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A Precautionary Approach to Assessment and Management of Pandalid Shrimp with Application to *Pandalus borealis* in NAFO Division 3M

by

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Introduction

The Scientific Council of NAFO conducted a review of the Precautionary Approach (PA) in June 1997 and developed an Action Plan that was endorsed by the Fisheries Commission at the Annual Meeting in September (NAFO, 1998a). Subsequently, a "Workshop on the Precautionary Approach to Fisheries Management" was held in March 1998. One of the terms of reference for the workshop specified that limit and target reference points be determined for all stocks under the responsibility of the NAFO Fisheries Commission. In relation to shrimp in Div. 3M, the workshop report stated that: "Due to the problems associated with lack of data and methods.…, no reliable precautionary [reference points] were selected.". The report noted, however, that: "The precautionary, qualitative "Traffic Light" checklist proposed by Caddy (SCR Doc. 98/8), was viewed positively as a first step to applying the PA to Div. 3M shrimp …..".

Following the November 1998 Meeting to assess shrimp stocks in Davis and Denmark Straits, shrimp specialists met for an additional day to further discuss the PA and to consider the selection of references and reference points in preparation for the spring 1999 meeting of Scientific Council. Although one day was not sufficient to complete the task, discussions were continued over several weeks through e-mail. It soon became evident that the identification of quantitative references, reference points, targets, limits, etc. was not the approach of choice and that efforts would concentrate, in the short term, on the development of stock-specific checklists that would include multiple, qualitative indicators of resource status.

Regional stock assessments for shrimp in the Estuary and Gulf of St. Lawrence and the Newfoundland-Labrador-Baffin Island offshore area early in 1999 were conducted using a traffic-light/checklist approach and served as a first test of the method. This paper reports on the recent experience of applying the approach to the assessment-management process in these areas. We also present a version designed for shrimp in Div. 3M (Flemish Cap) for consideration at the 1999 spring meeting.

Evolution of the "Traffic Light" Framework

The Precautionary Approach (as interpreted by agencies such as NAFO and ICES) involves a number of concepts that, for some time, have served as the basis for the assessment of shrimp stocks.

The use of three categories to describe the status of shrimp resources was first proposed by Mohn *et al.* (1992). At that time, it was intended to qualify the status of a shrimp population in a simple way (a traffic light approach) so that the TAC could be adjusted (increased, decreased or maintained) accordingly. It was recognized that the tools required for calculating adjustments to the TAC in response to observed changes in the status of the resource (i.e. quantifying the change by objective, scientific methods) were not available for shrimp generally and, therefore, adjustments had to be empirically or experimentally based. As a recent example, the TAC in the Estuary and Gulf of St. Lawrence was increased gradually by about 40 % from 1995 to 1999 in response to the very good condition of the shrimp resource as determined from the past assessments.

A tabular format for presentation of assessment results, first used in the beginning of the 1990s for Gulf of St. Lawrence shrimp, allowed the cross-examination of numerous indices, described the similarity in their behaviour and, therefore, facilitated comparisons between years and areas (Savard and Hurtubise, 1991). The format was well received within scientific peer review, by fishery managers and by stakeholders in the shrimp industry. It was found to be helpful in following the numerous indices and their tendencies (between years, between areas and between indices) and for understanding more clearly the rationale leading to the assessment of the status of the resource.

During the assessments of shrimp in the Gulf of St. Lawrence and in the Canadian northwest Atlantic in winter, 1999, resource status was determined by examining a number of indicators from the commercial fishery and research trawl surveys (Savard, 1999; Parsons *et al*., 1999). These indicators referred to factors that can affect fishing success, stock abundance and/or resource productivity. The factors were assessed from the standpoint of impact on resource status, on future abundance and stock productivity using three categories of evaluation: (1) positive outlook - green, (2) uncertainty about the magnitude of the impact - yellow and (3) concerns about the current and/or future condition of the stock - red. Overall resource status was then assessed by viewing all indicators in combination. The results were presented as performance reports for each management unit.

The examination of the indices was improved in the 1999 assessments by using a two- step approach: observation followed by interpretation. The idea was first used in the regional peer review of the northern Gulf snow crab assessment (R. Dufour and B. Sainte-Marie, Maurice Lamontagne Institute, Mont-Joli, Quebec, unpublished data). Results of numerical analyses performed on the data were followed by biological interpretations and implications for the status of the resource. The two-step presentation again was well received by fisheries managers and the shrimp industry. It was particularly useful for focussing the discussion on the analysis and interpretation of the indices. Inherently simple, the presentation avoided the confusion of discussions and mixing of issues.

Application

Gulf of St. Lawrence

Background

Landings of northern shrimp in the Estuary and Gulf of St. Lawrence have gradually increased since the fishery began in the mid-1960s. Landings rose from approximately 1000 to 7500 tons between the early and late 1970s, reaching over 15,000 tons by the late 1980s. Landings in 1998 amounted to more than 23,000 tons, a 40% increase over 1995 and a new high.

Shrimp harvesting in the Estuary and Gulf is controlled by a number of management measures, including TACs (total allowable catches) in the four management units or shrimp fishing areas (SFAs): Sept Îles (SFA 10), Anticosti (SFA 9), Esquiman (SFA 8) and Estuary (SFA 12). TACs have been taken in all areas since 1995. In 1998, there were 117 licences for shrimp. In 1997 and 1998, temporary allocations of shrimp were granted to fishers with groundfish licences. Other management tools include a minimum mesh size (40 mm) and, since 1993, the

compulsory use of sorting grates, which significantly reduce groundfish by-catches. The shrimp fishery runs from April 1 to December 31.

Commercial fishery statistics (shrimper catch and effort) are used to calculate catches per unit of effort (CPUE) and numbers per unit of effort (NPUE). The data are standardized to account for changes in the fleets (changes in fishing power resulting from vessel changes and fleet renewal) and seasonal fishing patterns.

Research surveys have been conducted in the Estuary and Gulf of St. Lawrence in August–September each year since 1990. The surveys use a stratified random design and are conducted from the Canadian research vessel *Alfred Needler*, equipped with a shrimp trawl. The survey indices (biomass and abundance) are relative indices, as the trawl used does not catch all the shrimp in the water column while passing over the seabed. However, since the survey is carried out in a standard manner from one year to the next and since it covers the geographic range of shrimp in the Estuary and the northern Gulf, the indices are considered to be reliable indicators of variations in shrimp abundance and biomass.

A cautious approach has been taken in assessing the shrimp stocks of the Estuary and Gulf of St. Lawrence. Management of the shrimp fishery has always sought to err on the side of caution in order to avoid overfishing and to minimize the negative impacts of harvesting.

1999 Assessment

In Canada, the Fisheries Resource Conservation Council (FRCC) reflected on the Precautionary Approach and its application to Atlantic groundfish stocks (Brêthes, 1998) about the same time the shrimp resource in the Gulf of St. Lawrence was being assessed. The FRCC proposed a similar approach with the evaluation of a series of indicators to determine the overall status of the resource. The results of the FRCC exercise were laid out in a tabular format called "performance report ". The Gulf shrimp assessment can be seen as a first application of the FRCC model on an invertebrate stock. The term "performance report" was used because it was felt to be well suited to the presentation of the results.

The assessment in winter 1999 used three categories of evaluation but the analogy of the traffic lights was not directly applied. It was thought that the concepts of uncertainty or concern were more appropriate to describe the meaning of the indices. An example of the method as used for the Sept Îles (SFA 10) fishery is given in Table 1. Indicators used in the assessment were grouped under three headings: fishing success, stock abundance and resource productivity. Most indices provided a positive outlook and reflected the current high biomass/abundance, large spawning stock and no increase in exploitation during the 1990's. The impact of observed spatial and temporal changes in fishing pattern was uncertain, as was the increase in Greenland halibut abundance with respect to predation mortality. The only "cause for concern" was the low numbers of small males encountered in the 1998 trawl survey that suggested low recruitment to the fishery. The overall assessment, based on combination of all indices concluded that the stock was in good condition in 1998 but, because of lower recruitment, could begin to decline in 1999. Therefore, stock status was somewhat uncertain in that it was not possible to quantify the future effect of reduced recruitment on either fishery performance or stock status.

The performance report is a powerful visual tool to explain how the conclusion on the status of a stock is reached. The indicators are not totally independent as some could represent correlated factors or different states of the same variable. For example, the abundance of males is used as an indication of the strength of the recruitment to the fishery. Therefore, it is believed to be linked to the abundance of females, the survey biomass and the fishery catch rates some years later. From this point, it became interesting to do a retrospective analysis to see how the performance report and the series of indicators could show the evolution of a stock over many years. The exercise was done for the Gulf of St. Lawrence Sept-Îles management unit for which two series of nine years of survey and seventeen years of fishery data are available. Annual performance reports were built for the research survey period (1990 to 1998) with data available up to the year of analysis (Table 2). The retrospective analysis shows how the "waves" of poor or strong year classes spread from one indicator to the other over time and how this affects the overall status of the stock.

Baffin Island, Labrador and northeastern Newfoundland

Background

Shrimp catches throughout the area extending from Div. 0A off eastern Baffin Island to Div. 3K off northeastern Newfoundland also have increased from less than 3000 tons in 1977 to almost 80,000 tons in 1998. During the first decade, the fishery was confined to small areas within Div. 0A, 2H and 2J but expanded to southern Div. 2J and 3K beginning in 1987 and north to Div. 2G and 0B in 1988. The fishery is currently carried out over a vast geographic area, including grounds that were previously thought to be unproductive for shrimp.

Catches are controlled by TAC in all shrimp fishing areas within Canadian waters - Div.0B (SFA 2), Div. 2G (SFA 4), Hopedale + Cartwright Channels (SFA 5) and Hawke Channel + Div. 3K (SFA 6). TACs have been taken in all areas since 1995. Also, a TAC-controlled fishery for *Pandalus montagui* occurs east of Resolution Island (SFA 2, 3 and 4, west of 63^0 W). The number of licences for large, offshore vessels to fish shrimp in these areas increased from 11 in 1978 to 17 up to 1996. TAC increases in SFAs 5 and 6 in recent years resulted in the establishment of an additional fleet component for vessels less than 19.8 m. About 300 such vessels participated in the 1998 fishery, primarily in SFA 6. Other management measures include minimum mesh size (40 mm) and, since 1997, the compulsory use of sorting grates. The fishery is open from January 1 to December 31 in all areas but sea ice coverage defines the season in northern waters.

Trends in catch (tons) and effort (hours fished) from vessel log records are monitored for all areas and years. CPUE, expressed as kg per hour, is calculated by year for each SFA and used as an indicator of change in the fishable stock over time. The raw data (catch/effort) for each SFA are standardized by multiple regression in an attempt to account for variation due to factors such as year, month, area and vessel.

Sizes of male and female shrimp in the catches are obtained from samples taken by observers on offshore vessels. Samples are adjusted upward to set, month and year for each SFA to derive a series of annual catch-at-length compositions. Age composition is inferred by identifying prominent year classes within the composite distributions and tracking their development over time.

Multispecies research trawl surveys have been conducted annually in the Newfoundland-Labrador offshore area since 1995. These surveys employ a stratified-random sampling design that was developed for groundfish but use a lined, Campelen 1800 shrimp trawl as the sampling gear. In Hawke Channel + Div. 3K (SFA 6), survey coverage has been extensive in areas where shrimp are abundant and reliable estimates of the distribution as well as abundance/biomass indices have been obtained each year from 1995 to 1998. Farther north, coverage is not adequate (or the survey design is not appropriate) to address the patchy distribution of shrimp in these areas. Therefore, survey results from 1996 to 1998 for Hopedale + Cartwright (SFA 5) and 1996 and 1997 for Div. 2G (SFA 4) are less reliable for interpretation of trends in the resource and approximate level of exploitation. No surveys have been conducted in Div. 0B (SFA 2).

Sampling of survey catches provided the data for constructing estimates of abundance at length and sex by area and year. As for the commercial data, age composition from surveys is inferred by identifying year classes within the composite distributions and tracking their development over time.

Management of the northern shrimp fishery by TAC aims to prevent over-exploitation of the shrimp resources. TACs are set conservatively and are closely monitored. Large increases in some TACs in 1997 and 1998 were based on new findings from multispecies research surveys initiated in 1995 which showed high abundance/biomass in these areas and low exploitation. Exploitation level was inferred by comparing nominal catch to the lower confidence interval (95%) of the biomass index. As indicated above, the index is believed to underestimate the actual biomass.

1999 Assessment

Assessment of northern shrimp in the Canadian northwest Atlantic in winter 1999 followed the approach used for the Gulf of St. Lawrence (i.e. observation, interpretation and evaluation of indices) but used the traffic light analogy

more directly. An example of the method as applied to Hawke Channel + Div. 3K (SFA 6) is given in Table 3. Indices or indicators relevant to stock status were grouped under fishery data, research data and ancillary data. The first two groupings included the traditional data sources used in stock assessments whereas the last attempted to incorporate other factors that are believed to be important in determining the status of shrimp stocks but seldom find their way into the process. Most indices were evaluated positively (green lights) and there were no immediate concerns regarding either current status or future prospects (red lights). Two indices addressing recruitment were evaluated as uncertain (yellow lights): survey results indicated that the 1995 and 1996 year classes were weaker than those of 1993 and 1994 and warmer than average water temperatures from 1996 to 1998 could result in reduced recruitment to the fishery. The overall assessment, based on the combination of all indices, concluded that the current status was favourable with high biomass/abundance of male and female components. Future prospects were uncertain, however, given that the available data suggested a decline in recruitment.

Assessments were carried out for the other three SFAs using the same method and the results for all four areas are summarized in Table 4. The summary showed clearly how uncertainty in resource status increased from south to north. No evaluation was given where data were absent. In the example provided in Table 3, data from both the commercial fishery and research trawl surveys were reliable. The uncertainty about recruitment was two-fold: uncertainty that the recruitment index was reliable with such a short time series and uncertainty about how any realized reduced recruitment will impact overall stock status. In the Hopedale + Cartwright area (SFA 5), fishery data were considered reliable but research data were uncertain regarding trend because the survey design did not resolve the patchy distribution on shrimp in this area. A similar situation was evident in Div. 2G (SFA 4) with the addition that industry, itself, was uncertain about the stock distribution in this area. Div. 0B (SFA 2) lacked research trawl surveys and the fishery data were difficult to interpret because of the mixed-species fishery (*P. borealis/montagui*) in the main fishing area and the uncertainty about population structure and boundaries.

NAFO Div. 3M (Flemish Cap)

A preliminary application to Div. 3M shrimp (Table 5) was prepared for discussion at the 1999 spring meeting based on the assessment conducted during the Scientific Council Annual Meeting, September 1998. The exercise was for illustrative purposes only and did not represent a new or revised assessment of the stock. Background information on the fishery and assessment methods can be found in NAFO, 1998b (p.162 - 163). Most of the status indicators were evaluated as uncertain (yellow lights). The fishery data were uncertain mainly due to the changes in fishing pattern between years and developing technology (e.g. double trawling). Research data were uncertain because they originated from surveys directed toward groundfish on Flemish Cap rather than shrimp-directed surveys. No estimates of current or future stock size were possible.

Appraisal of the Method

The method was viewed positively within the Laurentian and Newfoundland Regions, both for the assessment process and the presentation of results to clients and stakeholders. The appeal lay in its simplicity. All observations from the indicators considered in the process were described and interpreted in transparent terms and their strengths and weaknesses were evident. The format provided a mechanism for consensus building among scientists, fisheries managers and industry. It allowed for input from fishermen as well as consideration of possible environmental influences such as temperature and predation, despite their qualitative nature.

One weakness identified was the interpretation of the "uncertainty" or "yellow light" category. It first should be made clear that this category was not meant to signify "average" conditions. Uncertainty was defined as both uncertainty in the analysis of data (e.g. variance) and uncertainty in the interpretation of the observations (i.e. stock performance). There may be a need to separate this distinction in future formulations of the approach. Also, the "traffic light" analogy was one of convenience and did not strictly apply. Real traffic lights turn yellow to signify that red is coming and that, very soon, you will have to stop. There is no "uncertainty" in that sense. Also, in our application, yellow can precede green or need not appear at all between red and green for the same indicator. If the analogy, itself, causes confusion, it should be avoided.

Although the performance reports were very much appreciated by fisheries managers and industry, it is recognized that the exercise has not been completed. In the current application, the overall status of the resource is a combination of all indicators without considering their precision or their implications for stock performance. The

method lacks a weighting system that could be applied to each indicator to more adequately represent their uncertainty or the importance of their impact on shrimp conservation strategies. The precision and uncertainty of an indicator could be associated with the "observation" cell of the performance table while the weighting of the importance of the indicator could be associated with the "interpretation" cell. Then, the status of the resource would be a combination of the weighted indicators. A weighting system of this sort has been discussed amongst scientists but not with fisheries managers and the shrimp industry. However, the idea has been introduced and all parties realize that it is a good approach to improving the performance reports. It is also very important to have their input on the weighting system so that full support for the process can be attained. The final developmental step would link the status of the resource to clearly defined management decisions and options. When all steps have been taken, a framework for assessment and management of shrimp should exist in the precautionary context.

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TABLE 1. PERFORMANCE REPORT: SEPT ÎLES

INDICATOR	*OBSERVATION*	*INTERPRETATION*	*OUTLOOK*
FISHING SUCCESS			
Landings	40% increase in TACs and landings since 1995; TAC taken easily since 1995	Large biomass	
Catch (number)	19% increase since 1995; decrease in males (12%), increase in females (62%)	High abundance; mean weight of catches has increased	
Effort	40% reduction between 1994 and 1995; effort low and stable since 1995	High density	
Seasonal pattern	High monthly CPUEs in 1998; CPUEs decline over season	High density; return to seasonal pattern of early 1980s	
Spatial pattern	Effort reduced in southern part of Laurentian Channel; effort increased in western part of area	Change in distribution; geographic range may be shrinking	
Stock distribution	Drop in densities in southern part of Laurentian Channel; increase in densities in western part of area	Change in distribution; geographic range may be shrinking	
Industry perception	Good concentrations of shrimp in areas different from other years; few or no small shrimp	Densities still high, but change in distribution and low recruitment	
STOCK ABUNDANCE			
Biomass index	Increasing since 1992–93; 1998 stable in relation to 1997; 1997 and 1998 values highest in series	Large biomass	
CPUE	Increasing since 1992–93; 1998 value highest in series	High density	
Abundance index	Increasing since 1992–93; 1998 stable in relation to 1997; 1997–98 values similar to that of 1990	High abundance	
NPUE	Increasing since 1992–93; 1998 value highest in series	High density	
RESOURCE PRODUCTIVITY			
Population structure	Age structure stable from year to year; growth gradient from east to west	No loss of female component; productivity lower in eastern part of Gulf	
Size of males	Size of last mode of males smaller in 1998	Size at sex change will drop in 1999; females will be smaller	
Size of females	Increasing since 1994; very big in 1998	Fewer individuals for same catch	
Female abundance	Increasing since 1992–93; 1998 value highest in series	Large spawning stock	
Male abundance	Abundance of all male components relatively stable in 1992–96, but fell in 1998 to average level	Average recruitment to spawning stock	
Recruitment	Drop in male abundance to average level; very few small males in 1998 survey	Low recruitment to fishery	✕
Predation	Cod and redfish abundance low, but increase in turbot	Predation pressure will rise	
Exploitation rate	No increase with recent rise in catches; 1998 rates were same as those of early 1990s	Fishing mortality has not increased since early 1990s	
ASSESSMENT			
All indicators combined	**Stock in very good condition in 1998, but could begin to decline in 1999 because of lower recruitment**		

MEANING OF SYMBOLS:

POSITIVE OUTLOOK: *IMPACT UNCERTAIN:* *CAUSE FOR CONCERN:* ✕

TABLE 2. SEPT-ÎLES RETROSPECTIVE

INDICATORS	APPRAISAL						
	PREDATION	RECRUITMENT	POPULATION ABUNDANCE	FISHING PATTERN	FISHERY PERFORMANCE	EXPLOITATION	COMBINATION OF INDICATORS
1990	⊘	⊘	✚	✚	✚	✚	◇
1991	⊘	⊘	◇	✚	◇	✚	◇
1992	◇	⊘	⊘	◇	⊘	⊘	⊘
1993	◇	◇	⊘	◇	⊘	⊘	⊘
1994	✚	✚	◇	◇	◇	◇	◇
1995	✚	✚	✚	✚	✚	◇	✚
1996	✚	✚	✚	✚	✚	◇	✚
1997	✚	✚	✚	✚	✚	✚	✚
1998	◇	⊘	✚	◇	✚	✚	◇

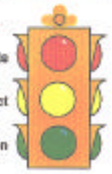
Positive appraisal	✚
Uncertainty regarding the impact	◇
Concerns regarding future prospects	⊘

Table 3. Performance Report: Hawke Channel + Div. 3K (SFA 6)

THE FISHERY	
Catch	Increased from about 11,000 tons during 1994 - 1996 to 21,000 in 1997 and 46,000 in 1998 due to TAC increases. TAC's have been reached each year since 1998.
Effort	Increased from 1996 to 1998 with the large increase in TAC. New effort primarily due to vessels < 65 feet. Some double trawling (about 5% of offshore effort in 1997).
By Catch	Small fish (e.g. turbot, redfish, capelin, arctic cod) are retained by the small-meshed gear from time to time. However, the mandatory use of sorting grates on shrimp vessels and low groundfish abundance in this area minimize the bycatch. In practice, fi

INDEX	OBSERVATION	INTERPRETATION	EVALUATION
FISHERY DATA			
CPUE - KG/HR	Increased for offshore fleet up to 1996 and has remained at a high level (> 2000 kg/hr). Inshore sector, including inexperienced fishers, had high catch rates when the fishery began in 1997.	Reflects an increase in the resource up to 1996, remaining at a high level since.	
Spatial pattern	Eastward expansion in effort by offshore vessels in early 1990's.	Reflects the discovery of high concentrations of shrimp along the shelf slope during the exploratory fishery in 1992 and 1993. These areas previously were thought to be unproductive.	
Temporal pattern	A winter-spring fishery for the offshore fleet and a summer-fall fishery for the inshore fleet.	Commercially viable concentrations of shrimp available throughout the year.	
Male abundance	The abundant 1991 year class began to recruit in 1994 and produced higher catch rates in 1995 and 1996. The 1993 year class dominated in 1997 and 1998 but appears weaker than the 1991.	Good recruitment of year classes produced in the early 1990's resulted in high catch rates of males since 1995.	
Female abundance	Catch rates of the female component increased from 1993 to 1996 and stabilized in 1997 and 1998.	Continued good recruitment since the mid 1990's is responsible for the increase in spawning stock throughout the 1990's. Spawning component remains healthy.	
Sex inversion	The median size at sex change varied between 21 and 22 mm carapace length throughout the 1990's.	Stability in maturity schedules suggests that favourable sex ratios are being maintained within the population.	
RESEARCH DATA			
Biomass/abundance index	The lower 95% confidence intervals for the biomass/abundance indices averaged about 400,000 tons/80 billion animals during the 1996 - 1998 period.	High biomass/abundance.	
Spatial pattern	Widely distributed throughout the management area.	Wider distribution in the 1990's compared to the 1980's, reflecting higher stock size.	
Recruitment (male age structure)	Survey abundance in 1996 and 97 was dominated by males of the 1993 and 1994 year classes. The 1994 year class dominated in 1998. The 1995 and 1996 year classes appear weaker.	Recruitment of males will likely decline, beginning in 1999 and continuing into the next millenium.	
Spawning stock (females)	Relatively stable. Increase in 1998 survey due to small females, possibly part of the 1993 year class.	Female abundance should be maintained in the short term (1999 and 2000) by the continued recruitment of the 1993 and 1994 year classes.	
ANCILLARY DATA			
Predation	Abundance of known predators such as cod, redfish, skate and American plaice remains low in the offshore areas.	Predation mortality remains low relative to periods of high predator abundance.	
Environment	Warmer than average water from 1996 to 1998.	Could result in lower catch rates (reduced recruitment to the fishery) beginning in 1999 and continuing into the next millenium.	
Industry perspectives	Catch rates were high in recent years with similar offshore catch rates in early 1999.	The resource is perceived to be healthy by both inshore and offshore sectors.	
ASSESSMENT			
Exploitation rate	Ratio of nominal catch to survey biomass index (lower confidence intervals) has been less than 12% for the past 3 years.	Catchability of the survey gear is believed to be <1. Therefore, exploitation rate likely has been <12%.	
Stock Status	**1999: Current status favourable with high biomass/abundance of male and female components.**		
	2000+: Available information suggests a decline in recruitment.		

Considering the possibility of a decline in recruitment, it is uncertain whether the current or an increased TAC can be sustained.



Concerns regarding current status and/or future prospects

Uncertainty regarding the impact

Positive evaluation

Table 4. Summary of Assessments - Divisions 3K - 0B.

	EVALUATION			
INDEX	Hawke+3K	Hope+Cart	Div. 2G	Div. 0B
FISHERY DATA				
CPUE - KG/HR	●	●	●	◉
Spatial pattern	●	●	●	◉
Temporal pattern	●	●	○	○
Male abundance	●	●	●	◉
Female abundance	●	●	●	◉
Sex inversion	●	◉	◉	◉
RESEARCH DATA				
Biomass/abundance index	●	◉	◉	○
Spatial pattern	●	◉	◉	○
Recruitment (male age structure)	◉	◉	◉	○
Spawning stock (females)	●	◉	◉	○
ANCILLARY DATA				
Predation	●	●	○	○
Environment	◉	◉	○	○
Industry perspectives	●	●	◉	◉
ASSESSMENT				
Exploitation rate	●	◉	◉	◉
Stock Status 1999	●	◉	◉	◉
Future Prospects 2000+	◉	◉	◉	◉

Concerns regarding current status and/or future prospects

Uncertainty regarding the impact

Cannot be evaluated ○

Positive evaluation

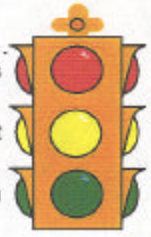


Table 5. Application of Traffic Light/Checklist Approach to Shrimp in Div. 3M (Flemish Cap)

THE FISHERY	
Catch	Increased from 28,000 tons in 1993 to 49,000 in 1996, then decreased to about 30,000 in 1998. Catches are underestimates due to overpack.
Effort	Total effort index (Catch/CPUE for Canadian, Icelandic, Greenlandic, Norwegian single trawl data) increased from 70,400 hrs. in 1993 to 226,000 in 1996 then decreased to 118,700 during 1997. Effort regulations were implemented in 1996 and have continued s
By Catch	Prior to 1995, redfish by-catch was problematic. Although much lower during the 1995-98 period, it is not clear whether this was due to the reduction of maximum bar spacings in sorting grates from 28 mm in 1994 to 22 mm in 1995 or to the absence of strong

INDEX	OBSERVATION	INTERPRETATION	EVALUATION
FISHERY DATA			
CPUE - KG/HR	Annual standardized CPUE's (single trawls only) were 399, 219, 268, 215, 224 and 285 kg per hr. for 1993 to 1998, respectively.	A substantial decline between 1993 and 1994 is indicated with no clear trend afterward. Difficult to interpret as an index of abundance due to changes in fishing patterns between years and developing technology.	
Spatial pattern	Expansion from the 300 - 500 m depth range on the northern half of the Cap during 1993 and 1994 to the eastern and southwestern areas and 200 - 500 m (occasionally >600 m in Flemish Pass).	Reflects targeting of small shrimp in shallow water or larger shrimp in deeper water.	
Temporal pattern	Fishing increases from January to July then decreases until December with the May to August period accounting for >60% of the logged effort each year to 1997.	Commercially viable concentrations and/or sizes not available throughout the year.	
Male component	The percentage (numbers) of males in the catches increased from 44% in 1993 to 72% in 1995, decreased to 57% in 1997 and increased slightly to 62% in 1998.	Reflects the shift in distribution of fishing effort into shallower waters with the decline of the 1988 year class from 1993 to 95 and the relative strength of the 1993 and 94 year classes since then.	
Female component	The percentage (numbers) of females decreased from 56% in 1993 to 38% in 1995, increased to 43% in 1997 and decreased slightly to 38% in 1998.	Reflects the decline of the strong 1988 year class from 1993 to 1995.	
Sex inversion	Reduction in size of shrimp at sex inversion	Possibly reflective of reduced female abundance.	
RESEARCH DATA			
Biomass index	Indices of biomass from EU surveys were relatively stable from 1995 to 1997 with a large increase in 1998. Faroese surveys also indicated an increase from 1997 to 1998.	The 1998 EU survey estimate is not comparable to previous years and confidence intervals for estimates were not available from the Faroese surveys. Not able to estimate current or future stock size.	
Spatial pattern	Highest densities occur in western, northern and northeastern areas and in depths ranging from 300 - 500 m. Distributions variable (without trend) between years.	Geographic distributions relatively stable.	
Recruitment (male age structure)	No reliable recruitment index from existing surveys.	Not possible to estimate size of year classes or predict recruitment in the absence of a time series of research surveys directed for shrimp.	
Spawning stock (females)	Female biomass indices from EU surveys were stable between 1995 - 1997 with a possible increase in 1998.	The 1998 EU survey estimate is not comparable to previous years. Not able to estimate current female stock size.	
ANCILLARY DATA			
Predation	Abundance of known predators such as Greenland halibut, cod, redfish, skate and American plaice remains low in Div. 3M.	Predation mortality is low relative to periods of high predator abundance.	
Immigration	Despite previous concerns for overfishing, recruitment has been maintained.	It is possible that recruitment and/or spawning biomass are being supplemented by immigration from adjacent areas in Div. 3LN and further northern in Div. 2J3K..	
Environment	Colder than normal conditions from the late 1980's to 1995 moderated in 1996 and continued above normal until 1998.	Effects of temperature on shrimp production in the Flemish Cap area are uncertain.	
Industry perspectives	No direct input from industry.	None.	
ASSESSMENT			
Exploitation rate	No analytical assessment was possible.	Fishing mortality is unknown.	
Stock Status	**1999: It is not possible to provide any estimate of current stock size.**		
	2000+: It is not possible to provide any estimate of future stock size.		

Despite uncertainty, the stock may be relatively stable, possibly showing an increase in 1998. There is still concern for the high proportion of males in the catch. Catch in 1999 should not exceed 30,000 tons.