Fisheries and Oceans
Pêches et Océans

Newfoundland Region

DFO Science
Stock Status Report # C2-05

NORTHERN SHRIMP OFF NEWFOUNDLAND AND LABRADOR

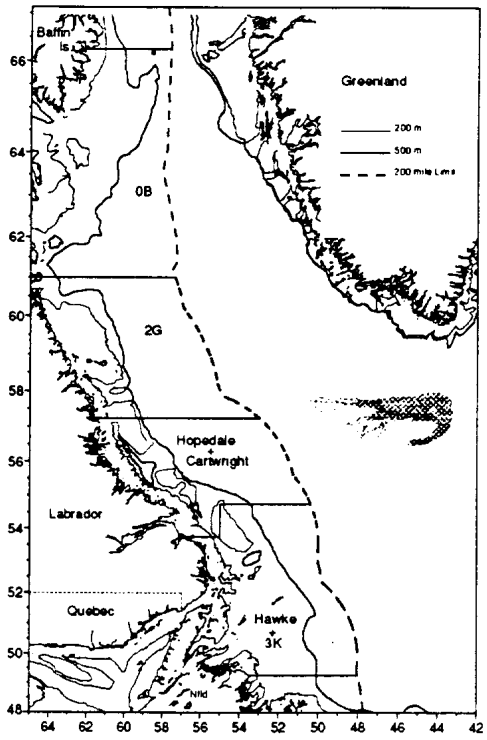
Background

Northern or pink shrimp (Pandalus borealis) are found in the Northwest Atlantic from Davis Strait to the Gulf of Maine. They live in areas where the ocean floor is soft and muddy and where bottom temperatures range from approximately 2 to 6° C. These conditions occur throughout the Newfoundland-Labrador region within a depth range of about 200 - 600 m, providing a vast area of suitable habitat. The species is the primary cold-water shrimp resource in the north Atlantic.

Northern shrimp are protandric hermaphrodites. They first mature as males, function as males from one to several years and then change sex to spend the rest of their lives as females. They are known to live for more than 8 years in some areas. Some northern populations exhibit slower rates of growth and maturation but greater longevity results in larger maximum size.

During the day, these shrimp spend much of the time resting and feeding on or near the ocean floor. At night, a substantial proportion migrate vertically into the water column, feeding on a variety of zooplankton. They are prey for many species including Atlantic cod, Greenland and Atlantic halibut, skates, wolf fish and even harp seals.

Status of the resource for each shrimp fishing area (SFA) is determined by monitoring: the fishery performance within and between years; distribution of the fishing effort; and the size/age/sex composition of the catches. Research trawl surveys in 1995 and 1996 provided data on stock size and structure for some areas. Using both sources of information, inference can be made on state of the spawning stock (female abundance), potential for future recruitment to the fishery (male abundance) and level of exploitation.



The Fishery

The shrimp fishery on the east coast of Canada began in the mid 1960's in the Gulf of St. Lawrence but it was not until the mid 1970's that an exploratory fishery developed off the east coast of Newfoundland and Labrador. During the late 1970's and early 1980's, the fishery occurred primarily in the Hopedale and Cartwright Channels and farther north in Davis Strait (Div. 0A). Annual catches increased to about 9000 tons in 1981 but then declined to only 3000 tons in 1984. Since then, however, catches have steadily increased, the 1996 catch of more than 30,000 tons being the highest reported. This increase was due to continued

high abundance in traditionally fished areas and the discovery of new fishing grounds throughout the Division 0B-3K area.

About 12 large, offshore trawlers are currently fishing 17 northern shrimp licences. These vessels use small-meshed otter trawls which are fitted with sorting grates to avoid by-catch while retaining the shrimp. Most of the catch is processed on board as either cooked or frozen product. The smallest or "industrial" shrimp is frozen in bulk for processing on shore.

The total allowable catch (TAC) for each fishing area is divided by 17, representing each participant's enterprise allocation (EA). The preferred species, for which most of the TAC's apply, is *Pandalus borealis*. Striped shrimp (*P. montagui*) occur at times as by-catch and, near Hudson Strait (SFA 3), represent the target species. The northern shrimp fishery requires 100% observer coverage to monitor activity and conduct sampling of the catches.

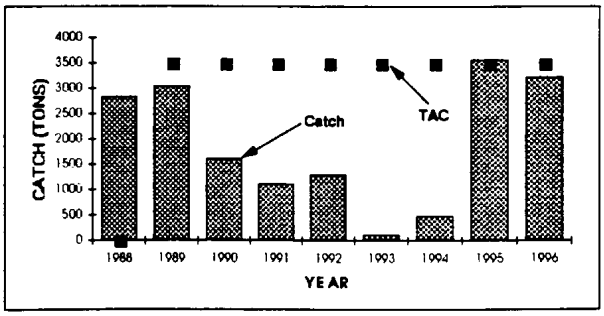
For the first ten years, this was primarily a summer-fall fishery but, since the late 1980's, has become a year-round operation.

NAFO DIVISION 0B (SFA 2)

FISHERY DATA

Catch and effort

The northern shrimp fishery in Division 0B began in October, 1988. Catches increased from about 2800 tons that year to 3000 tons in 1989 but subsequently declined to 100 tons in 1993. Catches increased to just under 500 tons in 1994 and to more than 3000 tons in both 1995 and 1996. TAC's have remained at 3500 tons since first implemented in 1989.



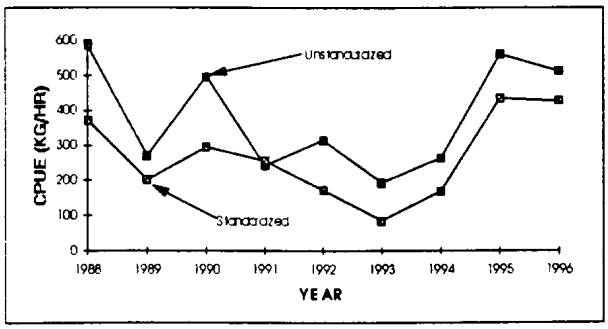
The 1995 and 1996 catch estimates are preliminary and likely influenced by catches of the striped shrimp, *P. montagui*, from the area east of Resolution Island.

Fishing effort for *P. borealis* increased substantially from 1988 to 1989, decreased to 1993 and increased again to 1995. Effort in 1996 was about the same as in 1995. In 1988, the fishery occurred north of 64^0 N with occasional tows near 66^0 N. Effort in 1989 was concentrated between 64^0 and 65^0 N but extended as far south as 62^0 N. More effort was distributed south of 64^0 N in subsequent years. The areas fished in 1995 and 1996 reflected the targeting of *P. montagui* east of Resolution Island.

Catch per unit effort (CPUE)

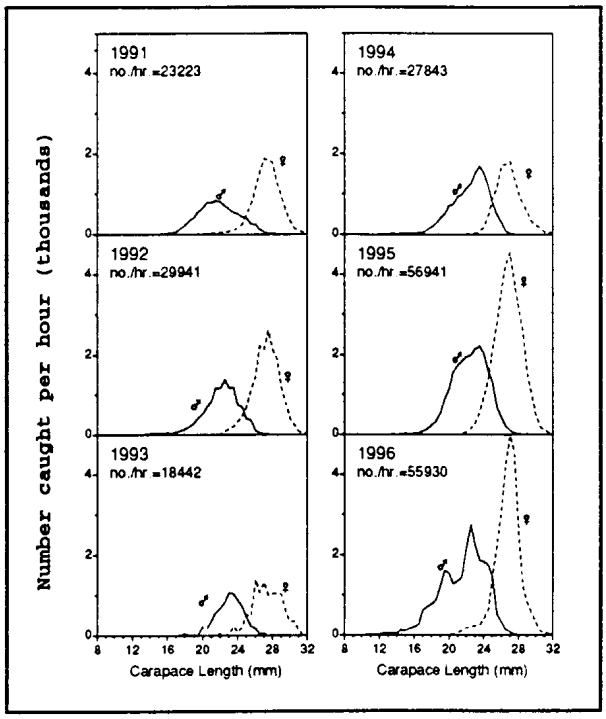
Annual CPUE's decreased from 585 kg/hr in 1988 to 271 in 1989 and increased to 497 in 1990. Catch rates decreased during 1991 - 1994 to the 200-300 kg/hr range but increased to more than 500 kg/hr in both 1995 and 1996. The data were analyzed to account for variation due to year and vessel effects. The model showed that the standardized, 1996 catch rate of 427 kg/hr was similar to the

1988, 1990 and 1995 estimates and higher than those of the remaining five years. Both series showed an overall declining trend to 1993 and an increase to 1995/96. No seasonal pattern in CPUE was evident.



Size composition

Catches in most years were composed primarily of large, female shrimp with an average carapace length (CL) of about 27 mm. Occurrence of higher proportions of the male component (<25 mm) after 1988 was coincident with the southward shift in fishing effort. In 1994, catches comprised both large males (23 - 24 mm) and females whereas, in both 1995 and 1996, the female component was dominant. Several size/age groups of male shrimp were evident in 1996.



RESOURCE STATUS/PERSPECTIVES

This area is difficult to fish due to the presence of ice and the apparent sudden shifts in water masses that are thought by fishermen to affect shrimp distribution. They have observed that shrimp concentrations throughout the area are elusive. This contrasts the situation in several southern locations where areas of high concentration support substantial levels of effort and CPUE, and persist from year to year. Nevertheless, fishermen believe that this large management area can support a higher level of exploitation and that the current TAC of 3500 tons is restrictive.

The status of this resource remains uncertain. CPUE is not considered to be a reliable index of stock conditions in this area. Fluctuations in both catch and catch rates are more likely a reflection of the degree of difficulty in locating concentrations of shrimp than they are

indicators of significant changes in the resource abundance. High catch rates still occur sporadically throughout the fishing area and, in 1995 and 1996, were frequently encountered in the southwest, east of Resolution Island as a *P. borealis/montagui* mixture. No research vessel surveys have been conducted or are planned for the area.

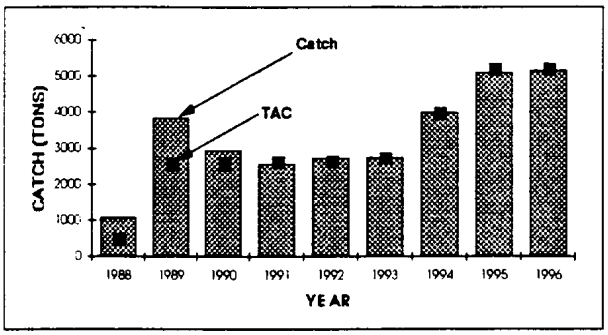
Although there is no biological basis on which to advise an increase in the TAC of 3500 tons, it is noted that four years of catches in the order of 3000 tons have not produced any detectable negative effects on the resource. The TAC was initiated as a precautionary level in an exploratory area. This "experimental" approach could be continued by providing for a substantially higher TAC for the 1997 - 1999 period. Any increase should be high enough to represent a significantly greater level of exploitation and the effects of the increase should be closely monitored.

NAFO DIVISION 2G (SFA 4)

FISHERY DATA

Catch and effort

Only incidental catch and effort were reported from Division 2G before 1988. Catches increased from about 1100 tons in 1988 to 3800 tons in 1989 and remained within the 2500 - 3000 ton range up to 1993. The 1994 catch increased to almost 4000 tons with an increase in TAC in the first year of the 1994 - 1996 Management Plan. A second, planned increase to 5200 tons for 1995 and 1996 resulted in catches at that level in both years.

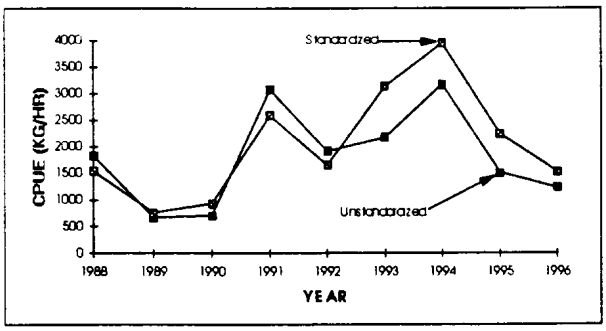


Fishing effort increased from 1988 to 1989, decreased to 1991 and remained relatively stable up to 1994 before increasing again in 1995 and 1996. From 1988 to 1990, the fishery occurred throughout the area which, during that period, was split into two management zones, north and south of 60^0 N. The 1991 - 1993 Management Plan combined the two zones and, since then, effort has concentrated in the north. Substantial by-catches of *P. montagui* were encountered at some locations both in 1995 and 1996.

Catch per unit effort (CPUE)

Annual CPUE's for the whole management area declined from about 1800 kg/hr in 1988 to 700 in 1989 and 1990. In 1991, the catch rate increased to more than 3000 kg/hr as fishing effort concentrated in the northern grounds. High CPUE's in the range of 2000 to 3000 kg/hr were maintained up to 1994 but declined to 1500 and 1200 kg/hr in 1995 and 1996, respectively. The CPUE data were analyzed to account for variation due to year, month and vessel effects. The model showed that the annual, standardized catch rate in 1996 for the whole area was lower than those of the previous three years and higher than the 1989 and 1990 estimates. The series showed an overall increase from 1989 to 1994,

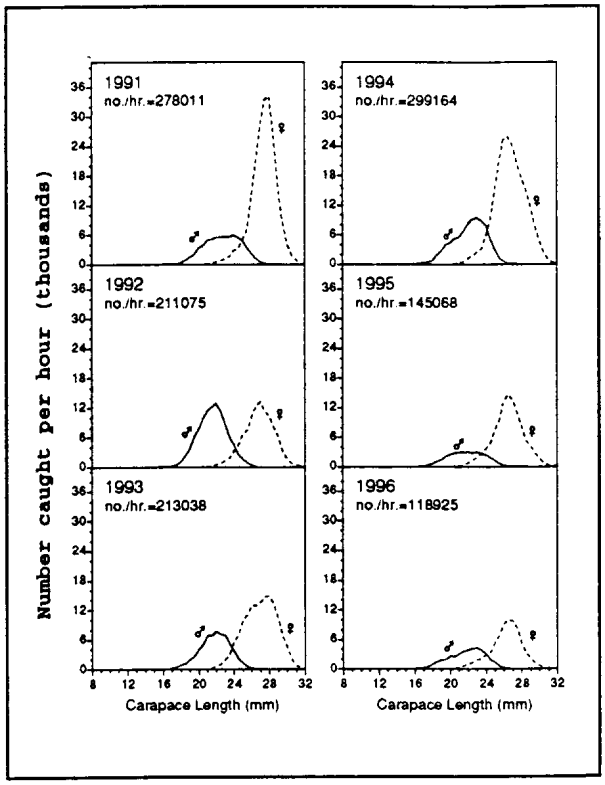
followed by a decrease to 1996, similar to the unstandardized rates.



The preferred fishing area (north of 60^0 N) is noted for producing high catch rates of large shrimp. The trend in unstandardized CPUE in this area was similar to that for the whole area. Standardized catch rates indicated that the 1995 and 1996 CPUE's were substantially lower than the 1993 and 1994 estimates.

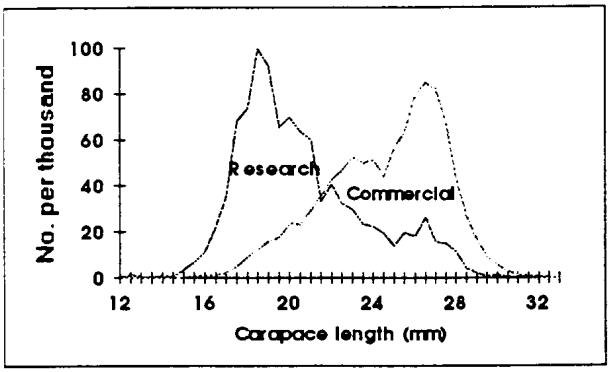
Size composition

High proportions of male shrimp (< 25 mm CL) and overall lower catch rates in 1989 and 1990 reflect the fishing activity south of 60^0 N in those years. Large female shrimp dominated in 1991 when effort shifted to the preferred northern grounds. Since then, the female component dominated the catches by number and weight in most years. In 1996, two distinct size groups of females about 24 and 27 mm were evident in the sampling data. The larger size is typical for the preferred area while the smaller is characteristic of more southerly fishing areas.



RESEARCH SURVEY DATA

The 1996 fall multi-species research survey in Div. 2G did not provide sufficient sampling for the estimation of shrimp biomass. Only 44 fishing stations were occupied and coverage was sparse in depths > 300 m in some areas, including the preferred fishing area. Length distributions showed a predominance of male shrimp (73% by number) and two size groups of females at 23 and 27 mm CL. The occurrence of the smaller female component, particularly in depths between 250 and 300 m, is consistent with the commercial sampling data for 1996. Fall research surveys, with increased sampling, can provide estimates of minimum biomass and show potential for the development of a recruitment index.



RESOURCE STATUS/ PERSPECTIVES

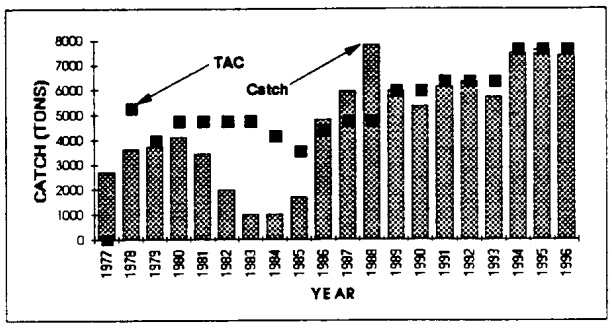
Although the continued occurrence of high densities of large, female shrimp in the northern grounds indicates that a healthy spawning biomass is being maintained, fishermen are concerned about the recent decline in CPUE. This decline was coincident with catches (and TAC's) increasing from 2700 tons in 1993 to 5200 tons in 1996. No biomass estimate is available from which inference can be made on the recent level of exploitation. There is no basis on which to advise an appropriate level of TAC.

HOPEDALE & CARTWRIGHT CHANNELS (SFA 5)

FISHERY DATA

Catch and effort

The northern shrimp fishery in Hopedale and Cartwright Channels began in 1977, following exploratory fishing in the previous two years. Catches increased from about 2700 tons in 1977 to 4100 tons in 1980, declined to 1000 tons in 1983 and 1984, increased again to 7800 tons in 1988 and then stabilized at roughly 6000 tons during the 1989 - 1993 period. The TAC's for the 1994 - 1996 Management Plan, which combined the two channels as a single management area, were increased by 20% to 7650 tons annually and catches subsequently increased, averaging 7500 tons during that period.



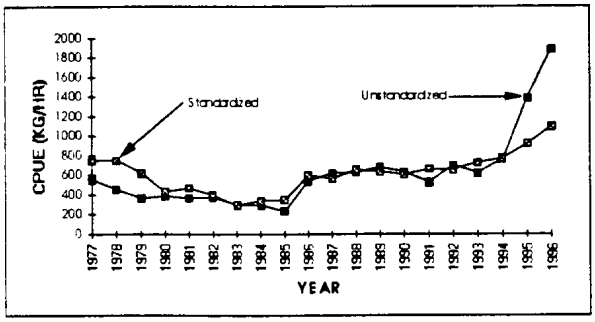
The proportion of the annual catch taken in and near Cartwright Channel, in the south, has increased from about 25% during the 1991 - 1993 period to 42% in 1994, 78% in 1995 and 90% in 1996.

Fishing effort showed approximately the same trend as catch up to 1992. In recent years, however, effort has decreased while catches have increased. Traditionally, effort has concentrated in four main areas: northern, eastern and southern Hopedale Channel and Cartwright Channel. In the 1990's, however, more effort was reported from the slopes of the shelf - north and east of Cartwright Channel. From 1994 to 1996, substantial effort occurred on the eastern slope during winter and spring.

Historically, a summer - fall fishery, in 1995 and 1996 it has become a winter - spring operation.

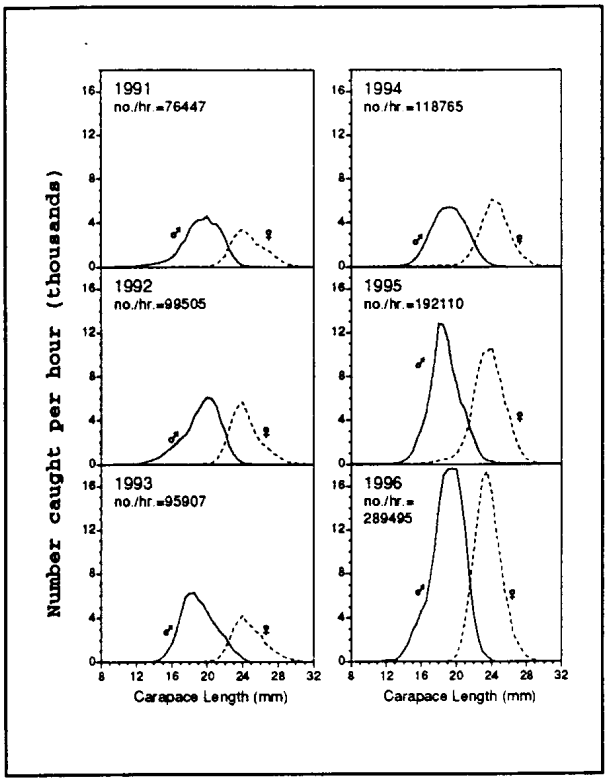
Catch per unit effort (CPUE)

Annual CPUE's declined from 552 kg/hr in 1977 to 230 in 1985, increased in 1986 and stabilized around a mean level of 615 kg/hr during the 1986 - 1993 period. Catch rates increased, thereafter, to 757 kg/hr in 1994, 1387 in 1995 and 1887 in 1996. The CPUE data were analyzed to account for variation due to year, month, vessel and area effects. The standardized 1996 catch rate of 1094 kg/hr was the highest in the time series and was significantly higher than the estimates in all years except 1978. Both series show approximately the same trend: a decline to the mid 1980's, a large increase in 1986 followed by stability to the early 1990's and an increase thereafter.



Size composition

Sampling data from 1988 to 1996 showed a component of females at 24 - 25 mm CL occurring each year. Recruitment of males between 16 and 23 mm has been consistent from year to year and males have contributed substantially to the catch in numbers. Both the male and female components showed increases in catch rates from 1994 to 1996. The length at which females begin to dominate the size distributions was smaller in 1995 and 1996 than seen in previous years.

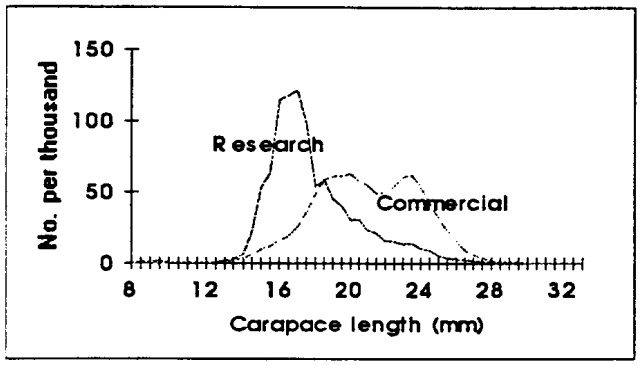


RESEARCH SURVEY DATA

The 1996 fall multi-species research survey provided data on stock size and composition for shrimp in the Hopedale + Cartwright management area. The preliminary biomass estimate was 235,000 tons with 95% confidence intervals of 0 and 609,000 tons. Two trawl stations which produced large catches were highly influential to the biomass estimate. By omitting these stations from the analysis, a minimum biomass of 82,000 tons was estimated with confidence intervals of 51,000 and 112,000 tons.

Length distributions showed a predominance of male shrimp (about 90% by number) throughout the survey area. The modal size structure did not conform to the growth model for this area but was consistent with the model

for the southern management area. Using the latter, most males are thought to belong to the 1993 year class. This implies either a change in growth within the area or immigration from the south. The change in the length at which females begin to dominate the size distribution, noted above for the commercial data, is consistent with the alternative growth model.



Fall research surveys can provide reliable estimates of minimum biomass and show potential for the development of a recruitment index. However, a time series of estimates is required before such information can be used quantitatively in the assessment process.

RESOURCE STATUS/PERSPECTIVES

The northern shrimp resource in the Hopedale and Cartwright Channels remains healthy with commercial catch rates stable over the late 1980's and increasing for both male and female components in recent years. Data from the research survey and commercial fishery in 1996 suggest that year classes produced in the early 1990's will maintain high catch rates for the next few years. Preliminary data from daily vessel hails show that the 1997 fishery has performed well in January and February, with monthly catch rates similar to those for the same months in 1995 and 1996.

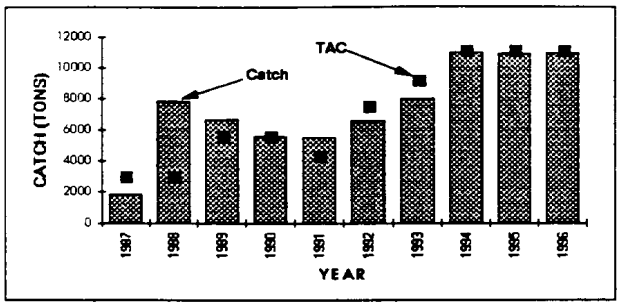
The 1996 catch of 7400 tons, when compared to either estimate of minimum biomass, reinforces the view that the impact of past fishing has been minimal. Given the current, positive view of the state of the resource and evidence of continued good recruitment in the next few years, an increase in the TAC for the next three years appears justified. Such an increase could be substantial.

HAWKE CHANNEL + DIV. 3K (SFA 6)

FISHERY DATA

Catch and effort

The shrimp fishery in Hawke Channel + Div. 3K essentially began in 1987 when 1845 tons were caught. Previously, only a few tons had been reported from Hawke Channel in some years. Catches increased to more than 7800 tons in 1988 and ranged between 5500 and 8000 tons from 1989 to 1993, inclusive. The annual TAC for the 1994 - 1996 Management Plan was set at 11,050 tons (20% more than the 1993 TAC) to include Hawke Channel, St. Anthony Basin, east St. Anthony, Funk Island Deep as well as three exploratory areas on the seaward slope of the shelf. Catches increased to 11,000 tons in each of the three years.



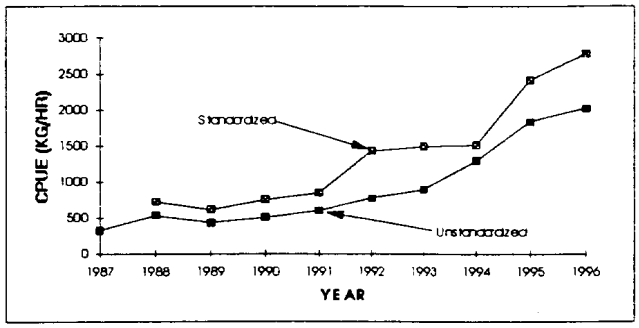
Fishing effort declined from 1989 to 1992, stabilized or increased slightly to 1994 and declined from 1994 to 1996. A displacement of fishing effort to the east occurred after 1991 due to several factors: the establishment of exploratory areas on the shelf slope in 1992 and 1993, the discovery of concentrations of shrimp in these areas, the occurrence of ice in winter and spring each year and the flexibility to fish recent TAC's anywhere within the large management area.

The fishery occurs, primarily, during the first five months of the year.

Catch per unit effort (CPUE)

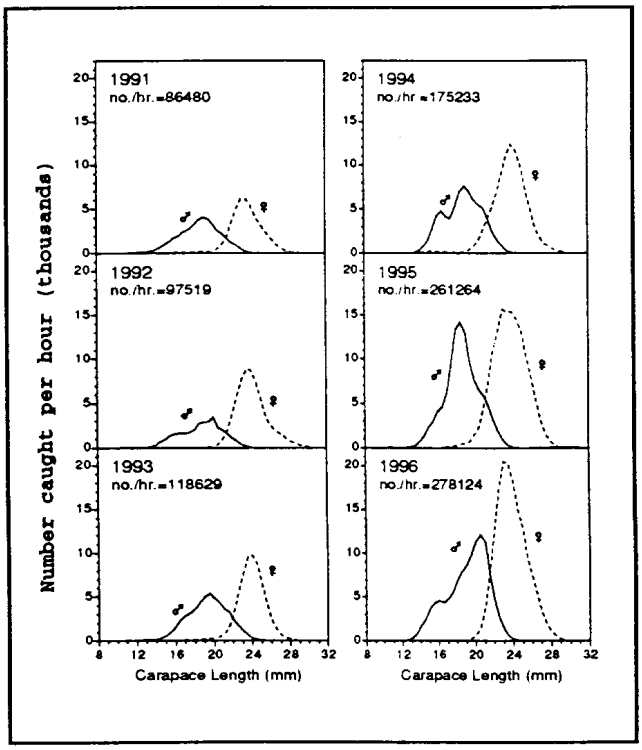
Annual CPUE's decreased from 536 kg/hr in 1988 to 432 in 1989 and increased steadily thereafter to 2020 kg/hr in 1996. The data also were analyzed to account for variation due to year, month, vessel and area effects. Standardized values showed the same overall increasing trend as the unstandardized series.

Despite high proportions of the total catches taken in the Hawke Channel area during the 1994 - 1996 period, catch rates for those grounds alone also continued to increase. Similarly, the 1997 fishery, to date, has concentrated in the Hawke Channel area and catch rates for January and February have remained high, at or above the 1995 and 1996 levels.



Size composition

Length frequencies from 1988 to 1996 showed dominance of the female component around 24 mm CL in most years.



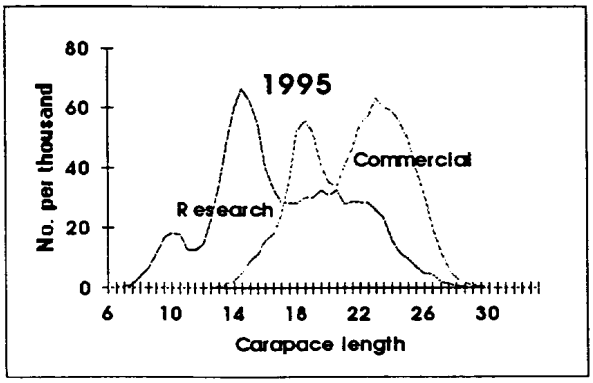
The relatively strong size group at 16 mm in 1994 (the 1991 year class) dominated the male component at 18 mm in 1995 and at 20 mm in

1996. The 1992 and 1993 year classes are also well represented at 18 and 16 mm, respectively, in the 1996 samples.

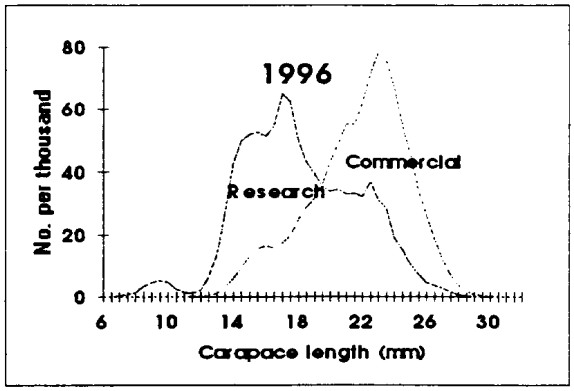
RESEARCH SURVEY DATA

The 1995 and 1996 fall multi-species research surveys provided excellent data on stock size and composition for shrimp within the management area. Shrimp were widely distributed and abundant throughout Hawke Channel + Div. 3K in both years with catches over much of the area exceeding 50 kg per 15 minute tow. The minimum trawlable biomass estimated in 1995 was 308,000 tons with 95% confidence intervals of 235,000 - 381,000 tons. The 1996 preliminary estimate was 580,000 tons (457,000 - 703,000 tons). About 46% of the 1995 estimate was male shrimp compared to 60% in 1996.

Length distributions from the 1995 survey showed the dominance (in numbers) of the 1993 year class at approximately 14 mm CL and clear representation of the 1994 year class at 10 mm.



In 1996, the 1993 year class was prominent at 17 mm, the 1994 strongly represented at 14 mm and the 1995 apparent at 10 mm. There was no indication of a change in growth for this area.



Survey coverage in both 1995 and 1996 was extensive resulting in biomass estimates that can be interpreted with confidence. The potential for a time series of surveys to provide a reliable recruitment index is even more apparent for this area with the representation of juveniles at age 1.

RESOURCE STATUS/PERSPECTIVES

The northern shrimp resource in Hawke Channel + Div. 3K is healthy and commercial catch rate data indicate that abundance has increased in recent years. Although the fall research survey time series is short, the level of biomass observed in both 1995 and 1996 confirms that shrimp are widely distributed and highly abundant. The recent level of catch is low compared to minimum trawlable biomass estimates.

Given the evidence for high abundance, a healthy spawning biomass and prospects for good recruitment to the fishery for the next few years, this resource would support a substantial increase in TAC for the next three

years. Accepting the survey results on stock size, increases would have to be several times the recent TAC level in order to approach exploitation levels which have been sustainable for shrimp fisheries in other areas.

GENERAL COMMENT

The current high level of shrimp abundance, particularly in the Hawke + 3K management area, is unprecedented in the Newfoundland - Labrador offshore area (see following map). Surveys of the early 1980's produced extremely low shrimp catches in areas where abundance now is high. It is clear that the present environment is favourable for shrimp survival. The absence of predators throughout the region implies decreased natural mortality for shrimp and the cold period from the late 1980's to the early 1990's might have contributed positively to the survival of larvae.

An opportunity now exists to expand the shrimp fishery substantially with a minimal risk of overexploitation. However, beyond the next few years, it is not possible to predict how long high abundance will last. Although water temperatures have moderated in the past year or two, there is little indication that finfish abundance is increasing. Recent conditions of low water temperature, reduced groundfish abundance and healthy shellfish populations appear anomalous and a return to more "normal" conditions at some time in the future is probable. Any plan for expansion of the northern shrimp fishery will have to address this possibility.

For More Information

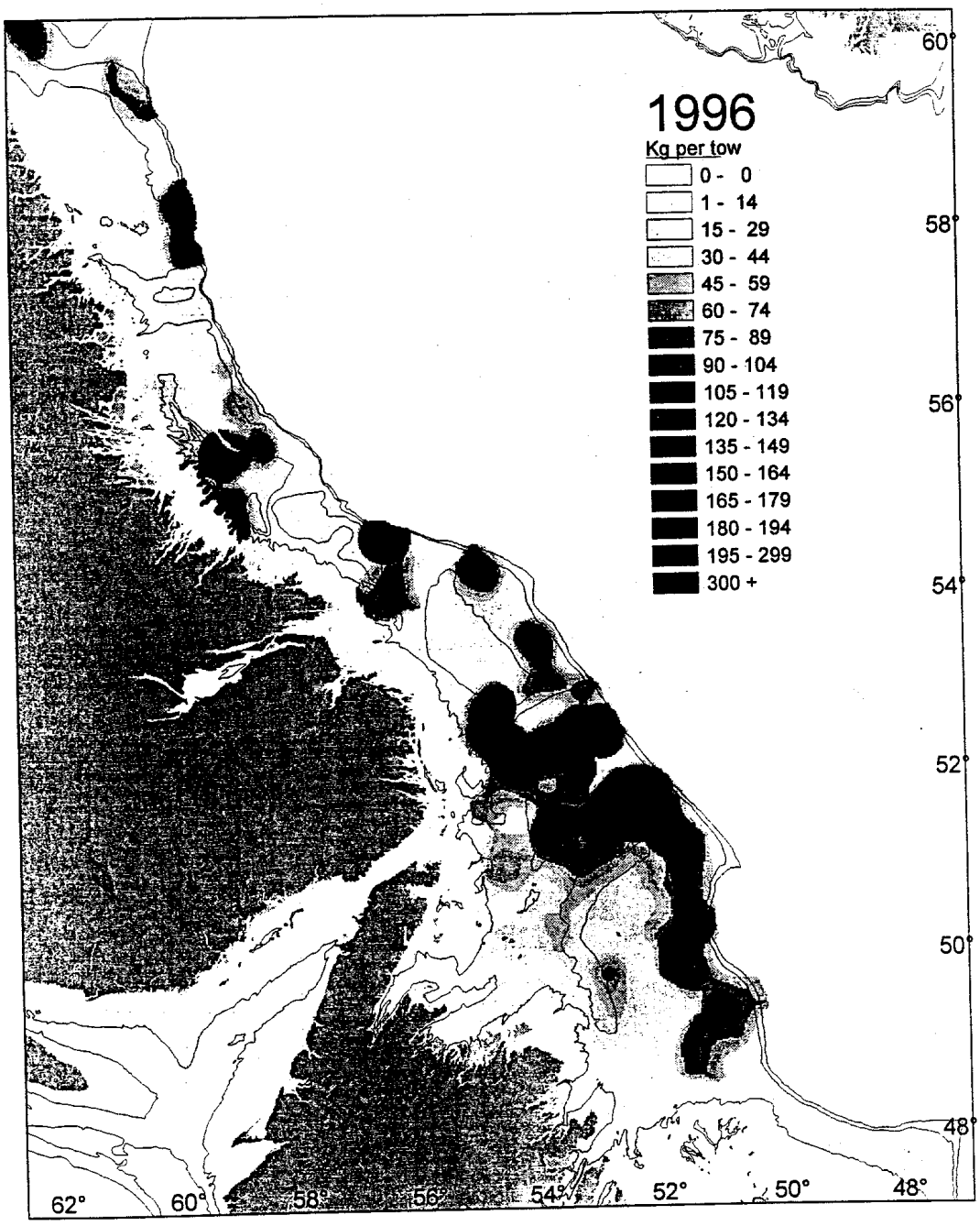
Research Document:

Parsons, D.G. and P.J. Veitch. 1997. Regional, review of the status of northern shrimp (*Pandalus borealis*) resources in areas off Newfoundland and Labrador (Divisions 0B to 3K). Canadian Stock Assessment Secretariat Research Document 97/05.

Contact:

Don Parsons
Tel. (709) 772-2093
Fax. (709) 772-4105
E-mail: parsons@athena.nwafc.nf.ca

This report is available:
Stock Assessment Regional Office
Newfoundland Region
Northwest Atlantic Fisheries Centre
P.O. Box 5667
St. John's, Newfoundland A1C 5X1
Tel: (709) 772-4355
E-mail: gperry@athena.nwafc.nf.ca



Distribution and density (kg per standard tow) of northern shrimp (*Pandalus borealis*) in the Newfoundland-Labrador offshore area determined from the 1996 research trawl survey.