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Catch and Stock Status of Porbeagle Shark (*Lamna nasus*) in the Northwest Atlantic to 2007

by

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Abstract

The abundance of porbeagle shark (*Lamna nasus*) in the Northwest Atlantic has declined substantially since the fishery began in 1961. In 2004, the population was designated as Endangered by Canada's COSEWIC, and in 2007, the species was proposed for listing under Appendix 2 of CITES. Although most of the porbeagle population resides in Atlantic Canadian waters, some porbeagle are caught outside of Canada's EEZ. Thus it is possible that porbeagle catches in unrestricted international waters could jeopardize Canadian attempts to allow recovery of the population. Therefore, the NAFO Fisheries Commission requested a review of historical and current catches and bycatches in both the NAFO Convention Area and the NRA, information on distribution and abundance, and identification of fishery areas or exclusion zones which might reduce incidental bycatch.

Porbeagle landings since 1961 have been as high as 9000t, but have averaged less than 500t annually since the introduction of restrictive Canadian catch quotas in 2001. Most of the Canadian catch has been by pelagic longline. Landings in the NRA were reported differently to NAFO and ICCAT, and have been small and sporadic with the exception of 2005 and 2006, when they exceeded Canadian landings. The accuracy of the 2005 and 2006 NAFO statistics for porbeagle has been questioned, but in general, they probably under-report actual porbeagle catches. The current recovery plan for porbeagle places strict and monitored catch quotas of 185t on Canadian vessels at levels that are less than the MSY catch of 250t. If NRA catches (either reported or unreported) are substantial (>100t), then total porbeagle catches (including the Canadian catch) would put the porbeagle exploitation rate at unsustainable levels. Population projections indicate that the population would crash at catch levels exceeding about 300t.

A forward-projecting age- and sex-structured population dynamics model was used to model the abundance and biomass of the population. A population viability analysis was used to project population recovery under various scenarios. Model variants place the present abundance at about 22% its size in 1961, and female spawner abundance at about 14% of its 1961 level. All models indicate that the population can recover if levels of human-induced mortality are kept below about a 4% exploitation rate, corresponding to a total catch of 185t. Although recovery rates vary among models, time scales are on the order of decades.

Porbeagle are a cold-water temperate shark species, with well defined temperature limits. Therefore, porbeagle exclusion zones in the northwest Atlantic could be defined as latitudes between 38-48 °N and temperatures at depth of 2-14°C. Particularly sensitive areas for porbeagle are those associated with mating off southern Newfoundland, suggesting that the NRA near the Grand Banks is also a mating area. The fisheries most likely to catch porbeagle are pelagic and bottom longline gear, as well as gillnets.

Introduction

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. It is the only large shark species for which a directed commercial fishery exists in Canadian coastal waters.

Fisheries management plans for pelagic sharks in Atlantic Canada established non-restrictive catch guidelines of 1500t for porbeagle prior to 1997 (O'Boyle et al. 1996). Because of the limited scientific information that was available at the time, abundance, mortality and yield calculations could not be made. A comprehensive research program on porbeagle was initiated at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia in 1998, which greatly increased our understanding of porbeagle biology and population dynamics (Campana et al. 2002a,b, 2003; Campana and Joyce 2004; Jensen et al. 2002; Joyce et al. 2002; Natanson et al. 2002), and led to several analytical stock assessments of porbeagle (Campana et al. 1999, 2001, 2003). Based on those assessments, the Shark Management Plan for 2002-2006 reduced the TAC to 250t, a value that was thought to correspond with F_{msy} and was expected to allow for stock recovery. The TAC was further reduced to 185t for 2006-2007, based on a recovery potential assessment which incorporated uncertainty in stock parameters (Gibson and Campana 2005). The 185t TAC reserved 60t for domestic bycatch, leaving only 125t for the directed shark fishery. A condition for the continuation of the directed porbeagle fishery was that a scientific survey for porbeagle be carried out in 2007 and again in 2009, so as to confirm the ongoing recovery of the population.

In May 2004, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the porbeagle as an endangered species. However, the federal government declined to list the species under Schedule 1 of Canada's Species at Risk Act (SARA), given that all necessary recovery measures had already been implemented.

The present document provides an up-to-date summary of national and international catches of porbeagle shark in the northwest Atlantic (NAFO 2-6). Population abundance is based on the age-structured population model, including recovery trajectories into the future, presented in Gibson and Campana (2005). The document concludes with suggestions for reducing incidental catches of the species in NAFO-regulated fisheries. The terms of reference as provided by the NAFO Fisheries Commission are:

8. With respect to porbeagle shark (*Lamna nasus*) in the NAFO Convention Area, the Fisheries Commission with the concurrence of the Coastal State requests Scientific Council, at a meeting in advance of the 2008 Annual Meeting, to provide the following:

a) Information on historical and current catches and bycatches of the species in the NAFO Convention Area and NRA, summarized by NAFO Subarea and fishery;
b) Information on the abundance and distribution of the species in the Convention Area and the NRA;
c) Identification and delineation of any fishery areas or exclusion zones which might reduce the incidental bycatch of this species in NAFO regulated fisheries.

Life History

Porbeagle sharks have low fecundity and late ages at sexual maturation. Age at maturity is about eight years in males and about thirteen years in females (Natanson et al. 2002). In the northwest Atlantic, mating occurs from September through November, and live birth occurs eight to nine months later (Jensen et al. 2002). Reproduction is thought to occur annually. Jensen et al. (2002) reports an average litter size of four young (range two to six). The life span of porbeagle is estimated to be between 25 and 46 years (Campana et al. 2002a; Natanson et al. 2002) and generation time is about 18 years (Campana et al. 2001). Porbeagle are thought to have a low natural mortality. Instantaneous natural mortality is estimated to be 0.10 for immature porbeagle, 0.15 for mature males, and 0.20 for mature females (Campana et al. 2008). Although these estimates are conditional on the gear selectivity assumed in their calculation, they are presently the best available for this population.

ToR 8a: Information on historical and current catches and bycatches of the species in the NAFO Convention Area and NRA, summarized by NAFO Subarea and fishery

Landings rose from about 1,900 t in 1961 to over 9,000 t in 1964 and then fell to less than 1,000 t in 1970 as a result of collapse of the fishery (Table 1; Figure 1). Reported landings remained less than 500 t until 1989, and then increased to a high of about 2000 t in 1992 as Canadians entered the fishery. Landings since 1998 have been increasingly restricted by quota within Canada, and since 2001 have been less than 500t.

Until recently, the large majority of the Canadian landings has been from the directed porbeagle fishery (Table 2; Fig. 2). There is almost no recreational catch. Catches by the Canadian fleet have traditionally been centred on the continental shelf off Nova Scotia and Newfoundland, well within the Canadian EEZ (Fig. 3). Relatively few of the foreign vessels monitored by the Canadian Observer Program have caught porbeagle, but those that have done so, have occasionally fished outside of the EEZ in the NAFO Regulated Area (NRA) (Fig. 4).

Canadian and foreign vessels reporting porbeagle landings are broken down by country and fishery in Table 3. It was not possible to determine from NAFO statistics whether or not foreign vessels fished in Canadian waters or the NRA prior to about 1986. However after 1986, virtually all foreign vessels fishing within Canada's EEZ were monitored by an observer program. Porbeagle catches by foreign vessels monitored by the Observer Program were very small after 1986 (Table 4), suggesting that most foreign (unmonitored) vessels fished in the NRA after 1986.

It is unclear to what extent reported catches reflect actual catches in the NRA. Catches by countries other than Canada were small and intermittent prior to 2005 (Table 3). Relatively large porbeagle catches – larger than those reported by Canada – were reported by Spain in 2005 and 2006, making the porbeagle catch total in the NRA the largest proportion of the total for those years. However, comments made at the NAFO Scientific Council meeting (June 2008) suggested that Spanish catches of porbeagle were negligible in those years, since only catches by otter trawlers were reported to NAFO. Indeed, porbeagle catches reported to NAFO seldom resembled those reported to ICCAT, the agency nominally responsible for large pelagic fisheries in the Atlantic (Table 5). Finally, porbeagle bycatch observed by Japanese observers on Japanese vessels could have amounted to ~200t in 2000 and 2001 (CSAS 2005), yet was not reported in either ICCAT or NAFO statistics. Since NAFO has not requested catch data of large pelagic fishes (including sharks) since 2004, the accuracy of the 2005-2006 catches by countries other than Canada (and excluding the questionable Spanish landings) are in doubt, and are probably under-reported.

The current recovery plan for porbeagle places strict and monitored catch quotas of 185t on Canadian vessels at levels that are less than the MSY catch of 250t (Gibson and Campana 2005. If NRA catches (either reported or unreported) are substantial (>100t), then total porbeagle catches (including the Canadian catch) would put the porbeagle exploitation rate at unsustainable levels. Population projections indicate that the population would crash at catch levels exceeding about 300t.

ToR 8b: Information on the abundance and distribution of the species in the Convention Area and the NRA

Distribution

The distribution of porbeagle within the NAFO convention area is well summarized by the distribution of the Canadian catch, which lies mainly on the continental shelf and slope (Figs. 3 and 4). The distribution of mature females varies seasonally, but is concentrated off southern Newfoundland and in the Gulf of St. Lawrence in the late summer and fall (Fig. 5).

The distribution of porbeagle in the NRA is not well known. Observed vessels have caught porbeagle in NAFO subareas 3 and 4 of the NRA, but for the most part, vessels fishing the NRA do not report the fishing location for porbeagle. Recent tagging of porbeagle with archival satellite popup tags has indicated that a certain proportion of porbeagle tagged on the continental shelf later swim into the NRA (Campana, unpublished). However, the extent or duration of time spent in the NRA is unknown.

Abundance

A forward-projecting age- and sex-structured population dynamics model was used in this analysis, as described in Gibson and Campana (2005). Within this model, the population was projected forward from an equilibrium starting abundance and age distribution by adding recruitment and removing catches. A key assumption in the model was that the porbeagle population was at an unfished equilibrium at the beginning of 1961, when the directed commercial fisheries for porbeagle began. Model parameter estimates were obtained by fitting the model to the available data using maximum likelihood. The spawner-recruit (SR) function (a Beverton-Holt function) was formulated such that the parameters were the maximum rate at which female spawners produce age-1 recruits (α) and the asymptotic recruitment level (R_{asy}), with both parameters estimated within the model. Survival from birth to age-1 was also estimated in the model. Additional features of the model included: a) splitting the fishery into three regions; b) integration of the CPUE analysis into the assessment model; c) addition of a model component to include tagging data; d) addition of a model component to estimate reference points; e) addition of a population viability analysis (PVA) to evaluate recovery trajectories.

Four model variants were prepared, since the estimation of natural mortality and selectivity was confounded, preventing the direct estimation of α when the integrated CPUE analysis was used. Three of the variants of the model used different reproductive scenarios with integrated CPUE, while the fourth used the externally standardized CPUE. 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.

- Model 1: GLM-standardized CPUE for immature and mature porbeagle; *M*=0.1 and 0.2 for immature and mature porbeagle respectively.
- Model 2: integrated CPUE by weight; *M*= 0.1 and 0.2 for immature and mature porbeagle respectively; constant α =2.0 (lower productivity scenario).
- Model 3: integrated CPUE by weight; *M*= 0.1 and 0.2 for immature and mature porbeagle respectively; constant α =2.5 (intermediate productivity scenario).
- Model 4: integrated CPUE by weight; *M*= 0.1 and 0.2 for immature and mature porbeagle respectively; constant α =3.2 (higher productivity scenario).

As described in Gibson and Campana (2005), Model 1 provided a poor fit to the data. Models 2-4 were considered to be the most appropriate representations of the porbeagle population.

Population viability analysis

Two methods were used to evaluate how fishing mortality affected recovery potential and timing. First, we projected the population forward deterministically from the estimated 2004 population size and age-structure using the estimated life history parameters and an assumed bycatch rate. We used the selectivity parameters from the Shelf-Edge fishery for these simulations. Simulations were carried out for 17 levels of bycatch mortality (defined as the proportion of the vulnerable biomass taken as bycatch) ranging from 0.0 to 0.1. Population projections were 100 years in length.

Model Results

All three models estimated that the number of mature females decreased abruptly during the late 1960s and early 1970s, increased in the late 1970s and early 1980s, followed by a decline in the 1990s that continued until 2005 (Fig. 6). Patterns were similar for both recruits and total population number, although the total number may have stabilized after 2002. The models indicated that the 2005 population was about 21% to 24% its total size in 1961, and that female spawner abundance 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 indicated an increase in the number of mature porbeagle since 2002.

Estimates of the population size in 2005 from the three models were similar, ranging from 188,000 to 195,000 fish (Table 6). The estimated number of mature females ranged from 9,000 to 13,000 fish or about 15% of the population. The effect of the reduced quotas from 2002 to 2004 varied among models: the model with the highest assumed productivity predicted an increase in total abundance of 3% between 2002 and 2005, whereas the model with the lowest assumed productivity predicted a decline in total abundance of 1% during this time.

The estimate of the mid-year vulnerable biomass in 2005 varied among models and assumed selectivity (Table 7). Assuming the Shelf-Edge selectivity, the preferred models (integrated CPUE) placed the vulnerable mid-year biomass in 2005 at just over 4,500t. The models with the lowest assumed productivity produced the highest estimates of the vulnerable biomass.

Estimated exploitation rates were similar from all three models. 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 reduced quotas. Estimates of exploitation in the Basin area in 2002 to 2004 were in the range of 0.009 to 0.022, in the Shelf-edge region were in the range of 0.019 to 0.039, and were about 0.001 in the NF-Gulf region in 2003 and 2004. Under all three models, the estimated exploitation rates in 2004 appeared to be sustainable.

Recovery trajectories

All deterministic PVA models indicated that the northwest Atlantic porbeagle population will recover if levels of human-induced mortality are kept low, although time to recovery varied with the different assumed productivities (Fig. 7). In the absence of human-induced mortality, recovery to $SSN_{20\%}$ should occur by about 2015. An incidental harm rate of 2% of the vulnerable biomass delays recovery to $SSN_{20\%}$ to the period between 2015 and 2020. At an incidental harm rate of 4% of the vulnerable biomass, estimated recovery to $SSN_{20\%}$ from all models occurs before 2020, although in the low productivity scenario, the population then drops slightly, increases again, and then remains stable at about $SSN_{20\%}$ for the remainder of the century. At an incidental harm rate of 7% of the vulnerable biomass, recovery to $SSN_{20\%}$ occurs only in the model with the highest assumed productivity.

In the absence of human-induced mortality, the three models place recovery to SSN_{msy} sometime between 2030 and 2060. An incidental harm rate of 4% of the vulnerable biomass is predicted to delay recovery to SSN_{msy} into the 22nd century (or later) by all models except the one with the highest productivity (a delay of 28 years relative to the scenario without human-induced mortality). At an incidental harm rate of 7% of the vulnerable biomass, the population will not recover to SSN_{msy}.

By 2015, this porbeagle population will have been fished for three generations. Using these models, in the absence of human-induced mortality, the population size in 2015 is predicted to be in the range of 228,000 to 260,000 individuals, including 47,000 to 50,000 mature animals. At a human-induced mortality rate of 4% of the vulnerable biomass (Shelf-edge selectivity assumed), the population size is predicted to be in the range of 197,000 to 226,000 individuals. Both of these scenarios represent increases in total abundance from 2005 (lower productivity model: 195,000 fish; middle productivity model: 191,000 fish; higher productivity model: 188,000 fish). At a human-induced mortality rate of 7% of the vulnerable biomass, the predicted population size in 2015 is less than the population size in 2005 from all but the most productive model.

Based on the middle productivity model, median recovery times to $SSN_{20\%}$ under the stochastic PVA model were slightly longer than under the deterministic model (Fig. 8). In the absence of human-induced mortality, the simulated populations showed little variability in recovery to $SSN_{20\%}$. As human-induced mortality increased, the variability in time to recovery to $SSN_{20\%}$ also increased. At a human-induced mortality rate of 4% of the vulnerable biomass, 80% of the simulated populations recovered to $SSN_{20\%}$ between 2016 and 2037. At a human-induced mortality rate of 7% of the vulnerable biomass, 42% of the simulated populations recovered to $SSN_{20\%}$. although none recovered to SSN_{msy}.

At a human-induced mortality rate of 2%, time to recovery to SSN_{msy} varied by about 3 decades and 90% of simulated populations recovered to SSN_{msy} by about 2075. At a human induced mortality rate of 4%, about 30% of the populations did not recover to SSN_{msy} within 100 years. None of the simulated populations recovered to SSN_{msy} at a human-induced mortality rate of 7% of the vulnerable biomass.

In summary, all analyses indicated that this population can recover, but recovery potential and times are sensitive to all levels of human-induced mortality. Exploitation rates less than about 4% of the vulnerable biomass are expected to allow recovery to both $SSN_{20\%}$ and SSN_{msy}.

ToR 8c: Identification and delineation of any fishery areas or exclusion zones which might reduce the incidental bycatch of this species in NAFO regulated fisheries

Porbeagle are a cold-water temperate shark species, and in the northwest Atlantic, are found almost exclusively between latitude 38-48 °N. In addition, porbeagle are seldom caught at temperatures (at the depth of the gear) exceeding 14°C. Therefore, porbeagle exclusion zones in the northwest Atlantic could be defined as latitudes between 38-48 °N and temperatures at depth of 2-14°C.

Although porbeagle distribution in the NRA is poorly known, porbeagle are widely distributed throughout the continental shelf area. They may be equally widely distributed in the NRA. Particularly sensitive areas for porbeagle are those associated with mating and pupping. Pupping areas have not yet been determined. However, mating areas are known to be present off southern Newfoundland, suggesting that the NRA near the Grand Banks is also a mating area.

Since porbeagle are a fast-swimming shark, they are seldom captured in bottom trawls. Pelagic and bottom longline gear, as well as gillnets, are most likely to catch porbeagles.

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Table 1. Reported porbeagle landings (mt) by country.

Northwest Atlantic (NAFO Areas 2 - 6)

Year	Canada	Faroe Is	France	Iceland	Japan	Norway	Spain	USSR	USA	Total
1961	0	100				1824				1924
1962	0	800				2216				3016
1963	0	800				5763				6563
1964	0	1214		7		8060				9281
1965	28	1078				4045				5151
1966	0	741				1373				2114
1967	0	589			36					625
1968	0	662			137	269				1068
1969	0	865			208					1073
1970	0	205			674					879
1971	0	231			221					452
1972	0	260				87				347
1973	0	269								269
1974	0									
1975	0	80								80
1976	0	307								307
1977	0	295								295
1978	1	121								122
1979	2	299								301
1980	1	425								426
1981	0	344			3					347
1982	1	259			1					261
1983	9	256			0					265
1984	20	126			1	17				164
1985	26	210			0					236
1986	24	270			5			1		300
1987	59	381			16			0	12	468
1988	83	373			9			3	32	500
1989	73	477			9			3	4	566
1990	78	550			8			9	19	664
1991	329	1189			20			12	17	1567
1992	814	1149			7			8	13	1991
1993	920	465			6			2	39	1432
1994	1573				2				3	1578
1995	1348		7		4				5	1364
1996	1043		40		9				8	1100
1997	1317		13		2				2	1334
1998	1054		20		0				12	1086
1999	955				6				3	964
2000	899		13		24					936
2001	499		2		25					526
2002	229		1		0				0	230
2003	139		2		0				0	141
2004	218		4		0				1	223
2005	203						221		0	424
2006	190						230		0	420
2007	87									87

Notes:
France data is from FAO Statistics (1996), 2000-2005 from FAO Fishstat Plus v 2.32
Northwest Atlantic Data for 1950-60 is from FAO (ICCAT Report of Shark Working Group, Miami, 26-28 Feb 1996)
Canada for 1961 - 90 is from NAFO
Canada for 1991 - 2002 is from DFO Zonal Statistics File, corrected to appropriate live equivalent weight.
Canada for 2003-2007 is from DFO MARFIS
Faroe Is for 1961 - 63 is from FAO (ICCAT Report of Shark Working Group, Miami, 26 - 28 February 1996)
Norway from 1961-86 is from NAFO
Northwest Atlantic Data for 1964 - 86 is from NAFO
Northwest Atlantic Data for 1987-2004 is from Scotia-Fundy & NF IOP (includes landings and discards)
Northwest Atlantic Data (US/ 1961 - 94) is from FAO (ICCAT Report of Shark Working Group, Miami, 26 - 28 February 1996
Northwest Atlantic Data for 2000-2006 from FAO Fishstat Plus v 2.32 Capture Production March 2008,
NAFO Database 21B or ICCAT Task 1 Dataset 2007
Northwest Atlantic Data for 2000-2006 (Japan) from NAFO Database 21B , catch for code 469, large sharks

Table 2. Canadian porbeagle landings 1991 to 2007.

		NAFO Subarea					
Year	Fishery	2	3	3M	4	5	6
1991	groundfish	.	.	.		0 .	.
	shark	.		162 .		166	1 .
1992	groundfish	.	.	.		4 .	.
	large pelagics	.	.	.		0 .	.
	redfish	.	.	.		0 .	.
	shark	.		232 .		404	172 .
1993	groundfish	.		0 .		3	2 .
	large pelagics	.	.	.		0 .	.
	redfish	.		0 .		0 .	.
	shark	.		339 .		566	9 .
1994	groundfish	.		0 .		3 .	.
	large pelagics	.		0 .		10	0 .
	shark	.		290 .		1246	17 .
	unknown	.		0 .		5 .	.
1995	groundfish	.		0 .		7	0 .
	large pelagics	.		3 .		18	0 .
	redfish	.	.	.		0 .	.
	shark		1	490 .		801	25 .
	unknown	.		1 .		1 .	.
1996	groundfish	.		0 .		6	2 .
	large pelagics	.		2 .		5 .	.
	redfish	.		0 .		0 .	.
	shark	.		297	2	697	19 .
	unknown	.	.	.		13 .	.
1997	groundfish	.		1 .		11	3 .
	large pelagics	.		0 .		6	0 .
	redfish	.		0 .		0 .	.
	shark	.		317 .		921	35 .
	small pelagics	.	.	.		0 .	.
	unknown	.	.	.		23 .	.
1998	groundfish	.		0 .		13	2 .
	large pelagics	.		6 .		8	0 .
	redfish	.	.	.		0 .	.
	shark	.		284 .		664	71 .
	unknown	.	.	.		6 .	.
1999	groundfish	.		0 .		11	2 .
	large pelagics	.		0 .		3 .	.
	redfish	.	.	.		0 .	.
	shark	.		168 .		700	70 .
	small pelagics	.	.	.		0 .	.
	unknown	.	.	.		0 .	.
2000	groundfish	.		0 .		6	0 .
	large pelagics	.		0 .		2	0 .
	redfish	.	.	.		0 .	.
	shark	.		253 .		606	30 .
2001	groundfish	.		1 .		8	0 .
	large pelagics	.		0	0	7	0 .
	redfish	.		0 .	.	.	.

	shark	.		35	.	445		1	.	
	small pelagics	.	.		.	0	.		.	
	unknown	.	.		.	1	.		.	
2002	groundfish	.		2	.	13		1	.	
	large pelagics	.		0	.	21	.		.	
	redfish	.		0	.	0	.		.	
	shark	.		25	.	168		0	.	
2003	groundfish	.		1	.	16		1	.	
	large pelagics	.		1	.	25		0		0
	shark	.	.		.	95		0	.	
2004	groundfish	.		1	.	17		0	.	
	large pelagics	.		0	.	16	.		.	
	redfish	.	.		.	0	.		.	
	shark	.	.		.	185	.		.	
	small pelagics	.	.		.	0	.		.	
2005	groundfish	.		3	.	16		1	.	
	large pelagics	.		0	.	12		0	.	
	redfish	.	.		.	0	.		.	
	shark	.	.		.	171	.		.	
2006	groundfish	.		3	.	11		1	.	
	large pelagics	.		0	.	35		0	.	
	shark	.	.		.	139	.		.	
2007	groundfish	.		2	.	16		1	.	
	large pelagics	.		0	.	17		0	.	
	redfish	.		0	.	0	.		.	
	shark	.		4	.	47		1	.	

Landings as recorded in MARFIS and ZIF

Table 3. Porbeagle landings by country, fishery and NAFO subarea as reported to NAFO.

			NAFO Subarea													Total by	
Year	Country	Fishery	2		3		3M	4		5		6		Unknown	fishery	NRA Total
			inside	NRA	inside	NRA	NRA	inside	NRA	inside	NRA	inside	NRA		inside+NRA	
1961	Iceland	groundfish			2										2	0
	USA*	groundfish								4					4	0
		large pelagics								2					2	0
	Germany*	unknown	28		7		2								35	2
	Iceland	groundfish			1										1	0
	Norway	shark	.		152		.	1532		140		.		.	1824	0
	USA*	groundfish								6					6	0
		large pelagics								2					2	0
		unkown								2					2	0
1962	Germany*	redfish	1												1	0
	Iceland	redfish			1										1	0
	USA*	scallop								6					6	0
		unknown								10					10	0
	Norway	shark	.		283		.	488		1445		.		.	2218	0
1963	Germany*	groundfish	2		1										3	0
	Iceland	redfish			2										2	0
	USA*	groundfish								59					59	0
		large pelagics								2					2	0
		unknown								358		313			671	0
	Norway	groundfish	.		2		.	.		.		.		.	2	0
		shark	.		738		.	1269		3756		.		.	5761	0
1964	Faroe Is	mixed	.		.		.	1214		.		.		.	1214	0
	Germany*	groundfish	4		7			1							12	0
	Iceland	groundfish	.		7		.	.		.		.		.	7	0
	Norway	shark	.		1030		.	1775		5255		.		.	8060	0
	USA*	groundfish								4					4	0
		unknown								85		682			767	0
1965	Canada	groundfish	.		.		.	1		.		.		.	1	0
		large pelagics	.		5		.	14		8		.		.	27	0
	Faroe Is	shark	.		1078		.	.		.		.		.	1078	0
	Germany*	groundfish	20		1										21	0
	Norway	shark	.		.		.	.		.		4045		.	4045	0
	USA*	groundfish								1101					1101	0
		large pelagics								1					1	0
		unknown								1280		393			1673	0
1966	Faroe Is	groundfish	.		741		.	.		.		.		.	741	0
	Germany*	groundfish	5												5	0
		large pelagics								3					3	0
	Norway	shark	.		.		.	.		506		868		.	1373	0
	USA*	groundfish								247					247	0
		large pelagics								5		3			8	0
		unknown	.		.		.	.		331		400			731	0
1967	Faroe Is	groundfish	.		589		.	.		.		.		.	589	0
	Germany*	groundfish													0	0
	Japan	mixed	.		.		.	.		.		38		.	38	0
	USA*	groundfish								92					92	0
		unknown								169		3			172	0
1968	Faroe Is	shark	.		682		.	.		.		.		.	682	0
	Germany*	groundfish			1										1	0
		redfish	1		1										2	0
		small pelagics						1		18		5			24	0
	Iceland	redfish			1										1	0
	Japan	groundfish	.		1		.	.		.		.		.	1	0
		mixed	.		.		.	7		5		.		.	12	0
		shark	.		.		.	.		.		28		.	28	0
		small pelagics	.		.		.	.		.		97		.	97	0
	Norway	shark	.		269		.	.		.		.		.	269	0
	USA*	groundfish								124					124	0
		unknown								30		24			54	0
1969	Faroe Is	shark	.		.		.	865		.		.		.	865	0
	Iceland	unknown			1										1	0
	Japan	mixed	.		.		.	3		132		73		.	208	0
	USA*	groundfish								13		1			14	0

		unknown					52	58		110	0
1970	Faroe Is	mixed	.	205	.	.	.	.	.	205	0
	Japan	mixed	.	.	.	15	334	325	.	674	0
	USA*	groundfish					61			61	0
		unknown					14	169		183	0
1971	Faroe Is	mixed	.	.	.	231	.	.	.	231	0
	Iceland	redfish		1						1	0
	Japan	mixed	.	.	.	81	64	78	.	221	0
	USA*	groundfish					1			1	0
		unknown					12	89		101	0
1972	Faroe Is	mixed	.	.	.	.	260	.	.	260	0
	Germany*	squid						2		2	0
		unknown	8	8						16	0
	Iceland	redfish		1						1	0
	Norway	shark	.	29	.	29	29	.	.	87	0
	Romania*	small pelagics					5	31		36	0
	USA*	groundfish					12			12	0
		unknown					6	96		102	0
1973	Faroe Is	mixed	.	.	.	269	.	.	.	269	0
	USA*	groundfish					6			6	0
		shrimp					3			3	0
		unknown					9	109		118	0
1974	USA*	groundfish					1			1	0
		shrimp					1			1	0
		unknown					4	52		56	0
1975	Faroe Is	mixed	.	.	.	20	60	.	.	80	0
	Germany*	groundfish	14							14	0
	USA*	large pelagics					1			1	0
		unknown					18	90		108	0
1976	Faroe Is	shark	.	.	.	290	17	.	.	307	0
	Japan	small pelagics					3			3	0
	USA*	groundfish					4			4	0
		large pelagics				2		2		4	0
		shark						1		1	0
		unkown					9	49		58	0
1977	Faroe Is	shark	.	4	.	288	3	.	.	295	0
	Germany*	groundfish	12	10						22	0
	Italy*	squid						3		3	0
	Japan	squid					12	4		16	0
	S. Korea*	squid					1			1	0
	Spain	squid	.	.	.	.	.	2	.	2	0
	USA*	groundfish					33			33	0
		unknown					4	49		53	0
1978	Canada	mixed	.	.	.	1	.	.	.	1	0
	Faroe Is	shark	.	20	.	101	.	.	.	121	0
	Germany*	groundfish	2							2	0
	Japan	squid					1			1	0
	USA*	groundfish					11	1		12	0
		large pelagics					3	3		6	0
		unknown					7	66		73	0
1979	Canada	mixed	.	.	.	2	.	.	.	2	0
	Faroe Is	shark	.	98	.	201	.	.	.	299	0
	Germany*	groundfish		2						2	0
	Japan	squid		2		1	20	2		25	0
	USA*	groundfish					9			9	0
		large pelagics		2		1	9	2		14	0
		unknown					6	37		43	0
1980	Canada	large pelagics	.	.	.	1	.	.	.	1	0
	Faroe Is	shark	.	111	.	312	2	.	.	425	0
	Japan	squid				2	13	6		21	0
	USA*	groundfish					21	6		27	0
		large pelagics		7			2	6		15	0
		unknown					151	70		221	0
1981	Faroe Is	shark	.	19	.	325	.	.	.	344	0
	Japan	squid				1	6			7	0
	USA*	groundfish					6			6	0
		large pelagics		4			8	3		15	0
		shark					31			31	0

		unknown					50	78		128	0
1982	Canada	groundfish	.	.	.	1	.	.	.	1	0
	Faroe Is	shark	.	.	.	214	45	.	.	259	0
	Japan	squid					10	4		14	0
	USA*	groundfish					37	1		38	0
		large pelagics		1		4	23	10		38	0
		unknown					11	59		70	0
1983	Canada	groundfish	.	.	.	4	.	.	.	4	0
		large pelagics	.	1	.	4	.	.	.	5	0
	Faroe Is	shark	.	76	.	170	10	.	.	256	0
	Germany*	groundfish		3						3	0
		redfish			1					1	1
	Japan	groundfish				1				1	0
		squid					2			2	0
	USA*	groundfish					29	2		31	0
		large pelagics		6		1	10	15		32	0
		shark					1	6		7	0
		unkown		2	1		16	41		60	1
1984	Canada	groundfish	.	.	.	6	3	.	.	9	0
		large pelagics	.	1	.	2	1	.	.	4	0
		mixed	.	.	.	5	2	.	.	7	0
	Faroe Is	mixed	.	.	.	126	.	.	.	126	0
	Germany*	groundfish		2						2	0
		redfish	1							1	0
	Norway	shark	.	.	.	17	.	.	.	17	0
	Japan	groundfish	3							3	0
		redfish		4		38				42	0
	USA*	groundfish					27	1		28	0
		large pelagics		7	3	1	6	25		42	3
		scallop						2		2	0
		shark						4		4	0
		unkown		1			21	35		57	0
1985	Canada	large pelagics	.	.	.	10	8	.	.	18	0
		mixed	.	.	.	7	1	.	.	8	0
	Faroe Is	shark	.	3	.	137	70	.	.	210	0
	Germany*	groundfish		5	3					8	3
		redfish		2						2	0
	USA*	groundfish					11	2		13	0
		large pelagics		6		9	9	14		38	0
		squid						1		1	0
		unkown		1			40	94		135	0
1986	Canada	large pelagics	.	.	.		8	.	.	8	0
		mixed	.	.	.	4	.	.	.	4	0
	Faroe Is	shark	.	.	.	270	.	.	.	270	0
	Germany*	groundfish		1						1	0
		small pelagics					37	1		38	0
	Japan	redfish		10		7				17	0
	Poland*	small pelagics					5	6		11	0
	USA*	groundfish					9			9	0
		large pelagics		4		5	33	33		75	0
		unknown		2			41	52		95	0
1987	Canada	groundfish	.	.	.	3	1	.	.	4	0
		large pelagics	.	.	.	11	10	.	.	21	0
		mixed	.	.	.	34	.	.	.	34	0
	Faroe Is	shark	.	.	.	260	.	.	.	260	0
	Germany*	groundfish	2	2						4	0
	Japan	groundfish	2	6						8	0
		redfish		1		11				12	0
	USA*	groundfish					49			49	0
		large pelagics		3	5		37	40		85	5
		scallop						1		1	0
		squid						1		1	0
		unkown		1	1		36	75		113	1
1988	Canada	groundfish	.	1	.	22	1	.	.	24	0
		large pelagics	.	2	.	21	8	.	.	31	0
		mixed	.	.	.	6	.	.	.	6	0
		shark	.	.	.	22	.	.	.	22	0
	Faroe Is	groundfish	.	19	.	.	.	.	.	19	0

		shark	.	69	.	182	.	.	.	251	0
	Japan	groundfish	3	2						5	0
		redfish		4		3				7	0
	USA*	groundfish				2	49	3		54	0
		large pelagics		12	11	2	22	49		98	11
		shark					1	1		2	0
		unknown			4	1	90	160		255	4
1989	Canada	groundfish	.	.	.	24	3	.	.	27	0
		large pelagics	.	6	.	33	7	.	.	46	0
	Faroe Is	shark	.	132	.	324	.	.	.	456	0
	Japan	groundfish	4			1				5	0
		redfish		2						2	0
	USA*	groundfish				1	50	25		76	0
		large pelagics		14	59		43	46		162	59
		shark						43		43	0
		unknown					21	51		72	0
1990	Canada	groundfish	.	1	.	23	2	.	.	26	0
		large pelagics	.	5	.	32	4	.	.	41	0
		shark	.	.	.	11	.	.	.	11	0
	Faroe Is	shark	.	129	.	401	.	.	.	530	0
		redfish		1						1	0
	USA*	groundfish				1	64	38		103	0
		large pelagics		13	19		53	109		194	19
		shark						10		10	0
		unknown		1			29	95		125	0
1991	Canada	groundfish		1		151	2				0
		large pelagics				25	19				0
		shark		166		170	1				0
		unknown				3					0
	Faroe Is	shark	.	12	.	598	.	.	.	610	0
	Japan	redfish		1						1	0
	USA*	groundfish					75	154		229	0
		large pelagics		18	18		29	132		197	18
		shark						205		205	0
		small pelagics					2	1		3	0
		unkown			1	4	26	254		285	1
1992	Canada	groundfish	.	.	.	31	1	.	.	32	0
		large pelagics	.	.	.	.	2	.	.	2	0
		shark	.	229	.	332	146	.	.	707	0
	Japan	groundfish				18				18	0
		redfish		1						1	0
	Russia	groundfish				27				27	0
	USA*	groundfish					100	26		126	0
		large pelagics		9	36		31	83		159	36
		shark						644		644	0
		small pelagics						1		1	0
		unkown			1		26	468		495	1
	Faroe Is	shark	.	124	.	435	.	.	.	559	0
1993	Canada	groundfish	.	1	.	24	4	.	.	29	0
		large pelagics	.	.	.	29	.	.	.	29	0
		shark	.	338	.	522	1	.	.	861	0
	Cuba*	groundfish				2				2	0
	Faroe Is	mixed	.	250	.	.	.	.	.	250	0
	USA*	groundfish					35	10		45	0
		large pelagics		30	25		17	55		127	25
		shark					110	573		683	0
		unknown					19	10		29	0
1994	Canada	groundfish	.	.	.	7	.	.	.	7	0
		large pelagics	.	11	.	57	8	.	.	76	0
		shark	.	281	.	1179	7	.	.	1467	0
	Japan	groundfish		1						1	0
1995	Canada	groundfish	.	.	.	12	.	.	.	12	0
		large pelagics	.	2	.	108	.	.	.	110	0
		mixed	.	2	.	.	.	.	.	2	0
		shark	1	464	.	700	25	.	.	1190	0
		small pelagics	.	.	.	9	.	.	.	9	0
	Japan	groundfish		16	1					17	1
1996	Canada	groundfish	.	1	.	7	.	.	.	8	0

		large pelagics	.	4	.	37	.	.	.	41	0
		mixed	.	1	.	2	.	.	.	3	0
		shark	.	295	2	668	19	.	.	982	2
	France	mixed	.	39	.	.	.	.	.	39	0
	Japan	groundfish		9	11					20	11
		redfish		4						4	0
1997	Canada	groundfish	.	1	.	10	2	.	.	13	0
		large pelagics	.	15	.	25	9	.	.	49	0
		mixed	.	7	.	1	.	.	.	8	0
		shark	.	227	.	935	27	.	.	1189	0
	France	mixed	.	13	.	.	.	.	.	13	0
	Japan	groundfish		22						22	0
		redfish		2						2	0
1998	Canada	groundfish	.	.	.	8	1	.	.	9	0
		large pelagics	.	1	.	18	2	.	.	21	0
		shark	.	253	.	652	70	.	.	975	0
		small pelagics	.	.	.	1	.	.	.	1	0
	France	groundfish	.	1	.	.	.	.	.	1	0
		shark	.	19	.	.	.	.	.	19	0
	Japan	groundfish		13						13	0
		redfish		1	3					4	3
	UK*	groundfish			4					4	4
1999	Canada	groundfish	.	.	.	3	2	.	.	5	0
		large pelagics	.	.	.	28	.	.	.	28	0
		shark	.	169	.	688	70	.	.	927	0
	Japan	groundfish		28						28	0
		redfish			2					2	2
2000	Canada	groundfish	.	.	.	1	.	.	.	1	0
		large pelagics	.	.	.	1	.	.	.	1	0
		shark	.	254	.	615	31	.	.	900	0
	France	mixed	.	13	.	.	.	.	.	13	13
	Japan	groundfish		24						24	24
2001	Canada	large pelagics	.	.	.	10	.	.	.	10	0
		shark	.	36	.	451	1	.	.	488	0
	France	mixed	.	2	.	.	.	.	.	2	2
	Japan	groundfish		24	1					25	25
2002	Canada	groundfish	.	2	.	35	.	.	.	37	0
		large pelagics	.	.	.	20	1	.	.	21	0
		shark	.	24	.	155	.	.	.	179	0
	France	mixed	.	1	.	.	.	.	.	1	1
2003	Canada	groundfish	.	1	.	.	.	.	.	1	0
	France	mixed	.	1	.	.	.	.	.	1	1
2004	Canada	groundfish	.	0	.	8	0	.	.	8	0
		large pelagics	.	0	.	20	.	.	0	20	0
		mixed	.	.	.	5	.	.	.	5	0
		shark	.	.	.	184	.	.	.	184	0
		small pelagics	.	.	.	0	.	.	.	0	0
2005	Canada	groundfish	.	1	.	13	0	.	.	14	0
		large pelagics	.	.	.	11	.	.	.	11	0
		mixed	.	0	.	7	0	.	.	7	0
		shark	.	.	.	160	.	.	.	160	0
		small pelagics	.	0	.	.	.	.	.	0	0
	Spain**	mixed	.	10	117	.	.	94	.	221	221
2006	Canada	groundfish	.	0	.	.	.	.	.	0	0
	France	groundfish	.	0	.	.	.	.	.	0	0
		mixed	.	0	.	.	.	.	.	0	0
	Spain	mixed	.	6	101	3	.	120	.	230	230

Catch in columns termed "inside" are considered to occur within the 200 mile limit and does not include catch from column termed "NRA"
NRA contains catch in NAFO subdivisions which fall outside the 200 mile limit, as well as non-Canadian or non-US catches after 1999
* For countries (Cuba, Germany, Italy, Poland, Portugal, Romania, UK, USA and S. Korea) without recorded porbeagle catch, code 469 "large sharks" was used.
For Canada in 1991 and Japan after 1975 (no reported porbeagle) code 469 "large sharks" was used.
USA fishing in subarea 5 and 6 assumed to be fishing within own EEZ
Catch of "large sharks" reported by Portugal in 2006 were likely basking or Greenland sharks, since gear used was otter trawl
** Spanish catches in 2005 were reported to FAO, but not NAFO

Table 4. Foreign porbeagle catch observed by the Canadian Observer Program.

NAFO Subarea

Year	Country	Fishery	3		3M	4		5	
			ALL	NRA	NRA	ALL	NRA	ALL	NRA
1979	France (mainland)	squid	.		.	0		.	
1980	USSR	groundfish	.		.	0		.	
		squid	.		.	0		.	
1981	Faroes	shark	.		.	26		.	
	Japan	large pelagics	.		.	3		.	
	USSR	groundfish	.		.	0		.	
1982	Japan	large pelagics	.		.	1		.	
1983	Cuba	groundfish	.		.	0		.	
	France (mainland)	groundfish	.		.	0		.	
	Japan	large pelagics	.		.	0		.	
	USSR	groundfish	.		.	0		.	
1984	FranSPM	groundfish	0		.	.		.	
	Japan	large pelagics	.		.	1		.	
1985	Cuba	groundfish	.		.	0		.	
	Japan	redfish	.		.	0		.	
	USSR	groundfish	.		.	0		.	
1986	Cuba	groundfish	.		.	0		.	
	France (mainland)	groundfish	0		.	.		.	
	Japan	large pelagics	0		.	4		.	
	USSR	groundfish	.		.	1		.	
1987	Cuba	groundfish	.		.	1		.	
	Faroes	shark	.		.	241		.	
	Japan	large pelagics	0		.	9		.	
		redfish	1		.	5		.	
	USSR	groundfish	.		.	0		.	
1988	Cuba	groundfish	.		.	0		.	
	Faroes	shark	.		.	246		.	
	Japan	large pelagics	0		.	9		.	
	Poland	small pelagics	.		.	0		.	
	USSR	groundfish	.		.	2		.	
1989	Cuba	groundfish	.		.	0		.	
	Faroes	shark	.		.	309		.	
	Japan	groundfish	.		.	0		.	
		large pelagics	0		.	8		.	
	Poland	small pelagics	.		.	0		.	
	USSR	groundfish	.		.	3		.	
		squid	.		.	0		.	
1990	Bulgaria	small pelagics	.		.	5		.	
	Cuba	groundfish	.		.	1		.	
	Faroes	shark	.		.	406		.	
	France (SPM)	groundfish	0		.	1		.	
	Japan	large pelagics	0		.	8		.	
	USSR	groundfish	.		.	8		.	
		small pelagics	.		.	2		.	
1991	Cuba	groundfish	.		.	4		.	
	Faroes	shark	93		.	673		.	
		unknown	.		.	1		.	
	Japan	large pelagics	.		.	20		.	

	Russia	groundfish	.	.	0	.
	USSR	groundfish	.	.	10	.
		small pelagics	.	.	2	.
		unknown	.	.	0	.
1992	Cuba	groundfish	.	.	1	.
	Faroes	shark	223	.	769	.
	Japan	groundfish	.	.	0	.
		large pelagics	0	.	7	.
	Lithuania	small pelagics	.	.	3	.
	Russia	groundfish	.	.	5	.
1993	Cuba	groundfish	.	.	2	.
	Faroes	shark	28	.	374	.
	Japan	large pelagics	.	.	5	.
		unknown	.	.	0	.
	Russia	groundfish	.	.	2	.
1994	Cuba	groundfish	.	.	0	.
	Japan	large pelagics	.	.	2	.
1995	Cuba	groundfish	.	.	0	.
	Japan	large pelagics	.	.	4	.
1996	Cuba	groundfish	.	.	0	.
	Japan	large pelagics	1	.	8	.
1997	Cuba	groundfish	.	.	0	.
	France (SPM)	groundfish	2	.	.	.
	Japan	large pelagics	0	.	2	.
1998	France (SPM)	groundfish	1	.	.	.
	Japan	large pelagics	.	.	0	.
1999	Cuba	groundfish	.	.	0	.
	France (SPM)	groundfish	0	.	.	.
	Japan	large pelagics	0	.	6	.
2001				.	.	.
2002				.	.	.
2003				.	.	.
2004				.	.	.
2005				.	.	.
2006				.	.	.
2007				.	.	.

Scotia-Fundy Observer Program 1979 to 2007; Newfoundland Observer Program 1996 to 2007

Table 5. Porbeagle catch recorded by ICCAT, 1961 to 2006.

Year	Country	Gear	NORT	NW	NWC
1961	Norway	longline	.	1824	.
1962	Norway	longline	.	2216	.
1963	Norway	longline	.	5763	.
1964	Norway	longline	.	8060	.
1965	Canada	longline	.	28	.
	Norway	longline	.	4045	.
1966	Norway	longline	.	1373	.
1968	Norway	longline	.	269	.
1972	Norway	longline	.	87	.
1978	Canada	longline	.	1	.
1979	Canada	longline	.	2	.
1980	Canada	longline	.	1	.
1982	Canada	longline	.	1	.
	USA	longline	.	0	.
1983	Canada	longline	.	9	.
1984	Canada	longline	.	20	.
	Norway	longline	.	96	.
	USA	longline	.	0	.
1985	Canada	longline	.	26	.
	USA	longline	.	0	.
1986	Canada	longline	.	24	.
1987	Canada	longline	.	59	.
	USA	longline	.	1	.
1988	Canada	longline	.	83	.
	USA	longline	.	0	.
1989	Canada	longline	.	73	.
	USA	gillnet	.	1	.
		longline	.	1	.
1990	Canada	longline	.	78	.
	USA	gillnet	.	1	.
		longline	.	0	.
1991	Canada	longline	.	329	.
	USA	gillnet	.	1	.
		longline	.	2	.
1992	Canada	longline	.	813	.
	USA	longline	.	1	.
1993	Canada	longline	.	919	.
	USA	longline	.	48	.
1994	Canada	longline	.	1575	.
	* Japan	longline	285	.	.
	USA	longline	.	104	.
1995	Canada	gillnet	.	2	.
		handline	.	0	.
		longline	.	1351	.
		trawl	.	1	.
	* Japan	longline	388	.	.
	USA	longline	.	35	.
1996	Canada	gillnet	.	4	.

		handline	.	0	.
		longline	.	1045	.
		trawl	.	2	.
	Japan *	longline	.	9	13
	* UK Bermuda	longline	.	0	.
	USA	longline	.	76	.
1997	Canada	gillnet	.	8	.
		handline	.	0	.
		harpoon	.	0	.
		longline	.	1322	.
		rod reel	.	0	.
		trawl	.	4	.
	* Japan	longline	.	.	16
	Spain	longline	.	.	3
	* UK Bermuda	longline	.	0	.
	USA	longline	.	55	.
1998	Canada	gillnet	.	11	.
		handline	.	1	.
		harpoon	.	0	.
		longline	.	1055	.
		trawl	.	3	.
	Spain	longline	.	.	9
	USA	gillnet	.	4	.
		longline	.	9	.
1999	Canada	gillnet	.	6	.
		handline	.	0	.
		harpoon	.	0	.
		longline	.	956	.
		trawl	.	2	.
	* UK Bermuda	longline	.	14	.
	USA	gillnet	.	3	.
		longline	.	0	.
		trap	.	0	.
2000	Canada	gillnet	.	2	.
		handline	.	0	.
		longline	.	899	.
		trawl	.	1	.
	* Spain	longline	.	.	131
	USA	longline	.	0	.
2001	Canada	gillnet	.	7	.
		handline	.	0	.
		longline	.	491	.
		rod reel	.	0	.
		trawl	.	1	.
	Spain	longline	.	.	3
	USA	gillnet	.	1	.
		longline	.	0	.
2002	Canada	gillnet	.	12	.
		handline	.	0	.
		longline	.	223	.
		rod reel	.	0	.

		trawl	.	1	.
	Spain	longline	.	.	5
	USA	longline	.	0	.
2003	Canada	gillnet	.	11	.
		handline	.	0	.
		harpoon	.	0	.
		longline	.	130	.
		trawl	.	1	.
	Spain	longline	.	.	2
2004	Canada	gillnet	.	10	.
		handline	.	0	.
		longline	.	220	.
		rod reel	.	0	.
		tended line	.	0	.
		trawl	.	1	.
	Spain	longline	.	.	5
	USA	longline	.	1	.
2005	Canada	gillnet	.	10	.
		handline	.	0	.
		longline	.	191	.
		rod reel	.	0	.
		trawl	.	2	.
	Portugal	longline	.	0	.
	USA	longline	.	0	.
2006	Canada	gillnet	.	6	.
		harpoon	.	0	.
		longline	.	184	.
		trawl	.	2	.
	Portugal	longline	.	0	.
	USA	longline	.	0	.

* UK Bermuda is from recorded catch for "pelagic" sharks
* Spain for 2000 is predominately from recorded catch for "pelagic" and "mackerel" sharks
* Japan is predominately from recorded catch for "pelagic" sharks

Table 6. Estimates of population size obtained from four models fit to the porbeagle data. See text for model descriptions.

		Model 1	Model 2	Model 3	Model 4
Differing assumptions: Differing data		α estimated CPUE by number imm/mat, stand.	α =2.0 CPUE by weight, integrated	α =2.5 CPUE by weight, integrated	α =3.2 CPUE by weight, integrated
1961	SSN	82,772 (328)	87,754 (800)	81,181 (448)	75,230 (371)
	N	876,150 (3,475)	928,880 (8,473)	859,300 (4,750)	796,310 (3,105)
1971	SSN	25,880 (262)	32,706 (452)	25,551 (335)	19,413 (259)
	N	368,280 (3,090)	429,580 (7,228)	371,480 (4,207)	318,660 (3,715)
1981	SSN	28,657 (254)	35,031 (439)	28,649 (338)	22,862 (257)
	N	318,890 (2,841)	385,650 (5,058)	342,620 (3,987)	302,760 (3,209)
1991	SSN	23,715 (266)	30,436 (436)	26,159 (362)	22,252 (294)
	N	323,830 (3,209)	397,370 (5,299)	375,110 (4,410)	355,190 (3,702)
2002	SSN	7,534.1 (297)	15,007 (512)	12,531 (426)	10,376 (355)
	N	102,390 (4,363)	198,040 (6,226)	190,300 (5,741)	184,450 (5,273)
2005	SSN	5,519.6 (290.52)	12,945 (540)	11,013 (436)	9,371 (371)
	N	94,309 (4,550.9)	195,230 (6,609)	190,520 (6,197)	187,960 (5,823)
2005/1961	SSN	0.066 (0.003)	0.148 (0.006)	0.136 (0.005)	0.120 (0.005)
	N	0.107 (0.005)	0.21 (0.007)	0.222 (0.007)	0.236 (0.007)
2005/2002	SSN	0.732 (0.010)	0.863 (0.008)	0.879 (0.006)	0.903 (0.006)
	N	0.921 (0.005)	0.986 (0.004)	1.001 (0.003)	1.019 (0.003)

Table 7. Estimates of the mid-year vulnerable biomass (metric tonnes) for 2005 from the four models and three fishery selectivities. Note that the vulnerable biomass is conditional on the selectivity and, given a selectivity is applicable to the entire population. The values do not apply separately to each region.

	Model 1	Model 2	Model 3	Model 4
Differing assumptions:	σ estimated	σ =2.0	σ =2.5	σ =3.2
Differing data	CPUE by number imm/mat, stand.	CPUE by weight, integrated	CPUE by weight, integrated	CPUE by weight, integrated
Biomass removed using:				
Basin selectivity	2,476.7 (115.56)	4,645.3 (156.69)	4,663.2 (275.94)	4,720.8 (233.54)
NF Gulf selectivity	1,553.8 (107.05)	3,972.5 (160.85)	3,661.6 (154.81)	3,431.2 (124.66)
Shelf selectivity	2,299.7 (116.9)	4,626.3 (263.97)	4,526 (147.24)	4,502.1 (582.26)

Fig. 1. Reported northwest Atlantic porbeagle landings by country.

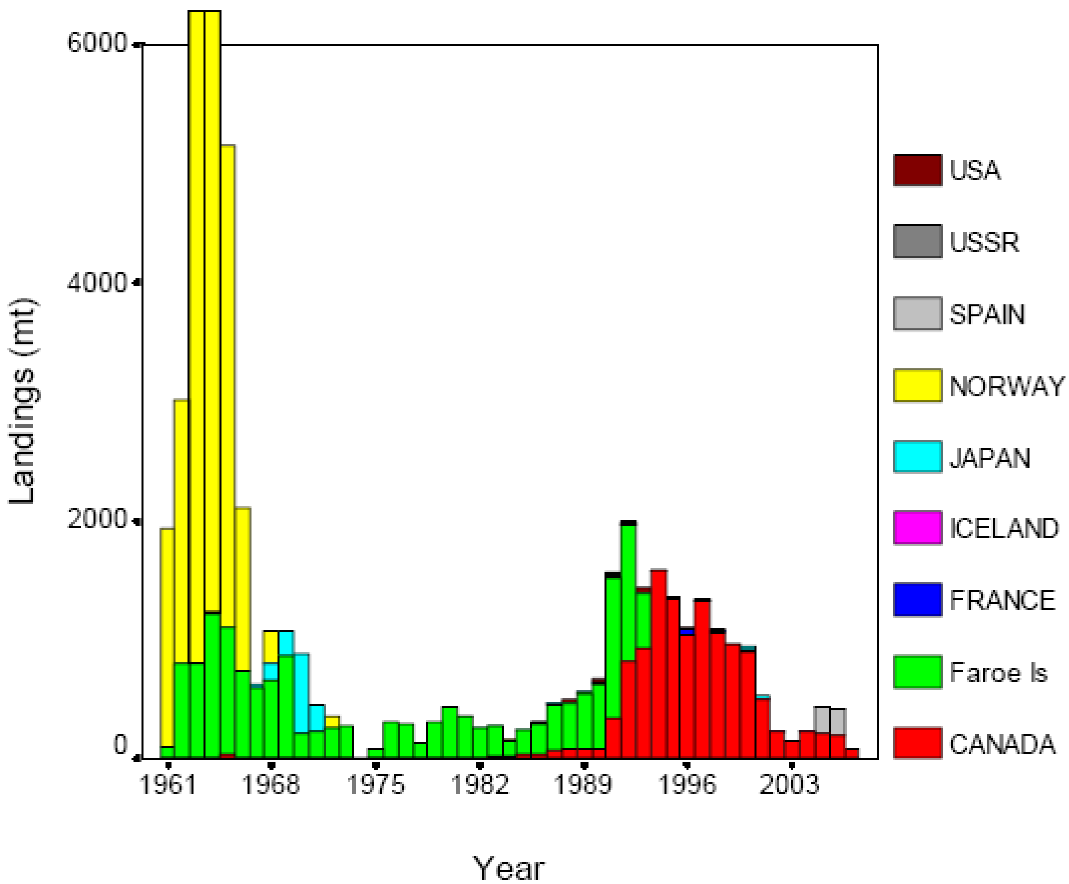


Fig. 2. Canadian porbeagle landings by fishery.

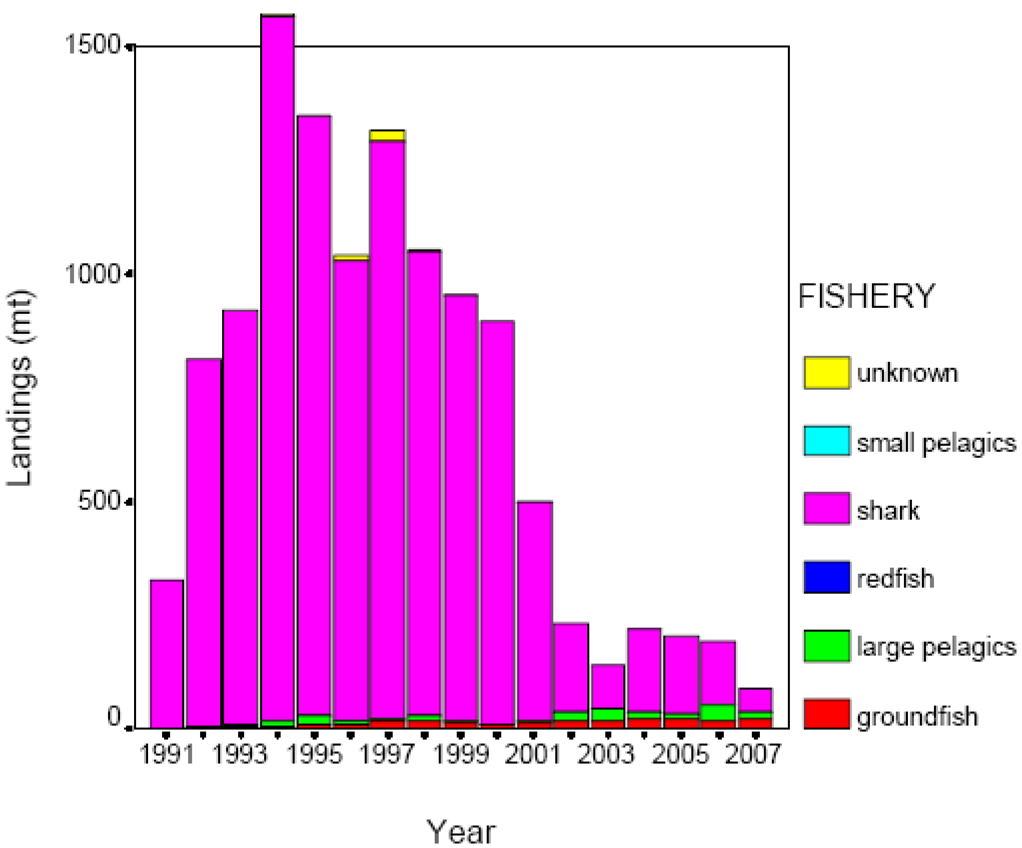
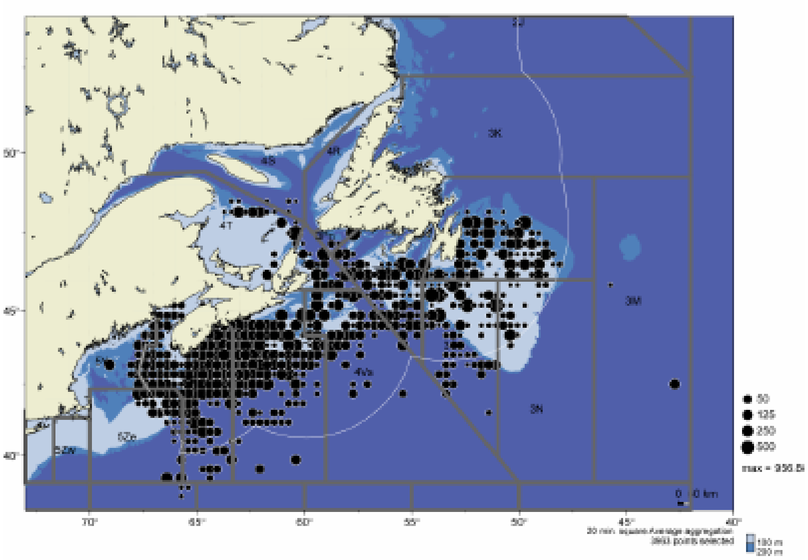


Fig. 3. Location of Canadian porbeagle landings.

Total landings Porbeagle 1996 - 2000 (data from DFO Zonal Statistics File).



Total landings Porbeagle 2004 - 2007 (data from DFO MARFIS).

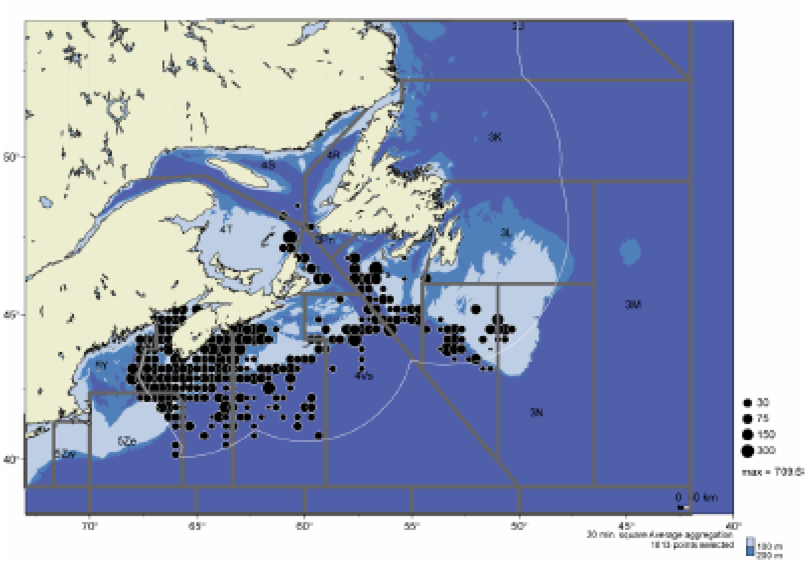


Fig. 4. Location of porbeagle caught by international fleets between 1996-2000, as observed by the Canadian Observer Program. There was no observed foreign catch after 2004.

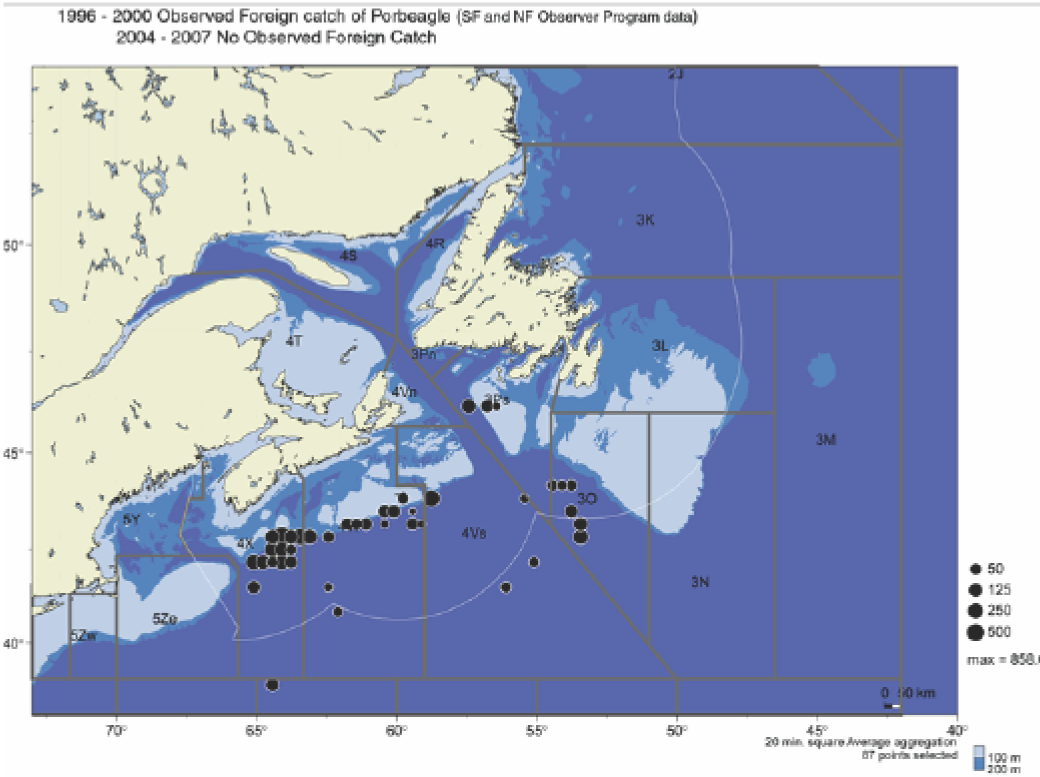


Fig. 5. Distribution of mature female porbeagles within the Canadian EEZ.

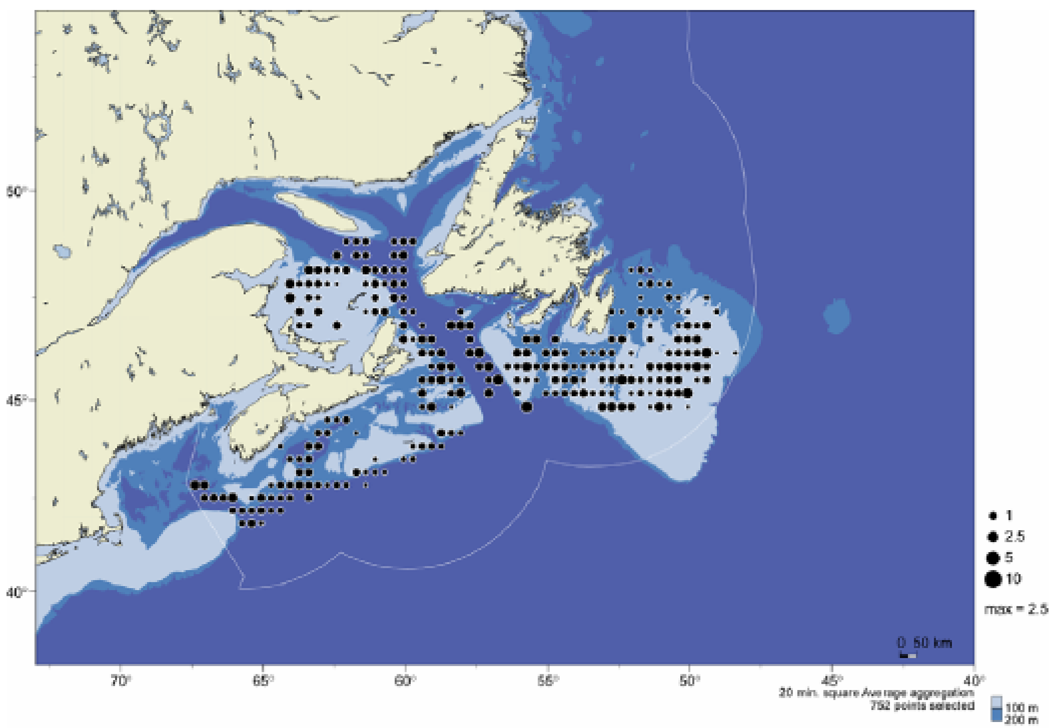


Fig. 6. Female spawner abundance, recruitment at age 1, and total population number from each of the four porbeagle population models. All models show similar trajectories.

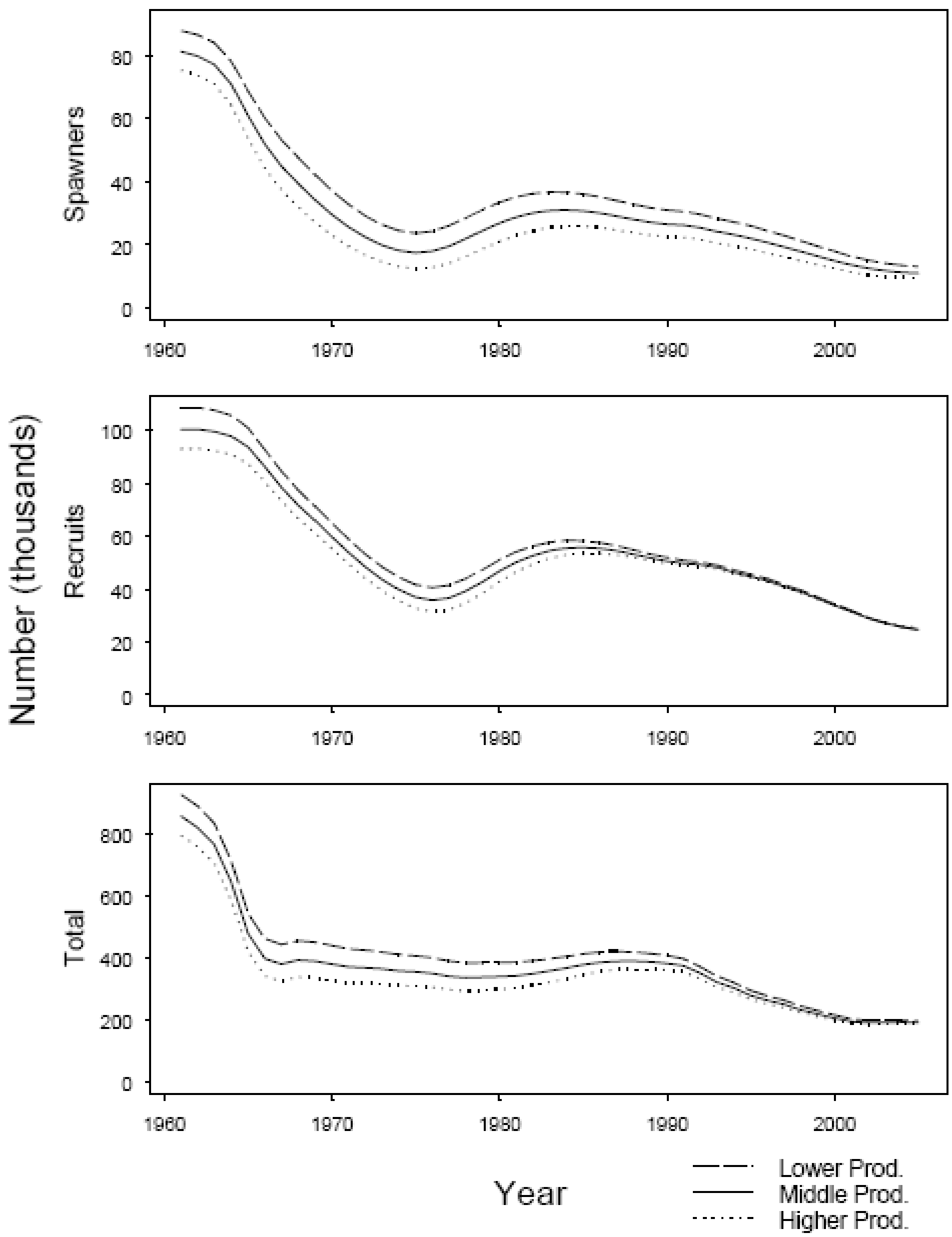


Fig. 7. Predicted deterministic recovery trajectories from each of the three porbeagle population models at each of four exploitation rates. All simulate populations recover at exploitation rates of less than about 4%.

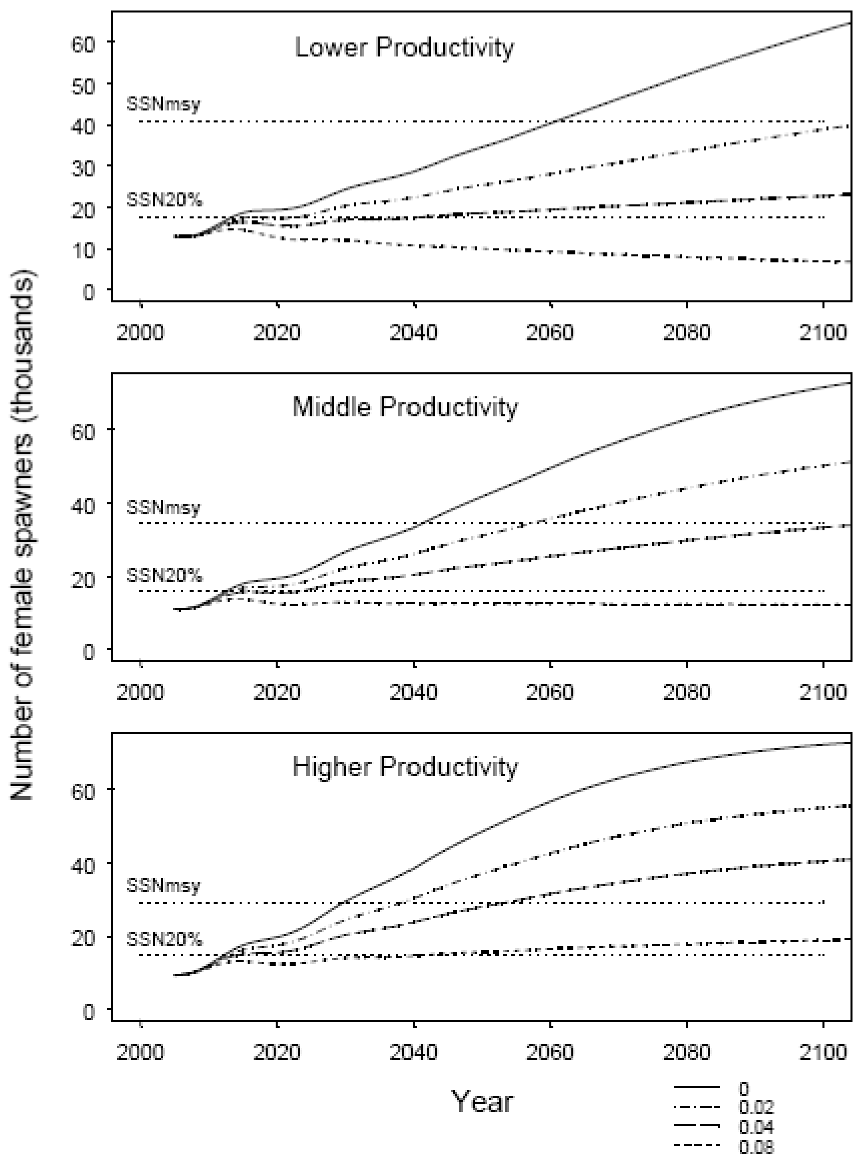


Fig. 8. Predicted stochastic recovery trajectories from the population viability analysis under four different exploitation scenarios. The lines connect The quantiles of the population size in each year from low (bottom line = 0.1) to high (top line = 0.9). Time to recovery at a 4% exploitation rate was 30-100+ yr.