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COMPLETION REPORT

Grantee: **JOHN CLYDE WILLIAMSON**

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Project Title: **COMPUTERIZED JIGGING MACHINES AS AN ALTERNATIVE MEANS OF FISH HARVEST**

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Computerized Jigging Machines as a Low Impact Alternative to Conventional Means of Harvest in the New England Fishing Industry

Final Report on Fishing Industry Grant 94-FIG-009
project number NA56FK0091
for period 3/1/95 through 4/30/96

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Introduction

This project involved the use and testing of a relatively new gear-type with, as yet, little exposure in New England. The jigging machines that we used were an all electric reel teamed with a programmable microprocessor, making them a sort of fishing robot. Hydraulically driven models are also available. This technology has been developed in Scandinavian countries where jig fishing remains a viable means of commercial harvest. We will refer to these as computerized jigging machines to avoid confusing them with the more familiar automatic jigging machines that use a mechanical trip-action device to impart the jigging motion.

As a small-boat fisherman, primarily a gillnet fisherman, I have had a growing curiosity about jigging technology for several reasons. Increasing gear conflicts with large trawlers displaced into in-shore grounds have driven up the costs of gillnetting from gear losses as well as limiting the bottom where gillnetters can set nets safely. And management measures to reduce the bycatch of marine mammals threaten to severely constrain the deployment of gillnets in some seasons of the year. A jig fishing operation would avoid these problems.

In the western Gulf of Maine, where I work, we had had a couple of years when a substantial body of jiggable fish had been around in the winter and early spring. Working around the weather, some small boats had done passably well with rod-and-reels. Two people in our area who had each invested in single computerized jigging machines to go along with their rod-and-reel use, reported good results.

I had read descriptions of how efficient and profitable jig-fishing was for small coastal vessels in Iceland and Norway, and how the Russians had even experimented with outfitting a 90 footer for jigging in the North Pacific. I looked at the numbers of party-boats working Jefferys Ledge spring, summer and fall, and instead of tourists shoulder to shoulder along the rail, I imagined computerized jigging machines.

I also knew that many people in New England, who had experimented with automatic jigging machines in the past had not found them worth the investment, but I understood that the technology that was now available was substantially more sophisticated. I decided that the only way to answer my questions was to fully rig a vessel solely for jig fishing, and to pursue it with as much time and persistence as I would any other type of commercial effort. I wanted to use the most sophisticated technology available in order to give the experiment every chance to succeed. I applied for grant funding and this is the report of that experience.

After 14 months of working with this gear I wish that I could say that this is a viable, year-round gear-type for small-boat fishermen in my area. I did not come close to demonstrating that. I did find that there are some opportunities where this gear will work well to compliment other forms of fishing effort. I did find that when there was a sizable body of groundfish under the boat, these machines were extremely efficient. I did find that jigging vessels we worked on in Iceland, operating in a year-round cod and pollock fishery, were very profitable, efficient and selective, but that there are a number of differences in conditions and fishing practices that might affect whether this gear-type could transplant successfully to New England, especially given the current state of the groundfish resource.

Project Rationale; Questions to be Answered

In proposing a demonstration of computerized jigging machines for commercial use, there were several points that needed to be addressed.

Primarily, we were looking for a marine mammal safe alternative to in-shore gillnetting that would be compatible with a typical gillnet vessel. In the mid-coast section of the Gulf of Maine harbor porpoise bycatch closures could soon restrict or eliminate gillnetting for all or parts of the fall, winter and spring. In the eastern Gulf of Maine, the summer and early fall months are at stake. These periods not only coincide with harbor porpoise presence but are high income months for gillnetters who primarily target cod and pollock. Together, both species make up the bulk of jigging landings in Scandinavia, and there was no reason to worry about marine mammal interaction. It seemed like a good fit.

Second, groundfish effort too often targets spawning fish aggregations. Codfish school up to spawn in the spring and pollock spawn in numbers in the fall. Scandinavians report that fish at the height of spawning activity are less susceptible to jigging machine effort but are hungry when they are done breeding. Therefore, it might be possible that jigging machines enhance the escapement of spawning groundfish. To the extent that they might prove to be an alternative to other forms of groundfishing, that could be a positive thing. The proposal sought to investigate the percentage of landings of ripe spawning fish with the use of these machines.

Third, we wanted to see what effects we might have landing juvenile fish. If jigging has one major drawback it is that there can be discards of undersized groundfish. We wanted to see how much of a problem this might turn out to be, whether it was simple to avoid fishing on juveniles, whether using larger hooks would help, and whether fish that were returned to the water had a reasonable chance of survival.

Fourth, all other things taken into account, jigging clearly has little or no impact on bottom habitat. To the extent that they might prove to be an economical alternative to other gear-types, that should be a desirable reason to encourage jig fishing technology.

Finally, the overriding question to be answered was: is this a commercially viable gear-type? What are the costs to rig a vessel? What are the costs of operation? What sorts of sea and weather conditions are limits to its performance? What volume of fish can we put on deck, of which species? Is this hard to learn?

Rigging the Boat

The vessel used for this project is a 42 foot fiberglass hull built by Provincial Boatworks, with a 357 hp Volvo engine. The boat cruises at 14 knots at 2150 rpm. Basically a lobsterboat style hull, it has a low sheer and no fish-hold, but carries enough fuel for a 400 mile range.

The electronics that we had to work with included a JVC 500 watt, dual frequency color sounder, a Raytheon 1000 watt, three frequency color sounder, a Raytheon Raychart plotter and a RayNav loran. I am not sure, in hind-sight, if a GPS navigational system might have given us more accuracy in attempting to pin-point and stay on top of small groups of fish.

Normally this vessel is rigged for gillnetting, hauling off of the starboard side. For this project we removed the starboard sidecurtain to have 20 feet of clear rail aft of the hauling station on which to mount the jigging machines.

On deck we installed two large, insulated fish boxes from portside across amidships. This left a working aisle along the starboard rail. Additionally, we mounted shallow plywood trays on the rail between the jigging machine mountings as a place to hold fish as they came out of the water (when a leader comes up with four or five fish on, you want to get them all on board before removing the hooks).

The jigging machine chosen for this project was the C-6000i, made by DNG Electronics, Akureyri, Iceland. I ordered six of these on the expectation that a crewman and I could each handle three machines, and that was the most that a boat this length could reasonably accommodate. I faxed the factory in Iceland a diagram of the vessel layout, rail width and height off the deck, and they returned a fax advising placement and a proposed design for stainless steel mounting brackets. The mounting brackets, when they arrived, turned out to be quite sturdy, with an arm on a double swivel arrangement that allowed us to position the machines out-board during fishing or to turn them well in-board when we were at the pier.

The C-6000i is made to run on either 12 volt or 24 volt systems but reportedly has much more hauling power when rigged for 24 volts (four of them actually brought a sink-gillnet to the surface, so there is some power there). They are provided with long, heavily insulated power cords that are hardwired into a breaker panel mounted in the wheelhouse. The breakers also act as surge-suppressors to protect the electronics. Each machine has two power leads to it's individual breaker switch and two communication leads to a central terminal (also in the breaker panel) that allow the six machines to "talk" to each other.

We installed a separate 24 volt generator off of the engine, with two "deep cycle" marine batteries in series. This gave us about 170 amp-hours of storage, and because the peak power demand of one of these jigging machines under full load is 3 amps, means we had almost ten hours of battery draw-down with the engine off.

The cost of the six machines, mountings, breaker panel, tariffs and shipping, plus the 24 volt electrical system came to about $21,000.

How Computerized Jigging Machines Perform

The machines used in this project are manufactured in Iceland by the DNG Electronics company. Another good manufacturer is the Oilwind Company in the Faroe Islands (off the north coast of Great Britain), and there is a Swedish machine on the market. I am sure there are others that I have not encountered, as well.

The DNG machines are compact, they weigh about thirty pounds, and are mounted on stainless steel stands at about chest height. The drive unit makes up the bulk of the machine, and is in a sealed cast-aluminum housing. The reel is mounted tightly to the right side of the housing on a direct-drive shaft coming out of the drive unit, which is essentially one large brushless electric motor. There is a control panel and display screen mounted as an integral part of the unit housing, and this faces the fisherman standing on deck. An 18 inch long stainless "fishing rod" extends a pulley out-board of the vessel (something like a snatch-block), creating a "fairlead" for the fishing line coming through the pulley and onto the reel. This rod is rigidly mounted but does have some spring action to it to absorb shocks.

The reel is 9 inches in diameter and 3 inches wide. It comes from the factory with 250 fathoms (500 meters) of dacron line wound onto it. (We tried fishing these as deep as 120 fathoms.) The line fills the reel to half its depth. When it is fishing, the machine "reads" the amount of line out by counting the revolutions of the reel as the line pays overboard.

The reel is mounted directly to the shaft of the induction motor; there are no gears. The strength of pull and the speed of retrieval are controlled by controlling the amount of electricity to the motor. At full "throttle" the machine draws 3 amps, which gives it enough pull to break 200 to 250 test monofilament line. At this maximum setting and with minimal weight on the line, the reel can retrieve at a speed approaching 800 rpm; most of the time we used them at a much lower power setting.

Drag on the reel, when it is paying out, is also created by a little bit of current to the motor to prevent free-spooling.

Between the reel and the fairlead pulley the line passes over a tensioning arm. This "slack sensor arm" is on a spring and moves in response to changes in tension in the fishing line; it relays this information through the housing by means of a magnetic pulse code. The computer inside the housing reads these messages and responds according to its program, ie.: the line has a steady pull --- "it must be paying out, so add a little drag to the reel"; or, the line has gone slack and stayed slack --- "it must have hit bottom, begin the jigging program"; or, there is a jerk on the line --- "we must have caught a fish, time to reel in".

The control panel has a display screen and four touch pad keys. Three of the keys are for manipulating the computer program menus on the display screen. The fourth key is the main control, tap it once and the line pays out, tap it twice and the machine reels in, tap it a third time to stop. Once the machine has its operating program in place for the day, this control key is what you use to run the machine with: down, up and stop.

Consider how the machine works in daily use with a typical program. You have found a school of codfish near the bottom and you have positioned the boat to drift over it. You have a monofilament leader of hooks with a weight at the end, and with a snap-swivel connection to the dacron line. You throw the weight and leader over, hit the control key once for "down" and the reel starts to pay-out. The machine counts how many feet of line are going out. When the weight hits bottom, the computer senses it and immediately reels in the slack bringing the weight up off of the bottom. Then the computer starts the jig stroke: the machine reels in and out. When a fish takes a hook the computer senses the "extra" drag, a bell sounds, and it starts to reel in. The machine counts the line as it is coming up. No matter how fast the retrieval speed, when it gets to within ten feet of the end, the reel automatically slows down, stopping just as the fish breaks the surface of the water. The bell sounds twice, "there's a fish waiting over here!".

The display screen and three computer keys allow the fisherman to select and tailor the various operations that the machine performs during the course of fishing. There are four menus of operations that can routinely be brought up on the display screen, and a fifth screen that is accessible for calibrating more basic functions.

All screens show voltage, RPM of the reel and length of line out, across the top.

Screen One has seven separate fishing operations that can be adjusted up or down depending on what you want the machine to do, what the conditions are, and what type of fish you are working on. **Sensitivity**, the first icon on this screen, controls how much drag will be on the end of the line before the computer decides it has caught a fish and reels in. At its lowest setting, it could be fishing with a 16 ounce sinker and a mackerel on the hook would set it off. At a much higher setting, it could be fishing in a hard tide with a ten pound weight and set to reel in only if a good sized codfish took a hook.

The **Power** icon controls how much current goes to the motor, and therefore controls how much pull there is on the line or how fast it reels in. Maximum setting is about 300 pounds, enough to lift a couple of lobster traps.

The **Jigging Speed** icon controls how fast the reel turns when it is in its jigging mode. At a very low setting you create a very slow jig stroke, at a high setting the stroke is very hard and quick.

The **Jigging Length** icon controls how long the stroke is, from six inches to about 60 feet (in comparison, the jig stroke for a man with a fishing rod would be six to ten feet, maximum). Combined with the **Jigging Speed** setting, you can program any sort of action for the hook, from a very light flutter, to a short sharp jerk, to a long slow pull.

The **Bottom Distance** icon controls how far above the bottom you want the hook and sinker to be working. You can set it so that the sinker will just graze the bottom at the low end of the jig stroke, or if working on highly uneven terrain like boulders, you might set it so that the sinker stays six feet above the bottom to avoid hang-downs. This setting is useful if the fish are up in the water, and you want to keep the hooks at that depth.

The **Bottom Time** icon controls how often the machine adjusts for changes in depth or uneven terrain. If the vessel is drifting onto a slope, the computer will re-establish the **Bottom Distance** every time the sinker touches bottom, but if the vessel is drifting away from a slope, the computer needs to interrupt the jigging periodically to find the bottom. At the minimum setting it does this once a minute, at the maximum, once an hour.

The **Waiting Time** icon is used to put a hesitation into the jig stroke. This is most useful when fishing with bait. Normally, on a zero setting, the jig stroke is steady, up and down. A setting of 3 adds a three second pause between the down and the up. Maximum setting is a minute-and-a-half pause.

These are the basic fishing functions that can be manipulated over the course of the day to adjust for changing conditions or opportunities. All of these setting can also be combined and stored in memory as pre-programed "fishing systems" for specific situations. On **Screen Two** there are five slots where self-designed fishing systems can be stored and called up with the push of a button. There are also ten other pre-programmed systems for standard operations, ie.: a basic codfish program, a pollock program, a bait-fishing program, a squid program, and various others designed for operating in areas of the water column.

Screen Three has controls for miscellaneous functions such as backlighting and units of measure (meters, feet or fathoms).

Screen Four has slots where you can store in memory jig strokes that you perform and that the machine mimics. You do this by turning the reel with a crank handle. As an example, if you turned the reel with a "stutter" and stored it in memory, you could call that up, insert it as part of a program from **Screen Two** and the machine would imitate the same "stutter" as part of the jig stroke.

Fishing in Iceland

Early in this project, three of us flew to Iceland to learn as much as we could about the machinery we would be working with, and about the conditions and techniques of Icelandic jig fishermen. The DNG company arranged for Alan and I to go fishing with several different fishermen at different locations around the country.

Iceland is a small country on an island in the north Atlantic halfway between Canada and the European continent. The north coast is within a few miles of the Arctic circle but because of a branch of the Gulf Stream the weather is fairly temperate; it only snows six months of the year. When we were there in May it was daylight for 20 hours a day.

The island is very rugged with volcanos rising right up from sea level. The north and west coasts have extremely long, deep bays, fjords, with long fingers of land between. The south and east coasts have sharp cliffs overlooking the sea or broad coastal plains. This sort of geography continues under water, and there is a fairly broad continental shelf around the island connecting it to the fringes of the North Sea grounds. In comparison, Iceland has about as much coastline as New England and the Canadian coast of the Gulf of Maine. The fishing is very good and 75% of their foreign trade income is generated by the commercial fishing industry and related products.

The country started moving toward their current system of fisheries management in the early 1980's. They have an ITQ (individual transferable quota) system for vessels over 28 feet. Originally, this fleet included trawlers, longliners and gillnetters, but, due to consolidation over several years, most of the small to mid-sized vessels have been bought and scrapped to provide quota for new, large trawlers. Reports are that even some of these newer vessels are being scrapped for their quota to be consolidated in a growing fleet of factory trawlers.

As part of the Icelandic management system, no trawling is allowed within 12 miles of shore. As the average size of vessels in the fleet grows larger, the bulk of fishing effort occurs further and further from the coast. Mid-sized vessels that are gillnetters or longliners have begun to disappear from the near-coastal zone.

Benefitting from this shift of effort away from the coast is the fleet of vessels less than 28 feet who work almost exclusively within the 12 mile zone and the fjords. These smaller boats are under a separate management system that simply fixes the number of licenses and fishing days. A schedule is negotiated annually that closes a total of 135 days distributed over the year (see the schedule on page 23).

As the make-up of the Icelandic commercial fleet has become polarized in very large and very small vessels, the fishing has become more profitable for all. As the pressure has been removed from in-shore grounds, stocks of cod, pollock and redfish that were depleted in past years have begun to rebuild, and jiggers report record-breaking landings.

Icelandic jig fishermen report that there are other benefits to fishing in areas segregated from trawling effort. They claim that fish are skittish and less likely to take a hook if there are trawlers working nearby; also, they say that fish school more readily and in bigger aggregations in these near-shore areas now that the traffic of fishing activities are not constantly busting them up.

Every harbor, large or small, that we visited had jig boats working out of it. The boats were almost all new and well kept. These are usually fiberglass hulls with raised decks. These are planing hulls, very light and fast, and capable of cruising at 25 to 30 knots. The diesel engine is below deck at the very stern, sometimes with an out-board drive for maximum maneuverability. Very broad little vessels, the focsle sleeps two comfortably with a small galley; the wheelhouse is well forward, usually with two bucket seats to port and starboard and an array of electronics. This is all very compact to get as much open working-deck space aft as possible. Below deck, forward of the rear engine compartment, is a 4000 pound fishhold. The deck over this hold has removable flush panels, so that the entire deck amidships can be removed opening the hold for easy offloading at the pier. Fish are dressed, iced and containerized on board. It is all very clean, efficient and modular.

These boats typically might have three jigging machines mounted along one side and also have a small longline system set up on the off-side. Or, if rigged solely for jigging, they might have four machines mounted, one on each stern quarter and along one side. Some boats favor having machines on the portside, some on the starboard (for reasons which I will explain later).

Every day we were there seemed to be windy. In the areas with fjords or bays there is usually a protected shore to work from. The art of reading the weather is to anticipate which direction the wind will be coming from and to work on grounds in the "lee" of mountainous peninsulas. Most often when we left the harbor in the morning, it would be just a few miles run either along the coast or across the bay. We often were working close to the beach and in as little as thirty feet of water. Of course, when the weather permits, these boats can just as well be found working in deeper water further off-shore.

On the fishing grounds the boats tend to work together in small groups. As they race onto the grounds they fan out over a wide area, each captain headed for a favorite spot. The color sounder is the key piece of equipment; if he does not see a substantial body of fish on the screen he keeps looking. The jigging machines are on and the gear is ready to be quickly deployed. When he does find a school of fish to his liking he comes around on it to get a sense of its size and then sets the boat up to drift over it. In shoal water we were working on schools of cod that showed to be two to four fathoms high and a couple of boat lengths across; a solid "red mushroom" on the color sounder.

On deployment, the weights and leaders go overboard and the lines payout. As the machines find the sea bottom, if near the edge of the school, they will only need to give a couple of jig-strokes before some will hookup and be on their way to the surface. The job is to get the fish on board, off the hooks, and the gear back on its way to the bottom again as fast as possible. Depending on conditions, the boat might get five or ten minutes of good fishing before losing the school. Then the job is to take a guess at what direction the school might be moving, come around on it and set up another drift.

Unless they are working on fish of their own, other vessels nearby will see the action and race over to set up drifts. Captains who work together are constantly on the radio to each other with fish locations, drift headings and the like. Several vessels working on a "tight" school of fish will, of necessity, set up within a boat-length of each other to drift consecutively over the school. A boat completing a drift will come around to get back at the end of the line.

Boats that are rigged with jigging machines on the port side rail will drift on a different heading than vessels with machines down the starboard rail. Working closely together on a group of fish, the left-handed and right-handed boats will start out lined up one after the other but then drift apart to left and right. The effect is to contain the fish between them and to keep the school from breaking up. Boats working together are better able to hold the fish or to follow them as they move across the bottom. Also, the activity of many lines in the water tends to excite the fish to strike more readily.

As a school of fish is caught up the boats working on them break off and wander away in search of the next opportunity. The vessels fan out again until someone else strikes a hot-spot. In this way these boats build a productive day and maximize the time they spend on top of fish. The idea is to move constantly, to not waste time on unproductive bottom, and to track the movements of schools across a large area.

In a trip to the far northeast corner of the island, to the port of Thorshofn fifty miles from the Arctic Circle, we heard tales of a fantastic run of cod that was just winding down; boats had been landing four or five thousand pounds a day for several weeks on end. More typically however, these men would see landings of a 1000 pounds for a ten hour day.

All the landings we saw over several days of fishing were scrod to large market cod and occasional redfish. The Icelanders observe a minimum codfish size of about 18 inches. The unwritten understanding is that undersized fish can be kept if the fish will not survive being returned to the water. Most undersized fish we saw were thrown back though enforcement of a minimum fish size seems to be fairly lax.

Computerized Jigging in New England

This project began in March, 1995 and lasted fourteen months.

We accomplished the rigging of the vessel in April and had a three week shake down period in April and early May to learn and test this new equipment. We spent these three weeks on Jefferys Ledge and in-shore on grounds where we had some familiarity as jigging locations. Much of May was taken up by the trip to Iceland to work with experienced fishermen there. From May through August we spent our time alternately between day trips to Jefferys Ledge and multiple-day trips to Cashes Ledge, Parkers Ledge, Fippenies, Three Dory Ridge, New Ledge and the Kettle Ground all in the western Gulf of Maine. September through to the end of the following April we spent solely on day trips to Jefferys Ledge and the Fingers.

Wind Speed, Sea Conditions and Drift

We never found ourselves working on a large enough body of groundfish to anchor. After consulting with partyboat people whom we were fishing near, we did try anchoring with a chum-bucket on bottom, but apparently there were not enough hooks in the water with enough activity to attract fish, or the jigging action was not enticing (please see Potential for this Technology to Evolve, page 14). We found it was quicker and more flexible to drift fish, and that we were better able to follow a school that way, and even to "herd" scattered fish.

There were times on Cashes Ledge and on New Ledge that the tide was just too strong to allow the lines to tend bottom. We found that doubling the sinker weights, to ten pounds was some help. However, we usually found ourselves, under these conditions, sitting on anchor waiting for slack tide. Tide was much less often a problem on Jefferys, though there were days that we did call it quits because the drift was too fast.

Similarly, wind speed was sometimes a problem, though not as much. Depending on the direction and speed of the tide, the wind could be blowing as much as 20 to 25 knots. What would cause more of an effect was the direction of the tide relative to the wind direction. Often the wind would offset the speed of the current, if they were both coming out of the same quarter. In those cases the lines could be tending bottom very well, hanging straight down from the vessel, while we were actually traveling over the bottom with some velocity. With a little headway, we could use the rudder to affect the "lay" of the boat and keep the lines from becoming tangled.

A wind direction as much as 110 degrees off the direction of the tide, to either side, allowed us to "balance" the boat and keep fishing.

Another more subtle factor was the direction of the current "on bottom", which could be much different than the direction of the surface tide. The combination of factors together, wind, surface current and bottom current, determined whether the hooks could tend bottom effectively, and whether the lines became entangled. Under ideal conditions all six machines could be operating at once with no problems. But often we found ourselves able to use only four machines, on a nine foot spacing between, to keep the line from tangling, and occasionally we cut back to three machines. (Please see diagrams A and B.)

To sum it up, there was a large range of tide and wind conditions that we could continue to fish in effectively. Wind speeds under 20 knots were usually not a problem, but tide was a consideration. Sea conditions were not a limiting factor, as we could adjust the settings on the machines to compensate for the roll of the boat.

May through August

During this period we were trying to master the gear, to see what it could do and what sorts of species we could "scare up" with it.

Fishing for cod and pollock proved to be frustrating. We did not find that these machines were competitive on Jefferys or the Kettle Grounds during these warm weather months. Most often the machines produced under a hundred pounds a day, and we found that we could do much better with a hand-held rod-and-reel. There were probably several reasons for this, most likely being that the "action" of the machines was still too "clumsy" to attract a "strike" when there is a lot of feed in the water and the fish are disbursed. (Please see the following section, Potential for this Technology to Evolve, starting on page 14.)

We did have a little better luck off-shore, on Cashes Ledge, during this period. On those trips we were stocking three to four hundred pounds per day, with much the same problem as in-shore, there being lots of feed around. Where we did well on Cashes was when we encountered pockets of hungry fish, mostly pollock, coming up out of the deep water. In those cases, we were working in 50 fathoms or more.

Though they snagged a dogfish occasionally, the jigging machines did not seem to attract them except when we used bait.

As an experiment, we also tried targeting mackerel. We found that using a combination of settings on the machines to simulate a gentle flutter, we could rig these with a multi-hook "tree" of 30# test monofilament gangions off of a heavier leader, and small bait hooks. Anchored in a body of schooling mackerel several fathoms down in the water column, four machines produced at the rate of 40 pounds of mackerel per machine per hour. This rig also worked well on herring.

September and October

Much of the summer we had been fishing around gillnets, and had lost a lot of gear to hang-downs. In frustration, we started looking for fish in deeper water, 50 to 70 fathoms. The area west of the Fingers off of Jefferys Ledge is very productive dragger bottom at times of the year, with lots of small pieces of structure rising up out of 90 fathoms. There had been little activity there for the preceding month, and, as it turned out for September and October as well, we had the area to ourselves.

In this case what we found were codfish that had taken "residence" on these bit of structure. In an hour, using a drift pattern on the plotter, we would clean what fish were there and then move on to the next piece of bottom. It was hit-or-miss on each new spot; if there was nothing on the first pass then we would move on to the next piece of bottom. This began to remind of the Icelandic experience only we were fishing in much deeper water.

The problem of working in deeper water is that, even on 200 Kz, the cone of reflection from the color sounder is getting to be pretty broad. It takes practice to learn to place the hooks through a pocket of fish with any precision; unless the fish are very hungry, you only have to be off by a few feet to miss them. And if the bottom current is running hard, it is only a guess as to where the hooks are in relation to the drift of the boat.

During this period we saw 40 to 50 pounds of harvestable cod and pollock per hour of fishing time. The discards of undersized codfish were about half that.

November through April

As the weather turned colder and nastier, there were fewer opportunity days, with the wind speeds marginal. With a decrease in gillnet activity, we returned to the southern end of Jefferys Ledge and Scantum Grounds. The fishing was very spotty, and we wasted whole days looking for fish. However, the water temperature was dropping, the fish were hungry, and when we did connect with a school the machines would be very busy for short periods of time. The codfish were very small on average, and we were discarding at the rate of two to one.

Things changed in April, which was the last and most successful month of the project. Harbor porpoise closures were in effect on Jefferys Ledge and thus there was no gillnetting activity for the first three weeks of the month. Hungry codfish were returning out of the deep water, there were a lot of small schools of 20 inch and larger fish, and we were able to use the machines effectively. Because we were able to pick and choose what we were fishing on, the discards of undersized fish were kept to a minimum, about 10% by number.

Discards and Their Survival

One recognized drawback to hook fishing as a gear-type, is the unwanted bycatch and discarding of juvenile fish. In the case of fish caught on a jig line, almost all undersized fish make it onto the boat with minimal damage and are perfectly lively. Unfortunately, if their swim-bladder has inflated on the trip to the surface and they can not absorb that excess buoyancy quickly enough, then they float when returned to the water. Trying to squeeze the air out of them usually ruptures the bladder.

A goal of this project was to get an idea of the magnitude of juvenile bycatch, an estimate of the survival of fish returned to the water, and to look for ways to target only legal sized fish.

Hook size did not seem to make a difference. At different times we used a mix of number 6, 8, 10 and 12 sized hooks, and caught undersized fish on all of them.

Jefferys Ledge has high concentrations of juvenile fish. When we were fishing there during the first eight months of the project, we most often were working on mixed schools of codfish between 17 and 23 inches. The discard rate (comparing the number of individual fish discarded to the total number of fish caught) ran consistently between 40% and 60%. In the early spring, with an influx of returning mature fish, it was much easier to stay away from juveniles, and the discard rate was around 10%.

On Cashes Ledge, the discard rate of codfish was between 20% and 25%.

Pollock were a different case. No matter where we were fishing, we often encountered large schools of undersized pollock. In those cases we would simply move the boat, as there was no sense in trying to fish through them. When we encountered more mature pollock, they were generally in smaller schools and all fish measured close to the same size. Therefore, the discard rate for pollock was either 100% or close to 0% depending on the location.

Almost all the redfish we caught were legal sized.

Small pollock seemed to have much more of a problem equalizing their swim-bladders than the cod. By estimate, more than 50% of the small pollock that we returned to the water remained at the surface, on their side, floating away to an unknown fate. Whereas, between 10% and 20% of codfish, by estimate, suffered that problem.

We did observed noticeably less of a problem with floaters when we used higher retrieval speeds. Typically, a man with a hand-held rod-and-reel will reel in a fish at 50 to 90 feet/minute, depending on the drag. The retrieval speed on the basic program setting of these computerized jigging machines is twice that, about 180 feet/minute. In the first several weeks of this project, we were working in shoaler water and this speed was adequate. As we started working in deeper locations, we started cranking up the retrieval speed to as much as 400 feet/minute. We noticed the difference for released codfish. Since this was counter-intuitive it raised additional questions on survivability.

Using a simple live tank on the boat, when conditions permitted, we observed for survivability of fish returned to the water. The tank held about 290 gallons of sea water to the top of the overflow, and we kept a supply of water running through it. Unfortunately, the movement of the vessel, especially lying at drift broadside to the sea, made the water in the tank very turbulent. Most fish that we placed in the tank to watch did well for the first two hours but very few survived more than four or five. It is probable that this had more to do with the exhaustion and stress of being in the tank than the stress of being caught on a hook. (All fish handled and sacrificed under observation were greater in length than the legal minimum.)

On three occasions however, days when the sea was very calm and we got into a small run of fish close to quitting time, we were able to successfully bring some of these fish alive to the UNH Coastal Lab for longterm observation. 35 codfish between 19 and 24 inches were handled in this way. 11 did not survive the three hour transport by boat, transfer and transport by pick-up truck to the UNH Lab. 3 more were lost overnight in their new home, a large holding tank at the Lab. And the remaining 21 fish survived for three months with no more casualties.

Fish that had been brought rapidly up from depth, showed no buoyancy equalization problems and had subsequently died in observation were also brought into the UNH Coastal Lab for dissection. In particular, we were looking at the condition of the swim bladder, which in every case appeared normal. Observations made while cleaning fish at sea were similar.

Conclusion: bringing fish rapidly up from depth may reduce mortality in discards, but a more formal controlled study would be necessary to demonstrate this. Discards returned to the water appear to do well if they survive the first 24 hours; how much mortality occurs due to the stress of being caught and handled we could not demonstrate in this study.

Impacts on Spawning Fish

Icelandic fishermen claim that jigging machines do not catch spawning fish as readily as other methods of fishing. It was a stated intention of this project to test that claim. However, the opportunity to compare for fecundity, a volume of jigging machine fish caught during spawning period with the catch from another type of vessel fishing nearby, never presented itself. Therefore, we were unable to demonstrate a control.

During the course of this project we caught one running-ripe female cod in early April.

Potential for this Technology to Evolve

After having worked with this technology for months, we came to appreciate these as "fishing robots" that we could program to capture some of the subtlety of a man with a fishing pole. But there were also limitations that we quickly bumped up against. In trying to overcome these limitations, working with the manufacturer, we caught a glimpse of the potential for this technology to develop in the future.

The Scandinavians employ jigging machines with a simple sinker of five to ten pounds, to carry the hooks and leader to the bottom. A taut leader has two to ten gangions attached, each with a hook and teaser that "swim" up and down following the action of the leader. The monofilament leader and gangions are 200 to 300 pound test, heavy enough to survive daily abuse. The technology has evolved in those climes on large bodies of feeding fish in cold water environments. We also found our best success working on large schools of hungry fish, especially during the early spring. But the fish seem to get pickier the warmer the water gets, and we found these machines often unable to compete with a hand-held rod-and-reel during much of the rest of the year.

During the warmer months, on the near-shore fishing grounds, we often found ourselves working alongside of party or charter vessels in 25 to 40 fathoms of water. There would be lots of feed in the water and cod or pollock would be disbursed. We would set up to drift over benthic structure that showed signs of groundfish, but the schools were usually small. The rate of catch was very poor, but, over time we observed that what groundfish there were seemed to be following our gear. Perhaps the "action" of the lead weights and leaders was herding the fish, not scaring them but not convincing them either. At times like this we found that we could entice a fish to strike by shutting off one machine and manually jigging the line as a simple handline. We also found that a rod-and-reel rigged with a diamond jig would work as well, and that a strike on one of these manually operated lines would often precipitate a brief flurry of hook-ups on the jigging machines. This led us to suspect that the jigging machine technology, which had evolved successfully within specific conditions, might be too clumsy for what we were attempting. In an effort to make the machines more subtle, that is, more attractive to choosy fish with lots of feed around, we tried to rig them with various weight diamond jigs and finer gauge monofilament, more similar to the gear that a rod-and-reel sportsman will use.

Diamond jigs (or norwegian jigs) are eight to thirty-six ounce lures, flat sided, shiny, with a treble-hook or pair of hooks attached. When used with a rod-and-reel, they dart like a baitfish on the up-stroke of the jig-stroke, and then flutter seductively as they sink when the fishing line goes slack on the down-stroke. However, when we replaced the usual 5 pound lead weight on the computerized jigging machines with diamond jigs, we found that the diamond jigs traveled straight up-and-down at the end of the leader, with nothing provocative about them at all. They simply hung there just like any other lead sinker. They were definitely not "fishy".

The reason for this is inherent in the engineering of the machines. In order to keep the reel from free-spooling during payout, a little electric current to the motor creates drag on the reel, much the same as keeping your thumb on a hand-reel when you cast the line. The problem is that there is the same drag on the computerized reel during the down-stroke of the jigging action, which is much different than having a slack line. No slack, no flutter, no bites.

Secondly, because the drag on the reel is preset by the manufacturer assuming a five pound sinker as standard, a sinker of significantly less weight causes the line to pay-out much too slowly. We found that under placid operating conditions we could adapt the program variances to work well with a 21 or 24 ounce weight, which allowed us to use 60 or 80 pound test monofilament line. However, it took several minutes to send the hooks to the bottom.

After experimentation with an array of different rigs, one solution was clear. We needed to be able to control or eliminate the amount of drag on the reel. Unlike other functions with a range of settings, there was no way to program the "trickle" of power to the motor during the pay-out or jigging operations. We consulted with the manufacturer in Iceland, outlining the problem. Their answer was to rewrite the basic program for the machines, providing a fifth screen "menu" that allowed us to access and control the drag on the reel. It was crude in that we could not differentiate between drag during pay-out and drag during jigging operations, but it allowed us to experiment with lighter gear configurations.

In order to reprogram the six computerized machines that we were working with, the DNG Company sent a small electronic device that plugged into the communications terminal in the breaker panel. It took about ten minutes to install the replacement program in all of the machines. DNG intends to keep improving the program package with input from fishermen, and make the program updates to all of their machines in use. They apparently will soon have the capability to reprogram and trouble-shoot their equipment from Iceland with vessels at sea via cellular phone and modem.

It is the infinite adaptability of the software (within the limits of the capability of the hardware) that offers the most interesting potential for this technology. The time line of this grant proved too short to adequately test this adaptability. We intend to continue to perfect the use of this gear on groundfish species, as well as to explore their use in other commercial fisheries such as bluefish or squid.

Conclusion

Jigging machine technology has evolved in some North Atlantic fisheries to be a highly profitable small boat alternative to other gear-types. Conditions that allow their viability in year-round use do not exist here in New England at this time. These factors are:

* A threshold number of vessels using this or a compatible gear-type.

* A threshold abundance of the groundfish resource.

* Marine habitat relatively undisturbed by other fishing activities allowing fish populations to aggregate in larger bodies.

As cod, pollock and redfish stocks rebuild under future management efforts, it is possible that this computerized jigging technology might be successfully introduced into a coastal fleet of small vessels in areas where environmental impacts are of overriding concern.

(The condition of cod and pollock stocks that we observed in Iceland, that successfully support jigging technology, are much more similar to New England's resource conditions that this researcher/fisherman remembers from the 1970's and early 1980's than what he observes today.)

Under present resource conditions there are niches where computerized jigging machines may prove to be a profitable supplement to existing effort. Certainly these could be compatible with a longlining operation, or an off-shore gillnet vessel.

The technology may also prove to be adaptable to harvest other commercial species such as squid. The ability to reprogram the microprocessor means that these have the potential to be used with any species that can be harvested by hook.

Personnel

The author of this report, John Williamson, was also the captain and principle investigator for this project. I have been a commercial fisherman since 1974. I have worked in the Alaska salmon driftnet fishery, I had a troller in the Florida king mackerel fishery, and in the Gulf of Maine I have run or worked on gillnetters, off-shore lobster boats, and small draggers.

Alan Vangile served as crewman. He also has been a commercial fisherman for over twenty years, having fished in Alaska and in New England in the groundfish, lobster and tuna fisheries. The vessel leased for this project belonged to him.

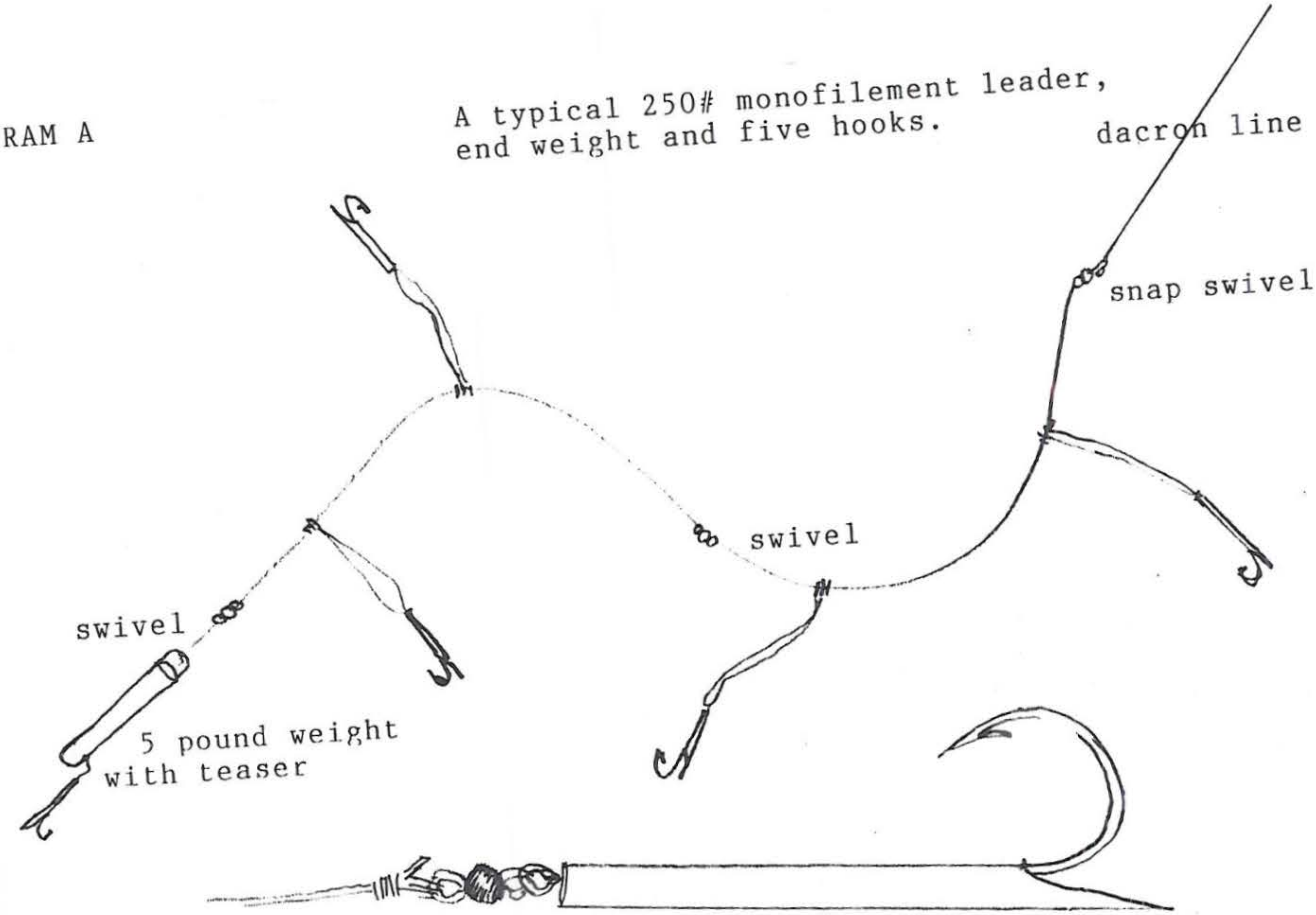
Roland Barnaby of the University of New Hampshire Sea Grant, acted as advisor. He has an extensive background in fishery innovation, as well as having owned or operated lobster boats, gillnetters and small draggers.

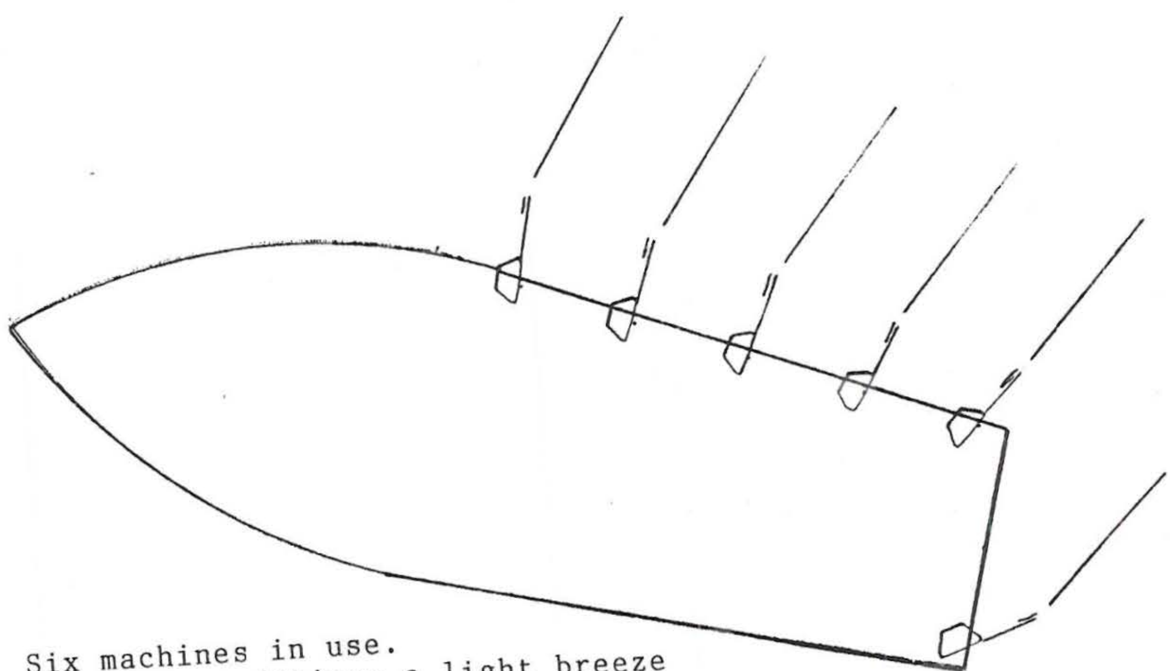
Raymond Gilmore of Smith and Gilmore Charter Boats acted as an advisor on gear handling.

Dr. Hunt Howell of the University of New Hampshire Coastal Lab served as advisor on the biological studies. Two graduate students with the Coastal Lab, Elizabeth Fairchild and Deb Bidwell, helped to compile the age and size distribution data.

DIAGRAM A

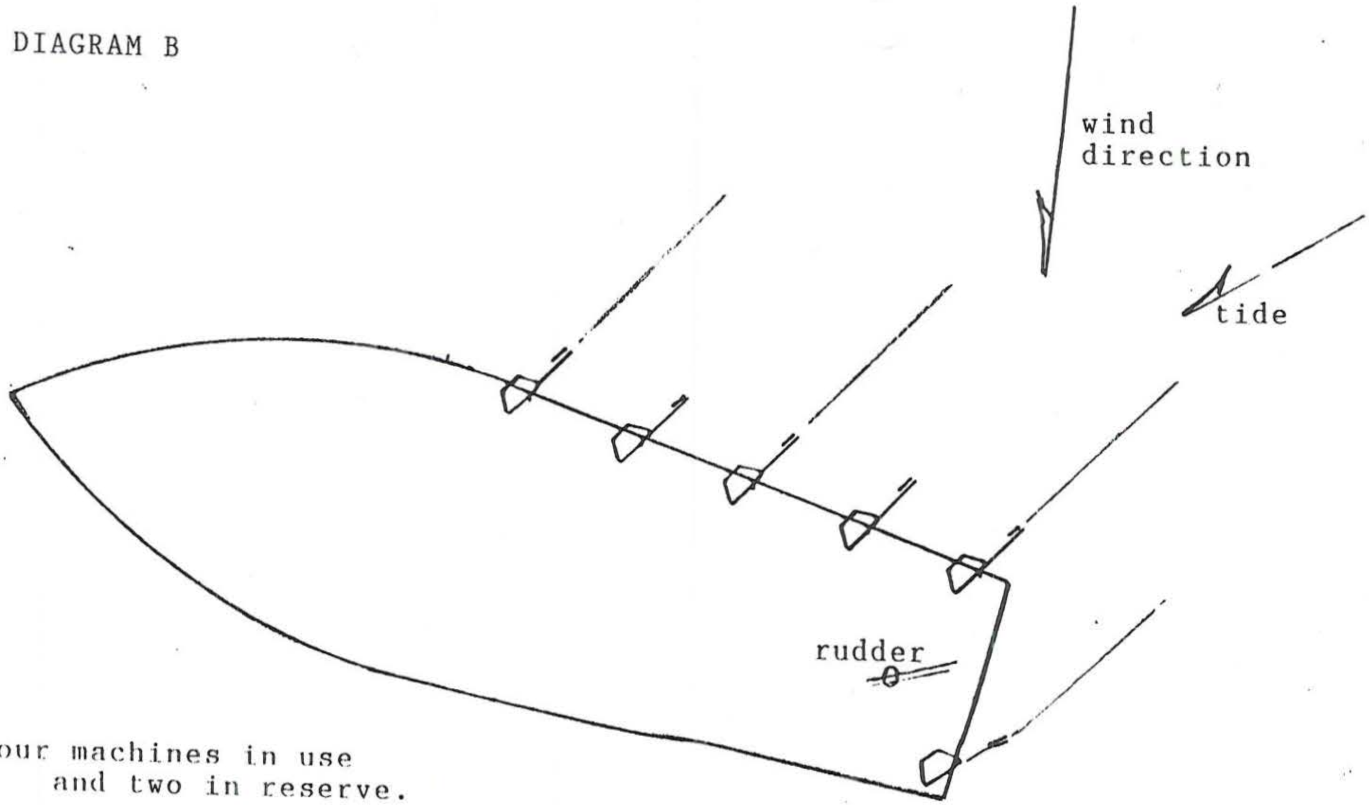
A typical 250# monofilement leader, end weight and five hooks.



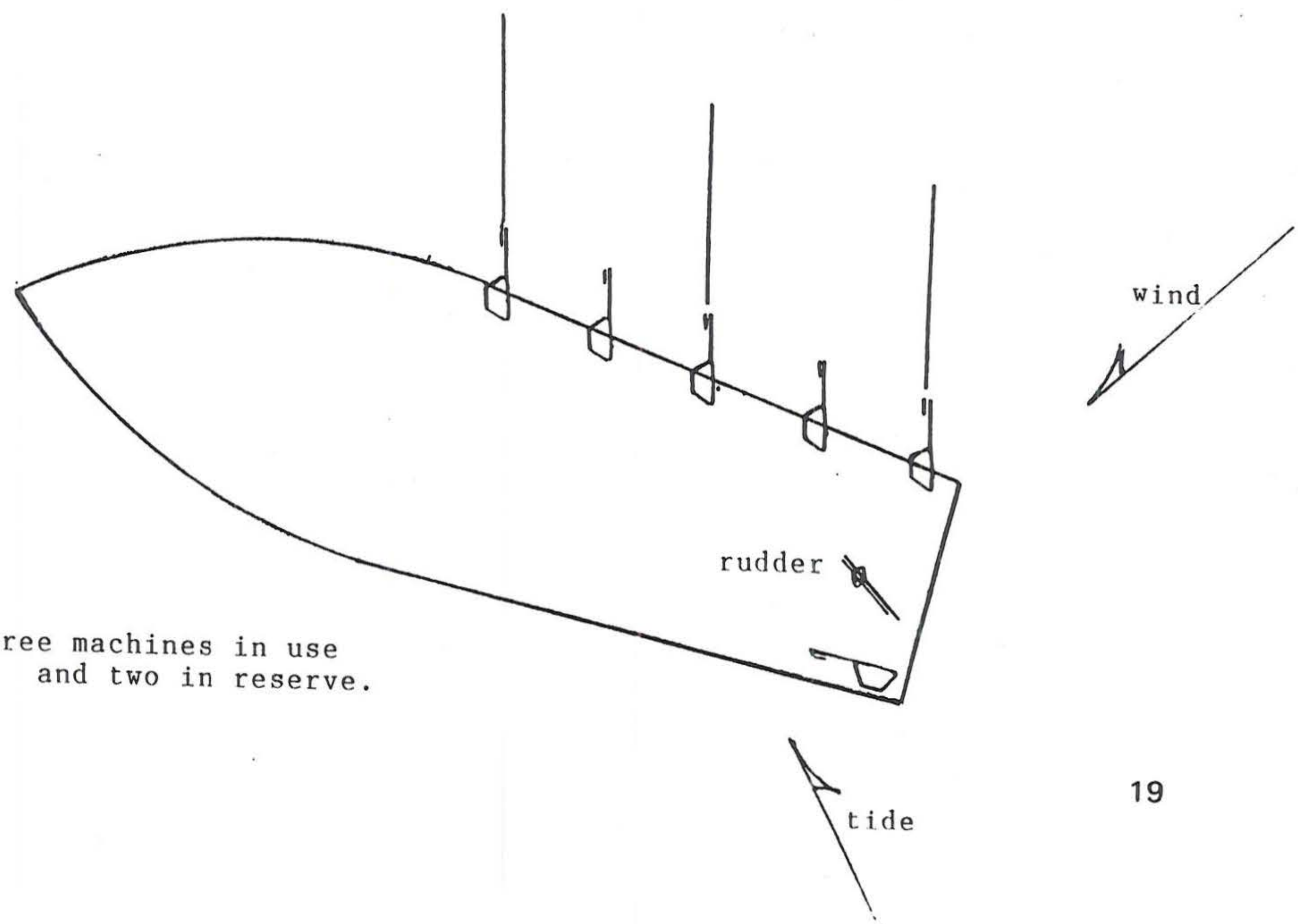


Six machines in use.
Ideal conditions,a light breeze
and slack tide.

DIAGRAM B



Four machines in use
and two in reserve.



Three machines in use
and two in reserve.

Fishing on the
Thorsofn Penninsula,
Iceland

Fishing in New England

A typical Icelandic
jig fishing hull.

SÓMI 860

Length: 8.59 m.
Beam: 2.59 m.
Deadweight: 3.8 tonnes
Gross tonnage: 5.9 tonnes

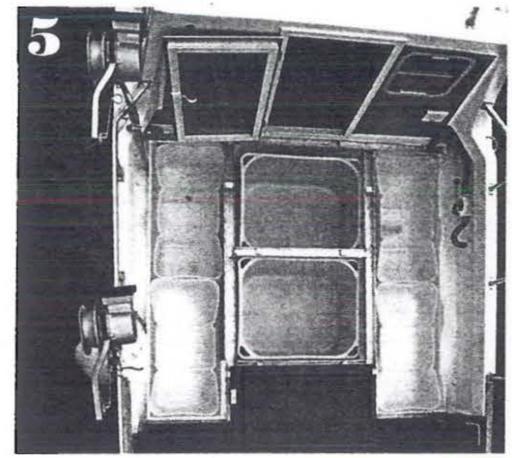
The SÓMI 860 is a new fishing boat produced at Batasmidja Gudmundar based on the design of the immensely successful SÓMI 800, a favorite among fishermen all around Iceland as well as in Greenland and the Faroes.

The SÓMI 860 is larger than its predecessor, 8.60 m overall (28') with a gross tonnage of 5.9 tonnes. All alterations have been made with a view to making the SÓMI 860 a better working boat with increased deck space, larger fish holds and greater carrying capacity.

The standard engine in the SÓMI 860 is a 306 hp Volvo Penta diesel engine with direct drive delivering a performance of 29 knots. Normal cruising speed is 20-25 knots. This exceptional speed is achieved by the boat's planing ability, which reduces drag and improves fuel economy in the bargain.

The cabin features rugged teak fittings, benches which double as berths, table, lockers, cooking facilities and W.C.

Wheelhouse equipment includes all controls as well as electronic navigational and fish-finding equipment and a chart table.



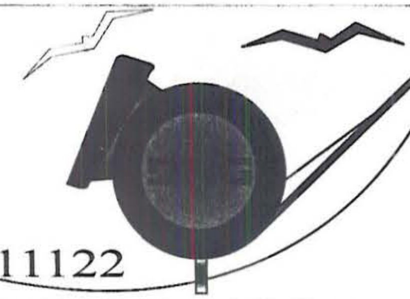
1 SUPERSTRUCTURE

The SÓMI 860 superstructure features six windows and a skylight/emergency hatch on the cabin roof. The mast will carry all aerials, navigational lights and deck lights. Windshield wipers.

6 ENGINE COMPARTMEN

Standard engine is Volvo Penta, 306 hp TAMD 61 A. Four batteries in engine compartment along with pumps and other engine-driven equipment.

The fishing year for jig fishermen in Iceland --- layover days are circles on the calender. 135 days off.



Banndagar krókabáta
frá 1. september 1994 til 31. ágúst 1995

September

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