there is a troll harvest of pink salmon as well. Two different types of trolling are used in commercial fishing in Alaska: power trolling allows the use of hydraulic winches to drive reels that will haul back the troll line; while hand trolling requires that the reels hauling back the line are operated by hand. Because the fish caught by trolling are dealt with one at a time, this mode of fishing has one of the lowest catches but produces some of the highest quality fish. Each fish is killed, bled, eviscerated, and packed on ice or stored in refrigerated sea water as it is brought aboard. Trolling is not allowed west of Cape Suckling in Alaska and it is most frequently employed in southeast Alaska salmon fisheries.

Whether power trolling or hand trolling, the reel-like mechanism that takes up and pays out the line is called a gurdy. The line itself is usually a fine, multiple-strand wire, similar to the stainless wire used to activate controls on an airplane, but thinner. The line is run through pulleys on long poles called outriggers, which are attached to each side of the vessel. Other lines may be run directly off the stern of the vessel. Regulations specify how many gurdies may be used to troll for fish and consequently how many lines may be fished at one time. At the end of the wire is a heavy weight—usually called a cannonball—that controls the depth at which the line is being fished. Also attached to the line is usually a flasher, separated by a short piece of leader from the hook and bait. The function of the flasher is to mimic a rolling fish. Salmonids often roll just as they take a piece of food, and the flasher, in mimicking this behaviour, excites a strike response in other nearby salmonids. Artificial baits that are used include soft plastic hoochies that are designed to imitate squid and spoons. Some troll fishers prefer to use fresh herring as bait. To accentuate the action of herring bait, the tail is often split, allowing each side of the tail muscles to waft back and forth as the bait is trolled. The hooks used by trollers are relatively expensive and are kept sharp. Open-eye hooks are generally preferred, and a stainless barrel swivel is often enclosed in the hook eye when the rig is made up. Still, spoons remain the most common trolling lure.

When a salmon strikes the bait, usually the forward motion of the vessel is sufficient to hook the fish. The tension in the line signals to the troller that they have a fish hooked, but some harvesters attach a bell to the outrigger pulley so that a sound is made. The line with the attached weight is then hauled in by the gurdy and the fish is dispatched. Generally, trollers do not use tenders to convey their harvest to the processing plant, but if a tender is provided by the processor, individual trollers may take advantage of this option to allow for greater time on the fishing grounds for their fleet.

Jigging Machines

The use of jigging machines has developed in Alaska in the past 25 years and has seen increased interest because of changes in regulations regarding state waters fisheries for groundfish such as Pacific cod. Jigging machines come in a variety of different kinds and manufactured in different countries. In essence, all follow the same basic principles. The device controls several weighted lines that can have from one to a number of hooks on each. The hooks are baited appropriately for the target species and lowered to an appropriate depth. The machine then “jigs” the line, moving it up and allowing it to fall back from a few inches (centimetres) to a foot (0.3048 m) or more. This jigging motion attracts the target fish, and they bite. When the device senses a fish on it, it reels in the line and the fish is dispatched. The depth, the rate of jigging, and the number of fish hooked before lines are reeled in are variables set by the operator.

Although a low catch fishery, mandates for a certain percentage of the groundfish quota to be taken from state waters has made jigging an increasingly popular method of fishing. A jigging operation is also relatively inexpensive to capitalize. Quality has the opportunity to be as high as that found in trolling and for the same reasons. Each individual fish can be dressed appropriately to meet market demands.

Meeting Regulatory Requirements

Limited Entry

Times have changed for Alaskan fishers of the twenty-first century. Before 1976, many people said they became fish harvesters because of their distaste for the paperwork associated with land-bound businesses. In 1976, Alaska instituted the limited entry program to control escalation of the number of vessels involved in the state's salmon fisheries. The state set up the limited entry commission, whose job it was to see that the limited entry permits were fairly apportioned to people who had a history in the Alaskan fishery. Permits were gear-type and region-specific. Not all regions in Alaska allowed use of all gear types. Those participants who met the requirements of the limited entry commission were given permits to continue legally fishing salmon in Alaska. The state endowed the harvesters with the value of the fishery by allowing permit holders to sell their permits for cash. The value of some limited entry permits soared, reaching values as high as $200,000 for drift gill net permits in Bristol Bay. The diminishment in the value of wild salmon since the early 1990s, brought about by highly skilled competition from salmon aquaculturists, has caused the value of these limited entry permits to plummet in recent years. It should be noted that by instituting limited entry in 1976, Alaska largely avoided allowing its salmon-harvesting industry to become overcapitalized. Overcapitalization of a fishery usually means that too many boats, worth too much money, are involved in the harvest of too few fish. This kind of a situation will reduce the average income per vessel to a level too low to sustain the costs of labour and ownership of the vessel.

Individual Fishing Quotas (IFQs)

Limited entry permits were followed by individual fishing quotas (IFQs) for halibut and black cod in the 1990s. These were mandated by the International Pacific Halibut Commission (IPHC) and the North Pacific Fishery Management Council (NPFMC). The method chosen to distribute the permits was initially controversial and some residual frustration remains. While the sale of IFQs is allowed and is dealt with much like a commodity, there are rules and regulations governing how they can be massed in one person's hands. After IFQs, moratorium permits were mandated by the National Marine Fisheries Service (NMFS) and NPFMC for vessels engaged in harvesting groundfish in the Gulf of Alaska and the Bering Sea. Some of the vessels groundfish fisheries in the Bering Sea were subsequently subjected to changes impelled by the passage of the American Fisheries Act in 1999. This act required that harvesting of Bering Sea groundfish be undertaken only by American flagged vessels. A number of factory trawlers were retired under the restrictions of the act, but the benefit has been the rationalization of the Bering Sea's groundfish fisheries. The rationalization has reduced overcapitalization of the Bering Sea groundfish fleet and has changed the fishery from a derby-like race for fish into a steady and predictable plan for harvests and deliveries to processors. Implementation of halibut IFQs ended the derby-style one-day openings. Unpredictable bad weather on the designated day of the halibut opening was the cause of a number of fatalities during the halibut derby era. Halibut IFQs also helped reduce overcapitalization of the halibut fleet—another laudable outcome.

Observer Program

The NPFMC and the NMFS also implemented controls to reduce the bycatch of certain quota species, such as halibut. To manage this, observers were mandated on trawl vessels in a schedule that is variable depending on the size of the vessel. The observers are trained in the identification of various fish and invertebrate species and are then assigned to each harvesting vessel. The cost for the observer program is borne by the vessel. Observers have unionized and cannot be forced to work 24 hours per day. The cost for each observer is currently about $300 per workday. Smaller vessels are not required to have full observer coverage and may only be required to have an observer on board for one out of three trips.

Vessel Monitoring System (VMS) Program

A recent regulation required by NMFS is the vessel monitoring system (VMS) program. This is an electronic device through which NMFS can make queries via radio from satellites as to the exact location of the vessel at any time. In addition to these regulatory requirements, new rules regarding the location and timing of harvesting is also restricted in response to the diminishment of certain marine mammals in Alaskan waters. Chief among these are the Steller sea lions. The rationale for restricting location and timing of fish harvests rests on somewhat scientifically shaky ground, given that the presumed cause of the decline in Steller sea lions was limitation of food for juveniles. The National Research Council, an arm of the National Academy of Sciences, stated that the decline was probably caused by predation on adults, not food limitation. The sum of new regulations promulgated in response to the endangered species listing of Steller sea lions reduced the workforce of seafood harvesters and processing workers in some coastal Alaskan communities by as much as 25%.

Student Activity

1. What method or methods of harvesting are used in the fishery near you?

2. If possible, try to speak with someone who has been in the fishery nearest to your community for many years. How has the local community been affected by fishing regulations over time?

Fish Products

Fish as Food: Nutritional Value of Fish as Human Food

Fish and seafood are excellent sources of protein, many minerals and vitamins, and the long-chain polyunsaturated fatty acids often referred to as omega-3 fatty acids. Fish has a positive nutritional image because of its relatively low caloric content, its high-quality protein, and as a source of omega-3 fatty acids. The protein content of fish muscle is approximately 20% of the weight of the muscle. Fish protein is of high quality, which means that it contains high levels of all of the essential amino acids in the balanced amounts required for human growth and development. Fish protein is also very digestible, which means almost all of the protein can be digested and used by the body. These are important points, as many proteins from other sources lack adequate amounts of the essential amino acids, or the proteins are poorly digested.

The percentage of fat in fish muscle varies greatly between fish species, from low values of 0.3% to values higher than 25%. Most fish fat is liquid at room temperature and contains high amounts of the long-chain polyunsaturated fatty acids, which is absent or present in smaller amounts in beef and pork. Two of the most important of the long-chain polyunsaturated fatty acids are eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA), which are found in large amounts in salmon and other high-fat content marine fish. A number of health agencies now recommend eating fish on a regular basis because of the many health benefits associated with these polyunsaturated fatty acids. It is interesting to note that human milk contains high levels of DHA and that the human brain has a large content of DHA. Cholesterol is found in animal products; and in fish it ranges in content from 40 to 60 mg/100g, which is lower than the amount found in most meat products. One problem with high levels of polyunsaturated fatty acids in food products is a rapid development of oxidative rancidity. Development of oxidative rancidity can be reduced by storing the products at lower temperatures and by using packaging that reduces the amount of oxygen that comes into contact with the product.

Fish muscle is a good source of many of the water-soluble vitamins, including thiamine, riboflavin, niacin, panothenic acid, folic acid, and vitamins B_6 and B_{12}. However, fish is not considered a good source vitamin C. Oil obtained from fish liver is a good source of the fat-soluble vitamins, especially vitamins A and D. Tissue content of vitamins will vary between species of fish. In the 1800s, before we knew about vitamins A and D, fish-liver oil was used to prevent night blindness and rickets. Fish is a good dietary source of minerals needed in large amounts, including phosphorous, sodium, and potassium; as well as minerals needed in smaller amounts, including copper, fluoride, iodine, and iron. Fish bone is often consumed in canned salmon products and provides calcium and magnesium. The iron content of dark muscle is higher than that of white muscle.

Fish Processing

Traditional Product Forms

Raw fish and meat rapidly spoil at room temperature because of the high content of water and the neutral pH of the fish. Spoilage bacteria cause most of the problems; however, mould and other micro-organisms can also cause serious spoilage problems. Spoilage is faster in fish than in other red meat and poultry products. Methods have evolved over centuries to eliminate or reduce spoilage of fish and still provide a palatable and nutritious product. Some of these processes include drying; drying and smoking; salting; and pickling of fish and meat. The drying of fish reduces the amount of water in the fish to the point where there is insufficient water available to support the growth of micro-organisms. Salt at concentrations higher than 8% will inhibit the growth of most micro-organisms, but often this is not sufficient to inhibit all bacteria and mould. The pH of some pickled fish products is lowered below pH 4.0 with the addition of acids such as acetic acid or vinegar. At these low pH values, most micro-organisms are unable to survive and grow. There are salted, dried, and pickled fish products available in the marketplace; however, most of these fish products are gradually falling out of favour with consumers.

Fish-Processing Operations

After fish such as pollock are harvested, they are immediately cooled with refrigerated sea water, or ice, and brought immediately to the processing plant. The amount of time from harvest to arrival at the processing plant is tightly monitored in order to maintain fish quality. After arriving at the processing plant, the fish are unloaded, washed, and sorted. Large processing plants use automated equipment to remove the heads and viscera. Some fish may then be washed, sorted, inspected, frozen or refrigerated, and sold as headed and gutted fish. Other fish will go through a filleting operation in which the fillets are mechanically cut from the backbone of the fish and then the skin is mechanically removed to produce a skinless fillet. There are different types of machines used for the mechanical filleting of different types and sizes of fish. Fillets are then inspected, trimmed, packaged, and quickly frozen. Because of the high levels of polyunsaturated fatty acids in fish tissues, low freezer temperatures are recommended for the storage of fish. The amount of time a fish product can be stored frozen is shorter than red meat and poultry products. To maintain product quality, the processing is completed as quickly as possible and the fish are kept cold during all of the stages.

In Alaska there is a large salmon-canning industry. Both red and pink salmon are canned in large volumes; however, the markets for canned salmon are gradually declining. In the canning process, salmon are first unloaded from the harvesting vessel and then washed; and the heads, tails, and viscera are mechanically removed. Specialized machines then cut the salmon into pieces and pack the correct amount of salmon into each can. Salt is then added and the cans are sealed. The sealed cans are heated in a retort for an exact amount of time and at a precise temperature to obtain a commercially sterilize product. After the cans are removed from the retort, they are cooled. In Alaska, samples of the canned product are evaluated for quality by an independent laboratory before the product is labelled and shipped. New pouch material that can withstand the high temperatures and pressures found in a retort have been developed. Salmon chunks are placed in the retortable pouches with salt; they are then sealed and heated in a retort to obtain commercial, sterile products. The pouch and canning process are similar in many respects, although the retortable pouch is more flexible.

Surimi is a product that is made by washing ground fish muscle repeatedly with water to make a white protein material that can be used to make a large variety of products, such as kamoboko, imitation crab, and other products. A large amount of high-quality surimi is produced in Alaska from pollock; and smaller amounts of surimi are made from Pacific cod and other species of fish. There are many different methods used to make surimi, and only an outline of the process is included here. The starting material is often a low-fat, inexpensive white fish such as pollock. The process can use fillets, fish mince, fillet trimmings, or other recovered muscle tissue. The first steps are to reduce the muscle to small particles; add water; and mix the fish particles and water. The washed muscle particles are then separated from the wash water, which is discarded; and the washing process is repeated several more times. The washing process removes much of the soluble protein, enzymes, fat, colour, flavour, and odour from the fish muscle particles. After the washing process is completed, the particles contain muscle protein and a lot of water, which is removed using either a large screw press or a large decanter centrifuge. The concentrated material is then mixed with a small amount of starch and other cryoprotectants, and formed into blocks that are frozen. The starch and cryoprotectants are added to maintain the quality of the frozen surimi during storage. Surimi made from pollock has a white colour, little odour and flavour, and excellent gel-forming properties, which are ideal for making a variety of other products.

Modern Product Forms and Techniques

The fish-processing industry is changing to meet consumer demands. The American public is slowly increasing the amount of fish consumed per year per person. Product growth areas include fresh and frozen fish and value-added products. Many large and small fish processors are marketing products that offer convenience, variety, and high-quality fish products. Individually packaged entrees and partially cooked and pasteurized products are available in the marketplace. There is an increasing demand for fresh fish and also a growing worldwide demand for live fish.

Fish By-Products and Use

Fish by-products refer to the tissues that remain after much of the fish muscle has been removed. Fish by-products include heads, frames, viscera, and skin. The most valuable by-product is the roe, which is collected from salmon, pollock, cod, and other fish species. Other edible parts, such as heads and stomach are often collected and sold. Fish skin has been made into gelatin and glue, and a small amount of skin is used to make fish leather. By-products can be used to make fertilizer and other products. In Alaska, most of the fish by-products produced in large shoreside fish-processing plants are used to make fish meal and fish oil.

Fish meal and oil have been produced in Alaska for more than 100 years. In 1882, a company was started to utilize whole herring for edible oil, fertilizer, and animal feed. Production between the 1890s and late 1910s was small, but during the First World War, fish-meal production increased; however, during the Second World War, production fell dramatically due to war restrictions and lowered herring quotas, and it was finally discontinued in the late 1950s because of poor economics and low catches. Modern fish-meal operations in Alaska were the result of favourable prices for fish meal; the passage of the Federal Water Quality Control Act of 1972; and the Fisheries Conservation and Management Act in 1976. In Alaska, modern fish-meal plants have been developed to handle the by-products from surimi, pollock and cod fillets, and salmon operations.

By-products are a good source of protein, minerals, and oil; and in Alaska the most abundant by-products are fish heads, frames, viscera, and skin. Fish meal is made by first grinding and then cooking the by-products. The solids, which consist of the protein and bone, are then separated from the water and oil. The solids are dried and milled to make fish meal. Fish meal is used as a feed ingredient for aquaculture in fish and shrimp farming, and in agriculture in the raising of livestock and poultry. The fish-oil fraction undergoes a clarification step to remove water and small particles and is then ready for use as a feed ingredient or as fuel.

Student Activity

1. What by-products come from the fish landed in or near your community?

2. How much fish do you have in your diet? What fish by-products do you consume or use, if any.

Sustainability of Fisheries Resources

Ask any Alaskan involved in the prudent use of marine resources in the state and you will find that they are deeply concerned that the resources remain sustainable. What does this mean? Translated into the language of harvesters and processors, sustainability means that the resource will be around for the long term. It means that these folks want harvest quotas to be set to allow for years of bad recruitment. Recruitment is the incorporation of pre-reproductive juveniles into the breeding population. Alaskan marine resource users believe these resources should be reasonably protected so that they will be available as an economic resource in the years to come. For communities along coastal Alaska, these are crucial issues because they deeply involve the economic viability of the communities. Alaska's fisheries management, both at the federal and state levels, is among the most effective available. Yet the geographical location of Alaska and the enormous climatological forces at play in the area makes its ecosystems highly dynamic.

Regime Shifts and Variable Climatic Conditions

Does a sustainable fisheries resource necessarily mean a static one? If we look at recent history we can see great shifts in the volume and kinds of species harvested. In Kodiak in the 1970s, harvesters took about 100,000 metric tonnes of shellfish—crab and shrimp—from Kodiak Island waters. By the mid-1980s, harvesters were capturing about 100,000 metric tonnes of pollock. In the 1990s the same harvesters were taking 100,000 metric tonnes of mixed groundfish cod and pollock. This illustrates two important points. The first is that harvesters and also processors need to have sufficient flexibility in the species they are allowed to harvest to account for regime changes to the available biota. Second, the crash of crab and shrimp populations in Kodiak in the late 1970s, contrary to a lot of the heated rhetoric, was primarily because of changing environmental conditions. In the mid-1970s, a large water mass migrated into the north Gulf of Alaska and persisted as an identifiable mass for a number of years. This water mass was measurably warmer than the water that it displaced.

We live in a dynamic, changing world. Regulations designed to protect stocks or the environment and to regulate the practices of people must take into account the natural variability that Alaska's environment is subject to. Alaskan waters lie at the northern edge of a zone of physiological tolerance for more southern species and at the southern edge of a zone of physiological tolerance for more northern species. The imaginary line separating these populations migrates north and south in latitude, depending on forces that are largely not understood. The dynamism of ecosystems in Alaskan waters is distinct in kind and magnitude from the kinds found in other parts of the country. The faunal regime shifts in Alaska seem more profound, and the dependency of coastal Alaskan communities on marine resources is deeper than that found elsewhere.

Essential Fish Habitat

A clause in the US Magnuson-Stevens Fishery Conservation and Management Act requires the identification of essential fish habitat by the North Pacific Fishery Management Council (NPFMC). Exactly what “essential fish habitat” is, is debatable. Presumably what legislators meant are those areas where species covered by the Magnuson-Stevens act are most vulnerable. Arguably, the most vulnerable life history stages for most species are the larval, juvenile, and spawning stages. Given the diversity of species involved in commercial harvests in Alaska, the most straightforward definition of essential fish habitat would focus on the nearshore and shallow-water areas of Alaska. This is where the majority of the larvae and juvenile fish congregate. Spawning for many species does not occur in discrete geographical locations but is governed by physiological conditions, as opposed to the situation of Pacific salmon, with their strong fidelity to their natal streams. A discrete geographical conceptualization of “essential fish habitat” fails to recognize that for fish, appropriate habitat is primarily governed by physiological conditions such as temperature, salinity, and oxygen content. It seems likely that more-precise descriptions of appropriate essential habitats for fish be mobile, not tied to discrete geographic locations.

Issues of Overharvesting

Sustainability is seriously threatened when species are overharvested. Current protocols employed by the NPFMC, the Alaska Department of Fish and Game, and the International Pacific Halibut Commission are deliberately designed to recognize stock diminishment early on and to adjust harvesting quotas to take these changes into account. One conundrum arises when a species population, for example Alaska pollock, declines precipitously. History suggests it will often be replaced with a distinctly different species or several different species. Harvest records from Kodiak already cited show this. Unless provision is made in regulations for the harvesting of changed faunas—that is, once populations have stabilized—the sustainability of coastal communities themselves may be endangered. Legislating constancy in a region where the ramifications of climatic change seems magnified may be short-sighted.

Long-Term Monitoring of Stocks

The responsibility for the long-term monitoring of stocks falls on both the National Marine Fisheries Service and the Alaska Department of Fish and Game. Using standard procedures developed over the long term, these agencies have assembled a time series of data that has been useful in identifying trends in the populations of marine species. New interest directed toward ecosystem-level management will require even better data sets. If we are to understand or predict the changes to the ecosystems—such as an alteration of the carrying capacity of regions—more accurate and more-frequently sampled data in the regions will be required, as well as assessments of the viability of specific life history stages. Also important are measurements involving the forage species that support the predatory fish species, as well as birds, marine mammals, and human consumers.

Student Activity

1. Are the marine resources nearest you used in a sustainable way? Are there harvest quotas to reasonably protect the marine resources so that they will be available as an economic resource in the years to come?

2. How would the loss of the marine resources nearest you affect you and the economic viability of your community?

Summary

Artifacts from early coastal settlements show that fishing was an important activity for the early inhabitants of Alaska. Today, the amount of fish harvested from the waters around Alaska is in excess of two million metric tonnes per year, and this industry is vitally important to the economy of its coastal communities. To maintain quality, fish must be kept cold and must be processed rapidly after being harvested. There are many different methods used to harvest fish, from large nets to baited hooks. Most of the seafood harvested in Alaska is delivered to shoreside processing plants, but factory trawlers that process them at sea account for about one-quarter of the landings in Alaska.

Modern fish-processing plants use automated equipment to make a variety of products, including fresh, frozen, dried, smoked, and canned items. In addition, fish is being developed as a component in ready-to-eat meals. Fish muscle proteins are also used to make surimi, a freezer-stable protein mix that can be incorporated into a variety of new food forms such as imitation crab or lobster. Per capita fish consumption is increasing in the United States, in part because of the discovery of the healthful nature of omega-3 fish lipids and the high-quality protein that fish contains.

Maintaining sustainable stocks is a goal shared by all interested parties. Many regulations have been promulgated in support of the effective and efficient use of our marine resources. These regulations include quarterly harvest quotas for individual species, controls over the bycatch of certain species, and the handling of the by-products of seafood processing. Scientists in the Alaska Department of Fish and Game and the National Marine Fisheries Service are studying the fish stocks; such long-term monitoring is essential if rational policy decisions are to be made.

Study Questions

1. Briefly describe the following methods of seafood harvesting:
    a. longline
    b. pots
    c. dredge
    d. seine
    e. gill net
    f. trawl

2. What are limited entry permits and individual fishing quotas (IFQs), and how have these affected the overcapitalization of the salmon and halibut fisheries?

3. List the nutritional benefits of including marine fish in your diet.

4. Describe the processes involved in making fish meal from fish by-products.

5. What is a meant by regime shift? Give an example.

References

Alaska Department of Fish and Game (ADF&G). 1998. Harvest statistics. [Online] http://www.adfg.state.ak.us/.

Bechtel, P. J., ed. 2004. *Advanced in Seafood Byproducts*. Fairbanks, AK: Alaska Sea Grant College Program.

International Pacific Halibut Commission (IPHC). 1998. Harvest statistics, [online] http://www.iphc.washington.edu/halcom/commerc/tables/1998breakdown1.htm. IPHC home webpage: http://www.iphc.washington.edu/halcom/.

Johnson, T., and K. Byers. 2004. *Ocean Treasures: Commercial Fishing in Alaska*. Fairbanks, AK: Alaska Sea Grant College Program.

Magnuson-Stevens Fishery Conservation and Management Act. Public Law 94-265. As amended through October 11, 1996. [Online] http://www.nmfs.noaa.gov/sfa/magact/.

Mecklenberg, C. W., T. A. Mecklenberg, and L. K. Thorsteinson. 2002. *Fishes of Alaska*. Bethesda, MD: American Fisheries Society.

National Marine Fisheries Service (NMFS). 1997. Harvest statistics. [Online] http://www.nmfs.noaa.gov/.

———. 2003. *Fisheries of the United States, 2002*. Washington, DC: National Oceanic and Atmospheric Administration (NOAA). [Online] http://www.nmfs.noaa.gov/.

National Oceanic and Atmospheric Administration (NOAA). [Online] http://www.noaa.gov/.

Potter, N. N., and J. H. Hotchkiss. 1995. *Food Science*. Fifth edition. New York: Chapman and Hall.

Shahidi, F., and J. R. Botta. 1994. *Seafoods: Chemistry, Processing, Technology and Quality*. Glasgow, UK: Blackie Academic & Professional.

Pearson, A. M., and T. R. Dutson. 1997. *Healthy Production and Processing of Meat, Poultry and Fish Products*, Volume 11. Dordrecht, Netherlands: Kluwer Academic/Plenum Publishers.

United States Department of Agriculture (USDA). Agriculture Research Service. [Online] http://www.ars.usda.gov/.

Windsor, M., and S. Barlow. 1981. *Introduction to Fishery By-Products*. Farnham, Surrey UK: Fishing News Books, Ltd.