RESPONSIBLE FISHERIES

SUMMARY

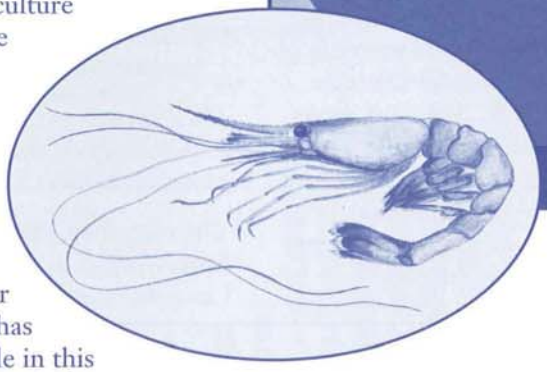
Conservation Harvesting Technologies – Northern Shrimp Fishery

October 1996

1.0 Introduction

The development and implementation of responsible fishing practices is a fundamental component in achieving long-term sustainable growth in the fisheries of Canada, and of all other nations.

Recognizing that fisheries should be conducted in a responsible manner, the Food and Agriculture Organization of the United Nations (FAO) has developed an *International Code of Conduct for Responsible Fishing*, in consultation with member countries. Canada has played an active role in this initiative. Our fishing industry now agrees that a truly Canadian Code of Conduct for Responsible Fishing must be developed in this country as a cooperative effort between the industry and government.



It is expected that the development of Canadian fisheries based on responsible fishing practices and industry-government cooperation will result in:

- A code of practice that includes an industry-government partnership.
- Cost-effective, safe and sustainable commercial fishing operations.
- Future market stability and international demand for Canadian fish products.
- An orderly and effective change-over in responsibility for fisheries harvesting to industry.
- Continuing of the move to conservation harvesting in all Canadian fisheries to avoid resource and energy waste.
- Promotion of a "greener" image for the industry.

The Northern Shrimp fishery is a good example of a harvesting sector that has already achieved significant progress toward achieving these objectives. This fisheries resource is also well managed, as reflected by the fact that annual landings have continued to increase relatively steadily since this fishery was established.

A typical northern shrimp trawler

The offshore shrimp fleet has made significant progress in improving its conservation performance, particularly in regard to the significant reductions in bycatches of groundfish that have been achieved.

This Canadian fleet is now considered to be the most conservation-oriented of any offshore shrimp fleet in the world. This fishing industry sector also strongly supports the concept of partnering with government in the co-management of this fishery, including a willingness to assume a major part of the cost of managing this fishery.

The industry is well organized to assume such responsibilities, and the association representing the vessel

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owners is one of the first to begin negotiations with Fisheries and Oceans Canada (DFO) toward achieving this goal.

A good example of such industry-government cooperation in this fishery was the Northern Shrimp Selectivity Workshop, which was organized by DFO in partnership with the Northern Shrimp Industry Association (now the Canadian Association of Prawn Producers). This workshop was held in St. John's, Newfoundland in 1993, and its purpose was to review shrimp selectivity research being carried in Canada and abroad, as well as industry consultations regarding their application in our Northern Shrimp fishery.

The recommendations resulting from this successful workshop were as follows:

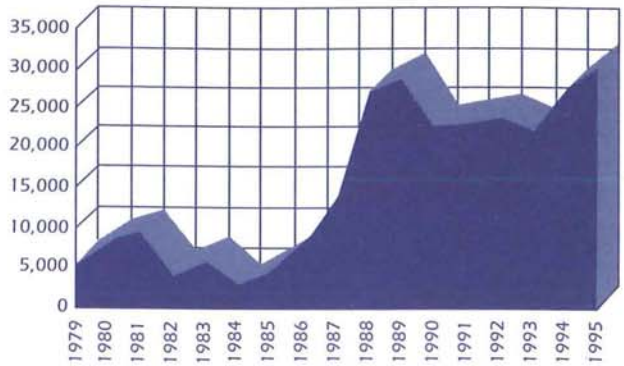
- Nordmore Grates should be used when conditions warrant to reduce the bycatch of finfish. (This was implemented as a regulation.)
- Further research should be undertaken on other gear selectivity devices.
- Current mesh sizes and shapes should be retained.
- Shrimp management areas should be rezoned and enlarged (implemented).
- Industry and government must cooperate in further research, with industry sharing part of the costs.
- Research should be conducted to determine if small redfish caught as a bycatch in the Far North recruit to any commercial fishery.

All recommendations except the last one have been implemented. The industry is planning, however, to collect samples of northern redfish this year for aging analysis.

The purpose of this document is to illustrate how one fishing sector, the Northern Shrimp fleet, has adopted many responsible fishing practices, and the beneficial effects in terms of resource conservation and economics that have resulted. The sustained harvesting levels and profitability in this fishery are also a good example of an effective and successful fisheries management system. Although most of the major conservation-oriented improvements in the fishing equipment and operational practices of this fleet have already been achieved, development work to further "fine tune" the conservation performance of this fishery are continuing.

Exhibit 1

Total Catches by the Northern Shrimp Fleet (tonnes)



2.0 The Northern Shrimp Fleet

The Northern Shrimp fishery is relatively new by Canadian standards. It developed as a result of exploratory work done by DFO in the mid-1970s. The fishery is now worth over $100 million per year and it employs over 600 people. Entry to this fishery has been limited to 17 licence-holders, and the fishing fleet currently consists of 12 modern factory-freezer trawlers over 40 m in length, some of which cost up to $25 million.

Two species of shrimp are fished commercially in Northern Atlantic Canadian waters:

- ***Pandalus borealis***, off the northeast coast of Newfoundland, Labrador and the Davis Strait, and to a lesser extent,
- ***P. montagui***, from Ungava Bay and Hudson Strait.

The Northern Shrimp fleet also fish occasionally on the Flemish Cap grounds (NAFO Div. 3M).

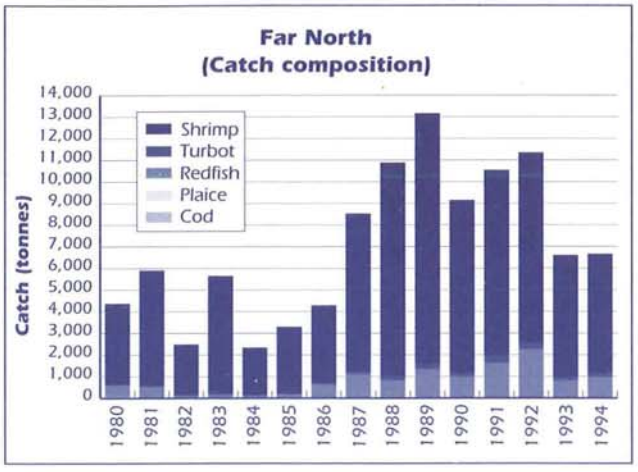
The Canadian Northern Shrimp fishery began in the mid-1970s. Landings increased rapidly during the mid-1980s, reaching 28,000 t in 1989, declining to 22,000 t in 1990, and then increasing steadily to reach 30,000 t in 1995. This relatively steady growth in catches is illustrated Exhibit 1.

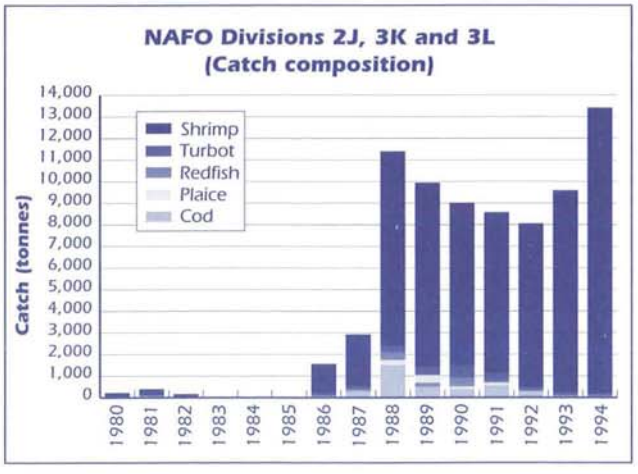
This shrimp fishery has six management areas with Total Allowable Catches (TACs) being established annually. These annual TACs are then divided into Enterprise Allocations (i.e., individual company quotas). All vessels in this fishery must have independent observers onboard at all times, with the full costs being carried by the industry.

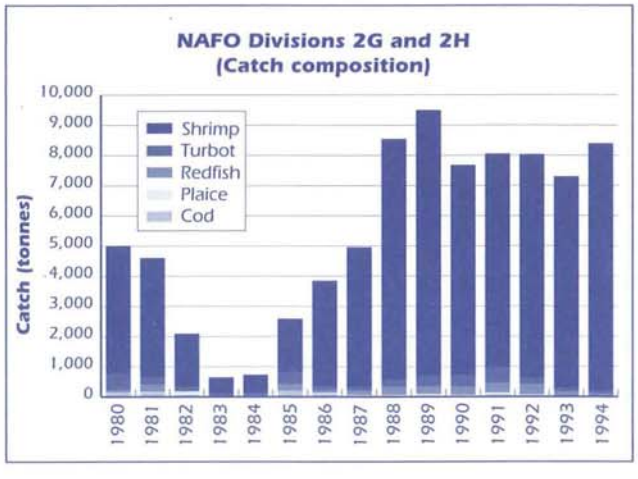
These factory freezer vessels process their catches at sea to maximize product quality and value. The largest shrimp are uncooked, individually quick frozen, and packed in 1 kg boxe. primarily for the Japanese market (i.e.,

Exhibit 2

Shrimp Catches and Groundfish By Catches by Major Fishing Area







"green" shrimp). The mid-sized shrimp are cooked, individually quick frozen and packed in 5 kg boxes primarily for the European market. The smallest, or "industrial" shrimp are frozen and shipped to "peeling" plants, which are mainly located in Europe, although some is directed to such final processing plants in Newfoundland and Quebec. Since the largest "green" shrimp product is worth three to six times more per kilogram than the small industrial shrimp (the value of the mid-sized shrimp being in between), it is in the economic interests of the vessel captains and owners to maximize the proportion of large shrimp caught within their individual quotas.

The gear used to capture shrimp is a modified otter trawl with small mesh (i.e., current minimum mesh size in Canada is 40 mm diamond). As a result, such shrimp fisheries result in the incidental capture of other fish species. The most commercially important bycatch species of this Northern Shrimp fishery are cod, redfish, turbot and American plaice. Because of the use of small mesh gear, this bycatch usually consists of small fish having no commercial value, and most of it is discarded overboard. The shrimp industry has always preferred to avoid or reduce such finfish bycatches because:

- their presence can damage the shrimp in the trawl, and increases the sorting problems and processing costs onboard the vessels, and
- the wastage of such juvenile fish is contrary to resource conservation principles.

The other gear-related problem encountered in all shrimp fisheries is the capture of small "industrial" shrimp, which is primarily an economic concern. This is not considered to be a significant resource conservation problem since Northern Shrimp abundance and catches have increased steadily during the past decade or so.

3.0 Groundfish Bycarches

Fishery observers have recorded the weight of all species in the catches of Northern Shrimp since 1980. The mandatory use of observers on all shrimp vessels since 1987, and a specific requirement of these observers to quantify all bycatch species for each fishing set, has yielded very detailed data on bycatch levels.

The following shrimp catch and bycatch data are summarized by major fishing areas as follows, since groundfish stocks and bycatch patterns do vary significantly in these areas.

- Davis Strait, Hudson Strait, and Ungava Bay (i.e., Shrimp Areas 2 and 3 in the Far North)
- NAFO Div. 2G and 2H (Shrimp Area 4 and part of 5)
- NAFO Div. 2J, 3K and 3L (Shrimp Area 6 and part of 5)

Exhibit 2 illustrates the pattern of shrimp catches and commercial groundfish bycatches in each of these areas.

Overall percentages of commercial groundfish bycatches in the Northern Shrimp fishery (i.e., totals for all areas) during the period 1991 to 1994 are shown in Exhibit 3.

Further details on shrimp catches and groundfish bycatches during 1994 are shown by major fishing area in Exhibit 4.

In general, groundfish bycatches, both in terms of weight and as a proportion of the shrimp catch, have declined dramatically in recent years, and were insignificant in 1993 and 1994. Although concerned about bycatches of redfish in some areas, DFO scientists have not identified the shrimp fishery as a significant contributor to recent declines in groundfish abundance in this area.

This reduction in bycatches has been achieved by:

- the introduction of the Nordmore Grate. This is a rigid grate that directs fish toward an "escape" opening at the top of the net, while allowing the shrimp to pass into the codend. This grate was introduced in northern Canadian waters in 1993, and used by some shrimp trawlers during that year. Based on observer bycatch records, the use of these grates was then made mandatory in areas where total groundfish bycatches exceed 300 kg per day; although many captains use them continuously;
- the decrease in abundance of most groundfish stocks; and
- an increasing conservation and responsible fishing attitude of captains and ship owners (e.g., moving fishing operations away from areas where high bycatch levels or very small shrimp are being encountered).

Examining the bycatches by fishing area and species, it can be seen that the majority of bycatch in the Far North (i.e., Davis Strait, Hudson Strait and Ungava Bay) is very small redfish. Redfish bycatches in this area appear to fluctuate on an upward trend in about a 4-year cycle, which may relate to recruitment pulses. Redfish bycatches peaked at over 25% of the weight of shrimp in 1992. Turbot, the second most abundant bycatch in the area, was only about 20% of the weight of redfish.

The Nordmore Grate is not usually used in this area because it has little or no effect on reducing bycatches. This is because the redfish are very small, mainly 10-20 cm in length, and they pass easily through the grate.

Exhibit 3

Groundfish Bycatch Trends in the Northern Shrimp Fishery – Percentage Bycatch of Catch (Total for All Areas)

Species	1994 (%)	1993 (%)	1992 (%)	1991 (%)
Cod	0.08	0.23	1.00	2.37
Plaice	0.33	0.28	0.45	0.82
Redfish	3.77	4.24	9.54	7.34
Turbot	1.48	1.88	2.41	4.73
Total	**5.61**	**6.63**	**13.40**	**15.26**

Exhibit 4

1994 Northern Shrimp and Finfish Catches (tonnes) by Major Fishing Area

Species	Davis Strait/ Ungava Bay (SA 2&3)	NAFO Div. 2GH	NAFO Div. 2J3K
Cod	0.7	1.1	22.0
Plaice	28.3	7.3	58.3
Redfish	949.4	95.1	29.8
Turbot	197.9	109.7	98.2
Shrimp	5,485.0	8,181.0	13,204.0
Total	**6,661.3**	**8,394.2**	**13,412.3**

There is also a question whether or not these very small redfish in the Far North ever recruit to any of the commercially exploited redfish stocks, and further research work on this matter is required. This redfish bycatch in the Far North is considered to be the only bycatch problem of any consequence in this fishery.

In NAFO Div. 2G and 2H, while the catches of shrimp rose from about 1,000 t in 1983 to over 8,000 t in 1989, groundfish bycatch tended to stay relatively stable during that period. The proportion of all four groundfish species as a percentage of the weight of shrimp fell dramatically in 1985, perhaps reflecting a reduction in groundfish abundance in the vicinity of the shrimp grounds. Bycatches were at their lowest in 1993 and 1994 because of the effect of the Nordmore Grate together with the reduced abundance of fish on the shrimp grounds.

In NAFO Div. 2J and 3K, bycatches peaked in 1988 mainly due to cod. After 1991, they dropped to very low levels. The total bycatch of cod in this area only amounted to 22 t in 1994, compared with a shrimp catch of about 14,000 t. Such a cod bycatch level of 0.01% displays the impressive fishing selectivity that has been achieved in this fishery. This low bycatch level is particularly significant, given the traditional economic importance of the Northern Cod stock in this area.

4.0 Gear Selectivity Development

Because of the worldwide problem with bycatches from shrimp fisheries, significant gear technology development has occurred and is continuing to improve the selectivity of shrimp trawls.

As mentioned, these historical and continuing gear selectivity developments are aimed at:

- First, reducing bycatches of other species such as finfish, turtles, etc.
- Second, reducing the catches of small and less valuable shrimp.

Selectivity research and development of shrimp trawls has focussed on the Nordmore grate, alternate grate configurations such as the "V-grates" and multiple size sorting grates, codend mesh sizes and shapes, other codend features such as plasticized mesh panels and "fish eyes", as well as Lastridge ropes.

A significant amount of technical work in all of these areas has been done in Canada by DFO in co-operation with the shrimp industry. Although major improvements in selectivity have already been achieved, further experimental work is continuing to further refine or "fine tune" the selectivity of this fishing gear. Each of the technical areas of shrimp trawl selectivity will be reviewed below, together with the results of the experimental work carried out particularly in Canada.

4.1 The Nordmore Grate

The Nordmore Grate was originally developed in Norway, and it consists of a rigid grid of closely spaced bars made of steel, aluminum or telflon, as shown in Exhibit 5.

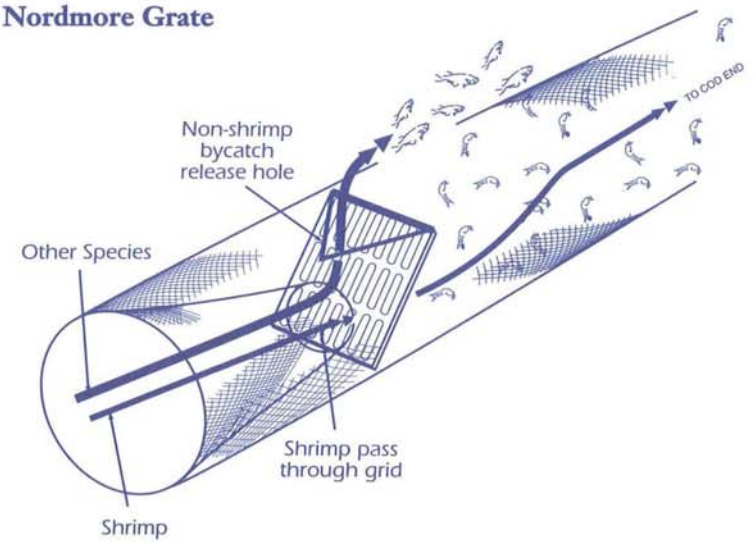
This grate attaches to the trawl net at an angle (about 50°) ahead of the codend. The grate directs fish toward an opening at the top of the net, while allowing the shrimp to pass into the codend. Guiding funnels made of fine mesh netting are usually used to direct catches to the bottom part of the grate and thereby increase the grid sorting area to which the catch is exposed.

In 1993, a major experiment was carried out on an offshore shrimp trawler to investigate the effectiveness of the Nordmore grate in reducing fish bycatches under commercial conditions.

Three different bar spacings were evaluated (22, 25 and 28 mm). All bar spacings proved to be effective in significantly reducing bycatches; the loss

Exhibit 5

The Nordmore Grate



of shrimp, however, was less with the largest spacing (28 mm) than with the 25 and 22 mm grates.

This resulted in the regulatory requirement that a grate with maximum 28 mm bar spacings be used whenever significant groundfish bycatches are encountered. Some experiments to evaluate the effectiveness of "soft" grates (i.e., constructed simply of trawl netting) have also been conducted since it was felt that such grates would be safer and easier to use than rigid grates. These were unsuccessful since finfish bycatch was worse than with a rigid grid, meshes became clogged with bycatch, and significant amounts of shrimp were lost.

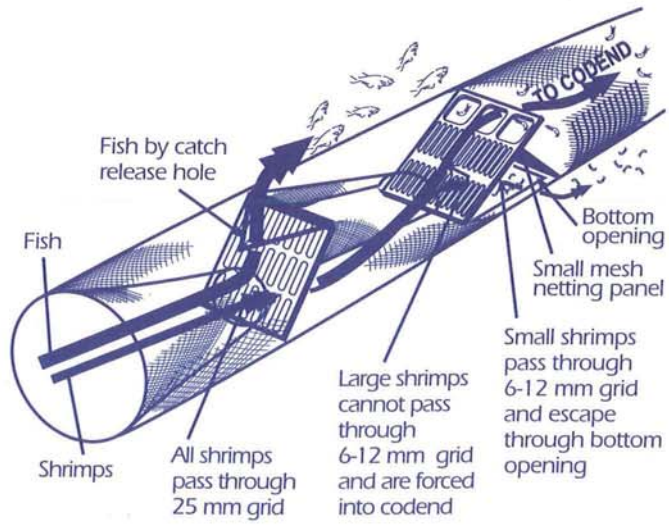
During the period 1990-1992 various experiments were also carried out in the Gulf of St. Lawrence and the eastern Scotian Shelf to demonstrate the selectivity of the Nordmore grate in the nearshore shrimp fisheries of these areas. This also resulted in the regulatory requirement that nearshore vessels use such grates while shrimp fishing in these areas.

Some of the Northern Shrimp trawlers have begun to use the grate at all times for a variety of reasons including convenience (i.e., not having to remove and install the grate depending on bycatch conditions); to further reduce bycatches; and to also protect against catches of large sharks and marine mammals, which can quickly destroy the shrimp catch if they reach the codend. In fact, some companies have made it mandatory for their vessels to use grates at all times.

The major problem in continuously using grates in this fishery include the possible loss of shrimp at the grate outlet when densities and catch rates are very high, and where bycatches of groundfish are negligible or non-existent.

Exhibit 6

Multiple Grate By Catch and Shrimp Size Sorting System



Some companies (on a voluntary basis) have also begun using grates with smaller bar spacings than the current regulatory maximum of 28 mm. Bar spacings as small as 19 mm, for example, have been used to further improve selectivity. It should be noted that the North Atlantic Fisheries Organization (NAFO) requires a maximum grid spacing of 22 mm for shrimp vessels fishing in waters outside Canada's fisheries jurisdiction (e.g., Div. 3M).

4.2 Shrimp Size Grid Selection Systems

The basic Nordmore Grate was designed primarily to reduce the bycatch of finfish. Therefore, it has not been effective in reducing catches of the smaller and less valuable "industrial" shrimp. As result, significant gear development work has been undertaken in Canada and abroad, aimed at improving shrimp size selectivity.

Most of the recent shrimp size selectivity development work, both in Canada and elsewhere, has however focussed on the use of multiple grates in the trawl. These systems show great promise, and it is expected that effective shrimp size selectivity will eventually be achieved with further technical refinement. It is also expected that the ability to size sort shrimp, will also enhance the ability of these grid systems to sort out and release very small groundfish (e.g., such as the 10-20 mm redfish caught in the Far North, as well as small cod and turbot). Although various configurations have been investigated, the basic configuration of the multiple grate or grid system is shown in Exhibit 6.

In this system, the Nordmore Grate first sorts out the groundfish bycatch, which exits the net though the Bycatch Outlet at the top of the net. After the shrimp passes though this grate, it is guided by a net panel toward the bottom of a Size Sorting Grate (i.e., having much smaller bar spacing than the first grate). The

naller shrimp are intended to pass rough this second grate and exit though an outlet at the bottom of the net. The larger shrimp reach the top of the size sorting grate and pass through openings into the codend.

The first experiment in Canada to evaluate the size sorting effectiveness of a multiple grid system was carried out by DFO on an offshore shrimp trawler in 1993.

An inverted grid system was used, and it showed promise in excluding industrial shrimp. Further tests were deemed necessary, however, especially to verify selection performance when shrimp are present in heavy concentrations.

Another experiment was conducted in 1994 on a nearshore vessel in the Gulf of St. Lawrence to determine if a single Nordmore Grate, with narrow bar spacing (12 mm) on the bottom and wider openings (25 mm) on the p portion, could size sort shrimp milarly to a multiple grid system. This approach was not successful since there was very little difference in the size of shrimp caught, and a high loss of shrimp was indicated.

Further multiple grid size sorting experiments were then carried out on various nearshore shrimp trawlers in the Gulf of St. Lawrence during 1995, using bar spacings in the size sorting grates that varied from 7 to 10 mm. A bar spacing of 5 mm was also briefly evaluated, however this was discontinued when excessive grate blockage was encountered.

These experiments indicated that the use of such size sorting systems resulted in an 8 to 9% increase in the catch of large shrimp.

Size sorting experiments also began to be carried out again in the Northern Shrimp fishery during 1995, and these are continuing.

Preliminary and unpublished results indicate that vessels using such multiple grid systems are consistently catching about 10% less industrial shrimp than other trawlers fishing in the same areas. A key technical challenge in the design of such size selection gear is to maintain significant water velocity flow through the whole multiple-grid system, since areas of low velocity in the vicinity of the grates impedes effective selection. As a result, the Marine Institute of Memorial University (under a contract with DFO) has been conducting flume tank tests of flow velocities in the grate areas of alternate gear configurations, and these are continuing.

There are two conservation concerns relating to shrimp size sorting systems. The first relates to the survival of the smaller shrimp that pass through the sorting process. The second is that the widespread use of these systems may change fishing patterns and possibly increase the mortality of the spawning female biomass.

4.3 Codend Selectivity

In addition to the use of sorting grates, the selectivity of shrimp trawls can be influenced by codend mesh sizes and shapes, as well as other adjustments or devices in the codend such as shortening Lastridge ropes, or introducing escape outlets or panels in this part of the trawl.

Technologies that have been tested in Canada and/or that are being used in other countries to improve the selectivity of codends include:

- ***Mesh Size*** — Current Canadian regulations require a minimum 40 mm mesh size (diamond) in the codend of Northern Shrimp trawls. Extensive experiments were conducted in 1993 to determine the selectivity characteristics and catch rates of codend mesh sizes of 45, 50 and 55 mm. The results indicated there was very little difference in catches of shrimp (amount and size) resulting from these different mesh sizes. Greenland increased the minimum mesh size to 55 mm and this reduced catches of industrial shrimp; however, the increased loss of large shrimp as well subsequently caused the regulation size to be reduced to 45 mm.
- ***Square Mesh*** — In 1992, an experiment was carried out with a nearshore shrimp trawler on the Eastern Scotian Shelf to evaluate the effectiveness of square mesh versus diamond mesh in reducing the catch of small shrimp. The results indicated that the square mesh codend released 40% more shrimp between 15 mm and 20 mm. A similar experiment carried out in 1993 on a Northern Shrimp vessel also indicated that the square mesh codend was more size selective.

Similar experiments in Iceland caused that country to make the use of square mesh codends mandatory in their shrimp fishery, primarily as a measure to reduce bycatches. The disadvantage of square mesh codends, however, is that they appear to result in more broken and damaged shrimp, and they are more difficult to handle.

- ***Lastridge Ropes*** — Lastridge ropes are used to reinforce the trawl and are installed lengthwise on the codend. By making such ropes shorter than the net (i.e., a "hanging ratio" less than 100%), the meshes are then looser and less distorted under towing tension, thereby facilitating the escape of small fish or shrimp. In 1993, experiments on a Northern Shrimp vessel were carried out using Lastridge ropes hung at 80%. The results indicated that the use of such ropes showed some promise; however, further tests are required to assess the effects of varying hanging ratios.

- ***Large Mesh Panels and Outlets*** — Other approaches for improving the selectivity of codends have included the insertion of escape panels with larger and/or plasticized meshes, or the installation of escape outlets (i.e., "fish eyes"). Such "fish eyes" have been found to be effective in reducing fish bycatches in the southern US shrimp fishery. The use of large square mesh panels in the Australian and US shrimp fisheries has also been effective. Only one experiment to evaluate the effectiveness of plasticized large mesh panels has been conducted in the Canadian Northern Shrimp fishery, and was inconclusive.

5.0 Conclusions

The Northern Shrimp fishery has been one of the most successful fishery sectors in Canada, from both a resource conservation and an economic point of view.

Although most of the major gear selectivity improvements in this fishery have already been achieved, further technical development in this area may still be justified to "fine tune" this conservation harvesting technology. Specific areas for additional experimental and design work include:

- Further evaluations of the optimum bar spacings in the Nordmore Grates and the conditions for their continued use.
- Experimental trials and design refinements of multiple grid, shrimp size selection systems.
- Additional investigation of the various devices to further improve the selectivity of codends, as described above.

There is optimism that conservation harvesting technology and operations will continue to be refined in the Northern Shrimp fishery for the following reasons:

- The attitude of this shrimp industry, as well as that of most other fishery sectors in Canada, has fundamentally changed in recent years to one of long-term resource conservation, in contrast to the previous widespread attitude of catching the most fish in the shortest time.
- There is growing industry acceptance of the principles of Responsible Fishing, and broad support for the development of a Canadian Code of Conduct.
- The joint initiative of the Canadian Association of Prawn Producers and DFO to develop and sign a partnering agreement for the co-management of this Northern Shrimp fishery will further strengthen the level of industry-government cooperation, which is necessary for the effective development of responsible fishing technology and practices.
- There is a strong economic incentive for the industry to further reduce the bycatch of finfish, since it damages the shrimp in the trawl and increases the problems and costs of processing onboard, and to reduce the catch of small shrimp because of its much lower value.
- Finally, the fishing industry worldwide has increasingly been the target of criticisms and product boycotts from a wide range of environmental groups and individuals. Many of these adverse publicity campaigns have been directed against the destruction of marine resources as a result of bycatches from gillnet, purse seine and trawl fisheries. The shrimp fishery, as well as all other fishery sectors, will have to respond to these public concerns by adopting more responsible fishing practices and promoting a "greener" image.

6.0 Points of contact

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