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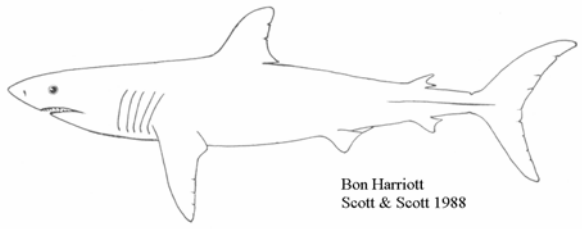
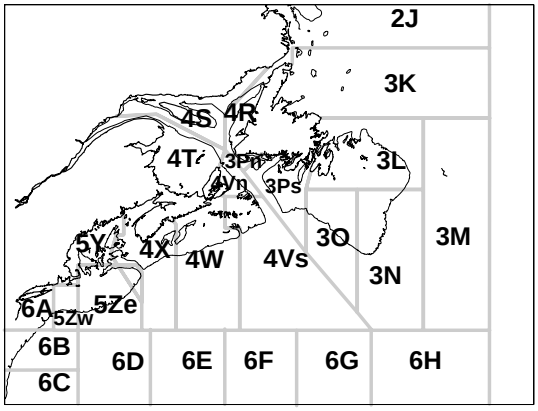
Canadian Science Advisory Secretariat
Science Advisory Report 2005/044

STOCK ASSESSMENT REPORT ON NAFO SUBAREAS 3 – 6 PORBEAGLE SHARK





Context

In 2004, porbeagle sharks (Lamna nasus) were designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are being considered for listing on Schedule 1 of the Species at Risk Act. This designation was based on the status of the population to 2001. At this time, the Northwest Atlantic population of porbeagle shark had been significantly affected by fishing pressure. Abundance of the population was low; it was estimated at about 4,400t which corresponded to 11% of the virgin biomass in 1961. The porbeagle population was considered to be at risk due to its low population growth rate and by exploitation. Given the low productivity of this species, it was expected to take at a minimum several decades to recover from its current low abundance level. Uncertainty was expressed by COSEWIC whether the quota reduction to 250t, implemented as a recovery action in 2002, would be sufficient to allow recovery. At that time, there was no evidence to indicate that the decline in porbeagle abundance had ceased, and the estimated population trends met the COSEWIC criterion for endangered status.

SUMMARY

- Porbeagle are presently designated as Endangered by COSEWIC and are being considered for listing on Schedule 1 of Canada's Species at Risk Act.
- Landings in 2002-2004 have been in the range of 139-229t, or about 23% the landings from 1998 to 2001. The reduction is primarily due to the quota reductions as part of a management plan to affect recovery.
- The catch-per-unit effort (CPUE) data indicate a declining trend for mature porbeagle from 1985 to 2004. CPUE for immature porbeagle declined during the 1990s, but has been high since 2003.
- A population model was used to estimate numbers-at-age and exploitation from 1961 to 2004. Three variants of the model were used, each with a different assumed productivity scenario.
- The models place the 2005 female spawner abundance at about 12% to 15% of its 1961 level, and about 86% to 92% of corresponding estimates for 2002. Changes in total number

from 2002 to 2005 are less with the 2005 abundance being about 99% to 103% that of 2002.
- Exploitation was highest during the early to mid 1960s, was low during the early 1980s, increased in the 1990s and decreased again since 2002 with the implementation of the management plan.
- The recent contraction of the fished area associated with the low catch quotas has made the interpretation of catch rates as indices of resource abundance difficult. This emphasizes the need for a broad-scale shark survey to determine how catch rates (and therefore abundance) vary with area and time across the range of the population.

DESCRIPTION OF THE ISSUE

Rationale for Assessment

In May 2004, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the porbeagle as an endangered species, and is being considered for listing on Schedule 1 of Canada's Species at Risk Act (SARA). If listed, activities that would harm the species would be prohibited and a recovery plan would be required. Decisions on permitting incidental harm and on recovery planning are dependent on current stock status, which is reported here.

Species Biology

The porbeagle shark (*Lamna nasus*) is a **large cold-temperate pelagic shark species** of the family Lamnidae that occurs in the North Atlantic, South Atlantic and South Pacific oceans. The species range extends from Newfoundland to New Jersey and possibly to South Carolina in the west Atlantic, and from Iceland and the western Barents Sea to Morocco and the Mediterranean in the east Atlantic. The porbeagle has a low fecundity, late age at sexual maturation and low natural mortality. Age at maturity is about eight years in males and about thirteen years in females. In the northwest Atlantic, mating occurs from September through November, and live birth occurs eight to nine months later. Reproduction is thought to occur annually. Litter size averages about 4 young, and ranges from 2 to 6 young. The porbeagle life span is estimated to be between 25 and 46 years and generation time is about 18 years.

Fisheries

The **fishery** for porbeagle sharks in the Northwest Atlantic (NAFO subareas 3 - 6) started in 1961 when Norwegian vessels began exploratory fishing on a virgin population. These vessels had previously fished for porbeagle in the Northeast Atlantic. They were joined by vessels from the Faroe Islands during the next few years. Reported landings in the Northwest Atlantic rose from about 1,900t in 1961 to more than 9,000t in 1964 and then fell to less than 1,000t in 1970 (Figure 1) as the fishery became uneconomical. Although the fishery was unrestricted, reported landings were less than 500t until 1989. Reported landings rose to almost 2,000t in 1992, due to increased effort by Faroese vessels and also due to the entry of Canadian interests into this fishery. Faroese participation was phased out of the directed fishery by 1994, at which time total landings by three Canadian offshore pelagic longline vessels and a number of inshore vessels was about 1,600t. Since that time, the fishery has been almost exclusively Canadian, with landings declining gradually to 1066t in 1998 in response to quota control. Catches by foreign (i.e. Japanese) vessels fishing outside of Canadian waters are not well known. During 2000 – 2002, estimates range from 15 to 280 mt annually. Canada introduced a shark management plan in 1995 which defined a non-restrictive catch guideline of 1,500t. In 1997, a TAC of 1000t was imposed

under the 1997-99 Shark Management Plan. The 2000-2001 Shark Management Plan restricted catches to a total of 1700t over a 2 year period while additional scientific information was collected. Based on those assessments, the Shark Management Plan for 2002-2006 reduced the TAC to 250t, a value that at that time was thought to correspond with F_{msy} and was expected to allow for stock recovery. Landings in 2002 to 2004 were 229t, 139t and 218t respectively.

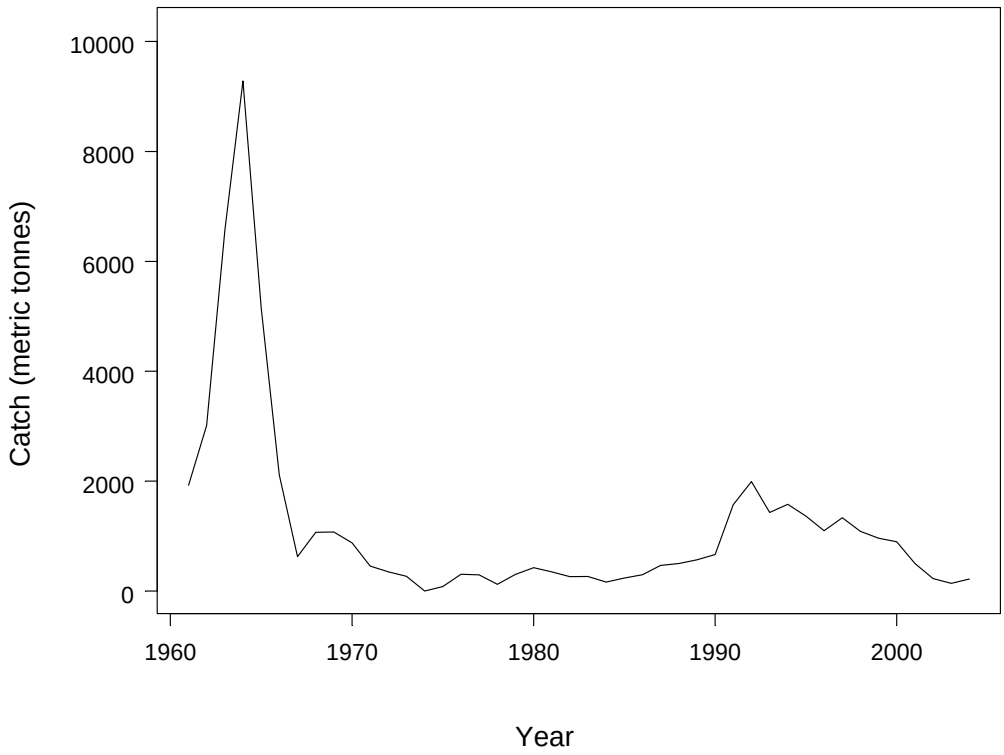


Figure 1. Porbeagle landings in northwest Atlantic (NAFO sub-areas 2-6) from 1961 to 2004.

Since the early 1990s, porbeagle sharks have been landed by a Canadian directed longline fishery as well as bycatch in several other fisheries. Canadian landings prior to this time were reported only as bycatch. Bycatch in the Canadian swordfish longline fishery, the Japanese tuna longline fishery, and various inshore fisheries is a small percentage of the catch, but has increased significantly recently. Bycatch of porbeagle in other fisheries was 53t per year in 2002 and 2003 and was 46t in 2004, representing over 20% of the reported landings. There is almost no recreational fishery for porbeagle sharks.

RESOURCE ASSESSMENT

The status of porbeagle was assessed using data from the commercial catch, including the amount, the catch-per-unit-effort, the proportions-at-length in the catch and tagging data. An age- and sex-structured, **forward projecting population model** was used for the assessment. The models estimate a starting population size and age structure (in 1961), and the population is projected forward by adding recruits (age-1 fish) to the population and subtracting catches and natural mortality. The porbeagle fishery is included in the model as three separate fisheries based on region: the “Basin”, “NF-Gulf”, and “Shelf-edge” regions (Figure 2). These regions were chosen because the vulnerability of porbeagle to fishing was thought to vary among these regions. Three variants of the model were used each with a different assumed reproductive scenario. In the lower productivity model, the maximum number of offspring per mature female that survive to age-1 was assumed to be 2. Values of 2.5 and 3.2 were used in the middle and higher

reproductive scenarios. Instantaneous rate of natural mortality was assumed to be 0.1 for immature porbeagle and 0.2 for mature porbeagle in all scenarios.

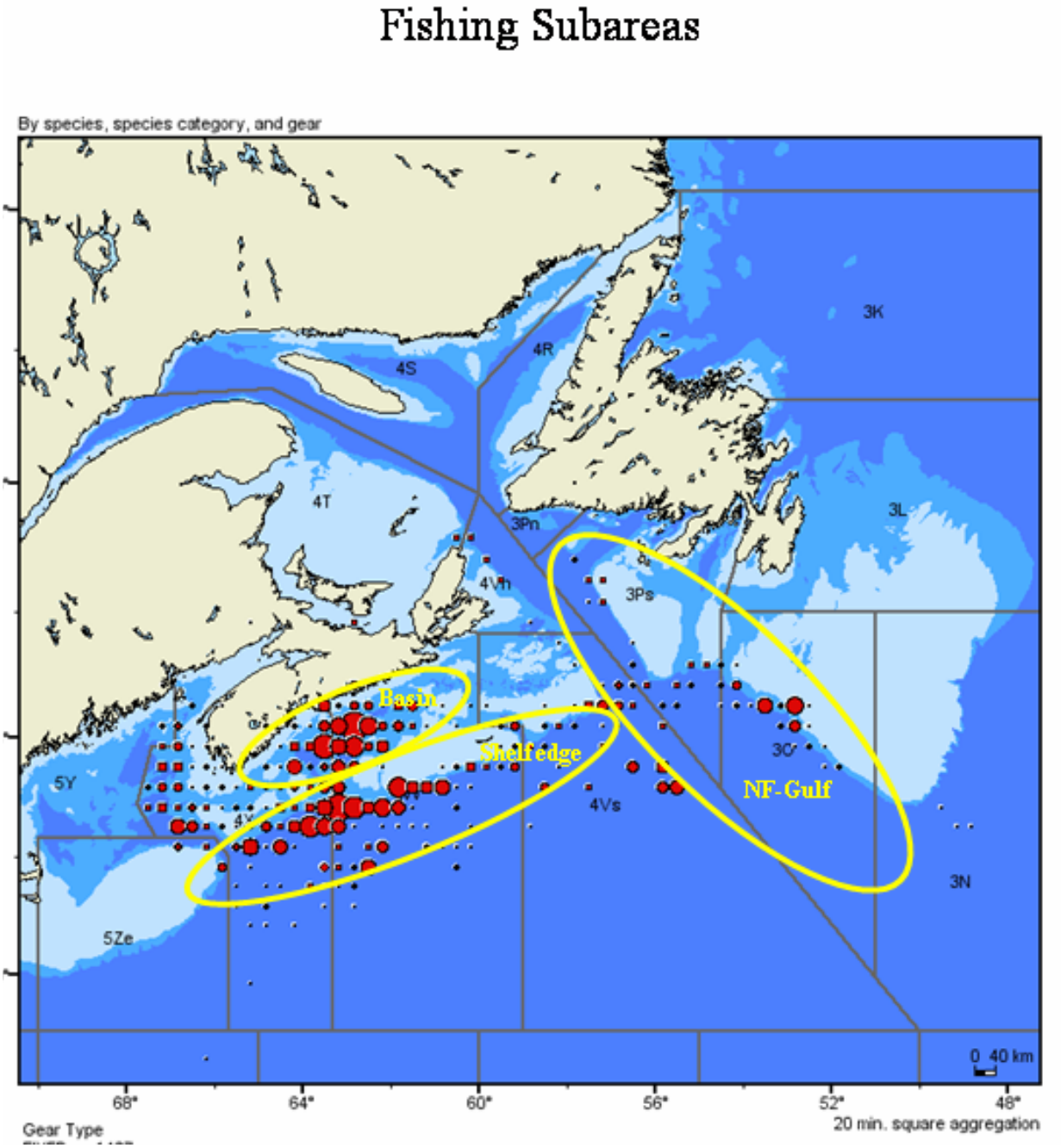


Figure 2. Map showing the three regions where porbeagle are fished. Gulf of Maine fish were considered to be from the Shelf-edge group.

Key Indicators

The **catch-per-unit effort (CPUE)** data indicate a declining trend for mature porbeagle from 1985 to 2004 (Figure 3). For immature porbeagle, in the Basin and Shelf-edge region, CPUE declined during the early 1990s but has been high since 2002 (recent estimates are quite variable). No trend is apparent for immature porbeagle in the NF-Gulf region, although this area

has been closed since 2002 to protect spawning females. Presently, the fishery takes place in a much smaller geographic area than in the past due to reduced quotas, area closures and fleet changes. The recent high CPUEs do not appear to be the result of the contraction of the areas fished: CPUEs in the areas presently being fished are also higher than in the past (Figure 4).

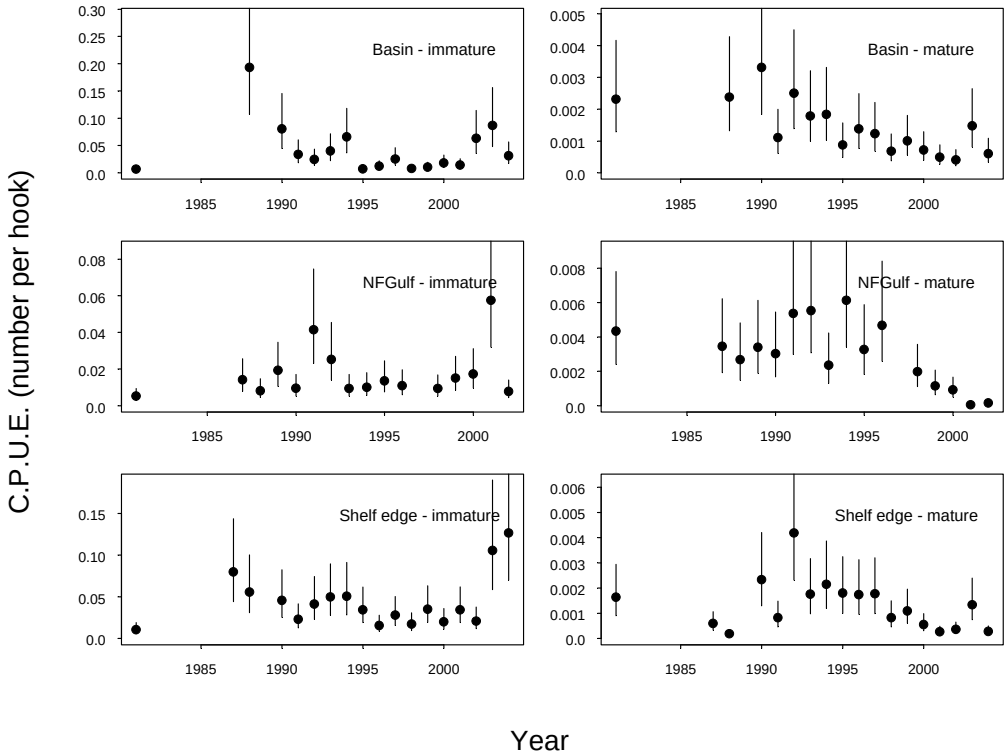


Figure 3. Standardized catch per unit effort (95% confidence intervals) for mature and immature porbeagle in 3 regions.

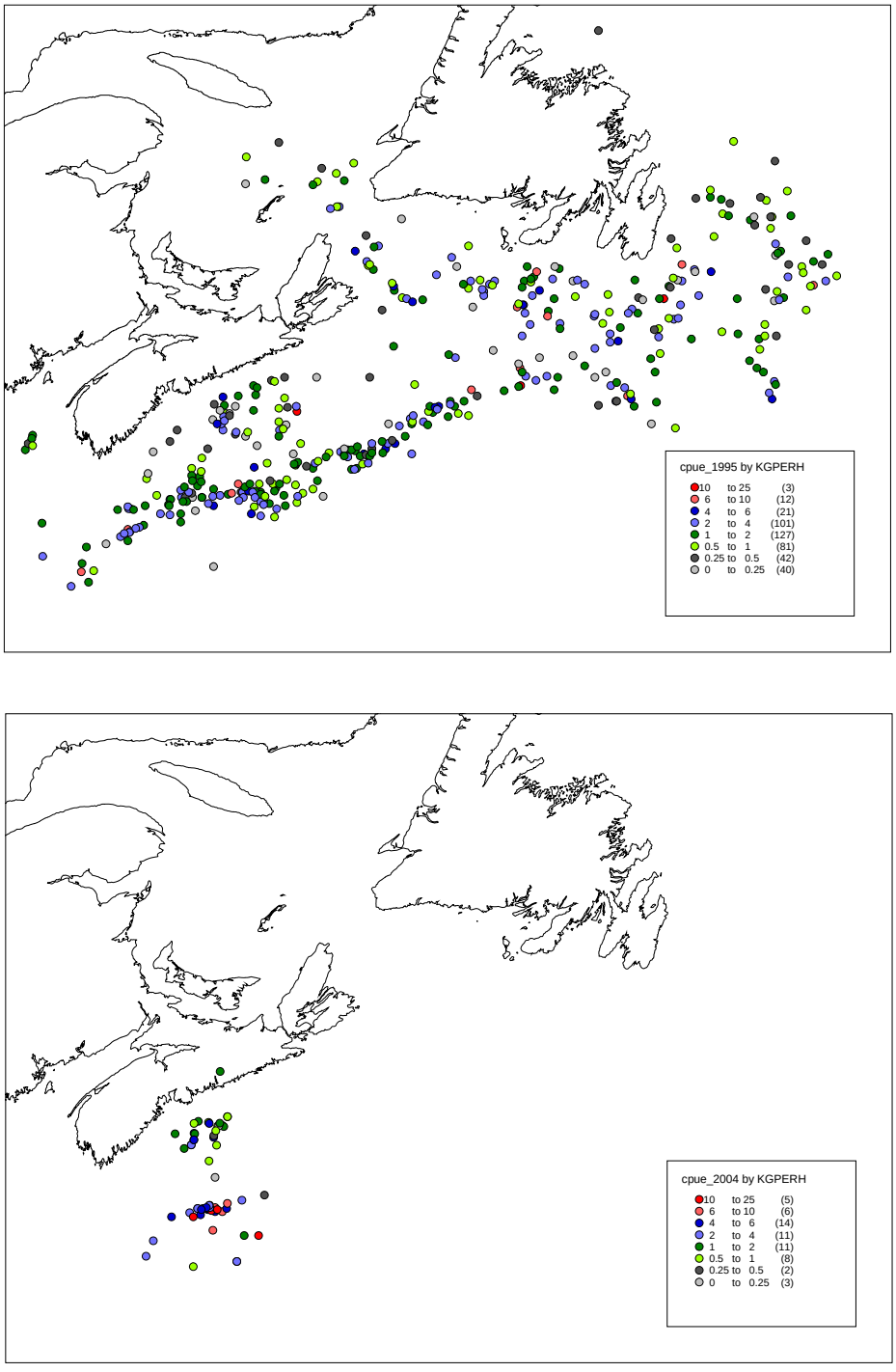


Figure 4. Comparison of the spatial distribution of CPUE (kilograms per hook) in 1995 (top) and 2004 (bottom).

Stock Trends and Current Status

All three models estimate that the number of mature females decreased during the late 1960s and early 1970s followed by an increase in the late 1970s and early 1980s, followed by a decline in the 1990s that has continued until the present (Figure 5). Patterns are similar for both

recruits and total number, although the total number may have stabilized since 2002. The models indicate that the population is about 21% to 24% its total size in 1961, and that female spawner abundance has declined to about 12% to 15% of its 1961 level. Most of the decline is thought to have occurred in the early to mid 1960s. The models indicate an increase in the number of mature porbeagle since 2002.

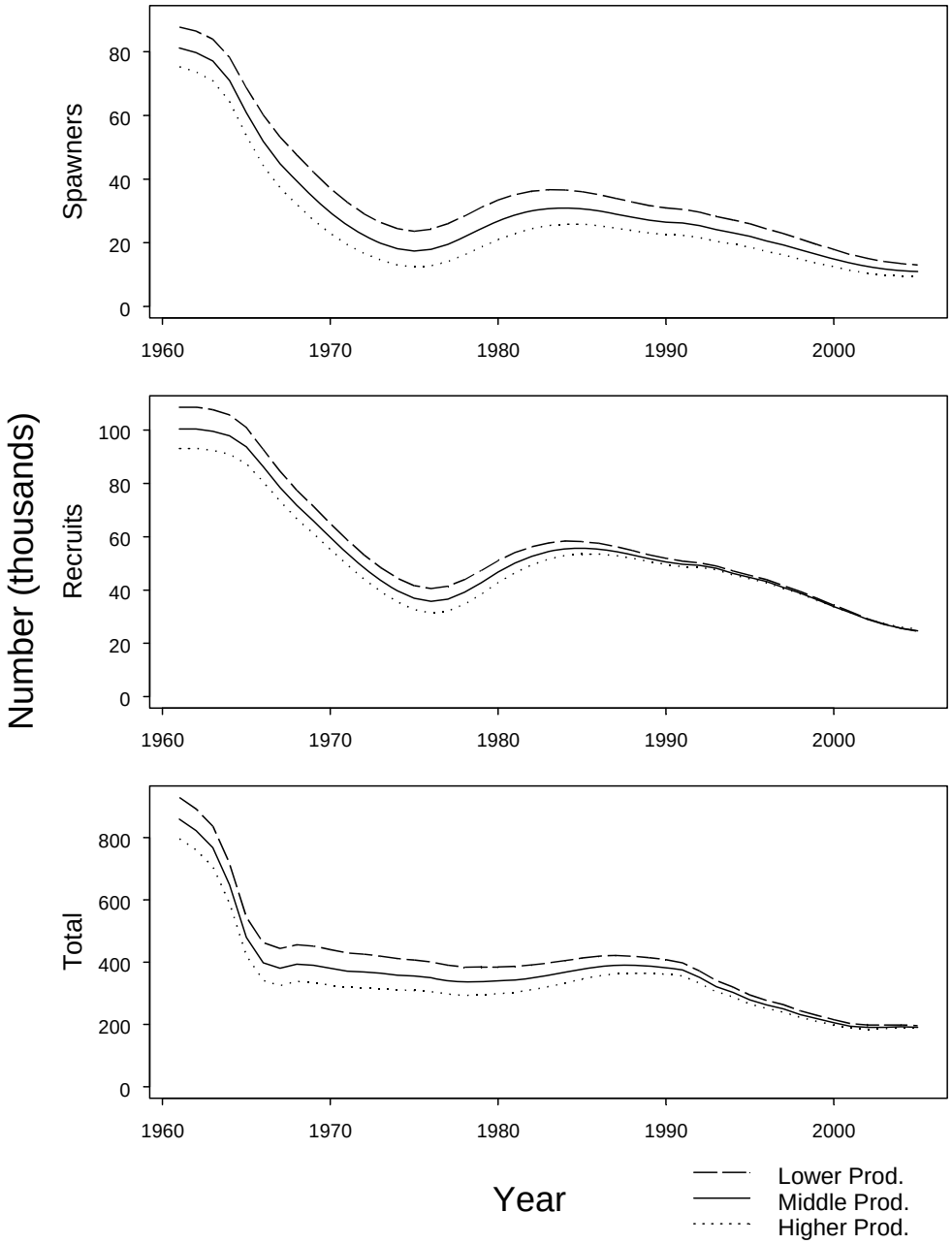


Figure 5. Estimated trends in the number of mature females (top), number of age-1 recruits (middle) and total number (bottom) from the three porbeagle population models.

Estimated Number ('000) of Porbeagle at the Start of 1961, 2002 and 2005

Group and Year	Productivity Scenario		
	lower	middle	higher
Total number:			
1961	929	859	796
2002	198	190	184
2005	195	191	188
Mature females:			
1961	88	81	75
2002	15	13	10
2005	13	11	9
Mature males and females combined:			
1961	235	217	201
2002	37	33	29
2005	38	35	33

Estimates of the **population size in 2005** from the three models are similar ranging from 188,000 to 195,000 fish. The estimated number of mature females range from 9,000 to 13,000 fish or about 15% of the population. The effect of the reduced quotas from 2002 to 2004 varies among models: the model with the highest assumed productivity predicts an increase in total abundance of 3% since 2002, whereas the model with lowest assumed productivity predicts a decline in total abundance of 1% during this time. All models estimate a decline in female spawner abundance (8% to 14%) since the implementation of the 2002 Shark Management Plan. At least two items likely contribute to different trends for total number and number of female spawners: higher exploitation on immature porbeagles in the late 1990s, as well as increased juvenile production as a result of reduced exploitation since 2002. The number of female spawners is expected to increase if the larger number of immature porbeagle presently in the population are afforded the opportunity to survive and mature.

The estimate of the **mid-year vulnerable biomass in 2005** varies among models and assumed selectivity. Assuming either the Shelf-edge or Basin selectivity, the estimates of the vulnerable biomass are in the range of 4,500t to 4,800t. If the NF-Gulf selectivity is used, the vulnerable biomass is estimated to be in the range of 3,400t to 4,100t. The models with the lowest assumed productivity produce the highest estimates of the vulnerable biomass.

Estimated **exploitation rates** are similar from all three models (Figure 6). Exploitation was highest during the early to mid 1960s, was low during the early 1980s, increased in the 1990s and decreased again since 2002 with the implementation of the management plan. The quota reductions from 2002 to present have lowered exploitation. Estimates of exploitation in the Basin area in 2002 to 2004 are in the range of 0.009 to 0.022, in the Shelf-edge region are in the range of 0.019 to 0.039 (the highest value in 2004) and are about 0.001 in the NF-Gulf region in 2003 and 2004. Under all three models, the estimated exploitation rates in 2004 appear sustainable.

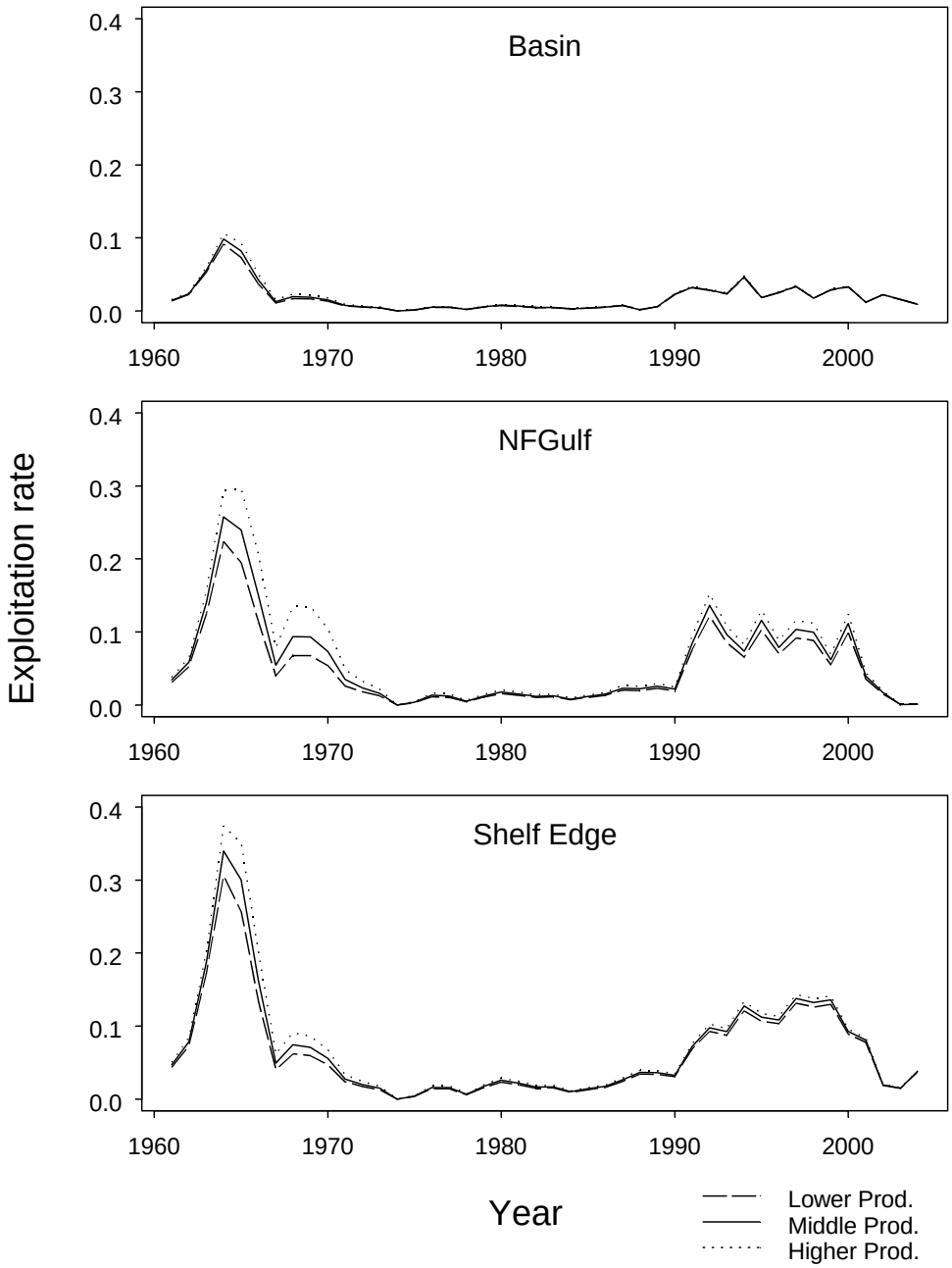


Figure 6. Estimated trends in exploitation rate (proportion of the vulnerable biomass removed by the fishery) in the Basin (top), Newfoundland -Gulf (middle) and Shelf-Edge (bottom) regions from the three porbeagle population models.

Sources of Uncertainty

The overall productivity of the population, including both reproductive rates and natural mortality rates, was not successfully estimated by the model. Three productivity scenarios were analysed to address this uncertainty.

The fishery takes place in a much smaller geographic area than in the past, making interpretation of CPUE difficult.

Two lines of evidence exist that indicate that present abundance is being underestimated by the models: the tagging data and the recent high CPUE in the Basin and Shelf-edge regions.

The model presently produces standard errors (a measure of the precision of the estimates) for model parameter estimates that are unrealistically small. An unresolved issue is therefore the uncertainty in estimates of population size and resource status.

CONCLUSIONS AND ADVICE

The total abundance of porbeagle in 2005 is 21-24% of that present in the unexploited 1961 population. The number of mature females is 12-15% of unexploited levels. Most of the population decline between 1961 and the present was associated with the 1960s fishery. Population abundance since the introduction of the current management plan in 2002 has remained stable, with projections (assuming an exploitation rate of about 4%) indicating a slow increase in population numbers. Current population size is estimated to be about 190,000 porbeagle, with about 36,000 of those being mature individuals.

The recent contraction of the fished area associated with the low catch quotas has made the interpretation of catch rates as indices of resource abundance difficult. This emphasizes the need for a broad-scale shark survey to determine how catch rates (and therefore abundance) vary with area and time across the range of the population. A fishery-independent shark survey could also provide an index of abundance and stock status, but would need to be carried out at regular intervals (1-2 yr intervals) to provide useful results. Since no such survey has been completed to date, the first survey would need to be implemented soon, while population abundance is known.

MANAGEMENT CONSIDERATIONS

Currently, the ability to monitor population status is highly dependent upon individual length measurements from the catch and set by set catch rates, both of which are fishery-dependent activities. There are no equivalent measures of population status which could be used in the absence of some form of fishery, since both the size composition and the catch rate of porbeagle in the bycatch fishery is very different from that in the directed fishery.

A fishery-independent shark survey could provide an index of abundance, but would be most effective in conjunction with size and catch rate data from some form of fishery. It is unlikely that a periodic survey, by itself, would provide a precise measure of stock status.

As the population grows, bycatch is expected to increase.

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FOR MORE INFORMATION

Contact: Steve Campana
Population Ecology Division
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia B2Y 4A2

Tel: (902) 426-3233
Fax: (902) 426-9710
E-Mail: campanas@mar.dfo-mpo.gc.ca
Shark Web Site: www.mar.dfo-mpo.gc.ca/science/shark

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Maritime Provinces
Regional Advisory Process Office
Fisheries and Oceans Canada
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: (902) 426-7070
Fax: (902) 426-5435
E-Mail: myrav@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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