PART I

FISHING VESSEL DEVELOPMENT
CHANGES IN THE WORLD FISHERIES SITUATION AND VESSEL NEEDS
DURING THE FISHING REVOLUTION AND AFTER

THE PAST TWENTY YEARS

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Abstract

Awareness of new and previously underused resources, together with several technical innovations caused a "revolution" in fisheries during the years 1950 to 1970. Catches rose by five to six percent a year and estimates of end-of-century production suggested a harvest of over 120 million metric tons. However, rising catches put pressure on many stocks, and this, together with the widespread claims to 200-mile limits and soaring fuel and other costs, halted the rapid growth in production. There remains a need to find around 100 million tons of food fish a year by 2000, double the present supply. This will require further efforts to fish under-utilized species, to assist Third World countries make the best use of their resources, and to get more from fish and shellfish already being caught.

The fishing revolution

The original intent of this paper had been to review the momentous developments in the world's commercial sea fisheries over a period roughly spanning the Third FAO Fishing Boat Congress in Gothenburg in 1965 and this conference here today. For the author, it was a convenient period as he went to Gothenburg soon after taking up an appointment in London as editor of Fishing News International. On reflection, however that conference, important though it was, did not mark a beginning nor an end in fishing boat design construction, or use. It did, in fact, take place when some of the most vital changes in the way we seek and catch fish were still in progress, or were just beginning.

Jan-Olof Traung, the organizer of the Series of Water Fishing Vessel Conferences, sensed this when he planned a Fourth Boats Congress for 1971; but by that time the Food and Agriculture Organization itself was changing and those in charge of fisheries were looking to other types of conferences. The major one to assess the state of the world's fish resources and the pressures on them took place in Vancouver in 1973, and a repetition appears planned through a monster FAO Meeting on Fisheries Management and Development to be held in Rome at the end of June, 1984. However, there is unlikely to be much practical talk there of vessels, methods, processes or products. For an opportunity to examine essential aspects of the fishing industry and its future, we have to thank people and those who they persuade to come and share their technical knowledge.
In hindsight, the world-wide fishing industry appears to have experienced a revolution, which, like that of France in the 18th Century or if Iran today, was no sudden turnaround but rather a protracted sequence of drastic and traumatic changes.

The early years

An example of these to come was to be found in 1948 in a village called Laaiplek on the West Coast of the Cape Province in South Africa. Fishing in the Cape had been transformed by the discovery that a small pelagic fish called the pilchard could be caught in great quantities for canning or for reduction into readily saleable fish meal and oil.

The industry there was at the beginning of a boom that would for a while put South Africa among the top fishing nations. Laaiplek, once a bleak community of impoverished fishermen, was the site of one of the new factories. It was a time when people still believed the sea to be "inexhaustible": with its fish and shellfish just waiting for the enterprising exploiters. To help it do this, the company at Laaiplek had called in expert help from the sardine industry of California. Three Neptune mechanical packing lines for Al tins and a new Enterprise fish meal plant revealed the American experience in this kind of fishing.

It also revealed two other things that presaged the coming revolution in fisheries.

First, the American involvement reflected the concern in California over a decline in the sardine (pilchard) catches - the first of many dramatic collapses that would be blamed (perhaps not entirely correctly) on over-fishing. California was to be one of the early post-war signs that the sea was not inexhaustible and that care had to be exercised in management of precious resources.

Second, with all the evidence of abundant stocks of pilchards and jack mackerel waiting to be exploited, South Africans were eager to try anything that would get them the biggest catches in the shortest possible time.

The top boat then feeding the factory was a wooden hull lampara seiner, newly built for about $11,000. Her net was worked by hand, with the help of a crude mechanical winch and pulley. The net was made of natural fibre, and a haul in it of 37 tons was talked about up and down the coast. There was no radio nor any other instrument in the wheelhouse other than a magnetic compass. Navigation was usually by sight of landmarks on the shore. But the boat did boast a new Caterpillar 80 hp engine, one of the first of many to be imported to power the growing fleet of Southern Africa.

From Laaiplek and nearby Velddrif, the pilchard boom was reaching 600 miles north to Walvis Bay in South West Africa (now Namibia). Boats grew quickly to 50, to 60 and 70 ft.
All the time in those and many other emerging fisheries, the status of
the fishermen was changing and so was the industry's attitude to its equipment
and its boats.

Britain, France, Japan and other fishing nations whose fleets had been
devastated by war or forced to stand still for years were doing more than just
replacing vessels. They were also experimenting with new types, new gear and
new ideas.

In addition to some remarkable recoveries, and a few steep declines,
the 1950's saw another aspect of the revolution - the emergence of fisheries
and fishing countries starting almost from nothing.

Peru was a boom industry more on the Southern African pattern. There
was very little there on which to base any kind of fishing activity. The Peru
catch in 1938 was 23,000 tons. At the beginning of the anchoveta surge in
1958 it was 235,000 tons. By 1970, it had soared past ten million tons a year
and was to peak soon after at 12.5 million tons. There were then some 1500
purse seiners supplying more than 100 meal plants. Aboard the boats were
fishermen and even skippers who, until the boom, had never even seen the sea,
let alone move out onto it. Peru was the world's largest catcher by the end
of the 1960's, followed by Japan, and then by another newcomer to the fishing
top league.

Like Poland and other Eastern European neighbors, Russia does not
have a large coastal sea fishery resource. Her development resulted from a
deliberate decision in the mid-1950s to obtain protein from fish by sending
ships out to work distant stocks that were then still readily available.

Russia, Peru and the expanding industries of Iceland, Norway, Canada
and Japan, were leading the fishing revolution because they were making use
of resource opportunities partly by going out and finding them, but also
because significant advances in the techniques of fish finding, navigation,
vessel design and construction (including use of materials such as GRP), in
gear materials and handling, and in processing and preservation enormously
increased their hunting capacity.

Further, the revolution was a response to an increasing demand for fish,
and to an effort to assist developing countries make use of it as a nourishing
food and an export earner. But it was the advances in technology that made it
all possible.

The new technology

It is possible to mention only the most obvious of these profoundly
significant technical developments of the 1950s and 1960s:

1. The British experiment with the stern trawler and with freezing at
sea. From the Fairfree trials of the late 1940s, the Salvesen Company
in Scotland planned and built its three Fairtry factory trawlers.
Not only did these ships demonstrate the advantages of trawling from the stern—they also pointed the way to hull arrangements that would accommodate processing machines and freezers in a factory deck.

Since the 1920s, Rudolf Baader of Luebeck had been devising machines, compact and proved by tests in shore factories, that were becoming available just at the time of the stern trawler experiments. Together with the horizontal and later the vertical plate freezers, they made it possible to take a factory and a freezing plant and cold store out to sea.

Although the Fairtryst enjoyed only a brief period of profitability, the idea quickly caught on in countries seeking ways of getting their fishermen to distant resources. Russia was one of the first, with an order placed in West Germany for 24 ships very similar to the Fairtryst. By the time of the Gothenburg conference, Britain and Russia had been joined by Japan, Poland, East Germany, Norway and Spain as operators of stern trawlers.

The heydays of the ocean-roaming fish factories have been compared to the age of the dinosaurs in the sense that they marked the upper extreme in size and capacity in the industry. If the high-performance processor trawler or big purse seiner was the Tyrannosaurus rex of this brief era, the meal factory ship was the gluttonous Brontosaurus.

Two such ships were allowed by South Africa to work for about three years at the end of the 1960s off the coast of Namibia. They had daily capacities of 2000 and 2500 tons (exceeded later by the 3000 tons of a Norwegian ship, the Norglobal). In 1968, the factory ship Suiderkruis was being fed by 18 catcher purse seiners, each about 75 ft. long and worked by eight crew. The top boats were catching 30,000 tons of pilchards a year and their crews were said to be among the world’s richest fishermen. In 1968 and again in 1969, the owners of the Suiderkruis reported profits of more than 1 millions pounds.

By the early 1970s protests from the shore forced the factories out. They went north to West Africa where they were joined by the Norglobal and the Astra, also from Norway. But the fishery of Namibia carries the scars of their pillage and the yearly haul of pelagic school fish is still less than a tenth of what it was in the years just before the factory ships arrived.

2. Floating factories such as these meal ships were able to get consistent large supplies of fish partly due to invention of the Power Block and because of the introduction of synthetic fibres to netting.

Mario Puretic’s power block for purse seines in 1953 and its application to fishing by the Marco company of Seattle ranks among the most significant of all technical innovations in fisheries. When Peter Schmidt of Marco visited Southern Africa in the 1950s not long after his company had introduced Puretic’s block to salmon seiners working
out of Puget Sound, even bigger applications were being made in
Iceland. Soon the power block in conjunction with the lighter and
stronger synthetic fibre nets was to turn the ailing pole and line
tuna clipper of California into the highly prosperous purse seiner.

The excesses in fishing that ruined the stocks off Namibia, that still
threaten the tunas, and which have made the purse seine the most feared
of all man-made predators of fish should not detract from the inventive
genius of Puretic and the development flair of Schmidt and Marco.
Their combination provides a classic study of R&D in the fishing
industry.

Along with the power block and the nylon nets, should also be
linked the work of applying hydraulic power to hauling machinery. In
particular, this development extended high-capacity fishing to even the
smaller boat and is today an important feature of the compact, multi-
purpose vessels extensively used by industries operating within their
200-mile limits.

3. The novel idea that the electrically generated sound pulses and echoes
of the early depth meters might be used to locate fish was being tested
in the 1930s. In Britain herring drifter skipper Ronnie Balls began
getting interesting results from a set in his boat the Violet & Rose.
The war interrupted this work but Balls and others took it up again in
the later 1940s. By the 1950s the fish finding echo sounder was
quickly becoming an essential aid to catching.

A logical offshoot from this development was the application of side
and forward probing asdic to fishing in the form of sonar. A number of
countries participated in this but the early commercial drive was by
Simrad of Norway.

With sonar even more than up-and-down echo sounding, interpretation
of the echoes was for years dependent on the skills of the skipper in
reading the signals. Now, with microprocessor technology, the modern
fish finding sonars and sounders "think" their way through all that
their high-performance transducers pick up from the sea. Fish spotting
has become a precise operation with the boat able to use its instru-
ments to target right onto its quarry.

Other instruments have been part of the fishing revolution -
position fixing Decca Navigator, Loran, Omega and now satnav, radar;
weather facsimile recorders; gyro compasses and autopilots; and all the
advances in radio communications. The wheelhouse of a modern fishing
boat is as instrument packed as that of a warship, and more than that
of the average merchant ship. The fishing skipper has become a skilled
and enterprising user of electronic aids.

4. The fishing echo sounder and sonar were to play an important role
in the 1960s in the trials leading to the one-boat mid-water or pelagic
trawl. This work was undertaken from West Germany by a team led by Dr. Joachim Scharfe. Between June 1959 and October 1968, 43 trial trips in commercial and research ships showed that big nets towed by ships with sufficient power between the sea bottom and the surface could take huge hauls of shoaling species such as the herring. One early success was an increase in the West German herring catch from 18,000 tons in 1964 to 93,000 tons, 93 percent caught in pelagic trawls.

One of the most recent applications of mid-water trawling is to fish the concentrated shoals of small blue whiting as they migrate in the winter and early spring to the west of the British Isles. Norwegian trawler/purse seiners now take around 180,000 tons of blue whiting a year fishing down to 600-800 fathoms.

Another application has been by German, Polish and other trawlers test fishing for the small crustacean krill in the Southern Ocean.

With the stern trawler design, synthetic fibre nets and improved gear handling machinery, the attractions of distant waters encouraged the building of larger and larger ships.

Biggest of all was probably the Russian prototype class GORIZONT, 364 ft. long and 7000 hp. In regular service all over the world are the East German built Super-Atlantiks, 335 ft. long with a claimed processing capacity of 125 tons.

From Italy came a 352 ft. super-trawler of 4000 hp with four Baader lines for filleting her catch. She was bought last year by a Faroe Island company and is now being employed fishing for blue whiting which is processed aboard into minced product for use in fish sticks.

5. Improvements and innovations in handling the catches and in processing and preserving them contributed to the fishing revolution. Apart from the processing machines and the plate freezers, they included plastic boxes which have encouraged the trend to boxing catches at sea; compact and economic ice-making machines; advances in refrigeration to increase opportunities for deep freezing and chilling-smoking plant such as the Torry kiln; shipborne meal plants; shore meal plants with stickwater evaporators and other devices to extract the maximum yield from industrial fish; and pelleted and powdered bulk meal transport and storage.

Rapid increase in catches

One very noticeable effect of this revolution was the rise year by year in catches, reported to FAO and compiled in its Yearbooks of Fishery Statistics. From the early 1950s and on to the beginning of the 1970s, the growth in the harvest of fish and shellfish was a remarkable five to six percent a year.
By the late 1940s the recovering fishing industries had restored the pre-war total of around 20 million tons a year. Some 15 years later, at the time of the Gothenburg conference, the total had reached 53 million tons with the marine sector contributing over 45 million tons.

A few years later the total was 60.5 million tons and by 1971 it was 70 million tons.

At that stage the industry had accepted what appeared to be inexorable expansion. Accepted confident forecasts for the future were accepted without looking too closely at some ominous clouds looming just over the horizon.

Over some 20 years, agencies such as FAO working in the Third World had been striving to introduce the benefits of modern fishing technology to boost fish supplies. There were the inevitable failures. Workers in the field learned by hard experience that not all machines or improved techniques are suitable for improving traditional small-scale fisheries.

But many developing countries were participating in the general rise of fisheries, not only Chile or Peru.

At about the end of the 1960s FAO attempted to relate its experiences in fisheries to what it estimated to be the fish protein need of the world at the end of the 20th century. It calculated that this would probably rise to over 120 million tons and suggested it could be met by an increase in the marine catch of known species by known methods to around 100 million tons. To this might be added another 20 million tons or more from inland fisheries with the main contribution coming from aquaculture.

The plateau of the 1970s

During the early 1970s the yearly catch settled onto a plateau at around 68 to 70 million tons. This was caused partly by a slump in the Peru fishery due to the effects of an El Niño; however, several other countries were reporting severe declines, and pressures began to build for more coastal state protection of stocks heavily fished by distant water fleets.

When the United Nations Law of the Sea Conference assembled in Venezuela for what was to be the first of many meetings, high on the agenda was the question of fishing limits.

Iceland could not wait. First she claimed 50 miles and, after contesting this with Britain and other ships, got it accepted. Iceland's trawler fleet was expanded to take the increased share of the resource. Soon she was claiming the full 200-miles. Eventually this was accepted and by 1977 Britain's huge distant water trawler fleet had been forced out of its most valuable grounds. As the Icelandic deepsea fleet grew, the British fleet faded away. In 1975, it totalled 158 distant water ships, with 45 of them freezer stern trawlers. This has now all but disappeared.
Within the EEC, Britain has negotiated a 36 percent share of the most popular species. But the fleet taking it consists mainly of compact coastal-type trawlers and seine netters, and smaller boats.

For a while Iceland revelled in her hard-won new limits as the cod catch rose past 400,000 tons a year, all of it for her boats and factories. But the stern trawler fleet has now grown to 104 ships and poor year-classes have meant less cod. This year her industry has had to go onto vessel quotas to make out a permitted cod haul of only 220,000 tons.

This is just one example of how wider limits have failed to produce the fishing bonanzas expected by their protagonists. In North America there are the problems of the Pacific Northwest and Alaska fisheries, and the troubled fishery of the Canadian East Coast.

These cases bear out the warning given by several authorities when the agitation for wider limits was at its height. One of them, Dr. John Gulland of FAO, showed that in 1970 non-local fleets took 7.1 million tons in a world marine total of 54.6 million tons. Other figures indicated an even higher proportion - up to 16.4 million in 58 million tons in the mid-1970s. No less than 11 million tons of this was from waters that would be enclosed by the wider limits.

One early effect, therefore, of the exclusive economic zones was a switch in catching effort from the high-performance distant water fleets to often smaller and usually less efficient coastal craft from the littoral state. In some cases this led to an improvement in fishing and in management of the stocks. In others catches fell or, as in the case of Iceland, over-capacity soon built up in the national fleet.

Soaring costs

With the spread of limits, the fear for stocks and the fishing collapses, the 1970s also brought the oil crisis.

In Britain it was noted that from 8 million pounds in 1972, the fuel bill of the fishing industry increased to 27.5 million pounds in 1974 and was expected to rise to over 33 million pounds in 1976. In France fuel prices went up 350 percent between 1970 and 1976, while fish prices rose 65 percent.

If limit extensions had not impeded the progress of distant water fishing, it might well have been stopped for many countries by the soaring price of fuel linked to the much slower rise in the price of fish.

As it is, some countries and fisheries could be reaching the unhappy position where it may no longer be economic to go out for species that do not command attractive prices.
More and more, as species and area controls put ceilings on how much can be fished, industries will need to consider allocating the catches permitted among skippers, owners or vessels. Such individual quotas are anathema to fishermen steeped in the idea of their craft as one involving great risks alleviated by great opportunities. But in this age of the Exclusive Economic Zone (EEZ), quotas and high costs, the fisherman is no longer gambling with a fair chance.

Canada is already applying a form of vessel quotas on her East Coast. Iceland is introducing quotas this year, and they are sure to spread to other fisheries.

The future

Given these and other curbs on free fishing of a common resource, what is the future of the industry and its boats?

First, the idea of replacing the millions of tons of hunted fish with the increasing crops of farms must be rejected.

Aquaculture appears sure of a strong future. Already it is contributing an estimated seven to eight million tons to the world supply of fish and shellfish. But much of this still comes from non-intensive, small-scale pond farming long established in countries such as China, the Philippines, Indonesia and India.

Intensive farming while holding out much promise is still mainly in a development stage, despite the successes round the world in trout farming, in the USA in freshwater catfish and in Norway and Scotland in farming Atlantic salmon. There is great promise in the non-intensive pond growing of penaeid shrimp. The mussel crops of Spain, France and Holland total hundreds of thousands of tons. However, it is likely to be necessary to wait well past the year 2000 before aquaculture produces the 20 million tons a year forecast for it 15 years ago.

In 1983, the world total harvest by hunting and farming was probably about the same as the 75 million tons of 1982. Of this, about 25 million tons went to fish meal leaving 50 million tons for direct food use.

In Rome during 1983, FAO Director-General Edouard Saouma said the food fish supply would have to be more than doubled by the year 2000 if the industry was to meet world consumption needs. But world production is presently rising by only about one percent a year and the total at this rate would barely reach 90 million tons.

Immediate challenges therefore are to get the best possible use from fish already being caught or farmed. This means reducing waste (for example, it is estimated that five to six million tons of so-called "trash" fish is being discarded each year by shrimp boats); developing new products such as crab sticks from Alaska pollack or minced fish from blue whiting; working on
the restoration of once-great fish runs (in Norway, for example, there is strong evidence that the Atlantic-Scandian herring stock is recovering); and developing stock enhancement and ranching.

FAO, quite rightly, stresses the important role to be played by the developing countries in getting the maximum possible use of resources within the new economic zone. Work in the Third World fisheries will be discussed in a later session of this conference; for the present it may be noted that the needs and the possibilities of these fisheries are vital to any consideration of the future of the industry.

Established large industries that have fallen on hard times could well be revived, given the right injections of investment, the markets and the will to recover.

As an example, Peru has seen her industry plunge from the top of the world to a catch in 1983 of 1.42 million tons. Even that may seem a good enough haul. But it has to support a fleet that still exceeds 300 vessels and too many meal plants and factories ashore. One urgent need is to cut down the number of meal plants to eight or ten (from over 100 in 1971). Another is to modernize an ageing and inadequate fleet so that Peru's fishermen can go after food species in the deeper waters, such as the mackerel and horse mackerel.

Looking to underutilized species, there does not appear to be untried options left.

The small ocean mesopelagic fish are mentioned in the more optimistic forecasts which estimate the resource at anything from a few million up to 100 million tons. But these fish, like so many others, are underused because they are small and difficult to process, are in remote fishing areas and even with the help of modern electronics may be hard to find.

The cephalopod resource offers a better prospect with estimates ranging from 10 million to 50 million tons and more. As with the mesopelagics, exploitation will require mainly long-range fleets and the cost of ships and fuel may curb enthusiasm.

The much-publicized krill resource in the Southern Ocean is estimated to be capable of yielding catches from a few million to hundreds of millions of tons a year. Krill has now been investigated, caught and processed for well over ten years. The catch in 1980 was 480,000 tons with Russia, Japan and Poland among the main catchers. In 1981 it dropped to 450,000 tons. It seems that krill fishing using a large pelagic trawl will have to be done by large processing ships, which are costly to build and run.

Just how expensive is indicated by the latest freezer stern trawlers built in Holland in 1983 and this year. The biggest so far is the 312 ft. long Dirk, a ship of 3019 gross tons and capable of freezing 180 tons of fish a day. She is powered by a 4300 hp MaK engine and is reported to have cost about $8.5 million. Dozens of ships of this type and size might be needed even to take the most modest estimate of the possible krill catch.

Perhaps it might be better to follow the advice of some American Pacific Coast researchers and try to seed the Southern Ocean with salmon. They would at least convert the abundant krill into a readily acceptable fish protein!
50 YEARS OF IMPROVEMENTS IN FISHING VESSELS - FROM 1950 TO 2000

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Abstract

Acoustic fish detection instruments and fishing gear made up of man-made strong fibres increased the fishing power considerably. The main machinery went from heavy-duty types like diesels and steam engines to light-weight automotive type diesels and sterling engines coupled through reduction gears with large ratios to ensure high propeller efficiency. Propellers were fitted with controllable blades and installed in nozzles. Hydraulics were introduced for the flexible drive of fishing winches. Special powered rollers and blocks were introduced as well as drums for the haul of purse seines and trawls. Full scale measurement and results from model tests gave designers the possibility of designing hulls with minimum power requirements and at the same time having sufficient stability and good seakindliness. Toward the end of the period a new optimism went through the fishing industry which then again invested considerably in medium-sized fishing vessels. A number of major International organizations like FAO, Unesco's IOC, EEC and OECD joined forces and built a most unorthodox prototype fishing vessel to celebrate the 21st century.

The 50s

In 1950 the world had started to recover after World War 2. In great secrecy during the occupation, France had planned a new fishing fleet for which, after the peace, they at once had placed orders also in the UK and the USA. That fleet had now begun to fish and those vessels influenced the design of similar vessels particularly in Germany, the Netherlands and the UK. The Scandinavian countries had got together in 1947 to compare notes of their fishing vessels and they found great differences between vessels fishing on the same waters. The learned naval architecture societies like RINA and SNAME published a few papers describing fishing vessel development. Hardy (1947) had described fishing vessel developments in many places in the world and thus also emphasized how little, if any, cooperation there had been between nations to develop efficient and economic fishing vessels.

Small vessels were built of wood and, when longer than about 80 ft, of steel. Most engines were heavy-duty, if not semi-diesels and steam. Some echo sounders had come into use for depth indication - but not for fish detection. Winches were powered from the main engines by belt or chain not hydraulically or electrically. Traps were handled from the side. Purse seines were handled either from two smaller boats or by the derrick of the main mast and a turntable. Netting materials were natural fibres which were very much subject to deterioration by rot or sun. Fish was preserved by ice. Crews accommodations were ascetic.
The Pacific coast fishing vessels of USA fished from the stern, and they had the wheel house forward. They created much interest in Europe. Also whale factory ships which hauled up the whales on a slip aft stimulated designers to consider stern fishing. The first fish factory trawler, Fairfree, working from the stern appeared in 1949 and she was soon followed by the Fairtry class built for the UK and USSR.

The United Nations Food and Agriculture Organization (FAO) organized in 1953 a World Fishing Boat Congress with sessions in Paris and Miami. The papers again referred to the many different fishing vessel types being used around the world. They discussed the important aspects of powering, whether high-speed or low-speed engines, whether fixed blade or controllable pitch propellers. They took up the problems of hull shape with regard to resistance in calm water and increased resistance in waves and in one important study measurements of the behaviour in a high sea of actual fishing vessels were given and discussed.

The second half of the 50s was then characterized by intense development work on all aspects of fishing vessel design and construction such as model testing to develop more economic and seakindly hull shapes, computer techniques to optimize results from such tests, rational formulation of construction rules for wooden ships, multiple reduction gears for main engines, nozzles and diesel-electric drives.

In 1957 FAO organized a Congress on Fishing Gear which again presented basic information on all the different fishing methods used and also for the first time reviewed the progress on fish finding, gear testing and new materials like man-made fibres. Those fibres permitted completely new designs of more efficient fishing gears which then also could be kept on board much easier than before, not being subject to rot or deterioration by the sun. These stronger nets could also be handled mechanically, thus a powered block for the hauling of large purse seines was developed by the American fisherman Puretic. A number of reports were given to the Congress on the use of echo sounders for fish detection, also the use of horizontal echo ranging = ASDIC = sonar. Similarly the use of light and electricity to attract fish was covered in papers.

The FAO Second Fishing Boat Congress in Rome in 1959 demonstrated now the large steps taken in fishing vessel development during the 50s. One paper on the use of glass reinforced plastics was presented. Again engineering was dealt with at large. There was a long list of papers dealing with resistance, seakindliness, and the use of computer techniques to develop optimum hull shapes. The use of bulbs and the choice of the optimum prismatic coefficient was suggested. The importance of sufficient stability was dealt with by several authors. Very small craft were covered in detail.

The time had come to predict the future, 15 years hence or 1975, and among the many ideas presented, this author stated:
"There are many technical developments which have been successfully applied on a laboratory or pilot scale, but which are not in common use by the industry. Here are a few:

- Echo-ranging (asdic)
- Fish attraction (light, electricity, vibration)
- Fish collection (pumps)
- Net design (using synthetic fibres and engineering principles)
- Underwater television (for record of gear behaviour and of fish entering the gear)
- Mechanized handling of trawl gear (by stern trawling or winding the gear directly on the winch)
- Extension of storage time (chilled seawater, anti-biotics and radiation)
- Transfer of crews and cargoes by airplane
- Fishing under ice (submarine)
- Artificial upwellings (by nuclear heating)
- New materials (plastic, aluminium, rubber)
- New power plants (gas turbines, nuclear, Wankel principle)

The fishing boat designer must keep such possibilities in mind, and he must also follow the development of his own profession, and in this he cannot avoid seeing how new boat types are being developed and how knowledge of theoretical naval architecture is being acquired at an accelerated pace."

The 60s

This decade also was one full of developments. The Second FAO Fishing Gear Congress in 1963 was the venue for a number of important papers describing further developments of man-made fibres and their applications in more effective fishing gear. Similarly progress in the use of acoustics for fish detection was reviewed. Several papers covered the powering of winches, particularly the use of hydraulic power to ensure a high degree of flexibility. The powered block had come to stay.

The fishing vessel designers and builders were quick to utilize the development in the fishing methods field. Much of this was reported to the Third FAO Fishing Boat Congress in 1965. Now one also started to consider techno-socio-economic problems and the very small fishing boats.

As before, FAO gave high priority to questions of hull shape in connection with economy of powering and seakindness because they felt that this was a common field where one country could learn from the other even if the fishing methods were different and boat types and boat sizes were not the same. A first report was given on FAO computer statistical analyses of a great number of results from model tests of fishing vessels which FAO had succeeded in collecting from various model testing establishments around the world and from individual owners of such tests. With the aid of the study four vessels were designed, 40, 55, 70 and 85 ft. Models were tested in two different establishments and, as Figure 7 shows, they proved to be better than anything else earlier tested, e.g., better than any of the models which had been used to make up the regression analyses. The final analysis, together with the obtained coefficients, was published in a separate document by FAO (Hayes and Engvall 1969).
FAO had organized a meeting on stability utilizing the Rahola suggestion for minimum dynamic stability in Gdansk in

The International Maritime Organization (IMO) organized, together with FAO, a fishing vessel stability working group which after many deliberations came up with essentially the same recommendations which were presented to a meeting in Torremolinos in

Plastics and aluminium as boat building materials were covered in several papers. The Italian architect and engineer, Nervi, had, during World War 2, developed a concrete-mix with which to build boats, and his paper describing this had been rediscovered by boat builders in the UK and New Zealand, who had started to use this material for fishing boats as well. FAO started collaboration with Nervi.

Actually at the end of the 60s it had become quite popular to arrange International meetings to discuss advances in fishing vessel design. There were meetings in Trieste, Italy; Montreal, Canada; Copenhagen, Denmark, and the Gold Coast, Australia, to mention a few. Also, some text books on fishing vessel design were published.

The 70s

FAO's planned Fourth Fishing Boat Congress in 1971 was not organized because FAO's governing body in the field of fisheries, the so-called Committee of Fisheries (COFI) felt that so many other organizations would gladly organize one. The Canadians continued with a number of important meetings on several aspects such as materials and winches. FAO organized smaller meetings on subjects like beach fishing.

The 70s was characterized by the implementation of National fishing zones, the so-called EEZ's. Also great increases in fuel prices scared people off from investing in fishing craft. The result was that many long distance fishing fleets disappeared. In some countries a few vessels were built for medium distance fishing.

The 80s

This decade was characterized by the energy problems and a general lack of initiative and imagination for fishing vessel improvements. Fishing vessel yards were closed down.

There was some positive thinking about the possibilities of using wind power to economize on liquid fuels. An important outcome of this was the re-activation of Flettner's proposal to utilize the Magnus effect for propulsion by wind. Also a suggestion to use the Magnus effect for rudders and propeller blades.

Aluminium caught on, ferro cement fell into oblivion. Working decks were covered in, so that the crews could work more independently of the weather. Cranes and mechanized rollers came more and more into use.

With advanced catch technology and sophisticated electronic fish detection apparatus, great quantities of fish were now caught so that many species suffered from overfishing.
Echo sounders and sonars had gone through extensive improvements in performance. A whole range of fish finders had ridden in on the waves of micro-processor technology. Electronic circuitry and signal processing had undergone great changes. The information was processed and presented in an easily understandable way for the operators, the fishermen.

With an understanding of the acoustic principles and the physical limitations such as beam-width, frequencies, source level, noise level, target strength, etc., a new generation of fish detection apparatus had developed: echo sounders, sonars and trawl mounted equipment.

The echo sounder now had functions such as scale expanders, dual frequency, trawl watch and operational memory. It became possible to determine whether the size of the fish was large enough to be worth fishing or not.

The use of color became common and it permitted a wider range than the paper recorder. The colors made it easier to interpret echo strength. Fish of a certain size could be recorded by the same color at all depths by the use of receivers with accurate time varied gain (TVG).

With the trawl instruments it was possible to monitor the sinking or raising of the trawl relative to bottom and surface due to the speed of the trawler, to observe the gap of the trawl and whether fish were entering or not. With a special catch indicator one obtained quantitative information of the catch.

To the original searchlight sonars were added omni-sonars and multi-beam sonars. They covered a wider sector in shorter time and had a very high source level and long detection range. Some such sonars were equipped with automatic target tracing, even several fish schools could be registered at the same time. The sonar's computer calculated the course and the speed of the schools which was displayed in true motion relative to the vessel itself.

At mid-80s a review was made of the 1959-predictions, e.g., what had happened after 25 rather than 15 years. The following developments had then taken place:

- Asdic - or sonar as it had then been renamed
- Use of light in fish attraction
- Pumps to transfer heavy catches into the hold
- Advanced net design
- Underwater television
- Winding the gear directly on the winches
- Storage by chilled sea water
- New materials such as plastic and aluminium

But many things had not yet materialized, and were perhaps not to come:

- Use of electricity and vibrations for attraction
- Use of anti-biotics and radiation for storage
- Use of rubber for construction
- Transfer of crews and cargoes by air craft
- Fishing under the ice by submarines
- Artificial upwelling by nuclear heating
- New power plants (such as gas turbines, nuclear, Wankel principle)
As far as the general recommendation that fishing boat designers should follow developments in their field, there is a great improvement here thanks to organizations like FAO and the technical journals which do much to disseminate information. Also, makers of engines, acoustic instruments and net makers do much to help the designers improve their technical knowledge. A major FAO report entitled: Fishing Boat Design made it possible for trained engineers without specialized knowledge of fishing vessel design to design efficient ones for the future.

The predicted use of hydrofoils, hovercraft and catamarans had not come about. The power requirements of hydrofoils and hovercraft seemed to have appeared too excessive for such a low priced commodity as fish.

The possibility of using aircraft, especially helicopters, was not utilized in spite of their popularity in connection with oil exploration. Aircraft could also have been used for acoustic detection - and perhaps carrying a light net for imprisoning catches until catcher craft could come.

The idea of locating fish under the ice cap had not, as far as known, been tested.

The ideas of using containers and other recent cargo handling equipment such as fork lift trucks came slowly into use by some progressive fishermen who also had started to use pallets.

Anti-rolling tanks were coming into use. However little of the research published on how to design less resistant and more seaworthy fishing vessels had been utilized by practising fishing vessel designers; they had apparently hoped for some prototype to confirm the validity of the suggested possibilities.

In 1959 one talked about nuclear propulsion of aircraft - so something similar was suggested for fishing vessels. This was 'out' because of the widespread resistance against nuclear power production - and also because no such plants were sufficiently light. There were several suggestions for the revival of steam. And the advocates of the sterling principle of external combustion engines worked hard to get this principle adopted by the automobile industry.

The ideas of using inflatable rubber catcher vessels might still materialize.

There was no awareness in 1959 that the price of fuel would increase so much. Other factors that influenced the situation in the mid-80s were:-

- Cost of labor (requiring further automation and mechanization)
- Shorter trips to improve quality of catches
- Demand by the crews for more comfort (both while fishing and while not fishing) and shorter trips

At the end of the 80s owners and fishermen were still very reluctant to obtain technical advice from institutions and consultants. They did not trust the competence of those offering to improve their operations. In some cases, they were actually buying considerable amounts of advice indirectly: when they bought acoustic instruments and other electronic equipment for navigation, they did not quite realize that the main part of the cost was for software and development and that only a small part was for the hardware itself.
The 90s

After the 'quiet 80s' a wave of optimism gave the fishing industry a strong lift at the beginning of the 90s. Population pressure, scarcity of meat and a general understanding that fish was a health food had increased fish prices so much that investments into equipment like vessels was not such a marginal investment as in the 70s and 80s. Also, Governments were now assisting the fishing industry as much as they did agriculture. In order to protect loans and subsidies, they required fishermen to pay openly for soft ware, for the design of vessels and equipment. The Governments also had their own ship research institutes devoting considerable time to fishing vessel developments.

Computer programs were developed with which one could determine the best shape of a vessel both with regard to minimum resistance at the required working speeds and at the same time having sufficient stability and the most agreeable working motions.

With the help of such programs it was now possible to consider new materials, like aluminium and light-weight high tensile fibre reinforced plastics without having (as in the 70s and 80s) to compensate for the lighter construction with ballast, which in many cases introduced impossible ship's movements.

All components became lighter: Sterling-engines did reduce the engine-weights by % without the propeller efficiency suffering because new light-weight reduction gears permitted high reduction ratios, thus low propeller r.p.m.

Remote sensing had become a reality: daily reports were now issued about the catchable fish concentrations, like weather maps. The acoustic instruments carried on board had increased in range and cover at the same time as prices had become comparatively less, so that even a small boat could use the most sophisticated equipment. A single instrument with a small transducer could act as both a high-speed sonar and an echo sounder with the whole range of practical frequencies. Actually, the sounder decided in relation to the target what would be the most effective frequency and it would then report to the operator in easily readable form, such as by print-out, what catches to expect at the fishing power of his specific vessel.

The whole unit would become much more compact than today. Similarly, other electronic devices like the radio would be miniaturized and able to cover all wave lengths, eliminating the need to carry a whole range of receiver/transmitters.

Also some special highly efficient fish attraction devices had come into use which worked with both acoustic signals, light of various colors and frequencies, electricity and vibrations. At the beginning of their use, serious problems arose when competing vessels were 'fighting' for the same schools. However, at the end of the decade, with the scientific management of the resources as a whole, solutions were also found to have vessels share the available schools in a just matter.

The work onboard was made easier with the aids of cranes and, more particularly, with the help of pumps to extract the fish from the nets and place them in the hold and then after landing to move them from the holds to the shore plants.
Individual boxing of fish with ice and the heavy and difficult internal moves of those boxes which had been found to be the best indication of good fish handling in the 80s, became outmoded by these more rational handling methods which also resulted in higher standards of hygiene. The fishing industry did realize that other industries had solved their handling problems more efficiently, such as the potato - and fruit - handling systems, and they took their experiences into account.

Crew accommodation, their feeding and entertainment when off work, became very much improved so that the crews were as well off as those on oil rigs. Several crews to one vessel became standard, no owner could afford keeping vessels idle when a crew was off duty.

Vessels were again built with better proportions between length and beam to ensure best possible behaviour in seaways, especially in head seas.

**The Year 2000**

To celebrate the new century, a number of the major International organizations with fisheries and oceanographic departments, decided to join forces and to build an unorthodox prototype fishing vessel. These were organizations like FAO's Committee on Fisheries (COFI), Unesco's IOC, EEC, OECD, etc. When ready the prototype will visit all major fishing grounds and fishing ports. High-liner fishermen from those ports will be invited to take command of the vessel to carry out trials to satisfy their curiosity. All operations will be carefully monitored by instruments and visual observations, and progress reports issued at frequent intervals. The trials will be recorded by TV-crews so that the interest of all fishermen can be kept high.

The outline specification of the prototype will roughly be:-

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull weight, light ship</td>
<td>80 feet</td>
<td>24 meter</td>
</tr>
<tr>
<td>Continuous power</td>
<td>21 feet</td>
<td>7 meter</td>
</tr>
<tr>
<td>Cruising speed</td>
<td></td>
<td>130 tons</td>
</tr>
<tr>
<td>Trawling speed</td>
<td></td>
<td>500 horse power</td>
</tr>
<tr>
<td>Fuel consumption at 10 knots cruising</td>
<td></td>
<td>10 knots</td>
</tr>
<tr>
<td>Average fuel consumption</td>
<td></td>
<td>3-3½ knots</td>
</tr>
</tbody>
</table>

The hull will have optimum prismatic coefficient, transom stern, bow bulb to reduce the bow wave and thus the resistance, stern bulb to equalize the wake and thus to improve the propeller efficiency, large propeller aperture to permit slow running propeller. The hull will have two stabilizing systems: fins for sailing to and from the fishing grounds and flume tanks to be used primarily when operating at low speed such as when fishing.

Main machinery will be by Sterling engines working through a reduction gear with multiple gear ratios to permit the use of most economic propeller r.p.m., propeller with controllable pitch blades or Flettner rotors, Flettner rotor rudder.

**Fish attraction system:**

Fish detection system utilizing remote sensing from satellites and sensors from the vessels placed in radio-directed unmanned helicopters, long range combined echo sounder and sonar with multiple frequencies and print-out facilities.
All-wave length radio transmitter/receiver

Multi-frequency radar, 3 - 10 cm

Navigation system utilizing radio-beacons, Loran, Decca and the global positioning system NAVSTAR.

Written Contribution
Future Development in Fishing Vessels
Bruce Culver

Fishery utilization will tend to increase over the rest of the century. Nations with large stocks of fish within their own contiguous zones will see their industry enhanced, others will decline.

Specific types of vessels to be built in the future will continue to be heavily dependent on local conditions, and will vary substantially from one part of the world to another.

Plastic will see increased use in small vessels. Aluminum is useful for small boats, but its disproportionate increase in price is already discouraging its use in larger vessels, even as a deckhouse material. Boats of more than 30 meters length or so will continue to be built of steel.

The diesel engine will remain the prime power source, tending to lightweight geared designs. Use of low grade fuels will increase dramatically. Fuel cost optimization will be important.

Methods of processing on board and preservation of catch will be important areas of development and will probably produce the most radical changes.

Marketing will be important, particularly to American producers. New products such as imitation shellfish produced from traditional Japanese surimi will open new and potentially lucrative markets.

Electronics continue to improve communication, controls, and navigation as well as fish finding.
PART II
FISHING VESSEL OPERATIONS
WATERFRONT USE CONFLICTS AND THEIR EFFECTS ON COMMERCIAL FISHING OPERATIONS IN FLORIDA

Leigh Taylor Johnson
Florida Sea Grant Extension Program

Abstract

Commercial fishing vessel operators increasingly face challenges to their use of the waterfront. These problems can become acute when changes are planned for waterfront traditionally used by commercial fishermen and seafood dealers. Five major trends contributing to competition for limited waterfront access points are population growth, waterfront residential development, pleasure boat proliferation, environmental constraints on development of waterfront facilities and growth of deep draft shipping in some areas. Efforts are underway and have succeeded in some places to find feasible alternatives where commercial fishing vessels have lost traditional waterfront facilities. Commercial fishermen and seafood dealers who buy from them should become aware of local trends which may affect future waterfront access, establish good communication with government agencies, and begin work where necessary to ensure that adequate facilities will be available for future docking and off-loading operations.

Introduction

Commercial fishing vessel operators in Florida increasingly face challenges to their use of the waterfront. Although problems of waterfront access seem remote from daily operations, they can become acute when changes are planned for waterfront traditionally used by commercial fishermen and seafood dealers. This report will review sources and examples of waterfront use conflicts affecting commercial fishing operations in Florida and describe ways in which some of them are being resolved. It should help to alert the seafood industry to trends which may affect their operations and to means of seeking solutions to problems which may arise.

Sources and Examples of Waterfront Competition

Five major trends are causing increased competition for limited waterfront access points in Florida. They are population growth, residential development in coastal areas, pleasure boat proliferation, environmental constraints on development of waterfront facilities, and growth in deep draft shipping in some areas. Population growth is the driving factor for much of this change and is predicted to continue well into the next century.

Population Growth

Florida’s population has doubled during the past twenty years, rising from 4,951,560 in 1960 to 9,746,324 in 1980, according to the United States Bureau of the Census (U. Fla., 1982) and is projected to reach 14 to 25 million by 2020 (Terhune, 1982). The University of Florida’s Bureau of Economic and Business Research estimates an
additional 1000 people per day were added to Florida's population in
the year from April 1, 1980 to April 1, 1981. The 35 coastal counties
contain 7,664,658 people, or 79% of the state's population. (U. Fla.
1982) Thus, the majority of the people are squeezed into the coastal
zone (Figure 1).

Residential Development in Waterfront Areas

The rate of growth in waterfront areas of a coastal county may
exceed its overall growth rate. For example, the number of electrical
meters connected in the barrier island cities of Brevard County in
east central Florida increased from 11,058 in 1970 to 17,383 in 1979.
However, the total number of meters in the county grew from 69,020 to
98,889 in the same period. (Wentworth, 1982) Thus, barrier island
development occurred at a rate of 57% compared to only 43% for the
county as a whole.

Florida Department of Commerce statistics for 1970-1979 show that
net migration accounted for 91% of the state's population growth
(FDOC, 1980). In fact, for the recent year 1980 - 1981, net migration
was responsible for 93% of Florida's growth (Terhune, 1982). This
trend suggests that many new residents may not be familiar with tra-
ditional commercial fishing industries. Also, the atmosphere of
urban and suburban neighborhoods is very different from that of rural
communities, which are directly dependent on land or sea for prosperity.
These factors may account for some of the conflicts which have occurred
between commercial fishing operations and coastal residents.

The April, 1984 issue of National Fisherman magazine discusses
the effect of special dock and commercial fishing license ordinances
in Pinellas County, an urban, peninsular county which lies between
northwest Tampa Bay and the Gulf of Mexico. The dock ordinance
prohibits the netting of fish, except by cast net, within 100 feet of
a public or private dock. The article explains that docks of resident-
ial homes line 100 miles of the Pinellas County bayshore, so that
80% of it is closed to commercial gill net fishermen. This restricts
the mullet gill net fishery, because mullet prefer shallow waters
close to shore. The 1983 Florida legislative session established a
$300 commercial fishing license for Pinellas County, whereas the
state's saltwater product license is only $25 for state residents, or
$100 for non-residents.

The Florida Keys are a 100 mile long traditional fishing community
which is changing in character as land is developed for retirement
homes, weekend retreats, and resorts. Commercial fishermen in many
areas of the Keys have found it convenient to live along a canal, moor
at home, and work on gear in the backyard. However, they now face
competition for waterfront property, as well as pressure from other
landowners who prefer a suburban or resort atmosphere.

Monroe County includes the Florida Keys, has 3768 registered
commercial boats, and leads the state in fishery landings (NMFS, 1982).
In 1980, the county enacted an ordinance regulating work on fish nets
and fish, lobster, and crab traps in some residential and business
Figure 1. Population growth in Florida and in coastal counties of Florida, 1965 - 1980.
zoning districts. New fishermen and those unable to prove they qualify for exception under a grandfather clause may not conduct some or all fishing gear related activities at home. Because land is scarce, expensive, and in demand for residential and tourist development, finding reasonable alternatives can be difficult.

**Pleasure Boat Proliferation**

The number of pleasure boats registered in Florida grew from 128,723 in 1965 to 466,775 in 1980, whereas the number of commercially registered boats grew from 27,608 to 31,116 in the same period (FDNR, 1965 - 1980). Figure 2 illustrates this difference in growth rates and Table 1 lists actual numbers of boats registered from 1965 to 1980. The anomaly between 1974 and 1975 pleasure boat registration statistics occurred because boats with an engine of less than 10 horsepower were not required to be registered before 1975 (Cato and Mathis, 1979).

Extrapolating population statistics for 1960 and 1970 produces estimated 1965 populations of 5,871,489 for Florida and 4,607,203 for the coastal counties (Figure 1). Comparing boat registration and population data for the fifteen year period 1965 to 1980, it is evident that the state's population increased by 66%, the number of commercially registered boats increased by 13%, but the number of registered pleasure boats increased by 263%.

The increase in pleasure boats has created a demand for slips and launching sites. For example, in southern Brevard County a marina located on the shore of the prime hard shell clam harvest area has been converted recently from a quiet facility serving both commercial and pleasure boats to a plush anchorage specializing in fishing tournaments. The loss of some mooring facilities and the boom in the hard shell clam fishery in south Brevard County have combined to force many commercial clammers to launch directly from the banks of the Indian River. This practice has drawn complaints from communities which fear it will erode the shoreline.

The 12 square mile area designated Body "F" by the Florida DNR supports an estimated 300 to 400 hard clam fishermen, so the competition for waterfront access is intense. A fishing camp which has allowed commercial clam fishermen to launch has found their unloading activities sometimes tie up facilities needed for sport fishermen. The county has built a new launching and docking facility in the area with funds from the Florida Motorboat Revolving Trust Fund. However, parking spaces are limited, so commercial and pleasure boats must compete for them.

Another result of pleasure boat proliferation has been conversion of marinas to private facilities associated with condominium developments. Of 12 marinas in the Melbourne-Palm Bay area of south Brevard County, three have been recently converted to "dockominiums". Boating Magazine reported a shortfall of 2000 to 3000 slips in Dade County (Miami area) in a 1983 article, which suggested that buying a condominum might be the only reliable way to get a good spot for a new...
Figure 2. Growth in number of commercial and pleasure boats registered in Florida, 1965 - 1980.
Table 1. Number of pleasure and commercial boats registered in Florida, 1965 - 1980

<table>
<thead>
<tr>
<th>Year</th>
<th>Pleasure Boats</th>
<th>Commercial Boats</th>
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<tbody>
<tr>
<td>1965</td>
<td>128,723</td>
<td>27,608</td>
</tr>
<tr>
<td>1966</td>
<td>136,706</td>
<td>32,927</td>
</tr>
<tr>
<td>1967</td>
<td>149,663</td>
<td>31,858</td>
</tr>
<tr>
<td>1968</td>
<td>164,875</td>
<td>30,490</td>
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<tr>
<td>1969</td>
<td>177,212</td>
<td>28,183</td>
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<tr>
<td>1970</td>
<td>192,554</td>
<td>29,065</td>
</tr>
<tr>
<td>1971</td>
<td>208,096</td>
<td>27,197</td>
</tr>
<tr>
<td>1972</td>
<td>229,426</td>
<td>24,962</td>
</tr>
<tr>
<td>1973</td>
<td>249,219</td>
<td>23,813</td>
</tr>
<tr>
<td>1974</td>
<td>276,112</td>
<td>21,782</td>
</tr>
<tr>
<td>1975</td>
<td>360,390</td>
<td>22,566</td>
</tr>
<tr>
<td>1976</td>
<td>409,554</td>
<td>26,784</td>
</tr>
<tr>
<td>1977</td>
<td>422,398</td>
<td>24,636</td>
</tr>
<tr>
<td>1978</td>
<td>434,818</td>
<td>24,805</td>
</tr>
<tr>
<td>1979</td>
<td>456,038</td>
<td>24,918</td>
</tr>
<tr>
<td>1980</td>
<td>466,775</td>
<td>31,116</td>
</tr>
</tbody>
</table>
Construction of marinas is expensive, requires a lengthy and complex permitting process, and is dependent on location of suitable land which is increasingly scarce. Because the return on total assets to the average marina in Florida in 1981 ranged from 7.4% to a negative 7.5% with the median less than 1.0% (Milton, et al., 1983), there is not a strong incentive to develop waterfront for affordable, public marinas.

When pleasure boat marinas are adjacent to commercial fishing vessel facilities and seafood processing plants, conflicts can arise. At Port Canaveral, pleasure boat marinas mingle along the waterfront with scallop, shrimp, and fish processing plants, where fishing vessels unload along the bulkhead. These activities generate noise, odors, and a hectic appearance which are at odds with the resort ambiance preferred by marina clientele.

**Environmental Constraints**

Increased attention to protection of the Florida marine environment is another factor constraining development of marinas which might replace lost commercial fishing vessel anchorages. The Florida Department of Environmental Regulation and the U.S. Army Corps of Engineers have strict policies regulating dredge and fill operations, which are necessary to construct and maintain basins of sufficient depth. Finding appropriate sites for disposal of wet, silty, salty spoil material is difficult, because coastal land is expensive and intensively used.

Bulkheading eliminates shallow water habitats which support many marine species and has a negative impact on fishery productivity. Approved shellfish harvesting areas are few, and marina developers proposing to build in or near these waters face opposition from shellfishermen and review by the Florida DNR's Shellfish Environmental Assessment Section. Would be marina developers must also consider whether the proposed basin would be in a state Aquatic Preserve, a Manatee Sanctuary, or an Outstanding Florida Water. Appropriate stormwater drainage or retention facilities must be constructed, and hazardous waste disposal guidelines and local zoning ordinances must be observed.

Much of the Indian River in south Brevard County is in the Body "F" shellfish harvesting area. A preliminary economic survey by the Florida DNR recently reported to the Florida Marine Fisheries Commission (Barrigan, 1984), estimated the ex-vessel value of Body "F"'s booming hard clam fishery to be between five and fifteen million dollars a year. Although docking, off-loading, and maintenance facilities are needed by the 300 to 400 fishermen participating in this fishery, their construction and operation could degrade the water quality in Body "F" to the point where it would lose its "Conditionally Approved" status.

In central Brevard County, a developer has received approval from
the Canaveral Port Authority to lease waterfront access to the Barge Canal crossing Merritt Island and providing access for boats from Port Canaveral to the Intra-Coastal Waterway in the Indian River. The developer faces a lengthy permit application process before he can build a commercial boat repair yard serving vessels with a draft less than 12 feet. Other shallow draft facilities may be needed along the Barge Canal in the near future as the Port Authority implements its plan to increase the percentage of waterfront committed to deep draft shipping.

**Deep Draft Shipping**

It is hard for ports to justify retaining deep draft docking areas for the relatively shallow draft vessels used in commercial fishing operations. When a deep draft vessel must use a shallow water port, it cannot carry a full load, which considerably increases cargo transportation costs. Maintaining bulkheads and other facilities is expensive, so ports must maximize revenues in order to keep up with the trend toward deeper draft cargo ships. Revenue from commercial fishing vessels and commercial seafood companies is generally lower than that from industrial shippers.

At Port Canaveral, much waterfront is owned by the military, which limits space for civilian use. The Port is a deep draft (35 feet) facility and the Port Authority plans to make more waterfront available to deep draft shipping, such as cargo ships and cruise liners. This will eventually displace a seafood company, a recreational marina, and some charter and party boats. It will also utilize much of the mooring area used by the commercial scallop, shrimp, and finfish fleets between trips and during storms. Seafood dealers estimate 100 to 150 boats may be in port during stormy weather at peak fishing periods.

Like Port Canaveral, Port Tampa is a deep draft facility. Its channel is being dredged from 34 feet to 43 feet deep, in order to accommodate larger, modern vessels. Phosphate ships currently must carry light loads, but should be able to ship full when the dredging is complete. Tampa has been home port for a commercial shrimp fleet of 70 to 80 vessels for 30 to 35 years. Four major companies purchase shrimp from these boats and processors handle both domestic and imported products. However, in 1977 the shrimp fleet was displaced when a shipyard needed space for expansion. The story of the new Tampa Shrimp Dock is an example of a successful effort to find an alternative facility for commercial fishing vessel operations.

**Examples of Conflict Resolution**

**Port Tampa**

When the Tampa shrimp fleet faced displacement from their docking area in 1977, the Administrative Services Director of the Port, Mr. Thomas O'Connor, undertook a relocation project. The U.S. Economic Development Administration granted three million dollars and Hillsborough County matched those funds with another two million dollars for construction of a new shrimp facility.
The new Tampa Shrimp Dock was begun in 1979 and opened in 1981. It features four finger piers, four seafood companies, two marine suppliers, a boat lift, repair yards, and some open bulkhead for maintenance activities requiring the boat to be tied alongside a broad bulkhead area. The four seafood companies are responsible for managing the piers and the open bulkhead, saving the Port Authority the expense of supervision.

Successful planning and implementation of this new facility required two years of planning, two years for construction, and careful coordination among funding agencies, the Port Authority, and the seafood companies who were the prospective tenants. The effort has preserved access to the Port of Tampa for commercial fishing vessels, and thus will maintain the possibility for fishery expansion to harvest the many underutilized species found in the Gulf of Mexico.

**Port Canaveral**

The portion of the commercial fishing fleet which will lose docking space with the expansion of deep draft facilities at Port Canaveral will have access to a commercial fishing dock and boat repair yard at Daytona Beach. The Ponce de Leon Inlet Port Authority is developing a shallow draft facility and would welcome additional vessels. Ponce de Leon Inlet is a reasonable distance from the calico scallop beds located off Cape Canaveral, and could present scallop trawlers an alternative to Port Canaveral without too much extra fuel cost.

Commercial seafood companies at Port Canaveral are working to improve the appearance of their facilities in order to establish an atmosphere more in harmony with neighboring marinas, restaurants, and cruise ships. Modern plants and offices have been built and work areas have been enclosed by attractive fences. The first annual Port Canaveral Seafood Festival successfully served 50,000 people in April, 1984 with the assistance of food, supplies, and labor donated by the seafood companies (Shealy, 1984). Such attention to good public relations will help the seafood industry face future challenges to use of the waterfront.

**Fishermen's Pointe**

Fishermen's Pointe is a limited cooperative established in Marathon in the Florida Keys to provide commercial fishermen with an alternative to the use of residential lots for construction, storage and maintenance of commercial fishing gear. The Organized Fishermen of Florida, the Florida Department of Community Affairs, the Florida Department of Environmental Regulation, and Monroe County staff worked with local fishermen and attorneys to develop suitable permitting, review standards, and ordinances for this development. One of the fishermen who played a key role in planning Fishermen's Pointe reported that all lots were quickly taken. Clearly, the project has met a need for onshore facilities for commercial fishing operations.
Conclusion

Trends affecting waterfront use for commercial fishing operations continue to pose problems for commercial fishermen and seafood dealers in Florida. Successful conflict resolution requires adequate planning time, funding sources, and good coordination among the seafood industry, government agencies, and developers of marine facilities. New facilities are expensive, appropriate land on which to build them may be hard to find, and permitting procedures are complex and time consuming.

Commercial fishing vessel operators and the seafood dealers who buy from them should evaluate local trends which may affect their operations. They should also establish good communication with government agencies and begin work where necessary to ensure adequate facilities will be available for future docking, maintenance, and off-loading operations.

References Cited


A SIMPLE METHOD TO DETERMINE OPTIMUM VESSEL SPEED

GEORGE A. LUNDGREN, P.E.
MARINE EFFICIENCY ENGINEERING - SEATTLE, WA

Abstract

Slower speeds save fuel. Do they save money? That depends upon the cost of fuel compared to the value of time. The paper describes a simple method of analyzing individual vessel fuel consumption characteristics from which a rational optimum operating speed may be chosen.

For any incremental reduction in speed, a corresponding increment of extra time required is the price which must be paid to save that incremental amount of fuel.

By measuring or estimating fuel consumption vs. vessel speed, the monetary value of each increment can be calculated and plotted. Optimum speed is then given directly for any value of the operator's time.

Examples are: A 100 ft SNAME trawler, 85 ft and 40 ft optimized fishing vessels from Traung, Doust, and Hayes (FW 3), and measured data from a 58 ft Alaska seiner, and a 33 ft deep-vee planing hull.

Introduction

Every boat has fuel consumption characteristics which are unique and distinct from all other vessels. Even sister ships will exhibit slightly different characteristics because of differences in displacement, trim, engine condition, etc.

Higher speeds save time but require more fuel. What is the best trade-off between time and fuel costs? The answer can be found using a simple analysis of a boat's individual fuel consumption "fingerprint."

The method is as applicable to a naval architect doing conceptual design as it is to a fisherman trying to decide what RPM to run. It requires knowing only: (1) gallons per hour consumed vs. speed, (2) the cost of fuel per gallon, and (3) the value of one's time.

Fuel consumption must be either measured or predicted over a range of hull speeds. Measured values automatically include complex effects of variations in hull, engine, and propeller efficiencies. Fuel consumption can also be predicted indirectly from horsepower, using either traditional EHP
prediction methods or measured RPM values and propeller law assumptions. By assuming values of propulsive efficiency and engine specific fuel consumption, fuel rate is determined.

Optimum speed is inversely related to the price of fuel. The higher the price of fuel, the more it pays to slow down.

Although it's difficult for some fishermen to come up with monetary values for their time, the term "optimum speed" is meaningless otherwise. A good approach is to ask: would I be willing to get where I'm going one hour later if somebody paid me five thousand dollars? How about fifty cents? Then just zero in between those values until it feels right.

Since the value of a person's time (or vessel's time) is different under different conditions, optimum speed is also different under different conditions.

The Method

The key to the analysis is to look at the difference in fuel needed to travel a fixed distance at two different speeds and compare that difference to the difference in travel time. To illustrate, consider the following example for an arbitrary 100 mile trip.

<table>
<thead>
<tr>
<th>RPM</th>
<th>1840</th>
<th>1808</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knots</td>
<td>9.94</td>
<td>9.87</td>
</tr>
<tr>
<td>Hours for 100 mile trip</td>
<td>10.06</td>
<td>10.13</td>
</tr>
<tr>
<td>Extra hours needed:</td>
<td>.07 hours</td>
<td></td>
</tr>
<tr>
<td>Gallons per hour:</td>
<td>19.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Gallons used:</td>
<td>191</td>
<td>182</td>
</tr>
<tr>
<td>Gallons saved:</td>
<td></td>
<td>9.0 gallons</td>
</tr>
</tbody>
</table>

Reducing engine speed 32 RPM adds a little over four minutes to a 100 mile trip, but saves nine gallons of fuel. That is equivalent to saving 128 gallons of fuel for every extra hour taken. The results are the same no matter what distance is chosen. The VALUE of traveling at the lower speed is 128 gallons per hour. Assuming fuel at $1.00/gallon, the vessel’s time would have to be worth at least $128/hour to justify traveling at the higher speed.

If VALUES are calculated for increments at successively lower speeds, eventually the point will be reached where it is no longer worth one's time to go any slower. That speed is the "optimum" or most cost effective speed. Going faster uses too much fuel, and going slower takes too much time.

In this paper, effects of incremental reductions in speed are analyzed. Marginal speed increases can just as well be
used.

A Typical Example

The previous illustration used measured data from a 335 HP, 58 ft Alaska seiner, displacing 130 tons, toing a seine skiff. VALUES for increments at other speeds are shown graphically in Figure 1 along with curves showing gal/hour and miles/gal vs. speed. Looking at the value curve gives some interesting insight into the economical operation of this boat:

If the fisherman's time is worth about $20/hour, the optimum speed to run would be 1500 RPM (8.7 knots). Note that nothing in the shape of either the GPH or MPG curves could produce the same conclusion. One might have suspected that 9.2 knots (1600 RPM) was the "best" speed, since fuel consumption rises sharply at higher speeds. In reality, it would only be the best (optimum) speed if time is worth $65/hr (assuming $1.00/gal).

Note that it doesn't make sense to run anywhere between 7 and 8 1/2 knots. When time is worth more than about 16 gal/hour, speed should be above 8.5 knots. When time is worth less than about 16 gal/hour, speed should be less than 7 knots.

As previously shown, time must be very valuable to justify operating at the higher speeds. As much as 128 gallons of fuel can be saved for each extra hour running, simply by slowing slightly from full throttle. That may seem extraordinary since the engine's maximum fuel consumption is 19.0 GPH, but is typical of vessels analyzed.

A Towed Model Example

In addition to being able to determine optimum operating speeds for existing vessels, the technique is useful during design and evaluation stages. Model tests of SNAME Trawler Model W-8 (sheet # 169) are used to demonstrate another example. Waterline length is 103 feet, beam is 22 feet, and displacement is 300 tons.

Some assumptions are first necessary to convert predicted EHP to expected fuel consumption. It is expedient and reasonably accurate to assume constant values of .5 for overall propulsive efficiency, and 18 hp per gph for thermodynamic efficiency of a typical four-cycle diesel engine (BSFC=.39 lb/ hp-hr). In other words, for displacement boats, dividing EHP by 9.0 gives reasonable estimates of fuel consumption in gal/hr. The increase in partial load specific fuel consumption at part throttle is somewhat offset by an increase in propeller efficiency.
In Figure 2 are plotted the original EHP data along with VALUE and MPG vs. speed curves. Again, several conclusions may be drawn which would not be obvious from either the EHP or miles/gal curves; time would have to be worth 900 gal/hr to justify running free at 14 knots. A big change in efficiency occurs just below 12 knots. Optimum speed is 9.2 knots when time is worth 50 gal/hr and 11.7 knots at 100 gal/hr. Obviously, many other statements could be made regarding economical powering or operational decisions.

Two FAO Optimized Hulls

As a result of a regression analysis of resistance characteristics of many fishing vessels, Traung, Doust, and Hayes developed four optimized low-resistance hulls. The results were published in "Fishing Boats of the World: 3" and presented at the Third FAO Fishing Boat Congress in 1965. To further demonstrate this method of analysis, the largest (85 ft) and smallest (40 ft) were chosen.

As before, fuel consumption in gal/hr was assumed to be equal to EHP divided by 9.0. The results for the 85 footer are shown in Figure 3. Some observations are: from 8.3 to 10.3 knots, the relationship between EHP and speed is nearly linear. If time is worth 20 gal/hr, it pays to run at 9.8 knots instead of any slower. Time value has to double to 40 gal/hr to justify the .4 knot increase from 9.8 to 10.2 knots. If time is only worth 10 gal/hr, 8 knots is optimum rather than 9.2 knots (since VALUE is greater than 10 gal/hr between 8 and 9.2 knots).

The results for the 40 footer are similarly plotted in Figure 4. Several comments regarding the 40 footer are: resistance is virtually constant from 5.7 to 7.3 knots giving constant miles/gal over the same range. The effect makes the VALUE zero over the range, meaning no matter how little time is worth, it never pays to run between 5.7 and 6.8 knots.

Since the boat is so easily powered, it is seen that speeds up to about 7 knots are extremely economical. Even at a time VALUE of 1 gal/hr, it doesn't pay to slow below 7 knots.

A Planing Boat

The previous examples utilized computer predicted resistance, model test resistance, and measured fuel consumption for several displacement vessels. The analysis is general in nature and is equally applicable to any mode of transportation such as automobile or aircraft.

The final example uses measured fuel consumption on a 33 ft deep-vee sport fisherman with twin turbocharged 270 hp, V-8
diesels, capable of 28 knots. Beam is 12.7 ft, deadrise is 17 1/2 degrees, and displacement is 19,900 pounds.

In this case, a propulsive efficiency of .55 and an engine efficiency of 18 hp/gph were assumed so EHP and resistance could be estimated. This was done only for discussion's sake since only GPH vs. speed is required to calculate VALUE. The resistance, GPH, MPG, and VALUE curves are shown in Figure 5.

The slope of the resistance curve is seen to be moderate from hump speed at about 10 knots to about 25 knots. This corresponds to moderate VALUES over that range, meaning it doesn't save much fuel to slow down in that range.

Above 25 knots resistance increases sharply, making VALUE increase to 50 gal/hr. This means that it is very worthwhile to run at 25 rather than 27 knots. Good places to run this boat would be 8, 17, or 25 knots. Poor places would be 10, 20 and 27 knots.

If this operator's time were worth 10 gal/hr, 23 knots would be the best trade-off of fuel for his time (even though miles per gallon are better at 17 knots).

**Propeller Law Estimates**

For existing vessels, if a fuel flow meter is not available, reasonably accurate estimates of fuel consumption can be made using tachometer readings.

Maximum fuel rate can be obtained either from manufacturer's data or estimated from maximum horsepower, using one GPH for each 18 hp. A more accurate value can often be derived from engine sales literature.

For displacement vessels, fuel consumption at lower RPM can be estimated by assuming a 3.0 (cubic) propeller law:

\[
GPH = \left( \frac{\text{RPM}}{\text{max RPM}} \right)^3 \times \text{max GPH}
\]

For planing hulls, a 1.9 power relationship can be used:

\[
GPH = \left( \frac{\text{RPM}}{\text{max RPM}} \right)^{1.9} \times \text{max GPH}
\]

**Figure 6** compares measured to estimated fuel consumption for the 58 ft seiner and the 33 ft planing boat examples. Differences in the two methods are seen to be small.
Summary

An analysis of the relationship between speed and fuel consumption is essential to both responsible new design and intelligent operation of existing vessels.

The proposed method is simple and uses either: (1) theoretically or empirically predicted EMP or resistance data, (2) measured fuel consumption, or (3) estimated fuel consumption using measured tachometer data.

VALUE is an indicator of the slope of a vessel's resistance curve in terms of the value of time. A negative VALUE means resistance is increasing as speed decreases, so a lower speed is pointless. A VALUE near zero means resistance and MPG are approximately constant.

If VALUE keeps rising as speed decreases, it pays to look at even lower speeds. Peaks in the VALUE curve are good spots to run (or design to) when speed is important.

If there is more than one possible speed for a given VALUE, use the lower speed if the curve has a maximum between the two possible speeds. Use the higher speed if the curve has a minimum between the two speeds.

The current value of one's time (or vessel's time) in equivalent gallons per hour determines the associated optimum speed directly from the VALUE curve. Other speeds simply do not economically balance time against money.
Figure 1
58 Ft Alaska Seiner

[Diagram showing the relationship between knots and Value (GPH) with lines for Mph and GPH labeled]
Figure 6

58 Ft Seiner
335 Hp

- Measured
- 3.0 Power Law

1000 1200 1400 1600 1800 2000 RPM

33 Ft Deep Vee
Twin 270 Hp

- Measured
- 1.9 Power Law

1000 1500 2000 2500 3000 RPM