THE DEVELOPMENT OF SPECIALIZED SHIPS, NETS, AND EQUIPMENT

A.L. Fridman *(Deceased)*
Fisheries Center, University of Rhode Island, USA

Keywords: Fisheries, fisherman, ocean, catch, species, stocks, ships, equipment, gear, nets, technology, mid-water, deep-water, trawling, artisanal fishing

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Summary

Fisheries technology is constantly moving toward higher catchability, more selective gear, and better methods for reducing bycatch. Fishing vessels have become larger and more efficient, their equipment becoming more powerful, and the quality of fish handling has improved. In this connection, services provided in fishing ports and at auctions have also improved.

When using more developed techniques and machinery, electronics, satellite, and other advanced technologies, the labor productivity of fishermen increases and the same results are obtained with a reduced number of ships. Artisanal fisheries employ many more people than industrial fisheries do because of the backward technology. Coastal communities are unable to compete economically with industrial fishermen.

Fishery industrialization is historically unavoidable. In the course of the planet's civilization, the developments of almost all communities were connected with particular industries, which were subsequently destroyed as new technology was developed. The

alternate view based on the understanding of fisheries from a community perspective, where social and humanistic considerations are held to be of equal importance to technical and economic considerations, is much more humane, liberal, and attractive. But in the final analysis this vision is self-deceptive. Fisheries will continue along the same road as other industries with implementation of all possible newest scientific methods, technologies, and innovations toward higher labor productivity.

The most significant aspect for the future of international common fisheries policy is the upbringing and training of fishermen, which makes them more intelligent and capable of managing their vital interests. The quality of manpower in the fishing industry has become greater. There are good prospects for the further reduction of fishing costs through more effective management and growing labor productivity with support of improved technology and equipment. It is inevitable that sooner or later the most difficult problem will arise, i.e. the reduction in the number of fishermen. More possibilities are available to those who are better educated. Their growing ability to defend their economic and social interests will help them to find ways to self-organize and self-manage.

1. Introduction

Commercial world fishing was affected like another branch of the economy by the fast-growing labor efficiency and other changes of the twentieth century. The changes influenced fishing technology, vessels, equipment, and fishermen themselves. Modern development of the catching process of fishing is characterized by an increase in power consumption, decrease in labor expenses, and use of more qualified staff on fishing vessels. The world fishing fleet continues to steadily grow, although new fishing grounds are rarely discovered. Most countries with large fishing fleets provide financial assistance for shipbuilding and gear purchasing and aid in fuel pricing. According to the FAO (Food and Agriculture Organization of the UN) data, total subsidies provided from governments are roughly US$54 billion annually.

The single most important development in the commercial fishing industry was the motorization of fishing boats. The high horsepower of steam engines encouraged the building of bigger fishing vessels and made it possible for fishermen to seek out new fishing methods farther from shore. This industrialization provided bigger catches but longer workdays, higher unemployment risks, and the collapse of an old lifestyle.

The invention of synthetic fibers for making nets and twine led to an increase in the size of fishing gear, and monofilament made nets less visible to fish. The use of hydroacoustics for fish detection allowed fishermen to locate fish aggregations and set better courses for trawling. Because the equipment has evolved and become highly specialized, highly qualified individuals achieve higher labor productivity.

In all fishing nations of the world the number of small-sized ships is many times greater than the number of large vessels. However, the smaller-sized ships report almost equal percentages of catch in each category of targeted fish. In the small-scale artisanal fishery it is necessary to invest about US$100 to US$1000 per fisherman, while to

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construct a large modern fishing vessel the investment would be US$10 000 to US$ 100 000.

Despite the supercapitalization in the fisheries of developed countries, new ship designs are constantly being produced to improve efficiency and safety and minimize the number of required crew. Developed countries, in an attempt to gain profits from their technological advances in fisheries, sell their licenses on different inventions.

After World War II, three major Technical Conferences on fishing methods and gear were sponsored by the FAO. The first took place in 1957 in Hamburg, Germany, the second in 1964 in London, England, and the third in 1970 in Reykjavik, Iceland. In the reports compiled for the meetings hundreds of experts, including scientists, engineers, and fishermen reviewed the entire spectrum of the most acute problems facing the fisheries industry. The tradition established by FAO Congresses has been continued with a World Symposium on Fishing Gear and Fishing Vessel Design held in 1988 in St. John's, Canada.

2. How Fishing Tools Appeared

The basic components of modern fishing gear were invented by the earliest known civilizations. Similar methods and materials and tools for construction fishing gear appeared on different continents. This suggests that faced with similar needs, people separated by great distances solved their problems in similar ways. As long ago as the ninth century AD, Lu Guimen in China wrote poems about fishing processes and about Fan Li, who created the scientific basis for aquaculture before the Great Wall of China was built.

Almost all items of modern fishing gear have been known from time immemorial. The effectiveness of such gear has dramatically increased because of the ingenuity of thousands of unknown inventive fishermen. These advances have allowed gear to be fished deeper, new grounds and new species to be fished, and gear to be fished in areas of environmental peculiarities.

The first method for catching fish, crabs, mollusks, and other aquatic organisms and plants was grabbing by hands. Early humans were gathering anything that could be used as food, especially where gleaning from flood plains was possible. Tides were also utilized when it was discovered that the labyrinths could be used to hold numerous fish. Eventually primitive tools were employed such as baskets for gathering and knives and tridents for spearing. With the invention of metal, sharpened tips were added and improved with barbs designed to keep fish on the tips. Bow and arrow, early forms of blowpipes, and small harpoons also came into use as ways to catch fish.

In an attempt to get closer to the fish, mollusks, turtles, and trepangs people started diving for them. This method was also used for gathering corals, amber, and pearls. On the African continent people found out that some seeds, roots, berries, and leaves can have a disorienting effect on fish. In some cases the chemicals paralyze the fish and they rise to the surface for easy collecting. Since then Mezolite epoch man has been using trained animals, dogs, otters, and birds, to aid in fishing.

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3. Differentiation of Catching Methods

Humans also learned to weave threads and make ropes in the Mezolite era, approximately 9000 years to 12 000 years ago. This led to the development of a new fishing method, using bait to be swallowed by the fish at the end of a line, with hooks for holding the fish on the line made of sharp sticks, bones, shells, or thorns taken from plants. Additional weights, called sinkers, were invented to add weight to hooks made of wood or other light material to make them fish deeper waters. Fishing rods were developed as a means to easily control the line and bait.

Watching the natural habits of the fish, humans learned how to attract or to scare them, so as to direct them to a place where they would be easy to catch. Among such devices and techniques were the use of torches at night to attract fish, different smelling baits, special attractive sounds, throwing stones to direct the fish, and floating rafts that fish would congregate under.

New ways of working with old tools were refined, such as jerking an empty hook until its movement attracts the fish. It was noticed that bottomfish, living among plants, stones, and corals, always try to hide somewhere. So people began to build artificial shelters of stones, bush branches, split bamboo, and wood. These early shelters are the first known forms of fish traps. After people learned to make dishes of clay, fishermen began to use pots to trap crayfish and octopus.

The appearance of fishing nets was a huge step forward in fishing. The main problems posed by fishing with nets was holding the caught fish and getting them out of the water. The oldest known relic of a fishing net is 8800 years old, measured by radio-carbon analysis. About 5000 years ago people began cultivating cotton in Peru, and making nets of cotton fiber.

A significant development was the appearance of scoop nets, based on bag-shaped nets. At first people were using hand landing nets mounted on special frames. Eventually, scoop nets were dragged over shallow waters, first by men, later by horses.

When people began to understand where fish congregated, beach seines appeared. Nets resembling beach seines were used from boats and were the ancestors of modern day trawl nets. With these nets fishermen could hunt for fish instead of waiting for them to take a hook or become trapped in a stationary net. Another development was a net that encircles a shoal of fish and is gradually closed during the hauling process. This procedure led to the development of lampara nets and purse seines.

It was eventually realized that fish could be captured in the mesh of a net by their gills or fins. This brought about the creation of gillnets, which move with a current or a vessel from which it is streamed. The opposite of the lift net is a falling gear net such as a hand cast net with weighted edges that encircle the prey.

The original idea of any fishing gear is based on the specific behavior of the targeted species. The most important factors determining the behavior of any species of fish are the predators that prey upon the species and the food that the fish prefers. It is believed

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that in some cases certain species are able to learn from experiences, form conclusions, and adapt their behavior to intensive fishing. Fishermen shadow this development by attempting to adapt their gear and methods of fishing to variable fish behavior.

Application of hydroacoustic instruments, submersible camera equipment for direct visual observation, and other technical means are helpful in understanding factors that determine fish behavior. Unfortunately, reliable data on fish behavior is scarce.

Japanese explorers Takafumi Arimoto and Yoshihiro Inoue observed with the help of scanning sonar that fish know of approaching objects before they are seen. Tuna can be attracted and concentrated by floating rafts placed on the ocean surface, supplied with radar reflectors. Sprat (kilka), saury, and sardine are actively attracted to a zone illuminated by artificial light directed from above or below the water surface. In distinction to the artificial light, an electric current acts universally on any species of fish. Depending on the power in the electric field, three types of fish responses exist: excitation (restless behavior), electrotaxis (movement toward the anode), and electronarcosis (shock). In oceans and seas, because of their higher salinity, this fishing principle was applied with pulsed current, which reduces required power. The use of air-bubble curtains, produced by an air-compressing unit, was tried as an aid to fishing, hiding fish schools to the point of capture from other fish schools. Russian and Norwegian scientists experiment with acoustic devices for fish attraction into trawls and purse seines.

In the 1960s Vadim Martyshevski and Victor Korotkov became the first people in the world to observe the actual process of commercial trawling. This was accomplished at a depth of 150 m using the Batiplan Atlant (see Figure 1), a towed underwater manned vehicle designed in Kaliningrad, Russia. Aquanauts have observed and measured the reactions of different species to otterboards and sweeplines, and the trawl catchability (the ratio between the factual number of fish caught and the number of fish met by the trawl). The influence of net coloring and sounds produced were investigated as determinants of fish behavior. Some work has been conducted to observe the influence of different types of footrope designs on benthic animals and seafloor habitat.

Figure 1. Batiplan

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4. Fishing Gear and Fishing Vessels

When primitive humans developed the first raft that allowed floatation, they essentially began the quest of catching fish in deeper waters and designing new ways of catching fish. All specific types of fishing vessels have been created under the commanding influence of corresponding fishing methods. The major categories of fishing vessels include trawlers, seiners, dredges, lift netters, trap setters, liners, trollers, vessels using pumps, and multipurpose vessels. Nonfishing vessels involved in the industry are motherships, fish carriers, hospital ships, fishery protection vessels, research vessels, and training vessels.

Seagoing fishing vessels range from several meters in length, in artisanal fisheries, to 100 m or greater, in ocean fishery. These vessels can draw up to several dozen millions of dollars worth of fish. Large fishery vessels tend to operate principally in the open seas, while medium-size vessels tend to fish inside the EEZ (Exclusive Economic Zone) marine areas. Small-decked vessels, open boats, and canoes operate mainly in coastal marine and brackish waters.

In designing a fishing vessel, the best results are achieved with the mutual cooperation of naval architects, fishing method and equipment specialists, and economists. The first requirement for vessel design is to provide a safe and reliable working platform for the crew. Strict requirements to the stability and seaworthiness of a vessel reduce the number of fishermen lost at sea. Shipbuilders and producers of equipment are interested in the fishing industry's sustainability and prosperity to keep them employed with orders. The critical factor in the decision to build a vessel is security of access to particular resources.

The development of new devices and systems of mechanization economized traditional fishing methods and reduced the number of crew needed to perform the duties easily and safely. In some cases the increased mechanization has been a key to the survival and further flourishing of some fisheries.

Since the beginning of the twentieth century purse seines were used for fishing in the open sea, their dimensions quickly grew, along with the number of crew needed to operate them. A device that radically changed the purse seine fisheries was a power block invented by American fisherman Mario Puretic. To create the power block, Puretic removed the existing hauling machine from the deck and hung it high in the air on the derrick. This way the gravity force of the heavy wet net became the main component of power, increasing the latter several times and excluding human labor from this process. The crew could be reduced by 2 to 3 times, and new types of purse seiners began to appear and became the most efficient vessels in the fishing industry. The implementation of the power block machines has been also useful in other fisheries. The Norwegian-based company Mustad and Son introduced an automatic Autoline system which was considered a major breakthrough in the longline fishing in the 1970s. Even comparatively small vessels equipped with the Mustad Autoline System can operate longlines with 15 000 hooks. The bigger modern vessels, known as autoliners, are capable of fishing a longline with 40 000 or even 50 000 hooks. Their daily catch can exceed 40 tons to 50 tons of fish, which means that the growth of labor productivity

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has increased 100 times (per fisherman) since the beginning of the last century. The fishery has also become much safer with the crew being able to perform most of their duties under the deck. Modern autoliners with two or even three decks has enough space for a processing factory and versatile equipment. These vessels are able to work in extremely rough high seas and are economically effective and attractive to both owners and crew. Among the large variety of modern fishing gears the most common and effective are the trawls, purse seines, longlines, driftnets and snurrevods . In Danish vaad means net and snurre explains the vibration of ropes forming the main part of the gear. The category of gear used by the vessels for catching is generally used as a criterion for their classification.

5. The Major Categories of Fishing Vessels

5.1 Trawlers

It is believed that trawls appeared for the first time in England in the fourteenth century. The openings of these trawls were not variable, and depended on the size of the rigid frame. In 1880 the first steel warps were manufactured, which allowed the depth of trawling to increase. In 1894 an English captain named Scott who was from Grantham applied for the first patent for otter boards, which are used to keep a trawl net open horizontally. This original design marked the beginning of the era of otter trawl implementation. Attaching floats to the upper line of the net and sinkers of different material and bobbins to the footrope served to enlarge the vertical opening of the net. In 1920, the Frenchmen Vigneron and Dahl implemented bridles, up to 100 m long, between the wing of a trawl net and the otter board. The bridles served to help herd the fish toward the mouth of the net, making the catch larger. Also in 1920 the German Captain von Eitzen had the idea of putting a third otter board at the headline of the trawl mouth to act like a kite. This allowed the capture of fish such as herring, which are commonly found well above the bottom. During the 1950s, the Russian engineer Igor Matrosov invented oval otter boards that have revolutionized the spreading technique of otter trawls. Different styles of trawlers can be seen across the world. Examples include side trawlers, stern trawlers, wet-fish trawlers, freezer trawlers, factory trawlers, and outrigger trawlers. In all cases they tow the trawl along the bottom of the seafloor or in the mid-water, then haul the net on board and lift the cod-end over the deck.

Figure 2. Stern trawler

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On a side trawler the trawl is set over the side and the warps pass through blocks hanging from two gallows. On the stern trawler (see Figure 2) the warps are led from the trawl winch through blocks to the afterdeck and over the stern. Freezer stern trawlers and factory stern trawlers are fitted with a stern ramp, on which the trawl is hauled onto the deck.

Freezer trawlers are outfitted with refrigerating plants and freezing equipment, while the factory trawlers are equipped additionally with processing plants, placed between decks. They are comprised of gutting and filleting machines. Such ships are able to catch fish under much more severe sea conditions and on distant fishing grounds.

Wet-fish trawlers keep fish in their fresh condition and so don't travel far to fishing grounds. Outrigger trawlers (see Figure 3) use strong outrigger booms to tow two or more trawls by means of warps passing through blocks at the ends of the booms. This method is used for shrimp trawling and sometimes for flatfish.

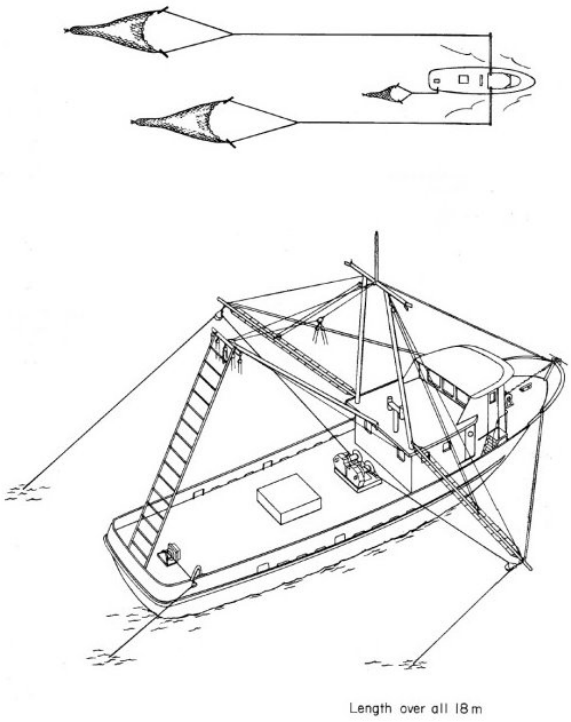

Figure 3. Outrigger trawler

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Biographical Sketch

Alexander L. Fridman, holds the Dip. Eng., Ph.D., and Dr.Sc. He was Honorary Researcher of Science and Engineering in the Russian Federation, 1994, by Decree of the President of Russia. He entered the fishing industry in 1945 as a student at the Fishing College. In 1946 to 1948 he worked as a deckhand aboard many vessels in different fisheries of the Caspian and the Barents Seas. Training as an engineer began at the Fisheries Experimental Station of the Murmansk Trawl Fleet. From 1951 through 1957, he served as a manager of the sea fleet operations of the Trawl Fleet in the North Atlantic. During the period 1957 to 1961, he served as an Assistant Professor in the Maritime Academy in Murmansk.

From 1961 to 1993, he was elected and held the position of Professor and Head of the Commercial Fishing Chair at the Kaliningrad State Technical University. From 1991 to 1994, he served as a Chairman of the Graduation Council appointed by the Government for awarding Ph.D. and Dr.Sc. Degrees in fishery science. During this time he lectured and consulted in Germany, Poland, England, Italy, Denmark, Canada, China, Japan, and Australia. He was also a participant at FAO Conferences, ICES Working Groups, and other international professional events.

Publications include roughly 200 articles, books, textbooks, and the author's patent license, all published since 1951. Since 1957 he was a Major Professor for 700 Dip. Eng. and for 25 Ph.D. candidates.

After retirement in 1994 he worked for half a year with the Australian Maritime College. From 1995 until his death in 2008 he was a Visiting Professor at the Fisheries Center of the University of Rhode Island, USA.

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