COSEWIC
Assessment and Status Report

on the

Barndoor Skate
Dipturus laevis

in Canada

NOT AT RISK
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2010. COSEWIC assessment and status report on the Barndoor Skate *Dipturus laevis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiii + 71 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
COSEWIC would like to acknowledge James Simon and Sherrylynn Rowe for writing the status report on the Barndoor Skate (*Dipturus laevis)* in Canada, prepared under contract with Environment Canada. This report was overseen and edited by Paul Bentzen, Co-chair of the COSEWIC Marine Fishes Specialist Subcommittee with the support of Dave Kulka, member of the Marine Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la grande raie (*Dipturus laevis*) au Canada.

Cover illustration/photo:
Barndoor Skate — Drawn by P.D. MacWhirter and extracted from Sulak *et al.* (2009).

Catalogue No. CW69-14/620-2011E-PDF
ISBN 978-1-100-18597-2

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Barndoor Skate

Scientific name
Dipturus laevis

Status
Not at Risk

Reason for designation
This species, one of the largest skates in the western Atlantic Ocean, and with an estimated generation time of 13 years, ranges on continental shelf habitats from Cape Hatteras to the Grand Banks. In Canadian waters, it is most common on Georges Bank and the western Scotian Shelf. Numbers declined in the 1960s, likely due to bycatch in fisheries directed at other species. Indices of abundance are made less precise by fluctuations in distributions and the ability of large mature fish to evade survey gear, but indicate that the abundance of mature individuals has not declined over the last three generations, and has increased during the last 1-2 generations. Survey catch rate data indicate an ongoing increase in the abundance of mature and immature individuals on Georges Bank and western Scotian Shelf. Data from American surveys on Georges Bank suggest that the species has increased to a level that is approximately half the abundance estimated for this species in this area in the early 1960s. There are no directed fisheries for the species, and regulations are in place to reduce mortality from bycatch.

Occurrence
Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

COSEWIC
Executive Summary

Barndoor Skate
Dipturus laevis

Wildlife species information

Barndoor Skate is one of the largest skates in the western Atlantic, reaching a total length of 163 cm. Another common name is the sharpnose skate and, in French, it is called grande raie. It is distinguished from other skates by (collectively) having an acute snout, a relative absence of thorns, an upper surface that is generally brown with numerous dark spots, and an oval spot or eye in the centre of each pectoral fin (wing). The lower surface is white to grey with dark pigmented ampullar pores in larger individuals.

Distribution

Barndoor Skate (*Dipturus laevis* Mitchill 1818) have been reported as far south as northeastern Florida but it has been suggested that the most southerly records may have been a misidentification. Recent US reports indicate that the species occurs north of Cape Hatteras but is most common north of Cape May (39ºN), on Georges Bank and in the Gulf of Maine. In Canadian waters, the species is most common on Georges Bank and the western Scotian Shelf to Sable Island. It is less common on the southern edges of the Scotian Shelf and the Grand Banks. This deepwater extension continues outside of Canadian waters to the tail of the Grand Banks as far east as the Flemish Cap. There are scattered reports of Barndoor Skate on the northern portion of the Grand Banks (identified by the Northwest Atlantic Fishery Organization (NAFO) as Div. 3L) and the Laurentian Channel in the Gulf of St. Lawrence.

There is no evidence to support more than one designatable unit for Barndoor Skate. Historically, they were generally distributed continuously from the southern half of the Grand Banks to south of Georges Bank. As the population declined, their distribution contracted to Georges Bank. As the population rebounded, the species expanded from relatively small areas on Georges Bank to the whole of Georges Bank, then to NAFO Div. 4X(southwest Scotian Shelf), and recently, back into NAFO Div. 4W(central Scotian Shelf) to the northeast. Low catchability by research vessel (RV) surveys may give the impression of apparent gaps in their distribution, but industry surveys in the same areas indicate that they are

Habitat

Barndoor Skate have been found on soft mud, sand, and gravel bottoms. They are widespread from 38-351 m (the deepest part of the survey) in Div. 5Z (Georges Bank). On the Scotian Shelf, Barndoor Skate are primarily caught in 50-150 m but have been reported from 24 to 375 m. Length frequency data from the halibut industry/science survey suggests that adults are common at depths greater than those surveyed by the DFO RV surveys. Juveniles and adults on both the Canadian and US sides of Georges Bank appear to occupy the same geographic areas. Juveniles were widespread on the western Scotian Shelf to Sable Island but adults were concentrated in the Fundian Channel. Off Newfoundland, Barndoor Skate have been recorded as deep as 1174 m although most fishery observer records, including some of the deepest records have not been confirmed with specimens or photos.

Preferred temperature range from US RV surveys is 3-18ºC for the Gulf of Maine to Cape Hatteras with a reported peak of 20ºC off Cape Hatteras. Salinity preference range is 32-36 ppt in the same areas. Based on Canadian surveys on Georges Bank, preferred temperatures are 3-13ºC, while on the Scotian Shelf, the temperature range is 2-11 ºC with a preference for 3-9ºC. In the Gulf of St. Lawrence, they have been recorded at temperatures as low as 1-2ºC.

Information on skate purse distribution is limited to reports of females containing fully developed eggs in December and January, both near Sable Island and in Kennebecasis Bay, N.B. As well, a single female with almost complete purses was sampled from the western half of Div. 4W, in September.

Biology

A comprehensive study on the biology of Barndoor Skate on the US side of Georges Bank revealed that length at 50% maturity (L_{mat}) for females was 116 cm while males matured at 108 cm. A preliminary aging analysis revealed faster growth (k = 0.14-0.18) and younger age of female maturation (6.5-7.2 years) than had been previously assumed. A preliminary study of Barndoor Skate in on the Scotian Shelf (Div. 4W) estimated L_{mat} at 114 cm. Annual estimates of fecundity from a single captive female from NAFO Div. 5Z were 33, 69, 85, and 115 purses from 2003 to 2007. Mean incubation time was 421 days.

In the study of Barndoor Skate from Div. 5Z, generation time was calculated to be 13 years but given the uncertainty in natural mortality (M) and the likelihood that growth is slower in Canadian waters, it is possible that the true generation time may be greater than 13 years.

Population sizes and trends

Because catchability in survey trawls is < 1, values of abundance and biomass reported here are considered to be minimum estimates. Mean population estimates were calculated from Canadian and US RV surveys for NAFO Div. 4VWX and 5Z based on one generation time or natural breaks in the data. Recent trends in population abundance were estimated using linear regression after log transformation for all sizes combined given the very low adult catch rates. These data are not provided for the other regions given very low catch rates.

Minimum abundance from the US Fall RV survey (Div. 4X5ZY6) during 1963-1975 averaged 1.1 million juveniles and 62,000 adults annually. During 1976-1994, mean abundance was 54,000 juveniles and 2,800 adults. During 1995-2007, there were 79,700 juveniles and 112,000 adults. The average of the first four years of this survey was 3.2 million fish while the average of the last four years was 1.7 million fish or 53% of the earlier period. Abundance estimates from the Canadian RV survey for Div. 5Z were calculated for the whole of Georges Bank as well as the Canadian portion only. Abundance of all size classes on Georges Bank averaged 52,000 fish during 1987-1995. During 1996-2008, abundance averaged 622,000 juveniles and 11,000 adults. On the Canadian side of the bank, total abundance of all sizes averaged 15,000 individuals during 1987-1995. Since 1996, there was an average of 43,000 juveniles and 2,300 adults. On the Scotian Shelf, the data were grouped into 3 generations: 1970-1982, 1983-1995, and 1996-2008. The average number of juveniles was 152,000, 15,000, and 118,000 for each of these three respective time periods. Number of adults for the same time periods was 11,000, 0, and 39,000.

The annual rate of increase from 1995 to 2007 for the US Fall and Spring RV surveys was 11% and 14%, respectively. If only the area surveyed on the Canadian side of the international boundary is considered, then the annual rates of increase become 10 and 11% for the Fall and Spring surveys, respectively.

The annual rate of increase from 1986 to 2008 for the Canadian Georges Bank RV survey was 6.0% for the entire bank but there was no clear trend in the data over this time period for the Canadian portion of Georges Bank alone. If only the last generation is considered (1996-2008), then there is an annual rate of decline of 18.3% in the Canadian zone. As stated above, the US Spring RV survey for approximately the same area, one month later, shows an annual increase of 11%.

On the Scotian Shelf, the annual rate of increase based on the DFO Summer RV survey from 1996 to 2008 was 8.9%. Industry surveys since 1996 indicate similar rates of increase ranging from 3.2% to 11.8%.

Limiting factors and threats

There are no directed fisheries for Barndoor Skate in Canadian waters. The skate fishery in the Newfoundland Region directs for thorny skate and the directed fishery for skate in the Maritimes Region was on the eastern Scotian Shelf. Bycatch of Barndoor Skate in these fisheries was minimal. It has been suggested that Barndoor Skate populations were reduced to extremely low levels because they were taken as bycatch in other major fisheries. Therefore, total reported landings of all groundfish species by all countries were summarized annually from NAFO Divisions as a proxy for effort as it was not possible to determine bycatch rates of skate except for localized fisheries in the last few years. These landings were compared with RV catch rates where possible. This analysis revealed that the collapse of Barndoor Skate was coincident with a sharp increase in landings on Georges Bank in the mid-1960s. Landings slowly fell to less than one third of their maximum by 1985 and have been stable since then. The sharp increase in Barndoor Skate RV abundance observed since the mid-1990s has occurred during a period of relative stability in total landings.

The disappearance of Barndoor Skate on the Scotian Shelf and Subdiv. 3Ps does not appear to be linked to an increase in landings although the recent increase in Barndoor Skate abundance on the Scotian Shelf is occurring during a period of very low landings in this area.

An examination of Canadian at-sea observer reports from Div. 5Z and 4X since 1986 suggests that total annual bycatch (discards) amounted to 25-115 t in each area. There is a high degree of uncertainty in these estimates due to low levels of observer coverage. Survival of discarded Barndoor Skate is unknown but the mortality of other skate species was estimated to be greater than 50% in the Gulf of St. Lawrence.

Information on potential threats to Barndoor Skate is limited. Given their large size, it is likely that adults may only be preyed upon by large sharks and marine mammals. An examination of the DFO Maritimes stomach data base revealed only one instance of Barndoor Skate being consumed by another fish (Simon *et al.* 2009). Predation on egg cases by gastropods has been observed for skate species in other areas but no data exist for Barndoor Skate. The only potential threat for which there are quantitative data is mortality from groundfish fisheries.

Special significance of the species

Skates are targeted by commercial fisheries for their pectoral fins (wings) and, typically, large skates such as winter skate and Barndoor Skate would be preferred over smaller skates in American markets. It is possible that the wings of Barndoor Skate have been marketed as winter skate in the past but their possession has been prohibited in US fisheries since 2004 and it would not have been possible to market any Canadian landings in the US since this time.

Existing protection

The 1999 stock assessment of the skate complex in the US concluded there was no cause to list Barndoor Skate as endangered but recommended that the species remain on the candidate list (NEFSC 2000). Following that assessment, a Fisheries Management Plan (FMP) was developed by the New England Fishery Management Council (NEFMC) when they were informed that Barndoor Skate were overfished. This FMP was implemented in September 2003 and prohibited the possession of Barndoor Skate (NEFSC 2007). Internationally, New England Barndoor Skate was proposed as an addition to the IUCN Red List as “critically endangered” in 2003 (Dulvy 2003).

The federal *Fisheries Act* provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries. Current regulations state that in the Gulf Region, skates are to be returned to the water, and if alive, in a manner that causes them the least harm. In the Maritimes Region the policy is similar in that skate are to be returned alive if possible when discarded, but skate can be landed as a bycatch in other fisheries and there is no requirement to record them to the species level. There is also no requirement for fishers in both regions to record these discarded skate in their logbooks. In the NL Region the >65’ fleets are authorized to release skate but must record them in their logbook, while the <65’ fleets are not authorized to release skate and must land whatever they catch. In neither fleet is there a requirement to record skate to the species level. In the managed skate fisheries in the NL Region, management conditions are in place that require minimum mesh sizes, hook size, limits on the quantity of gear, and there is an annual quota. They are not required to record skate landings to the species level; however, some observer coverage is required in this fishery and there have not been any records of Barndoor Skate since the fishery began.

The distribution of Barndoor Skate overlaps The Gully Marine Protected Area (MPA) on the outer portion of the Scotian Shelf. There, regulations prohibit the disturbance, damage, destruction or removal of any living marine organism within it. However, this area represents only a small fraction of the Barndoor Skate’s distribution and abundance in Canadian waters.

TECHNICAL SUMMARY

Dipturus laevis
Barndoor Skate grande raie
Range of Occurrence in Canada: Atlantic Ocean (Southern Grand Banks to Georges Bank)

Demographic Information

Generation time calculated as age of 50% maturity +1/M, where M is the estimated natural mortality rate.	13 yrs
Estimated percent increase in total number of individuals over the last generation. Scotian Shelf (1996-2008,13 years) Georges Bank, Canadian zone (1986-2008, 23 years) Georges Bank, Canadian zone (1996-2008, 13 years) The recent apparent decline in abundance in the Canadian zone was coincident with annual increases of 10-11% from the Canadian strata of the US Spring and Fall surveys of Georges Bank during 1995-2007. The greatest concentration of Barndoor Skate seen in that last decade was caught just across the international boundary by the US Spring survey and the decline noted in the Canadian zone survey may be due to seasonal migration or other unknown factors. If the whole of Georges Bank is considered, the annual rate of increase is 6% from the Canadian survey since 1986 and 11-14% from the US surveys from 1995-2007. Southern Grand Banks (only 3 individuals caught since 1971) It is suspected that the catchability of Barndoor Skate, especially adults, is very low. There are insufficient adults caught in these surveys to provide reasonable estimates of trends in adult abundance; therefore total number for all sizes caught from the RV surveys are provided. Details on how these estimates were calculated can be found in the Population Sizes and Trends section.	 8.9% annually no trend -18.3% annually (values are all individuals, immature and mature) Unknown
Projected percent increase in total number of individuals over the next generation.	Likely to continue to increase based on incoming recruitment and relatively low fishing activity

Estimated percent increase in total number of individuals between first and last 5-year periods of available time series. Scotian Shelf: Estimate 1970-1974 – 72,000 Estimate 2004-2008 – 267,000 Georges Bank (Cdn): Estimate 1986-1990 – 22,000 Estimate 2004-2008 – 30,000 The number of adults caught by the surveys is very low and high variability in the trend creates uncertainty in these estimates. Given the annual variability, the data are provided for the first five years of the survey (above) and by generation (below). Note that on Georges Bank, the Canadian and US populations are contiguous and that part of the annual variability is due to the side of the line on which the fish are caught. As above, details are provided in the Population Sizes and Trends section. Scotian Shelf (by generation, all individuals, immature and mature) 1970-1982 163,000 1983-1995 15,000 1996-2008 157,000 Georges Bank (Cdn, all individuals, immature and mature) 1986-1995 15,000 1996-2008 45,000	370% increase (all individuals, immature and mature) No change (all individuals, immature and mature)
Are the causes of the decline clearly reversible? RV surveys on Georges Bank and the Scotian Shelf tracked the decline of Barndoor Skate in the early 1970s to very low numbers. The recent increases on Georges Bank and the western Scotian Shelf indicate that the original decline was reversible. See text for explanation.	yes
Are the causes of the decline understood? The decline on Georges Bank was likely due to the species being caught as bycatch in directed groundfish fisheries. A large increase in groundfish landings during the mid-1960s was likely the primary cause for the decline of Barndoor Skate. The decline on the Scotian Shelf and in Subdiv. 3Ps does not appear to be coincident with any changes in landings. See Limiting Factors and Threats section.	Yes, for at least one part of the species range.
Have the causes of the decline ceased? Fishing effort (landings) has been relatively low for the last 15 years.	No, but fishing effort has declined.
Inferred trend in number of populations The species has been expanding into areas that it formerly occupied over the last 10 years as abundance has increased. The assumption is that individuals belong to one population.	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown but not likely
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence Includes the Canadian side of Georges Bank, the Scotian Shelf including the deepwater slope strata and the southern flank of the Grand Banks.	~ 200,000 km²

Observed trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO) Calculated from the DWAO (designed weighted area occupied) of RV survey sets that captured Barndoor Skate on Georges Bank and the Scotian Shelf. Includes the southern flanks of the Grand Banks and the Scotian Shelf where they were observed during the industry halibut survey by using % occurrence (~25%) in that survey to calculate area.	~9000 km²
Observed trend in area of occupancy	Increasing
Are there extreme fluctuations in area of occupancy? Area of occupancy inferred from survey data has large fluctuations due to the low numbers caught in the survey – a single fish has a large impact on this variable.	Unknown
Is the total population severely fragmented?	No
Number of current locations Georges Bank to Sable Island plus the waters deeper than 150 m on the southern flanks of the Scotian Shelf and the Grand Banks.	Unknown
Trend in number of locations As abundance has increased on Georges Bank, they have reappeared in Div. 4X and now in Div. 4W. This may be an artifact of the otter trawl gear as they have occurred in longline surveys years before they appeared in the RV survey. Note the distribution in Div. 4W in the Sentinel and DFO Surveys.	Unknown
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	No

Number of mature individuals in each population

Population	**N Mature Individuals**
Georges Bank (Cdn Zone) and Scotian Shelf (1996-2008) Average number of adults: Georges Bank (Cdn) 2,300 Scotian Shelf 39,000 Barndoor Skate are poorly sampled by the RV survey and this value is highly underestimated but the magnitude is unknown. See Population Sizes and Trends.	41,300
Total	
Number of populations (locations)	Unknown

Quantitative Analysis

	Unavailable

Threats (actual or imminent, to populations or habitats)

The primary threat to Barndoor Skate is mortality as bycatch in groundfish and scallop fisheries. This threat has been greatly reduced as fishing effort has declined in the 1990s and 2000s. The survival of discarded Barndoor Skate is unknown.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? The population has been increasing between 11-14% annually since 1995. The total average abundance from 1963-1975 (one generation) from the US RV survey was 1.2 million fish of which 62,000 were adults. The estimate from 1995-2007 (one generation) was 0.9 million fish of which 112,000 were adults. The problem with catchability and estimation of total number applies to both the US and Canadian surveys. Barndoor Skate have been observed from the tail of the Grand Banks and the Flemish Cap but they appear to be extensions of Canadian populations at the end of their range and are not thought to provide immigration possibilities.	
Is immigration known?	Probable
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Yes

Current Status

COSEWIC: Not at Risk (November 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Not at Risk	Not applicable

Reasons for designation:

This species, one of the largest skates in the western Atlantic Ocean, and with an estimated generation time of 13 years, ranges on continental shelf habitats from Cape Hatteras to the Grand Banks. In Canadian waters, it is most common on Georges Bank and the western Scotian Shelf. Numbers declined in the 1960s, likely due to bycatch in fisheries directed at other species. Indices of abundance are made less precise by fluctuations in distributions and the ability of large mature fish to evade survey gear, but indicate that the abundance of mature individuals has not declined over the last three generations, and has increased during the last 1-2 generations. Survey catch rate data indicate an ongoing increase in the abundance of mature and immature individuals on Georges Bank and western Scotian Shelf. Data from American surveys on Georges Bank suggest that the species has increased to a level that is approximately half the abundance estimated for this species in this area in the early 1960s. There are no directed fisheries for the species, and regulations are in place to reduce mortality from bycatch.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable
Criterion C (Small and Declining Number of Mature Individuals): Not applicable
Criterion D (Very Small Population or Restricted Distribution): Not applicable
Criterion E (Quantitative Analysis): Not applicable

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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2010

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WILDLIFE SPECIES INFORMATION

Name and classification

Barndoor Skate *Dipturus laevis* (Mitchill 1818) is a member of the Class Chondrichthyes, Subclass Elasmobranchii, Order Batoidei, and Family Rajidae (Collette and Klein-MacPhee 2002; Sulak *et al.* (2009)). Another common name is the sharpnose skate and, in French, it is called grande raie.

Morphological description

Barndoor Skate are distinguished from other skates by (collectively) having an diamond-shaped body (disc) with an acute snout, no spines on the midline of the disc, 23-40 irregularly spaced thorn-like spines (often worn down on larger skates) on the dorsal midline of the tail, and one row of thorn-like (lateral) spines on each side of the tail. The upper surface is generally brown with numerous dark spots, and an oval spot or “eye” in the centre of each wing (pectoral fin). The lower surface is white to grey; usually with dark pigment underneath its snout that fades to a dirty white on the abdomen and outer wings. Its lower surface also characteristically has dark-pigmented pores in larger individuals (Collette and Klein-MacPhee 2002; Figure 1).

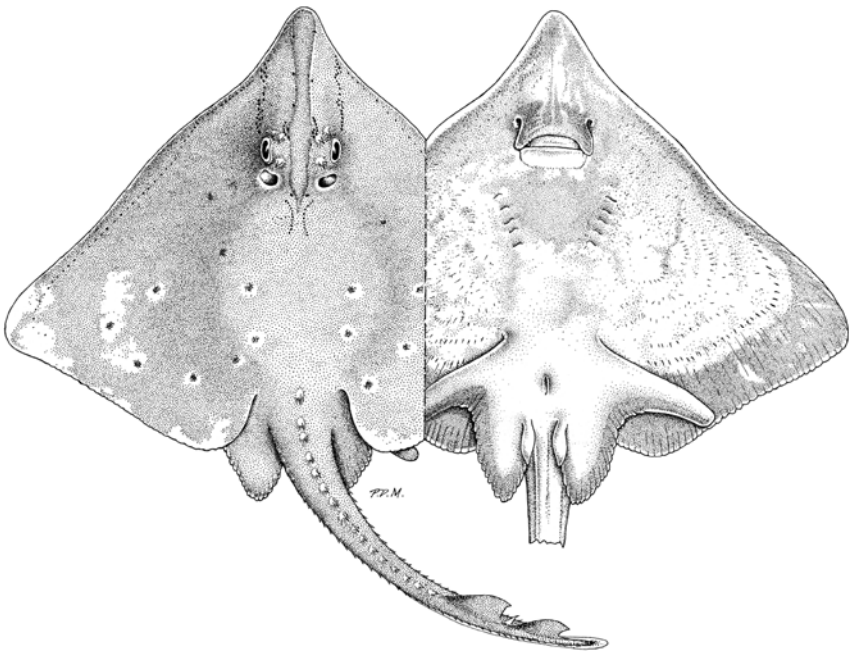


Figure 1. Dorsal and ventral views of a Barndoor Skate as drawn by P.D. MacWhirter and extracted from Sulak *et al.* (2009).

Designatable units

There is no evidence to support the definition of more than one designatable unit for Barndoor Skate. Historically, they were generally distributed continuously from the southern half of the Grand Banks to south of Georges Bank (Simon *et al.* 2002). As the population declined, their distribution contracted to Georges Bank (although no information exists for the deeper waters off the shelf prior to the 1990s). As the population rebounded, the species expanded from relatively small areas on Georges Bank to the whole of Georges Bank, then to Div. 4X, and recently, back into Div. 4W. Low catchability of Barndoor Skate by research vessel surveys may give the impression of apparent gaps in their distribution but industry surveys in the same areas indicate that they are much more abundant and continuously distributed than previously thought. It is unknown whether this trend will continue or whether the species will repopulate areas where it was thought to be common prior to 1970.

DISTRIBUTION

Global range

Barndoor Skate is one of the largest skates in the northwest Atlantic, growing to about 1.5 m in length and 20 kg in mass (Scott and Scott 1988) although fish as long as 163 cm have been recorded recently (Simon *et al.* 2009). It is one of a group of closely related species that includes *Dipturus batis* in European waters and *D. floridana* off the southern United States (Bigelow and Schroeder 1953). Its range was reported to extend from as far north as southwestern Grand Bank and the southern Gulf of St. Lawrence, south to waters off northeastern Florida (Scott and Scott 1988) but McEachran and Musick (1975) suggested that the most southerly records may have been a misidentification of *D. floridana* and that *D. laevis* may not occur south of Cape Hatteras (Figure 2). Recent US observer reports suggest that *D. laevis* is often caught off Virginia and North Carolina but it was felt that these reports were likely misidentifications (NFSC 2007). The species is most common north of Cape May (39ºN), on Georges Bank and in the Gulf of Maine (Div. 5Y5Ze5Zw) (NFSC 2007).

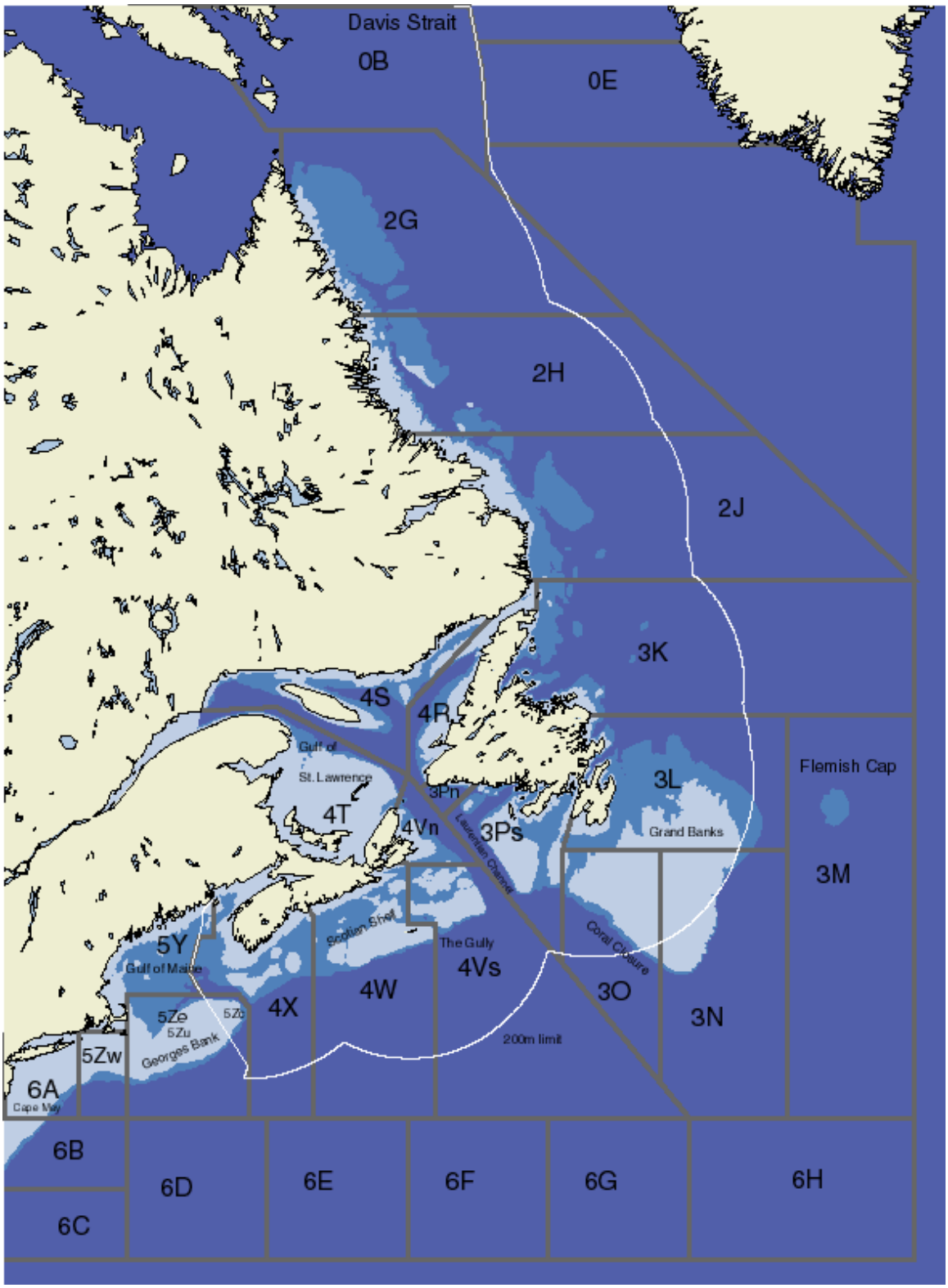


Figure 2. Geographic display of the areas and NAFO Divisions described in this document.

Earlier reports that the species extended as far north as the Davis Strait (Kulka et al. 2002) are now believed to have been misidentifications, and the northern limit of the species is believed to be Div. 3L (Simon et al. 2009). An examination of commercial fisheries data by Kulka et al. (2002) reported that Barndoor Skate were more widely distributed and found at much greater depths than had been previously described. They were reported as far north as the Labrador Shelf to 62ºN and seaward to a depth of 1600 m. These observations were based on combined observer reports from the Newfoundland and Labrador and Maritimes Regions. It was later noted that there were discrepancies in species identification between observers from the two regions. Samples identified as Barndoor Skate were collected from a number of fisheries and returned to the Northwest Atlantic Fisheries Centre in St. John's, NL for confirmation by the regional expert on skate identification. It was determined that none of the specimens identified as Barndoor skate north of Div. 3L were correctly identified. These samples indicated a potential problem in the identification of Barndoor Skate especially from fisheries north of 50ºN and at depths greater than 1000 m. An intensive species identification program was developed for observers. New species identification cards were created that have greatly improved confidence in observer reports of Barndoor Skate.

As a result of the above concerns, the 3247 records of Barndoor Skate from the Newfoundland and Labrador observer database were re-examined. Criteria were developed to determine whether species identification could be confirmed and applied against the dataset. As a result, only 309 of the original records were considered valid and, of these, only 209 occurrences came from the Newfoundland and Labrador Region. The remaining 100 records were from the other Atlantic regions. These criteria may have resulted in the elimination of valid records of Barndoor Skate but the resulting dataset is believed to better reflect the distribution of the species (Simon *et al.* 2009).

Canadian observer reports also indicate that the species occurs as far east as the Flemish Cap and on the tail of the Grand Banks (Div. 3NO) (Simon *et al.* 2009). Approximately 50% of the global range of Barndoor Skate is within Canadian waters.

Canadian range

In Canada, Barndoor Skate is currently distributed from the Canadian portion of Georges Bank (Div. 5Zc) to approximately 61ºW (west of Sable Island) on the Scotian Shelf (Figure 2). They are also caught in longline fisheries along the outer edge of the Scotian Shelf and the southern edge of the Grand Banks (Div. 3PsO) and beyond the Canadian zone to the tail of the Grand Banks (Div. 3NO). They are also occasionally reported from Div. 3LM and along the Laurentian Channel in the Gulf of St. Lawrence. Historical records indicate that prior to 1970, they were common on the eastern half of the Scotian Shelf (Div. 4VW) and St Pierre Bank (Subdiv. 3Ps) (Casey and Myers 1998).

BIOLOGY

Life cycle and reproduction

A comprehensive study on the biology of Barndoor Skate was conducted by Gedamke *et al.* (2005) and Gedamke (2006) from Georges Bank (Div. 5Z). This work was based on 2310 fish collected from Closed Area II (which is adjacent to the international boundary with Canada) on Georges Bank in 1999, 2000, and 2001 (Figure 3). This area was closed to draggers in 1994 and reopened to limited scallop fishing in 1999. It was from this gear sector that the samples were collected. Growth parameters were developed and observations on length at maturity made. Of the 2310 fish examined, only 87 were determined to be mature based on visual inspection of the reproductive organs (Gedamke *et al.* 2005). Length at 50% maturity (Lmat) for females was 116.3 cm while males matured at 107.9 cm. The combined length at 50% maturity was 112 cm. A preliminary analysis of 118 vertebrae (two readers) revealed faster growth (k = 0.14-0.18) and younger age of female maturation (6.5-7.2 years) than had been assumed by Casey and Myers (1998). Results from the von Bertalanffy growth model yielded Linf = 166.3 cm, k = 0.14, and t_o = -1.2912. Given that the largest fish examined was 133.5 cm, it was suggested by Gedamke (2006) that Linf might have been overestimated. When the von Bertalanffy model was rerun with an assumed Linf of 150 cm, the growth coefficient (k) increased to 0.18.

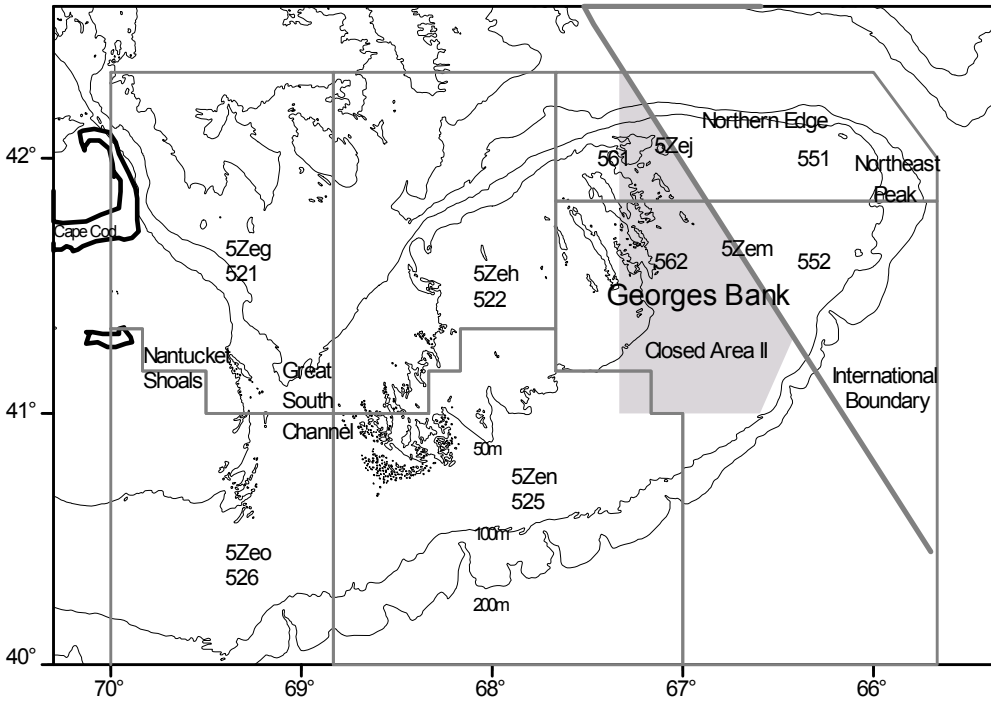


Figure 3. Georges Bank showing Closed Area II where Gedamke (2006) developed biological parameters used in this document.

A small-scale biological study on Barndoor Skate from Div. 4W conducted in 2001 estimated an L_{mat} of 114 cm (Simon *et al.* 2002).

Parent et al. (2008) described captive breeding of Barndoor Skate at the Montreal Biodome. Five individuals were acquired in 1997 and after 6.5 years, the single remaining female began producing skate purses. Annual estimates of fecundity of this female and incubation times of the resulting purses were recorded from 2003-2007. This fish produced 33, 69, 85, and 115 purses annually in this period. The length of the female in 2007 was 122 cm. Purses were laid throughout the year with a slight peak in the fall. Incubation time ranged from 343 to 494 days with a mean of 421 days. At birth, hatchlings averaged 19.3 cm in length and 32 g. Survivorship was good and after 2 years in captivity, individuals ranged from 49 to 60 cm, which is comparable to the estimated length at 2 years of 45-60 cm by Gedamke (2006). Water temperature at the Montreal Biodome was maintained at 10ºC.

Generation time was based on aging information collected by Gedamke (2005) on Georges Bank because no aging data exist from Canadian waters. Estimated age at 50% maturity for females was 7 years and assuming a natural mortality rate (M) of less than 0.2 due to large body size, a generation time of 13 years was calculated as the age of 50% maturity plus the inverse of an estimated natural mortality rate of 0.17 (Gedamke 2006). Given the uncertainty in this estimate of M and the likelihood that growth is slower in Canadian waters, it is possible that the true generation time may be greater than 13 years.

Genetic description

There are no documented studies of population structure of Barndoor Skate based on genetic analyses among regions within Canadian waters. In the absence of genetic or other data pointing to the contrary, the species is therefore considered a single designatable unit.

Predation

Information regarding predation on Barndoor Skate is lacking. An examination of the DFO Maritimes stomach database revealed only one instance of Barndoor Skate being consumed by another fish (cod; Simon et al. 2009). Given their large size, it is likely that adults may only be preyed upon by large sharks and marine mammals. Juveniles would be vulnerable to a number of fish species but their fast growth (Gedamke 2005) would reduce the time that they would be vulnerable to such predation. Egg capsules of another skate species in the North Sea have been found to exhibit signs of predation by gastropods (Cox et al. 1999) and this may be applicable for Barndoor Skate in the northwest Atlantic.

Dispersal/migration

Direct observations on the migration patterns or dispersal of Barndoor Skate do not exist but a comparison of the distribution plots of the various seasonal surveys on Georges Bank suggest there may be some southward movement in winter (Figures 4,5,6,7). As abundance increased on Georges Bank, the species began to reappear in Div. 4X and has recently begun to reappear in the western portion of Div. 4W. Whether these observations are due to dispersal/migration into areas formerly occupied by the species from an area of concentration or whether the species was always present in all areas but at low levels and is now being encountered more frequently as abundance increases is unclear. However, the distribution of Barndoor Skate in Canadian waters is continuous with that in US waters so a rescue effect seems possible but difficult to quantify.

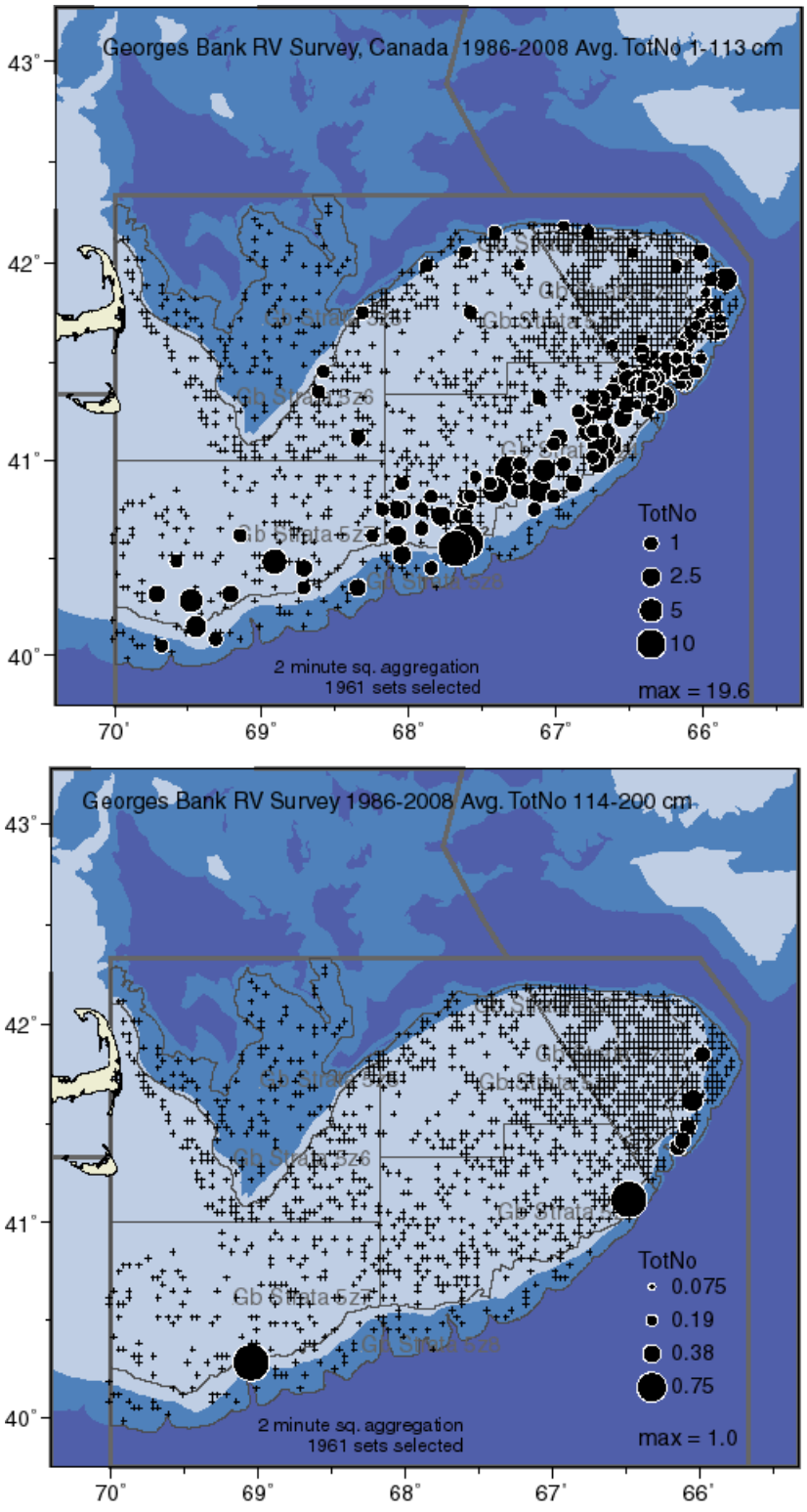


Figure 4. Distribution of Barndoor Skate measuring 1-113 cm and ≥114 cm in length as indicated by the Georges Bank RV Survey, 1986-2008. Aggregation used was average total number (avg totno) in each 2 minute square of latitude.

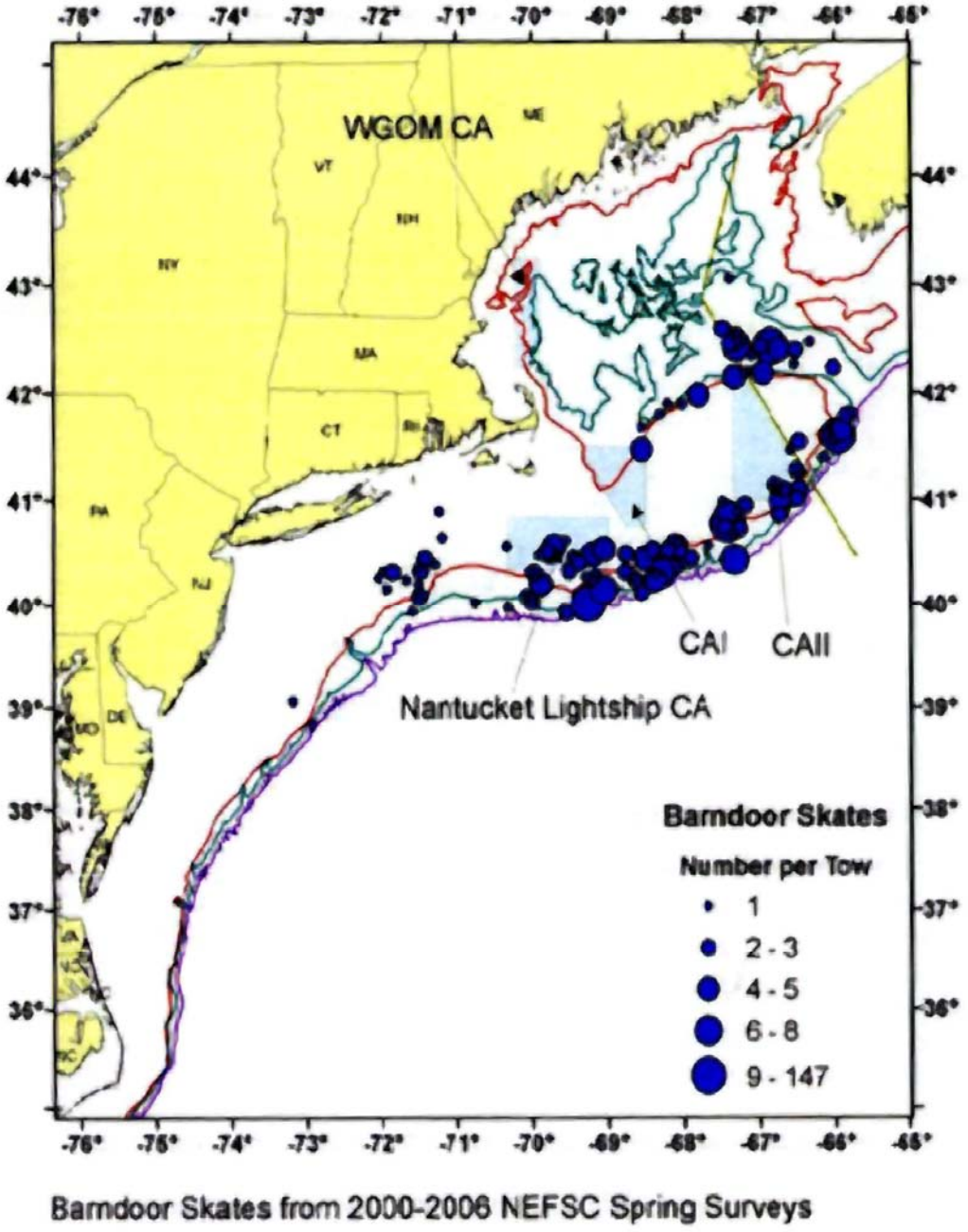


Figure 5. Distribution of Barndoor Skate as indicated by the US Spring RV survey (NMFS 2007).

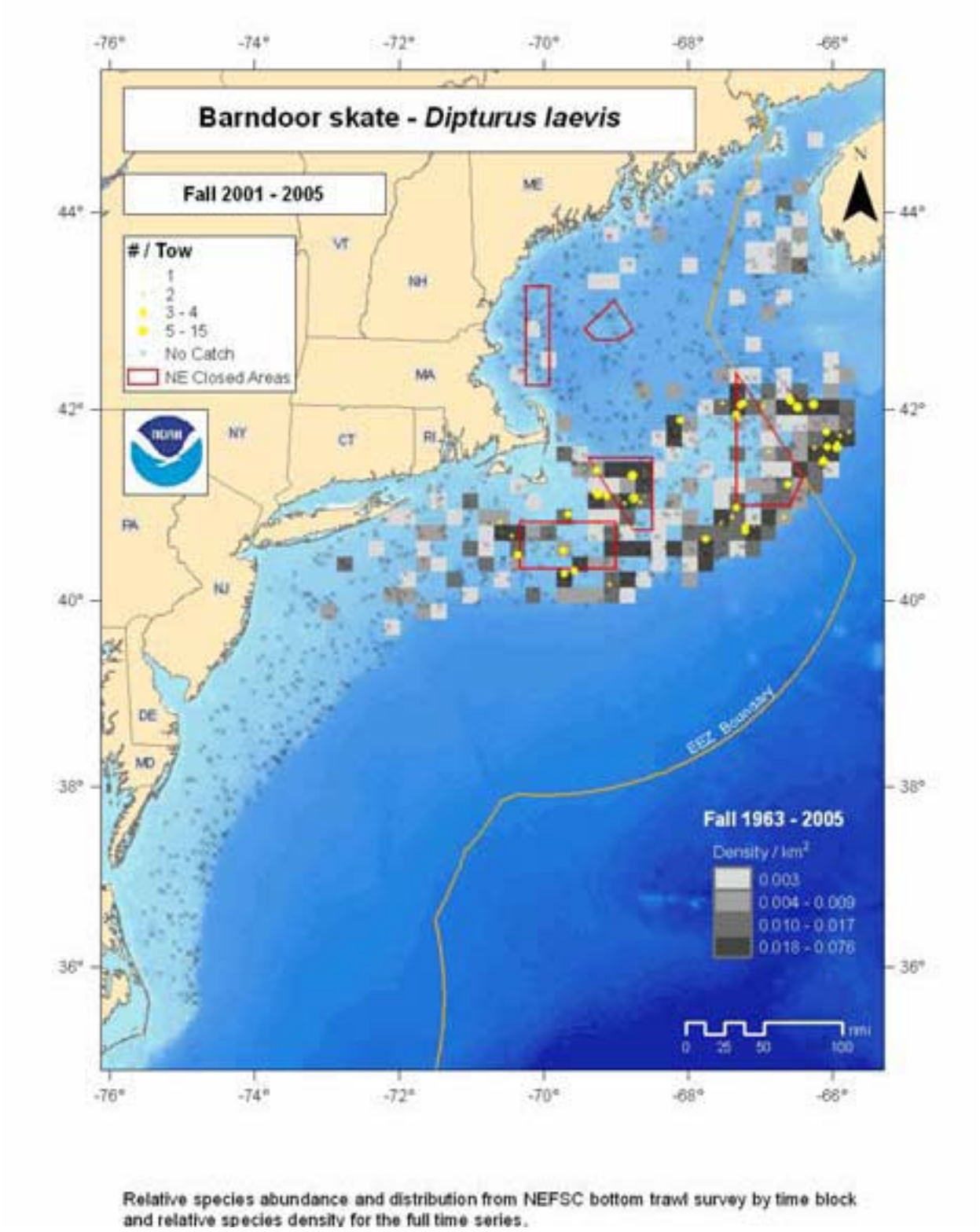


Figure 6. Distribution of Barndoor Skate as indicated by the US Fall RV survey (NMFS 2007).

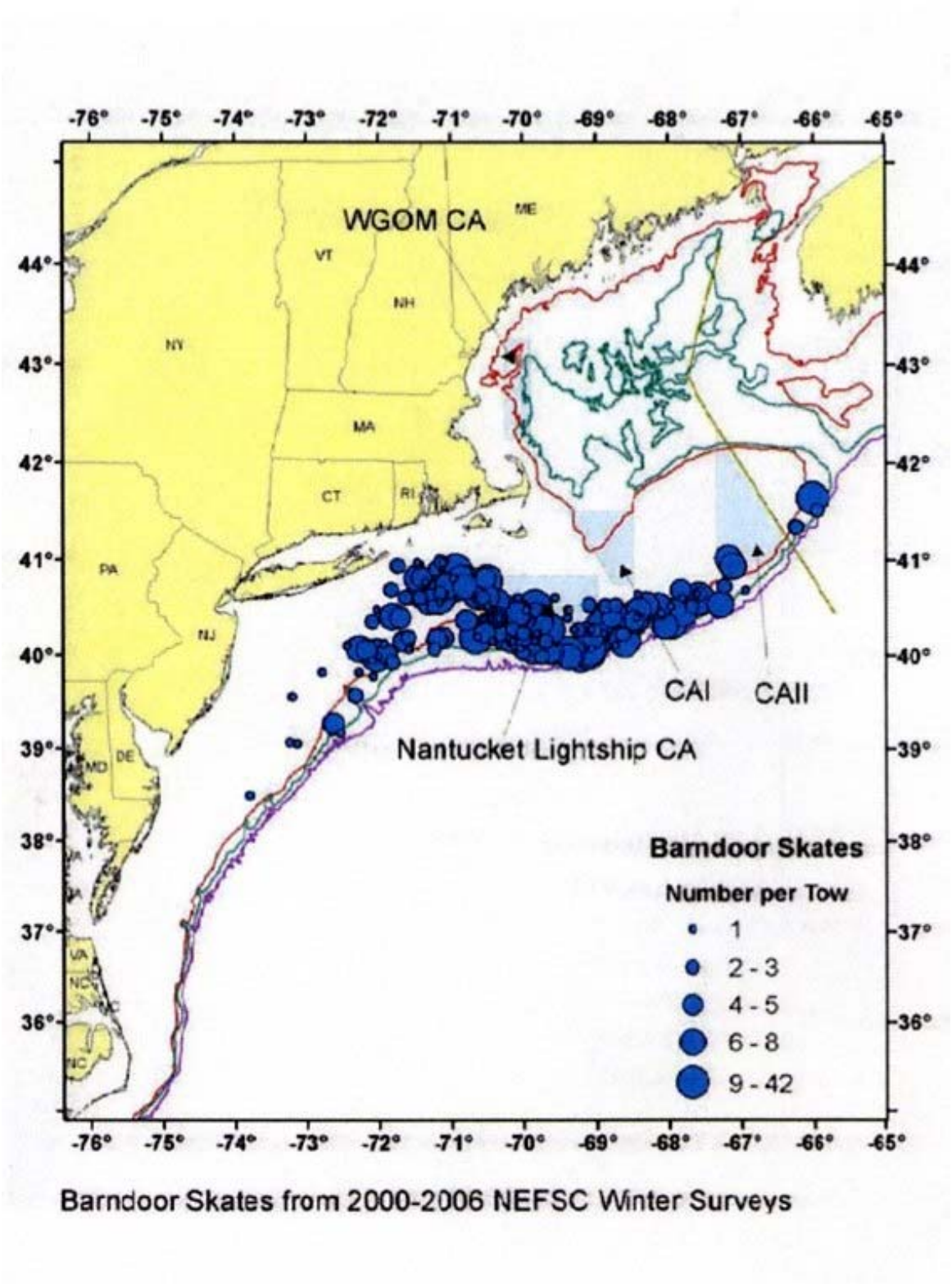


Figure 7. Distribution of Barndoor Skate as indicated by the US Winter RV survey (NMFS 2007).

Interspecific interactions

The diet of Barndoor Skate is dominated by fish and crustaceans although the proportions of these items change dramatically with body size. Small Barndoor Skate (<70 cm) are predominantly bottom feeders; they mainly consume shrimp and crabs with fish comprising less than 2% of their diet. The most important shrimp prey on the Scotian Shelf are pandalids whereas crangonids are the primary shrimp consumed on Georges Bank (Simon *et al.* 2009). Large Barndoor Skate (>70 cm) consume substantially more fish than crustaceans with fish sometimes representing greater than 90% of their diet. Large Scotian Shelf Barndoor Skate consume large proportions of Silver Hake and Haddock whereas those on Georges Bank consume Sculpin, Red Hake, and Ocean Pout. In both areas, they consume Herring (Simon *et al.* 2009).

Adaptability

Barndoor Skate are not known to possess special adaptations that would allow them to better survive extreme events caused by natural catastrophes or anthropogenic impacts.

POPULATION SIZES AND TRENDS

Sampling effort

Research Vessel Surveys

Research survey data from four different DFO regions were examined: 1) Newfoundland and Labrador (NL); 2) Quebec; 3) Gulf; and 4) Maritimes. Given the regional nature of survey activity by Fisheries and Oceans, the information is presented on a regional basis (Figure 2). This administrative separation has led to differences in the seasons and years surveyed as well as differences in gear employed. However, all regions use trawl gear and a stratified random survey design. The following sections summarize the major regional differences in survey time periods, gears, and seasons. The details of these differences are considered in more detail by Kulka et al. (2006). Seasonal surveys conducted by the US extending from Cape Hatteras to the Scotian Shelf (Div. 4X) are also reviewed. No conversion factors are available for this species for any of the changes in vessels or gear that occurred during any of the survey series in any of the regions examined. These surveys cover most of the known range of Barndoor Skate with the exception of deeper areas.

Quebec Region

Bottom trawl groundfish surveys from the Quebec Region were examined, separated by differences in vessel, gear, time of year, and area surveyed. This resulted in the creation of four RV series for the region dating back to 1978. In general, the surveyed area included the northern Gulf (Div. 4RS), strata deeper than 183 m (100 fathoms) in Div. 4T including the Lower St. Lawrence estuary, as well as the southeast Gulf (Subdiv. 3Pn). In all cases, the sampling methodology followed a depth-stratified random survey design (Kulka et al. 2006).

The Winter surveys were conducted by the *Gadus Atlantica* from January 1978 to 1994 using an Engels 145 trawl. The area surveyed varied over the series, mainly due to prevention of fishing by ice cover. The average area surveyed was 62,550 km^2 with the smallest area in 1992 amounting to 31,737 km^2 and the largest area in 1980 amounting to 100,400 km^2. Survey coverage in Subdiv. 3Pn and Div. 4R was good during this series while coverage in Div. 4S was more variable (Kulka et al. 2006).

Summer (August) RV surveys have been conducted in the northern Gulf since 1984 using a variety of vessels, gears, and areas surveyed. From 1984 to 1990, the survey was conducted by the *Lady Hammond* using Western IIA trawl gear. Total surveyed area (Div. 4RST) was fairly constant from 1985 to 1989 averaging 95,700 km^2; however, in 1984 and 1990, coverage was reduced (Kulka et al. 2006). From 1990 to 2005, the survey was conducted by the *Alfred Needler* equipped with a URI 81'/114' (University of Rhode Island) shrimp trawl. Additional shallow strata (20-50 fathoms) were added at the onset of the *Alfred Needler* survey. Over the series, the surveyed area averaged 111,300 km^2. The minimum area surveyed was in 1990 with 95,070 km^2 and the maximum area surveyed in 1995 with 119,000 km^2. Subdiv. 3Pn was sampled from 1994 to 2003 (Kulka et al. 2006). Since 2004, the northern Gulf of St. Lawrence has been surveyed by the *Teleost* equipped with Campelen gear. The area surveyed varied from 91,600 to 116,115 km^2 but Subdiv. 3Pn was not surveyed.

Gulf Region

Data are from annual bottom trawl surveys conducted in the southern Gulf of St. Lawrence each September since 1971. Surveys used a stratified random design with stratification based on depth and geographic region. Surveys were conducted using a Yankee 36 trawl from 1971 to 1984 and a Western IIA trawl since 1985. The research vessels conducting the survey were the *E. E. Prince* from 1971 to 1985, the *Lady Hammond* from 1985 to 1991, the *Alfred Needler* from 1992 to 2002, the *Wilfred Templeman* in 2003, and both the *Alfred Needler* and the *Teleost* in 2004 and 2005. Fishing was conducted only during daylight hours (07:00-19:00) in 1971-1984 but 24-h per day since 1985. Where applicable, catches were adjusted for diel differences in fishing efficiency as described by Benoît and Swain (2003).

Newfoundland and Labrador Region

Stratified-random surveys have been conducted by Canadian research vessels in the Spring (April to June period) of each year from 1971 to 2008. A summary of the stratified-random survey design adopted by the DFO - NL Region was reported by Doubleday (1981). While survey design has remained constant, additional strata have been included in recent years, along with modifications to some of the original strata (Bishop 1994). A significant change in the surveys is the addition of shallower and deeper strata after 1993. The Spring survey can be split into three time periods based on the trawl used in each period: 1971-1982 (Yankee-41.5 gear, Vessel: *A.T. Cameron*), 1983-1995 (Engels-145 Hi-lift gear, Vessels: *Alfred Needler*, *Wilfred Templeman*), and 1996-2007 (Campelen-1800 gear, Vessels: *Alfred Needler*, *Wilfred Templeman*, *Teleost*).

Stratified-random Autumn surveys have been conducted by Canada in Div. 2J3K from 1977-present (Vessels: *Gadus Atlantica* [to 1994], *Teleost*, *Wilfred Templeman* [since 1995]) and in Div. 3L (Vessels: *A.T. Cameron*, *Wilfred Templeman*, *Teleost*) from 1981 to present. In 1990, Autumn surveys also extended onto the southern Grand Banks in Div. 3NO. Surveys were conducted with the Engel trawl prior to 1995 and with the Campelen trawl since 1995. It must be noted that Canada does not survey Subdiv. 3Ps in Autumn and did not survey Div. 3NO before 1990. Furthermore, Autumn surveys reach deeper maximum depths (~1,400 m in recent years) than those in Spring (~750 m) (Kulka *et al.* 2006).

Maritimes Region

The DFO Summer survey has been conducted annually on the Scotian Shelf (Div. 4VWX) since 1970 using a stratified random design based on depth and geographic area. In 1995, coverage was expanded into three deepwater strata on the edge of the shelf, but they have not been included in these analyses because Barndoor Skate have not been caught in these strata. From 1970 to 1981, the survey was conducted by the *A.T. Cameron* using a Yankee 36 trawl. In 1982, the *A.T. Cameron* was replaced by the *Lady Hammond* using the Western IIA as the new standard trawl. In 1983, the *Lady Hammond* was replaced by the *Alfred Needler* also using the Western IIA trawl. In 1991, the *Lady Hammond* conducted the second leg of the survey on the eastern Scotian Shelf due to the *Alfred Needler* breaking down. In 2004, the *Alfred Needler* was replaced by the *Teleost*. The 2005 survey was conducted by both the *Teleost* and the *Alfred Needler* to investigate differences in catchability between the two vessels, but due to the very low number of individuals encountered this has not been investigated for Barndoor Skate. In 2006, the survey was conducted by the *Alfred Needler*. In 2007, the survey reverted back to the *Teleost* and in 2008, the sister ship of the *Alfred Needler*, the *Wilfred Templeman*.

The 4VWCOD (Spring) survey has been conducted since 1986 on the eastern half of the Scotian Shelf (Div. 4VsW). This survey uses a stratification scheme that was meant to optimize the abundance estimates of cod. During 1986-2003 and 2005-2006, the survey was conducted by the *Alfred Needler* using the Western IIA trawl. No surveys were conducted in 1998 or 2004. The 2007 survey was conducted by the *Teleost* using a Western IIA trawl. Deep water strata in the Laurentian Channel were added to this survey in 1993.

The February/March survey on Georges Bank (Div. 5Z) commenced in 1986 using Western IIA trawl gear and a stratified random design. The *Alfred Needler* has been the primary vessel except in 1993 and 2004 when the *Wilfred Templeman* was used. The survey concentrates on the northeast peak of the bank (Canadian portion) with the remainder (US portion) surveyed at a lower intensity.

US

Research surveys of the east coast of the US and the southern half of the Scotian shelf have been conducted by NMFS each Fall since 1963 and each Spring since 1968. Both surveys use a stratified random design similar to the Canadian Summer RV survey of the Scotian Shelf (Figure 8). Two research vessels, the *Albatross IV* and the *Delaware II*, have been the primary survey vessels with the *Atlantic Twin* surveying the inshore areas from Autumn 1972 to Spring 1975. Generally, a Yankee 36 trawl has been the standard survey gear except a modified Yankee 41 trawl was used during the Spring survey from 1973 to 1981. In addition, there was a change in the trawl doors in 1985. No conversion factors are available for any of the changes that occurred during either survey series. Data from a Winter research vessel survey (2000-2006) that uses a similar survey design but a chain sweep with small cookies to better target flatfish are presented for comparison.

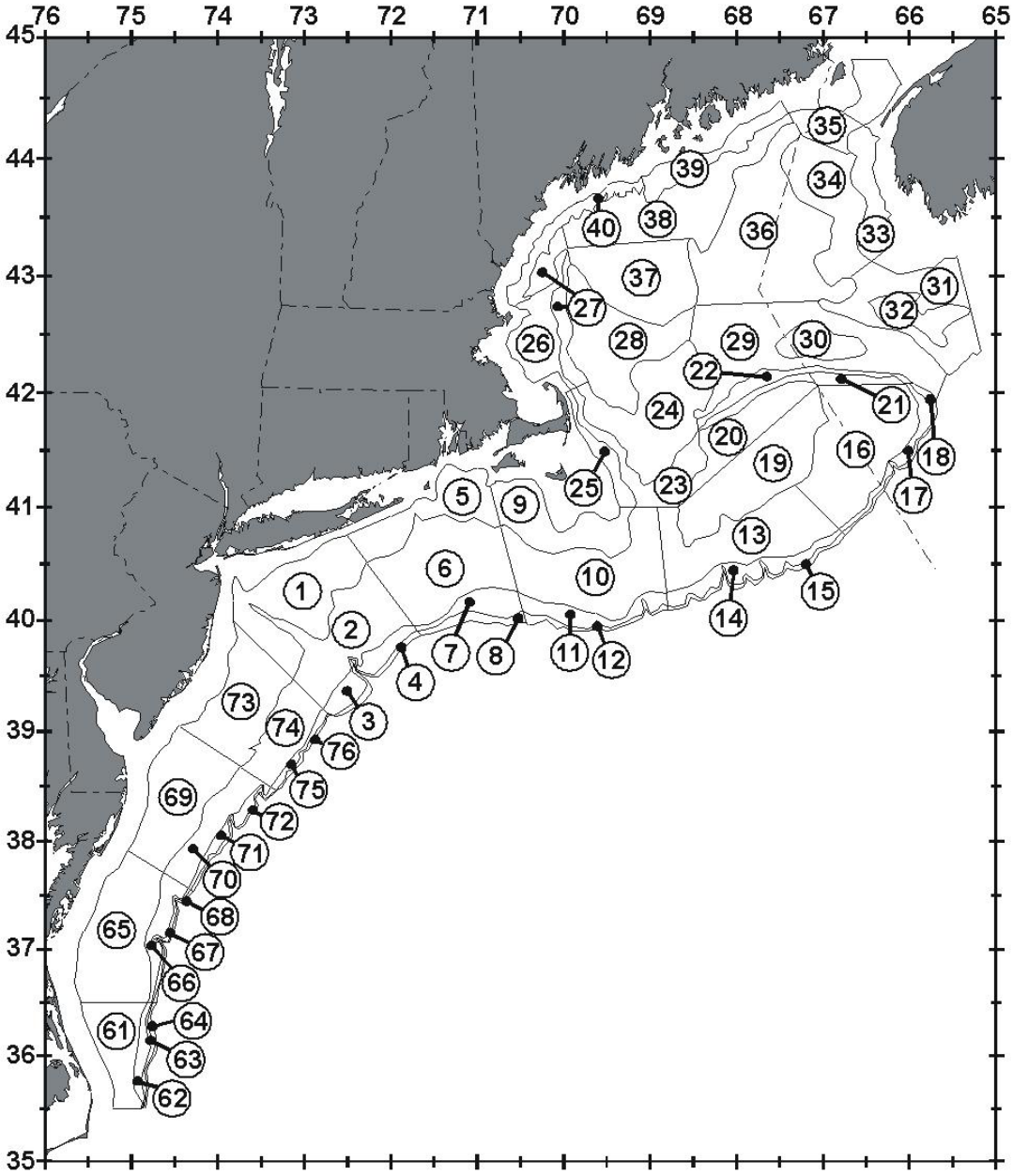


Figure 1. Strata sampled on NEFSC offshore bottom trawl surveys. Depths range from 27 to > 200 meters.

Figure 8. Stratification scheme used in the Spring and Fall US RV surveys.

Industry Surveys

Three industry/science surveys based in the Maritimes Region and conducted since the mid-1990s were also evaluated. These surveys have standard sampling designs. The industry participants have undergone training for sampling methods and species identification and, in addition, trained observers have been deployed on the majority of the participating vessels.

The Individual Transferable Quota (ITQ) Fixed Station Industry Survey in Div. 4X began in the Summer of 1995. This survey is conducted by four otter trawlers using a balloon trawl which has smaller diameter footgear than the RV survey gear and, therefore, potentially higher catchability of Barndoor Skate. The area sampled is similar to the RV survey except the area inshore of the 50 fm line is also surveyed.

The Div. 4VsW Sentinel Survey is a stratified random longline survey conducted by industry participants. The series began in Fall 1995 and includes all areas surveyed by the RV survey in Div. 4VsW as well as three additional inshore strata. In 2005, the survey was reduced to those three inshore strata as well as four core strata that were thought to be the centre of distribution for Haddock. Skate were not identified to species until 1996 so our analysis begins in that year.

The Halibut Industry Survey began in 1998 using longline gear primarily on the Scotian Shelf with sets extending into the southern portion of the Grand Banks. An index fishery conducted by the same participants fishes in waters deeper than the regular survey, primarily in the slope waters of the Scotian Shelf and the Grand Banks. Details on location, gear type, time of year, duration, and sampling effort are described by Armsworthy et al. (2006).

Overview of regional information

Quebec

Barndoor Skate were caught in only three of the 7,830 survey sets in Div. 3Pn4RST (0.04%). Two fish were caught in the upper reaches of the Laurentian Channel in 1985. In 2005, a single fish was captured in the same area. All fish were caught in water greater than 200 m. Given the low abundance, area of occupancy was not calculated (Figure 9).

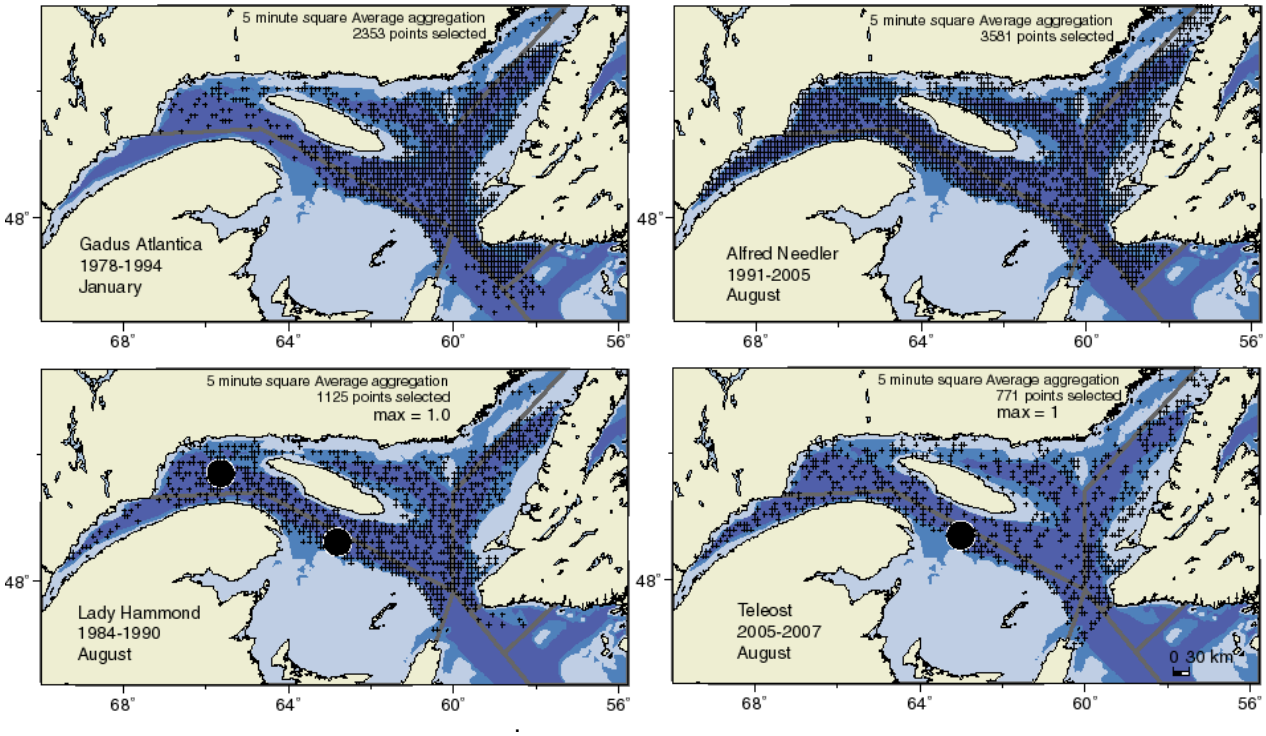


Figure 9. Distribution of Barndoor Skate from the northern Gulf of St. Lawrence research vessel surveys. Barndoor Skate have been caught in only 3 of 7830 survey sets. No biological information was collected from the 2 individuals caught in 1985 during the Lady Hammond cruise. The individual caught during the 2005 Teleost mission was 114 cm.

Southern Gulf of St. Lawrence, Div. 4T

Barndoor Skate were recorded in only eight of the 5163 survey sets (0.15%). These fish were caught in 1972, 1974, 1979, 1984, 1987, 1988 (2), and 1990. All fish were caught along the edge of the Laurentian Channel at a depth range of 60-358 m (Figure 10). Given the low abundance, area of occupancy was not calculated.

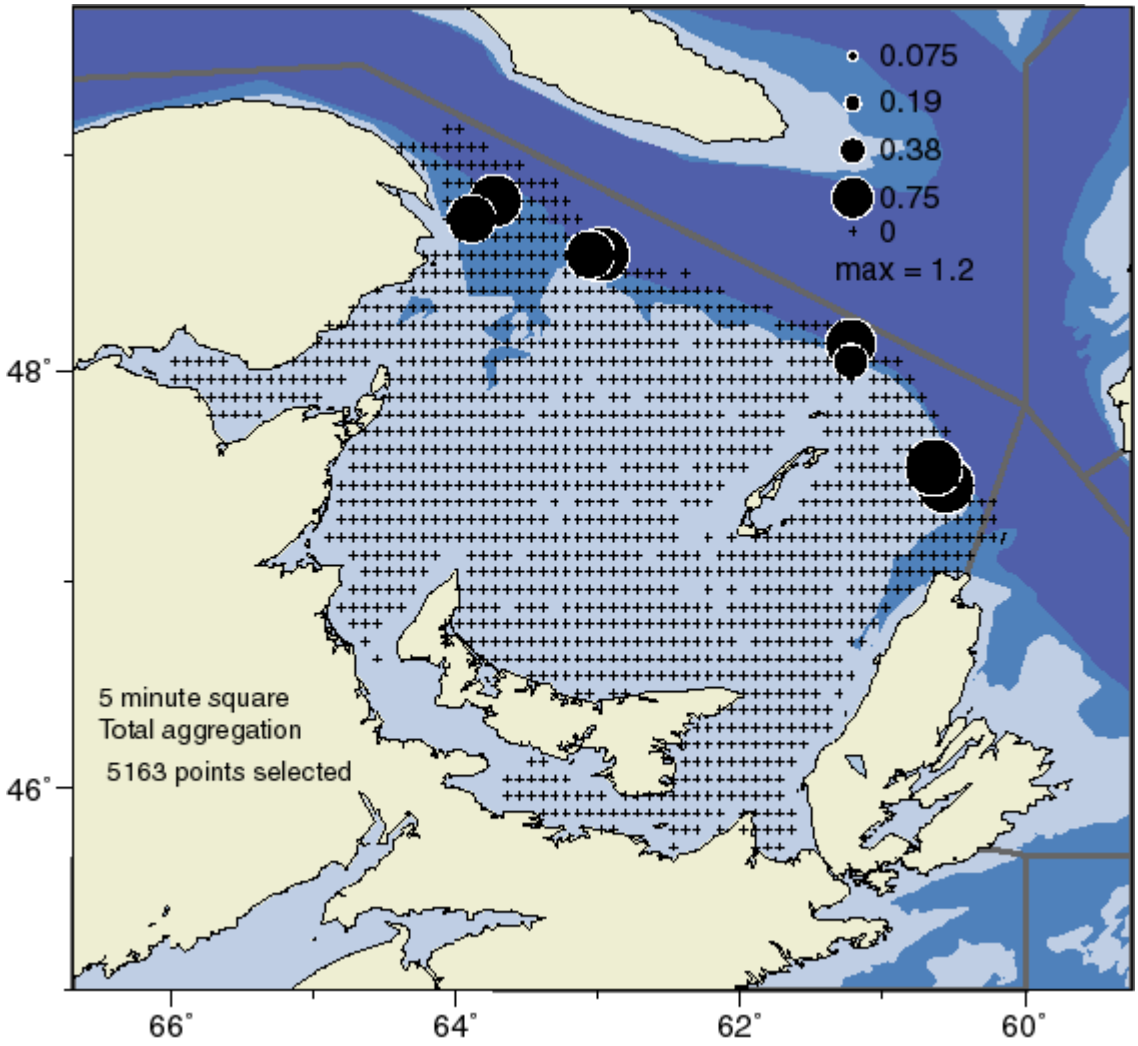


Figure 10. Distribution of Barndoor Skate from DFO research vessel surveys in Div. 4T, 1971-2007. A total of 8 Barndoor Skate have been caught in this series; length range: 36-138 cm. Fish were caught in 1972, 1974, 1979, 1984, 1987, 1988 (2), and 1990. Percent occurrence over the time series is 0.15%.

Newfoundland and Labrador

The Spring RV survey is primarily confined to Subarea 3 with a few sets in Subarea 2. A total of 15,315 sets have been conducted since 1971. Only three Barndoor Skate have been recorded in the entire time series. These were from 1974, 1976, and 1977. The depth of capture was 208, 241, and 338 m, respectively. Two of the fish were captured in Subdiv. 3Ps while the other was caught in Div. 3L (Figure 11).

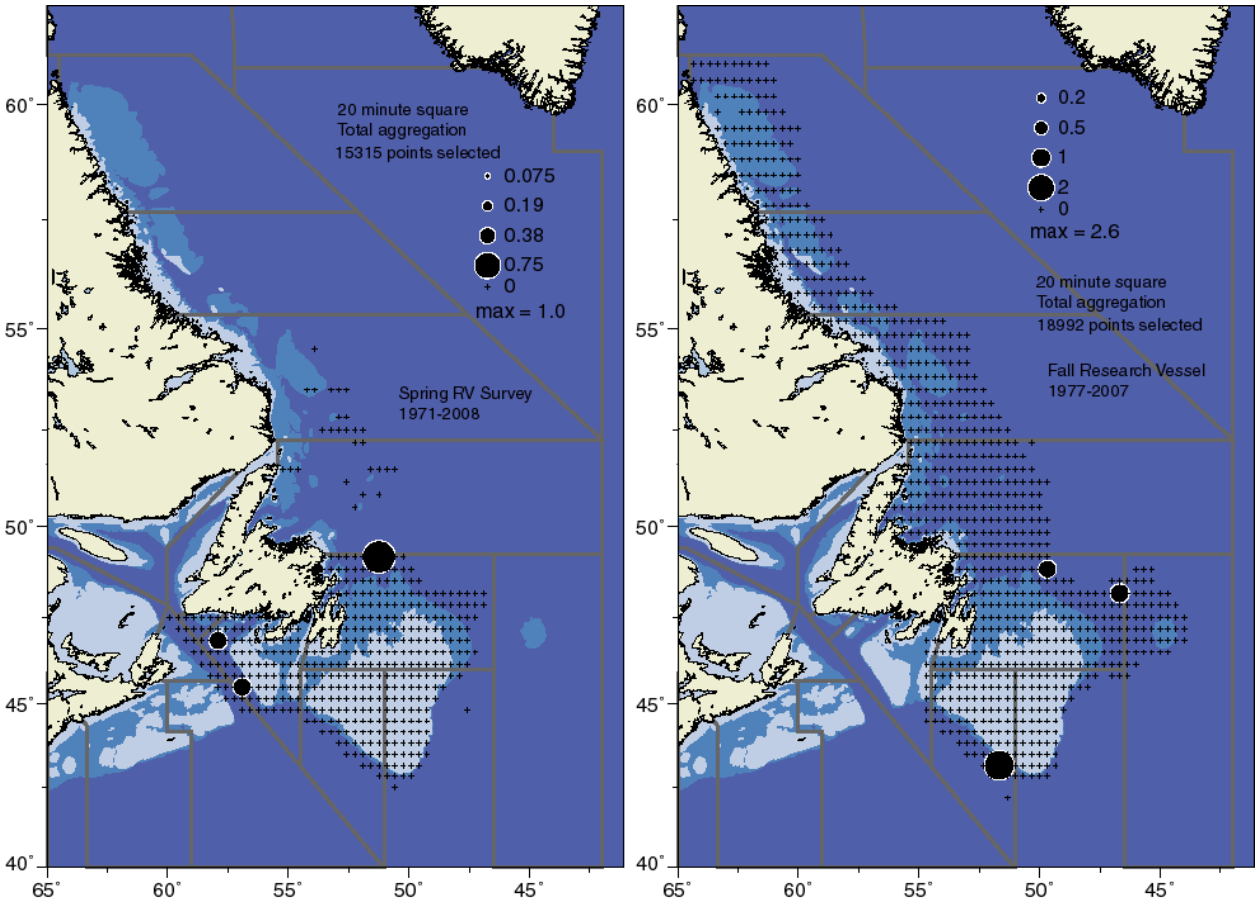


Figure 11. Distribution of Barndoor Skate from the Spring (1971-2008) and Fall (1977-2007) research vessel surveys in the Newfoundland and Labrador Region. In recent years, the Fall survey has been extended into deeper waters and Campelen trawl gear has been used. A total of 8 fish were captured in over 34,000 sets.

The Fall RV survey extends from the Davis Strait, Subarea 0, south to the Grand Banks (Div. 3NO), and east to Div. 3M (outside Canadian waters). A total of 18,992 sets have been completed since 1977. Only five Barndoor Skate were recorded from this series. These fish were caught in Div. 3M in 1996 at a depth of 1040 m, in Div. 3O in 2000 at depths of 499 m(2) and 634 m, and in Div. 3L in 2001 at a depth of 1174 m. (Figure 11). The individual captured at 1174 m represents the deepest confirmed record of Barndoor Skate from any Canadian RV database. Given the low abundance, area of occupancy was not calculated.

The distribution of Barndoor Skate as indicated by bycatch recorded by at-sea observers in Newfoundland commercial fisheries is shown in Figure 12. These data indicate that the species was widespread along the Laurentian Channel, Div. 3O, and outside Canadian waters in Div. 3M. Most of these records are from 1978 to 1982. Since 1998, there have been only 21 records of the species, 19 of which have come from the Flemish Cap (Div. 3M). By comparison, there has been only one record of Barndoor Skate from Div. 3M in the RV survey (captured in 1996).

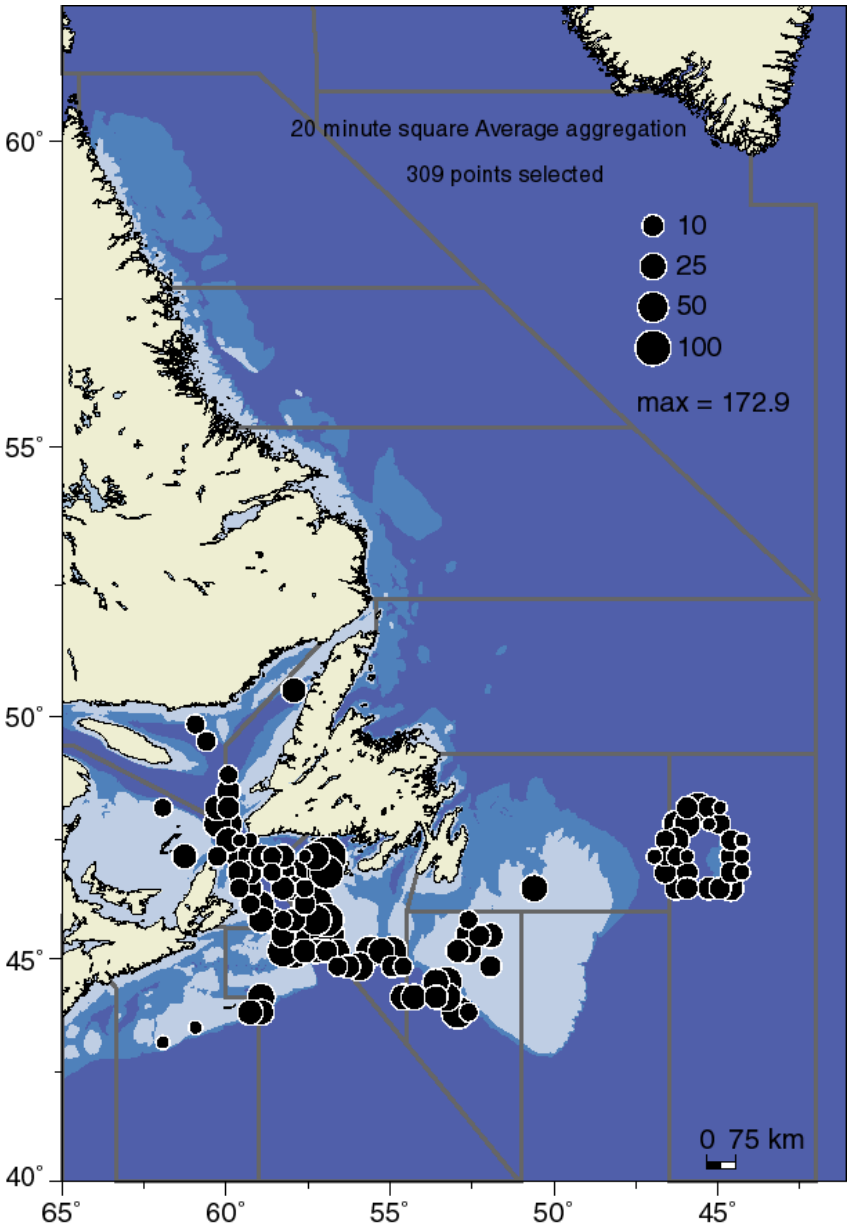


Figure 12. Distribution of Barndoor Skate since 1978 from commercial fisheries as determined by the Newfoundland Observer Program.

Data from the Halibut Industry Survey indicates that the species is caught on the southern edge of the Grand Banks in Div. 3PsNO but sampling did not extend beyond the tail of the Grand Banks.

Maritimes

Summer Survey of the Scotian Shelf (Div. 4VWX)

Research vessel and industry survey information from the Maritimes Region were examined for the presence of Barndoor Skate. The Summer survey is the longest-running survey series in the Maritimes Region. It has been conducted every year in July since 1970. Out of the 6783 sets completed during 1970-2008, only 86 or 1.3% contained Barndoor Skate. The composite distribution pattern revealed a few areas of concentration, notably the western Scotian Shelf and the Gully (Figure 13). The distributional data was separated into two time periods, 1970-1992 and 1993-2008, to compare when the species was originally abundant to the most recent time period (Figure 13). During 1970-1992, Barndoor Skate were scattered across the entire shelf with some particularly large sets recorded near the Gully on the eastern Scotian Shelf and in Div. 4X (Figure 13). From 1993 to 2008, Barndoor Skate were concentrated in the southern half of Div. 4X and in the western portion of Div. 4W. No Barndoor Skate were caught east of 62ºW. Separating the data into juvenile (1-113 cm) and adult (≥114 cm) size classes revealed that juveniles have been caught throughout the survey area while adults have been caught less frequently by the survey and primarily in the Fundian Channel (Div. 4X; Figure 14).

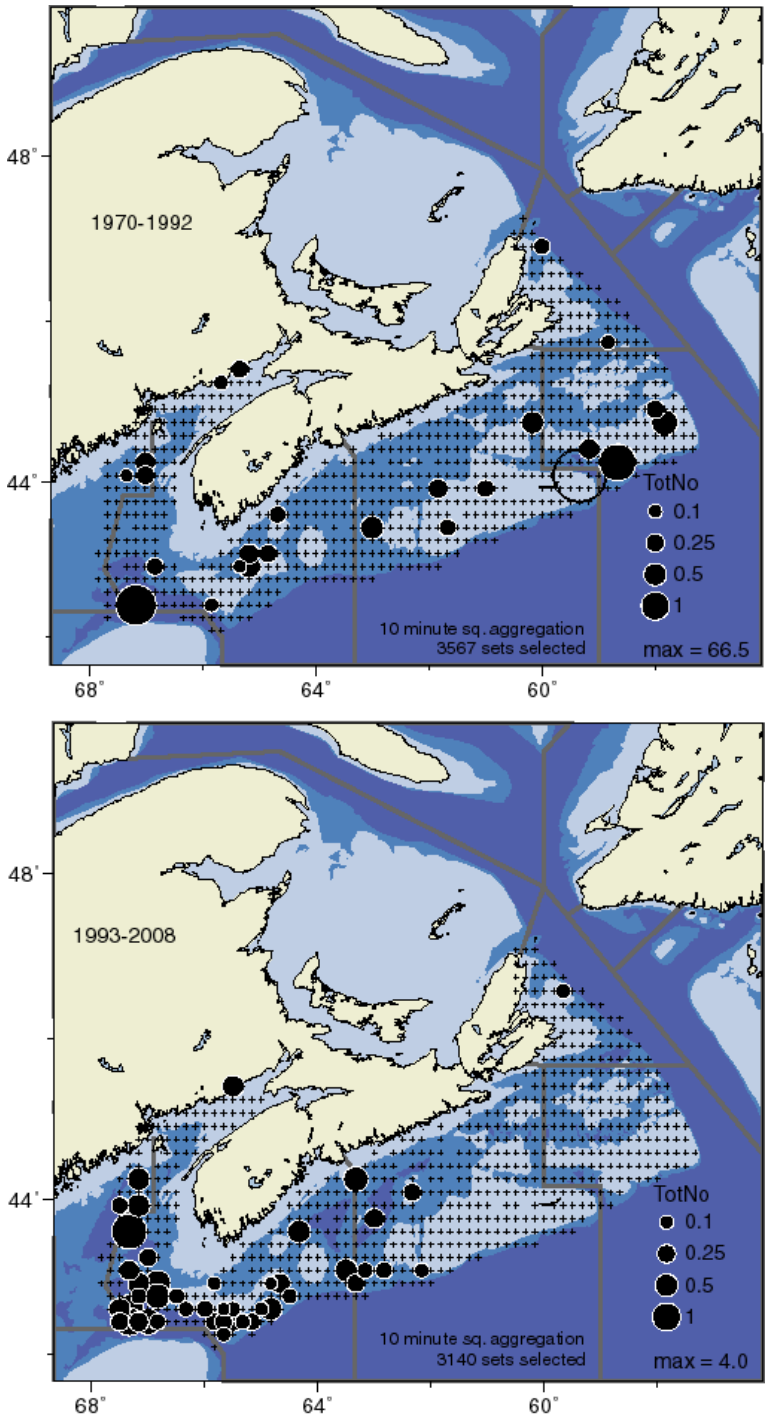


Figure 13. Distribution of Barndoor Skate in the Maritimes Region as indicated by the Summer RV survey from 1970-1992 and 1993-2008.

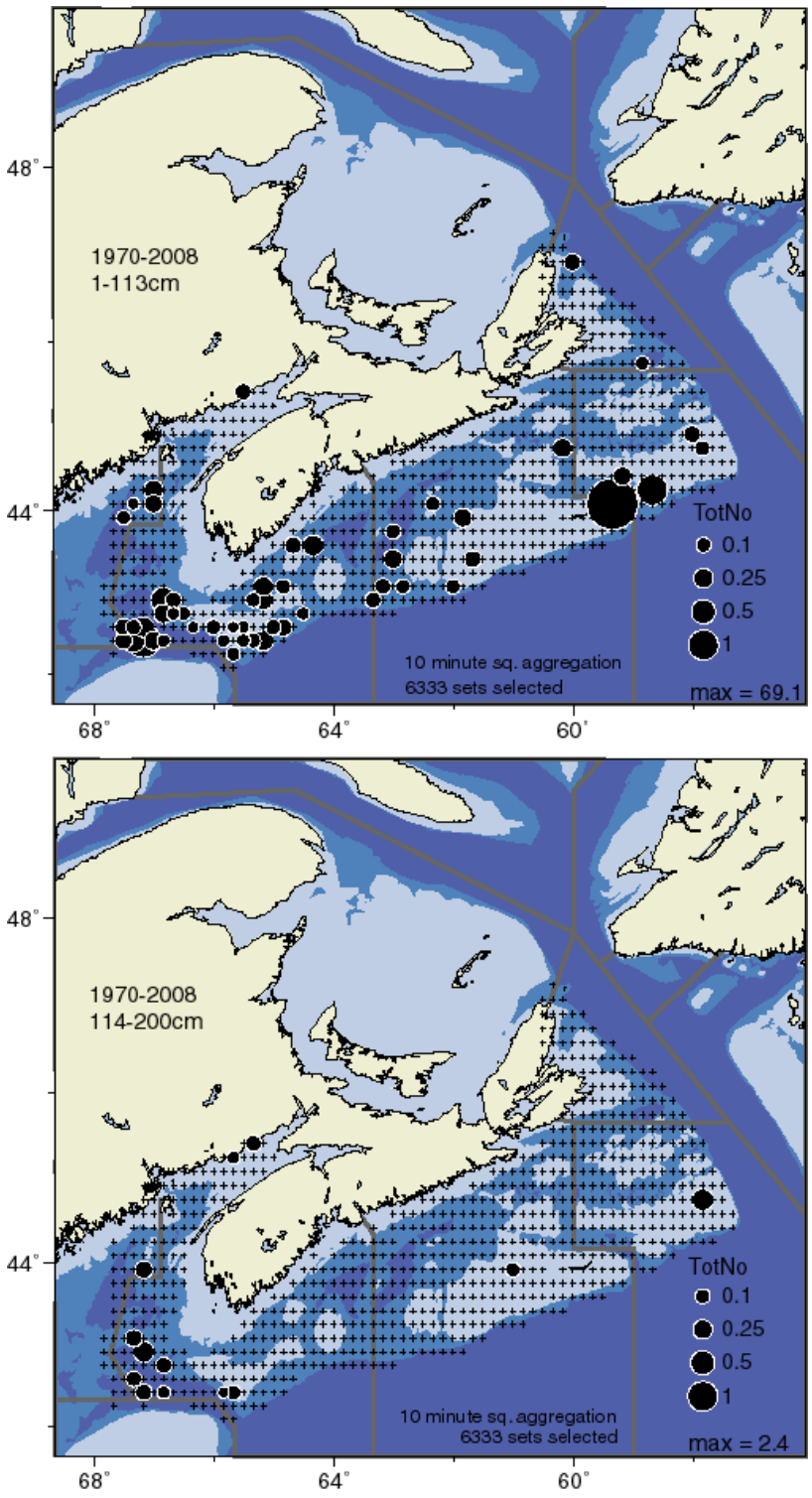


Figure 14. Distribution of juvenile (<114 cm) and adult (≥114 cm) Barndoor Skate in the Maritimes Region as indicated by the Summer RV survey, 1970-2008.

ITQ Survey in Div. 4X (Otter trawl)

The composite distribution pattern of Barndoor Skate from the ITQ survey was similar to that from the Summer RV survey but the species was found to be more abundant and widespread within the same area (Figure 15).

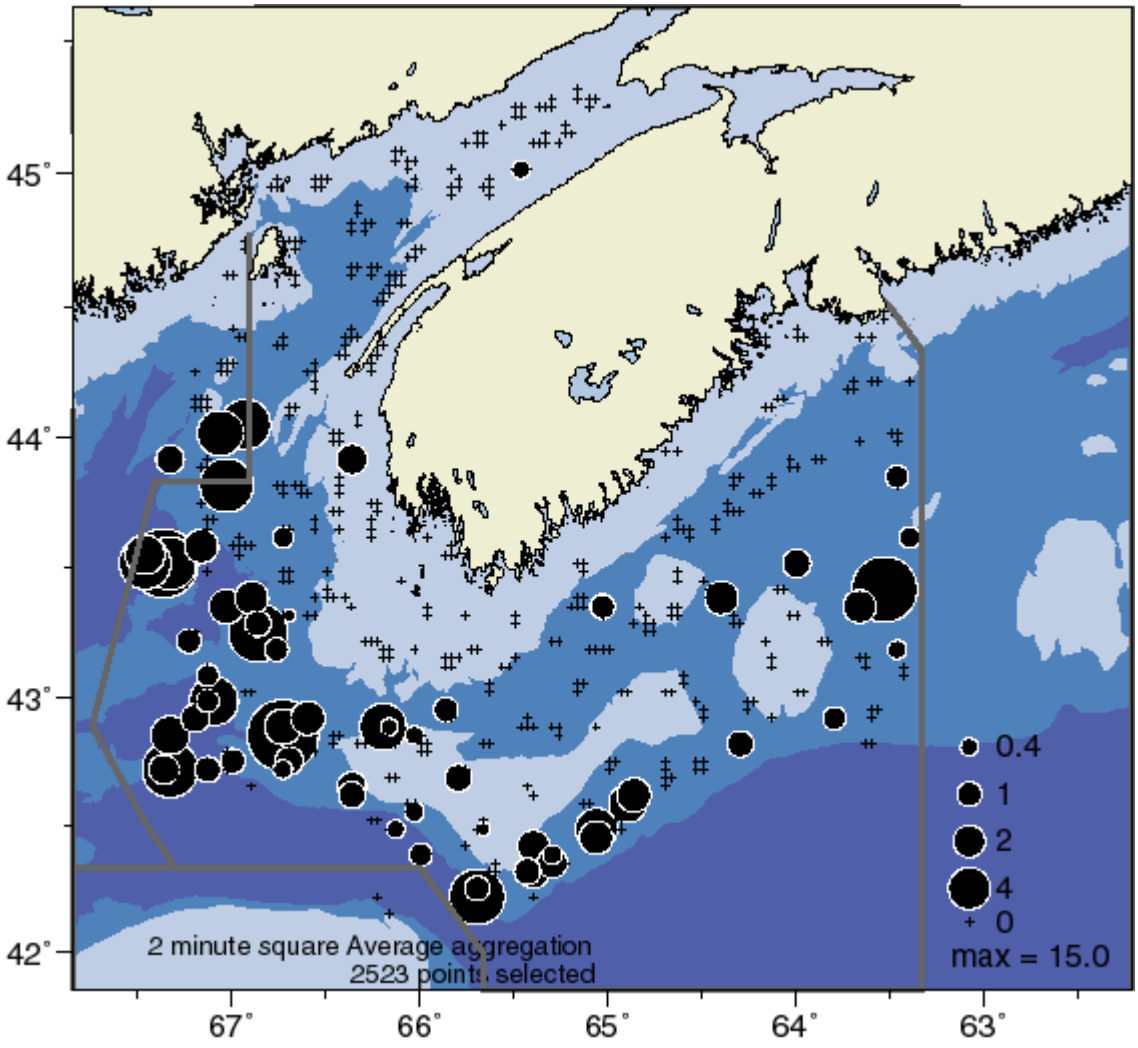


Figure 15. Distribution of Barndoor Skate as indicated by the ITQ survey in Div. 4X, 1995-2008.

Sentinel Survey of the eastern Scotian Shelf (Div. 4VsW Longline)

Barndoor Skate from the Div. 4VsW Sentinel Survey were concentrated along the western boundary of the survey area (or central Scotian Shelf) between Emerald Basin and Emerald Bank and southward to the edge of the shelf (Figure 16). This area is almost entirely covered by the four core strata that were sampled throughout the series. Total number of survey sets was 2027 with 176 reporting Barndoor Skate (8.7%).

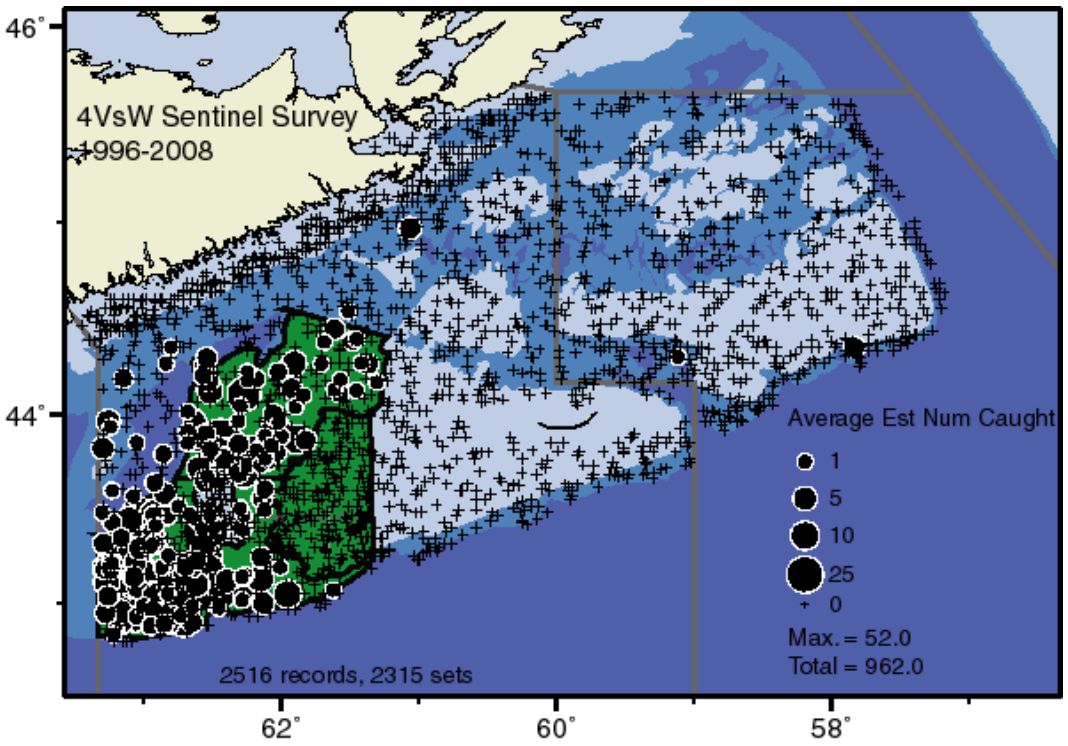


Figure 16. Distribution of Barndoor Skate (#/tow) as indicated by the Div. 4VsW Sentinel Survey, 1996-2008. The core strata that have been fished annually are indicated in green.

Halibut Survey of the Scotian Shelf and southern Grand Banks (Div. 3NOPs4VWX5Z Longline)

The fixed portion of the halibut longline survey revealed that Barndoor Skate were primarily caught in Div. 4X and the western part of Div. 4W (Figure 17). Distribution in Div. 4W was similar to that seen in the Sentinel Survey. In addition, Barndoor Skate were found along the southern edge of the Scotian Shelf and the Grand Banks (Figure 17). The commercial index portion of the survey fished in waters that were often deeper than the fixed portion and Barndoor Skate were identified in these waters as far east as the tail of the Grand Banks (Figure 18). Total number of sets in the fixed station surveys was 1994 with 269 records of Barndoor Skate (13.8%).

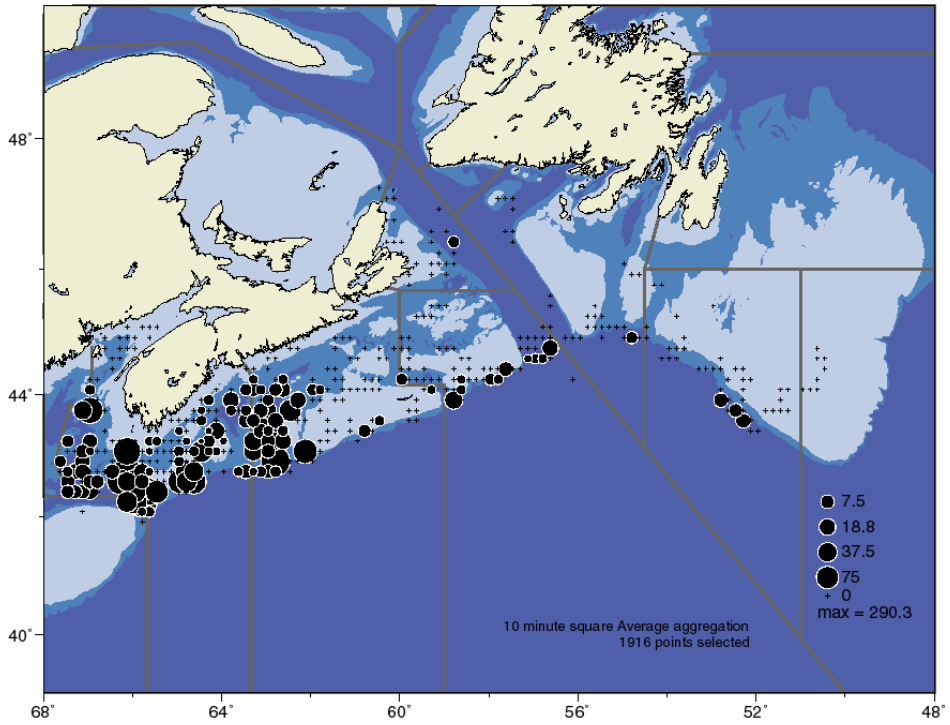


Figure 17. Distribution of Barndoor Skate as indicated by the fixed portion of the halibut industry survey in Div. 3NOP4VWX5Z, 1997-2007.

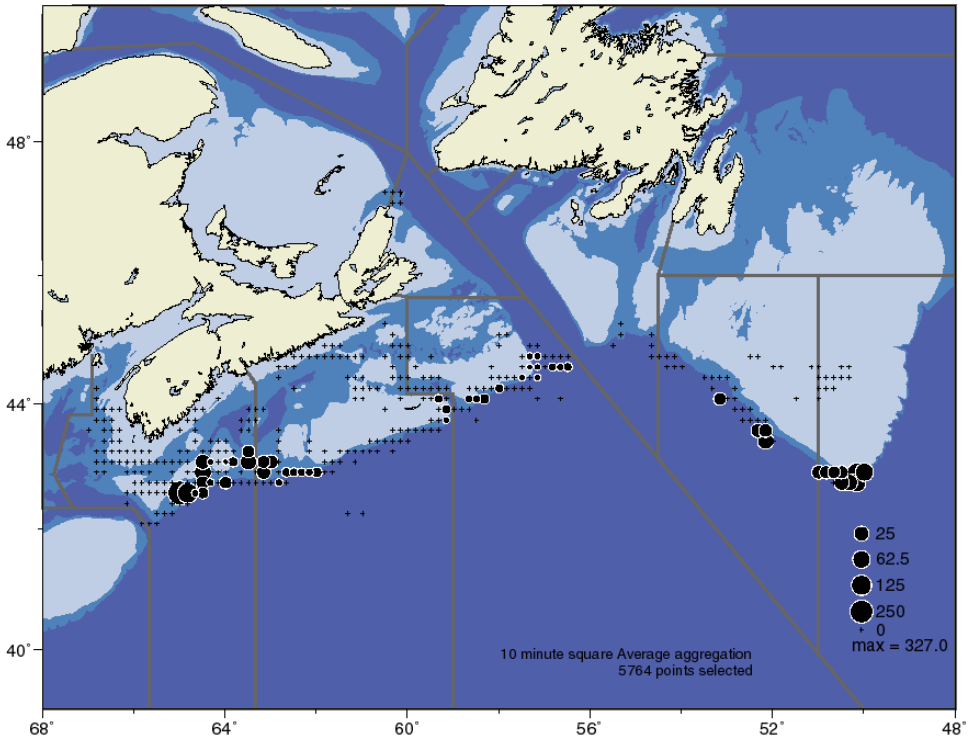


Figure 18. Distribution of Barndoor Skate as indicated by the commercial index portion of the halibut survey in Div. 3NOP4VWX5Z, 1997-2007.

Spring Survey of the eastern Scotian Shelf (Div. 4VsW)

The annual March survey of the eastern Scotian Shelf has only two records of Barndoor Skate out of 1795 sets since the beginning of the series. In 2000, a 37 cm fish was caught in 230 m near the Gully and in 2002, a second fish was caught in 130 m near the Div. 4X boundary (Figure 19).

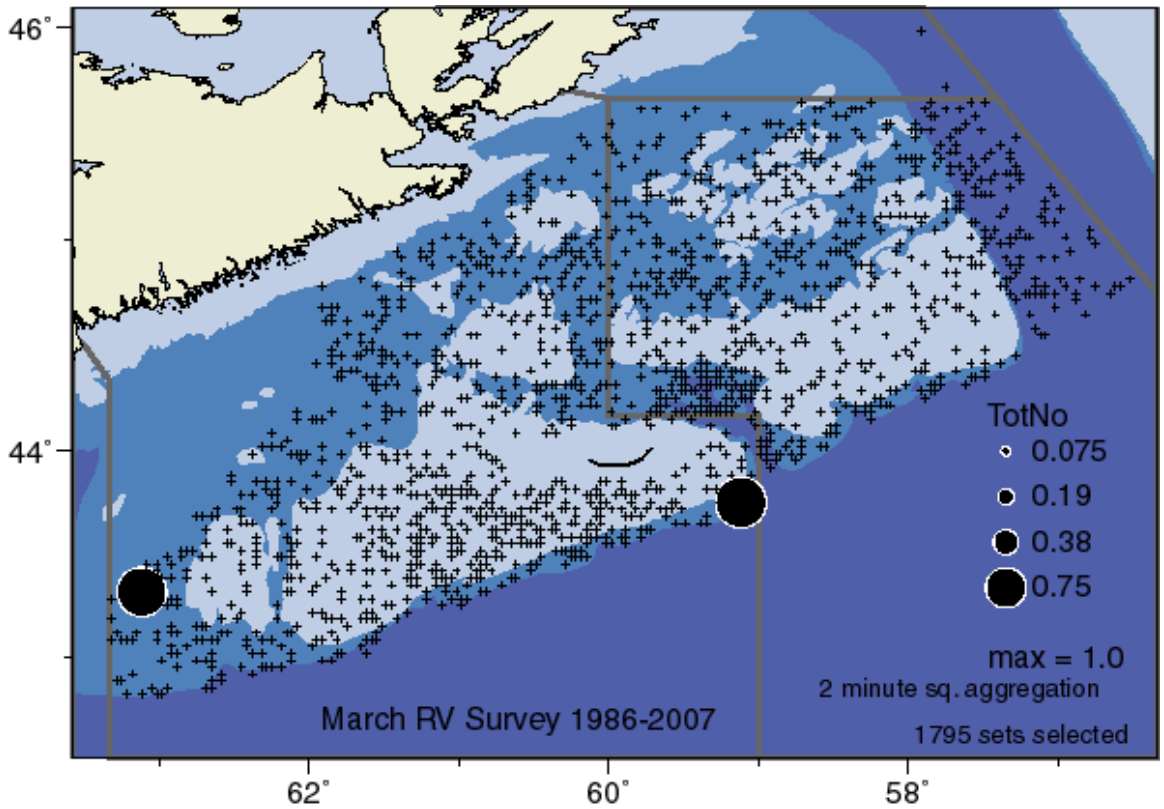


Figure 19. Distribution of Barndoor Skate as indicated by the 4VWCOD RV survey, 1986-2007.

Winter Survey of Georges Bank (Div. 5Z)

A total of 2038 sets have been completed since 1986 with 158 or 7.8% containing Barndoor Skate. Barndoor Skate were primarily distributed along the southern flank of Georges Bank from the Northeast Peak to the Great Southwest Channel (Figure 4) with small concentrations along the northern edge of the bank. There did not appear to be a break in distribution between the Canadian and US sides of the bank. Abundance predominantly consisted of juveniles distributed throughout the survey area. Adults were primarily distributed on the southern edge of the northeast peak of the bank (Figure 4).

US

A comparison of the seasonal surveys conducted by the US revealed some small-scale seasonal movement by Barndoor Skate. Distribution during the Spring RV survey was similar to the Canadian 5Z survey in February with an additional concentration in the Fundian Channel (NEFSC 2007; Figure 5). Results from the Fall survey (2001-2005) suggest that the species may spread out across the bank, especially the southwestern channel area, but there was no movement into the inshore region (NFSC 2007; Figure 6). The Winter survey indicates that the centre of distribution was near the Nantucket Lightship at that time of year and this may involve some movement from Georges Bank (NMFC 2007; Figure 7). Given the high levels of abundance along the southern flank of the bank, it is possible that the species' distribution continued into deeper waters and the entire population was not sampled.

Area of occupancy

This section provides information on the trends in design weighted area occupancy (DWAO) within the Maritimes Region (Div. 4VWX and 5Z) based on the DFO annual bottom-trawl surveys in those areas.

Area of occupancy (A_t) was calculated for year *t* as follows:

$$A_t = \sum_{i=1}^{n} a_i I \quad \text{where } I = \begin{cases} 1 \text{ if } Y_i > 0 \\ 0 \text{ otherwise} \end{cases}$$

where *n* is the number of tows in the survey in year *t*, Y_i is the number of barndoor skate caught in tow *i*, and a_i is the area of the stratum fished by tow *i* divided by the number of sites fished in that stratum (Smedbol et al. 2002). Given the relatively few sets in an annual survey that capture Barndoor Skate, the DWAO index will be low in relation to the total area surveyed. Catches of Barndoor Skate in the other regions were insufficient to calculate meaningful estimates of occupancy.

In Div. 4VWX, average area of occupancy from 1970 to 1980 on the Scotian Shelf was approximately 1700 km^2. From 1981 to 1992, Barndoor Skate were only caught in two of the survey years. Since 1993, this index has increased from less than 1000 km^2 to a peak in 2007 of 7,850 km^2. The 2008 estimate, of 6,140 km^2, is the second highest in the series (Figure 20).

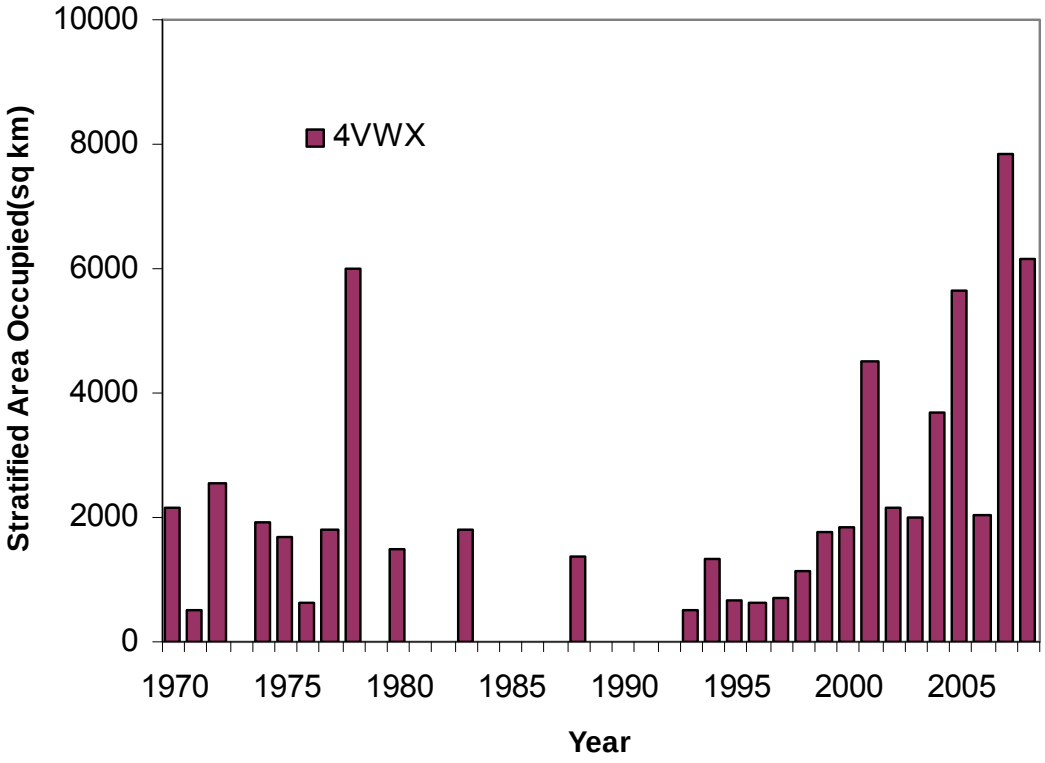


Figure 20. Area of occupancy (km^2) for the Scotian Shelf (Div. 4VWX) based on the Summer RV survey.

On the Canadian portion of Georges Bank (Div. 5Zc), the area of occupancy remained below 800 km^2 from 1987 to 1997, increased to an average of 1120 km^2 from 1998 to 2006, and fell to pre-1998 estimates in 2007 and 2008 (Figure 21). If the entire bank is considered, then prior to 1994, stratified area occupied remained below 2500 km^2. From 1994 to 2007, the mean stratified estimate was 7971 km^2, with a peak of 14,100 km^2 in 1999. The 2008 estimate was 1,220 km^2 (Figure 21).

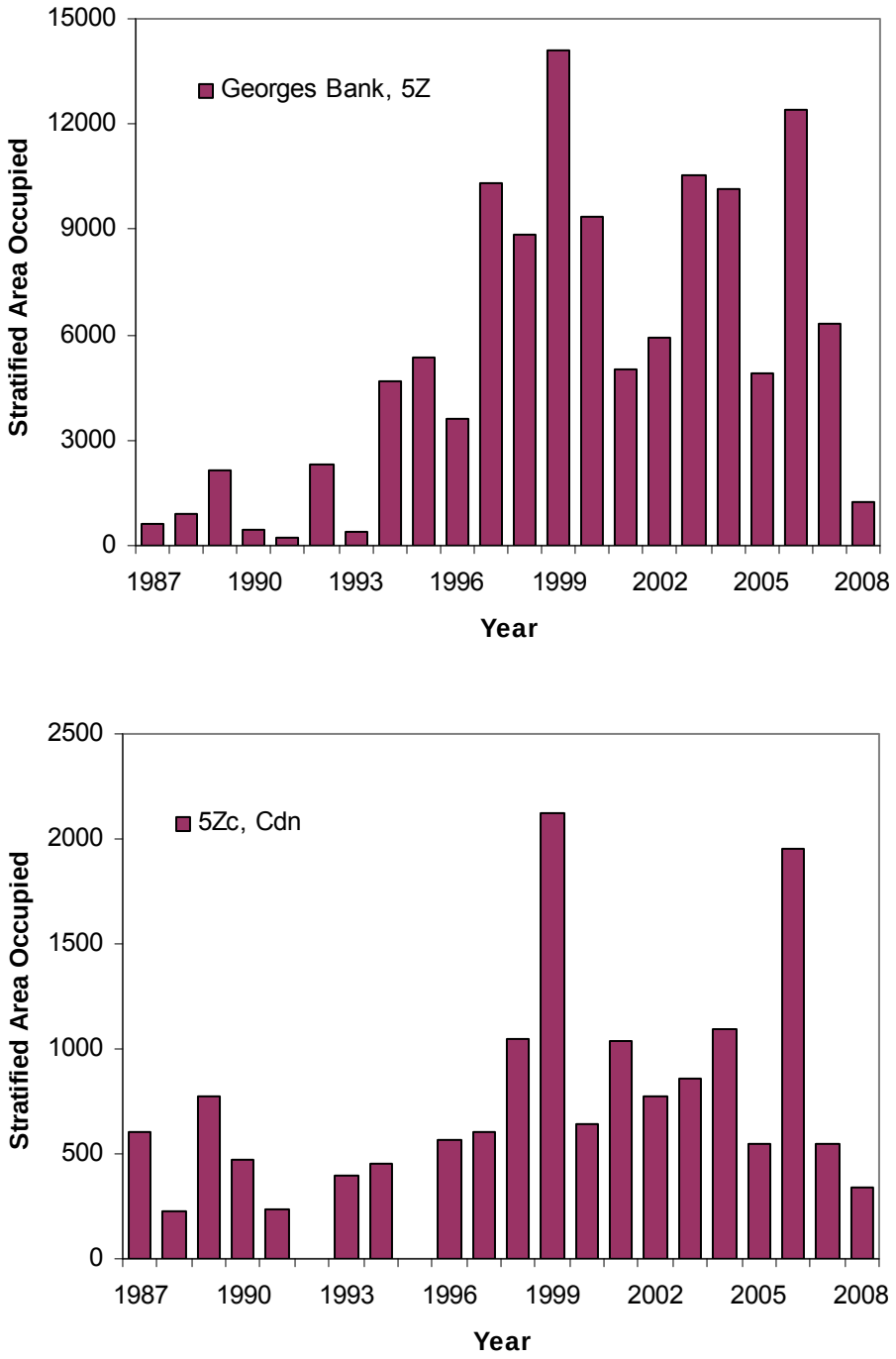


Figure 21. Area of occupancy (km^2) for Georges Bank Div. 5Z based on the Canadian Georges Bank RV survey. Entire bank is shown in top panel and Canadian zone only is shown in bottom panel.

The total area surveyed by the US is 174,868 km^2. In 2007, the area occupied by Barndoor Skate was 20,323 km^2.

Because stratified area occupied was not available for the Sentinel and Halibut surveys, the percentage of sets in which Barndoor Skate occurred in those surveys was used. The trend was similar to stratified area occupied in the RV surveys. Percentage of sets occupied in the Sentinel Survey increased from less than 20% within the core area to greater than 40% of the sets (Figure 22). In the Halibut Fixed Station Survey, skates occurred in approximately 10% of the sets from 1998 to 2004. During 2005-2007, this increased to 18-32% of the sets (Figure 23).

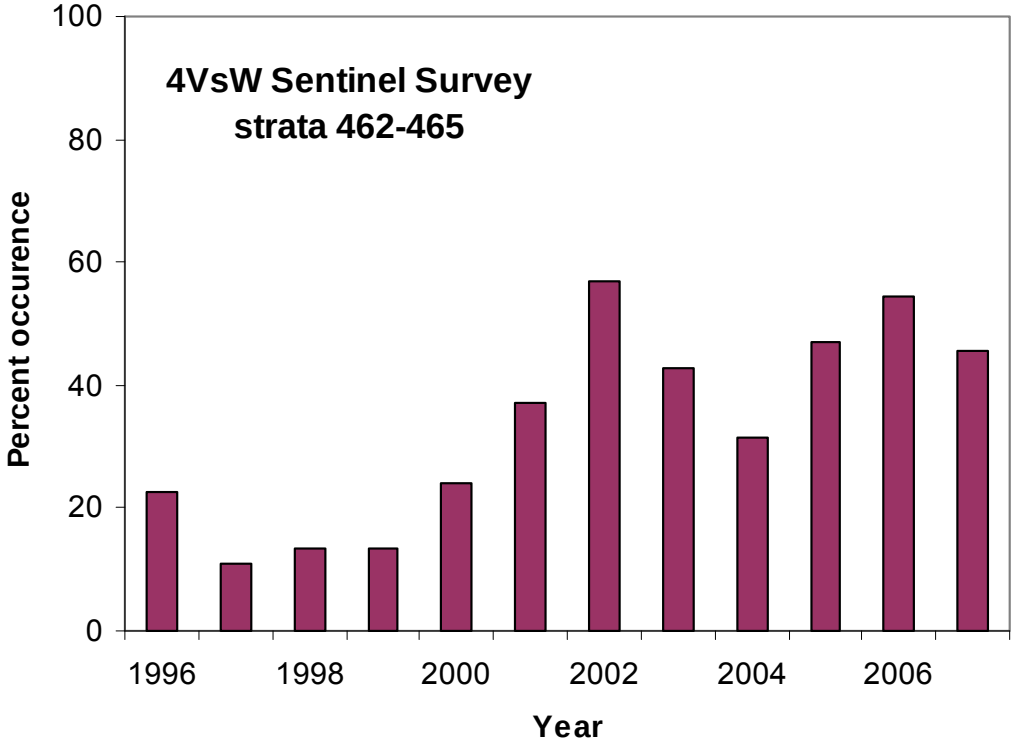


Figure 22. Percent occurrence of Barndoor Skate in the core strata (462-465) in the Div. 4VsW Sentinel Survey from 1996 to 2007.

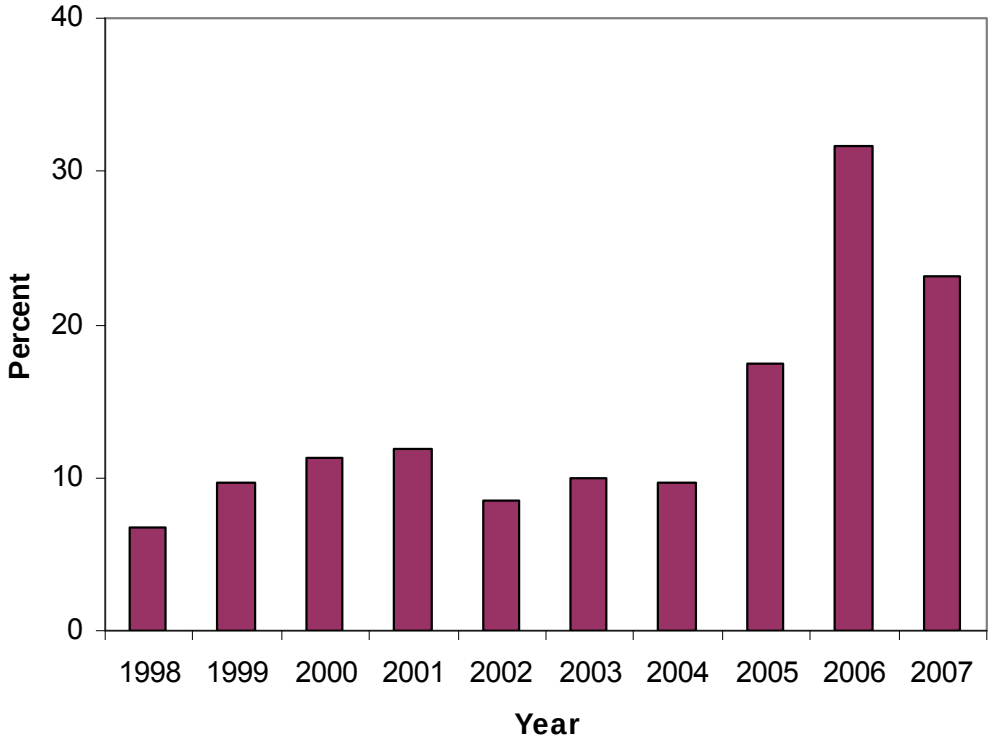


Figure 23. Percent occurrence of Barndoor Skate in the fixed sets of the Halibut Survey.

Barndoor Skate have not been encountered in the deepwater sets (366-731 m) of the Maritimes Region since they were included in the survey in the mid-1990s. During that same period, a small number of Barndoor Skate were caught at those depths in the Newfoundland and Labrador Region. The use of the Campelen Trawl may have increased the catchability in that region. In both the Maritimes and Newfoundland and Labrador regions, Barndoor Skate were caught in the 366-731 m depth range by the halibut survey during the same time period. The total area of the deepwater strata in Div. 4VWX is 4459 km^2, which would be approximately the same area as the deep water strata in Div. 3NOP.

The total area of the Flemish Cap (Div. 3M) that is shallower than 700 m is 59,740 km^2. It is unknown how much of the bank is occupied by Barndoor Skate.

Abundance

Estimates of minimum trawlable abundance were calculated by extrapolating RV survey catch per tow to the total number of trawlable units in a survey area. These estimates should be considered minimum estimates given that catchability of the survey gear is much less than one. This is particularly the case for large skate species such as Barndoor Skate (see Edwards 1968 discussion below). Minimum total population estimates were calculated from the research vessel surveys for Div. 5Z and Div. 4VWX

from the Canadian and US surveys. These data are not provided for the other regions given the very low catch rates in those areas. Similarly, it was not possible to estimate minimum trawlable abundance from the industry surveys. Estimates were provided for juveniles and adults where possible. Given the sharp decrease in abundance in the 1960s and 1970s, a long period of sporadic catches of Barndoor Skate in the 1980s, followed by recent increases, it was not felt to be appropriate to calculate decline rates over three generations (39 years). Instead, mean estimates of total abundance were calculated by generation (13 years) or natural break points in the data and then compared.

Edwards (1968), using cameras, noted that Barndoor Skate were particularly adept at avoiding capture by survey gear although did not provide an estimate of catchability. Harley *et al.* (2001) in their analysis of trawl survey catchability used Edwards (1968) to estimate a catchability factor of 0.1 for Barndoor Skate.

Casey and Myers (1998) calculated total population abundance of Barndoor Skate from non-standard pre-1970 transect surveys. Transect survey data were converted into stratified abundance estimates. Subsequently, half of the data collected before 1970 was multiplied by 2.08 assuming that catches during night were higher and most of the sets in that period were during the day. Edwards (1968) catchability factor of 0.1 for other skates was then applied to further adjust all estimates. This resulted in all catch rates being multiplied by a factor of 6.7 prior to 1970.

Although we have been able to confirm that Barndoor Skate were caught in the pre-1970s surveys, the lack of consistent survey design, the use of unknown gear types, and uncertainty in whether fishing was conducted over a 24-hour period suggests that it is inappropriate to calculate total population estimates prior to the advent of the standard surveys in 1971 for Subdiv. 3Ps and Div. 4VW and 4X (Simon *et al.* 2009). An examination of the DFO pre-1970s database in 2002 revealed that mean catch per tow estimates of Barndoor Skate in Div. 4X during 1962-1969 and in Div. 4VW during 1958-1969 were much higher than estimates from the subsequent standard stratified surveys in the same areas and estimates declined rapidly to near zero by the start of the standard survey (Simon *et al.* 2002). Survey estimates occurred in each of the above years as opposed to only three annual observations by Casey and Myers (1998) on the Scotian Shelf for the same time period. It is unclear why only a subset of the data was presented by Casey and Myers (1998). An attempt to replicate their observations in Subdiv 3Ps was unsuccessful but it was noted that in some of the years when they assumed only daytime fishing, operations continued around the clock and thus, the multiplication factor applied would be inappropriate.

US

Annual mean minimum abundance from the US Fall RV survey (Div. 4X5ZY6) during 1963-1975 (one generation) was 1.1 million juveniles and 62,000 adults. During 1976-1994 (19 years), mean abundance was 54,000 juveniles and 2,800 adults. During 1995-2007 (one generation), the estimate was 79,700 juveniles and 112,000 adults. The average of the first four years of this survey was 3.2 million fish while the average of the last four years was 1.7 million fish or 53% of the earlier period (Figure 24). Although the current recovery of Barndoor Skate on Georges Bank appears to comprise primarily juvenile fish, the percentage of juvenile fish is actually lower for the 1996-2008 (87.7%) period than the 1963-75 (94.7%) time period.

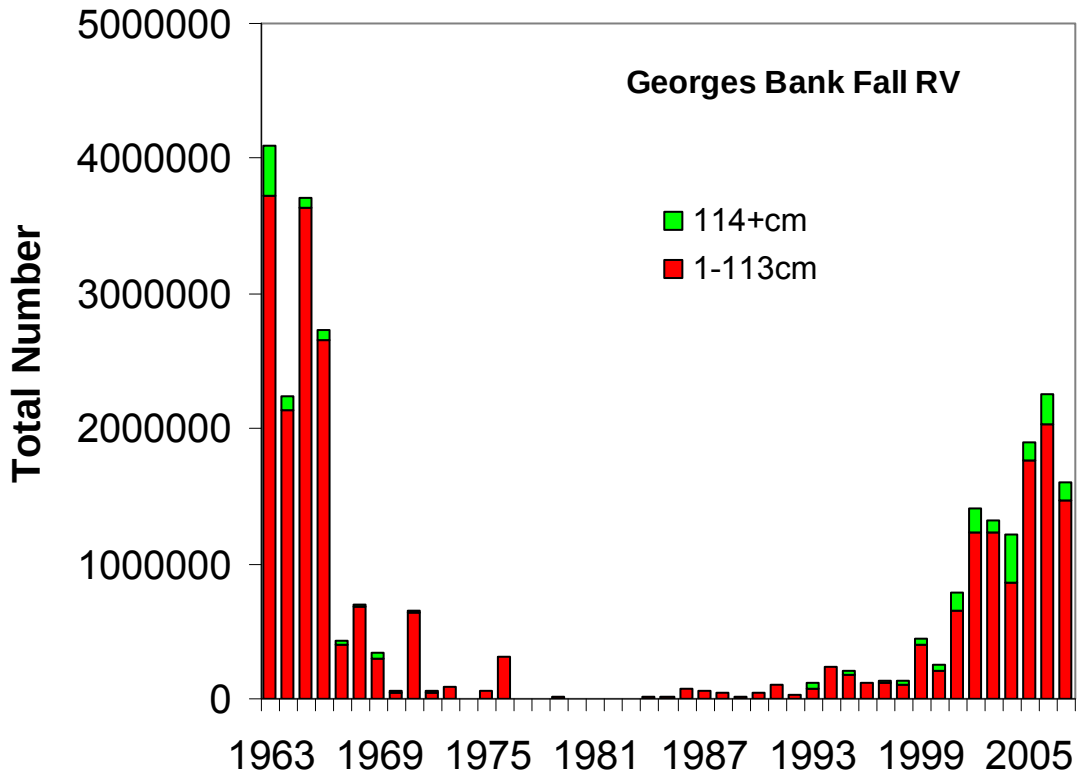


Figure 24. Total abundance of juvenile (1-113 cm) and adult (≥114 cm) Barndoor Skate from the US Fall RV survey.

Canada

Georges Bank, Div. 5Z

Abundance estimates from the Canadian RV survey for Div. 5Z were calculated for the whole of Georges Bank as well as the Canadian portion only. Total abundance of all size classes on Georges Bank averaged 52,000 fish during 1987-1995. During 1996-2008 (one generation), abundance averaged 622,000 juveniles and 11,000 adults (Figure 25). On the Canadian side of the bank, total abundance of all sizes averaged 15,000 individuals during 1987-1995. Since 1996, there was an average of 43,000 juveniles and 2,300 adults (Figure 26).

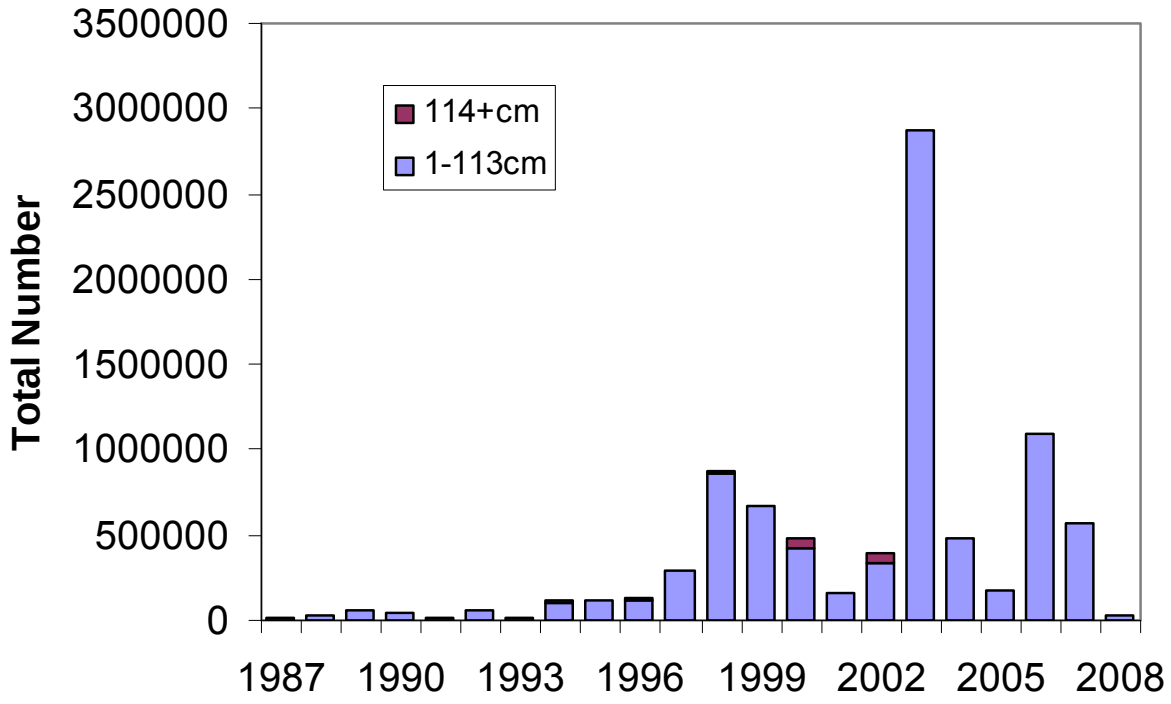


Figure 25. Stratified total number of juvenile (1-113 cm) and adult (≥114 cm) Barndoor Skate as indicated by the Canadian RV survey of Georges Bank.

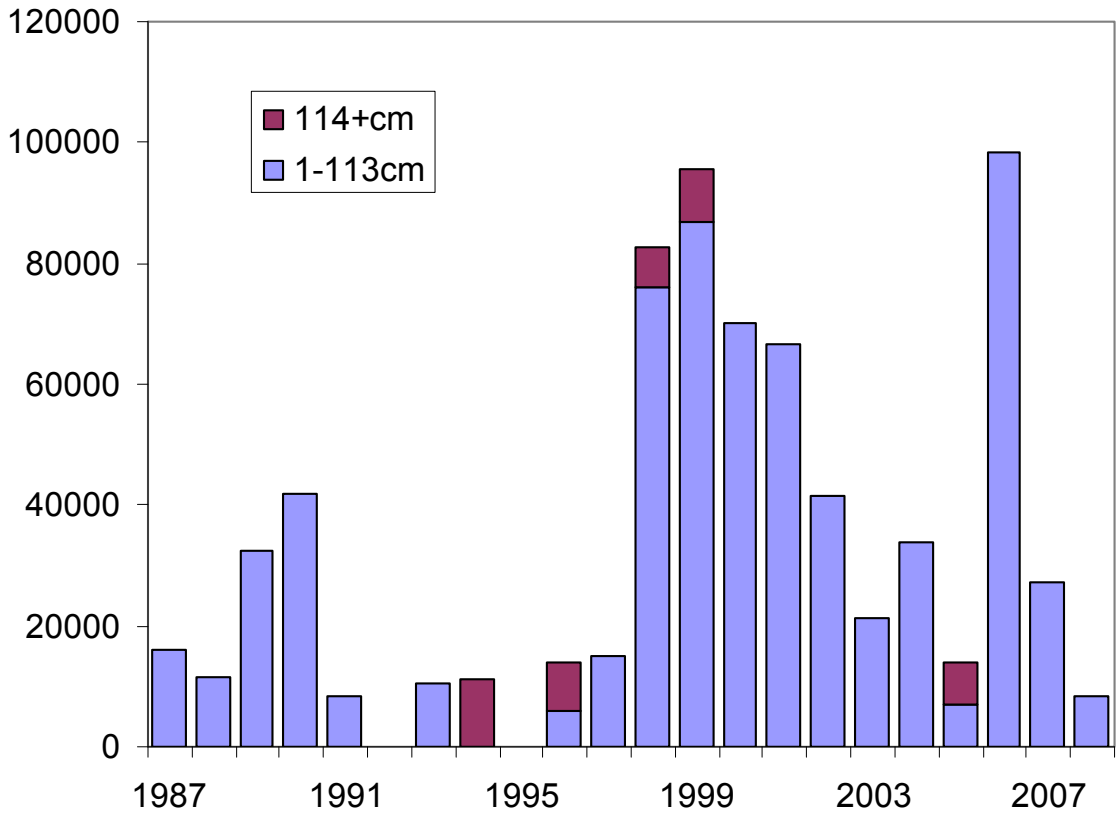


Figure 26. Stratified total number of juvenile (1-113 cm) and adult (≥114 cm) Barndoor Skate as indicated by the Canadian RV survey of Georges Bank, Canadian side only.

Scotian Shelf, Div. 4VWX

Data pertaining to the Scotian Shelf were grouped into three generation periods (13 years): 1970-1982, 1983-1995, and 1996-2008. The average annual number of juveniles was 152,000, 15,000, and 118,000 for each of these three time periods, respectively. The number of adults for these same time periods was 11,000, 0, and 39,000. The 1978 survey year was included in the calculations for the 1970-1982 period even though the survey contained three sets with the highest number of individuals (76, 12, and 8) from the entire Summer survey series and might be considered anomalous. If this year is excluded, the mean number of juveniles decreases to 38,000 from 152,000 while the average number of adults increases slightly to 12,000 (Figure 27). There is also a perception that the current recovery of Barndoor Skate in this area is primarily juvenile fish but the percentage of juvenile fish is similar (76.1 and 75.2%) for the 1970-82 (excluding 1981) and the 1996-2008 time periods (Figure 27).

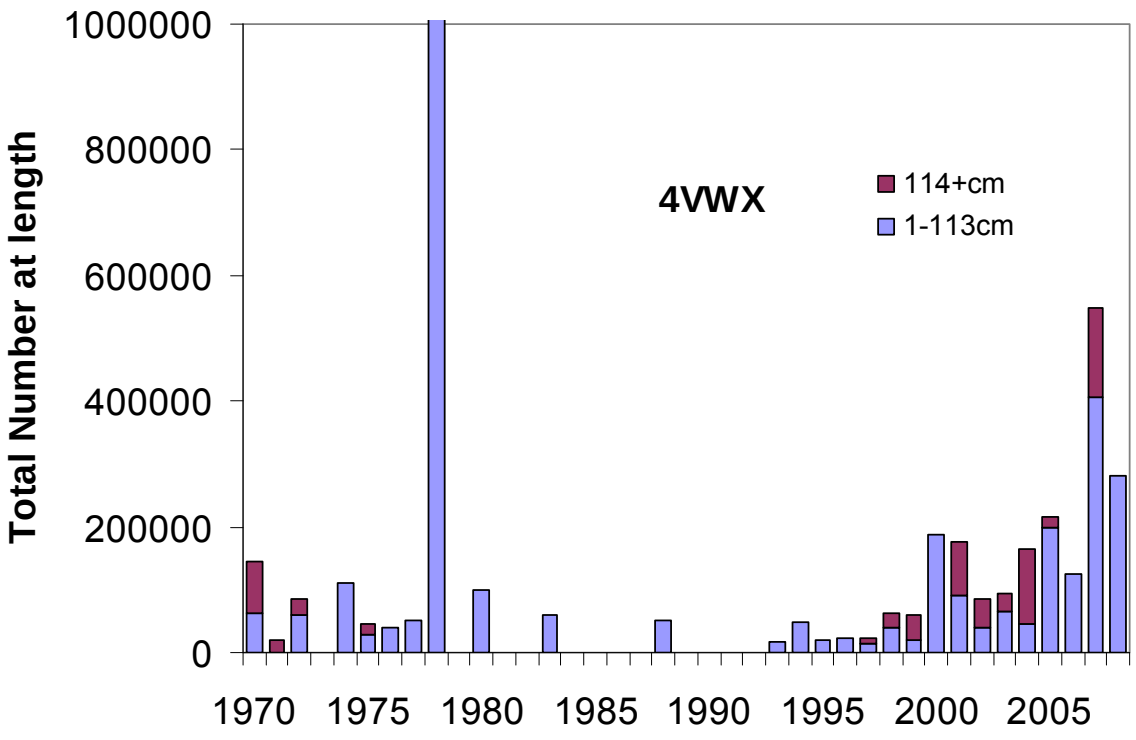


Figure 27. Abundance trends (total number) for juveniles (1-113 cm) and adults (≥114 cm) from the Summer RV survey in Div. 4VWX.

Fluctuations and trends

Trends in population levels were estimated using linear regression after log transformation. Concern has been expressed on the use of this method when the data series in question is complex and non-linear so rates of increase are provided for only the most recent periods. Given the sharp decrease in abundance in the 1960s and 1970s, a long period of sporadic catches of Barndoor Skate in the 1980s, followed by recent increases, it was not felt to be appropriate to calculate decline rates over three generations (39 years). Instead, rates of change in abundance were calculated by generation (13 years) or natural break points in the data. Given the very low abundance of adults and the unknown catchability by length, separate rates of change in abundance for juveniles and adults were not calculated for any of the data sets examined.

US

The annual rate of increase from 1995 to 2007 for the Fall RV survey was 11.4% for all size classes (Figure 28). The trend in total abundance from the Spring RV survey was similar to the Fall RV survey for the same area (Figure 29) and the annual rate of increase from 1995 to 2007 (one generation) for this survey was 14% for all size classes (Figure 30).

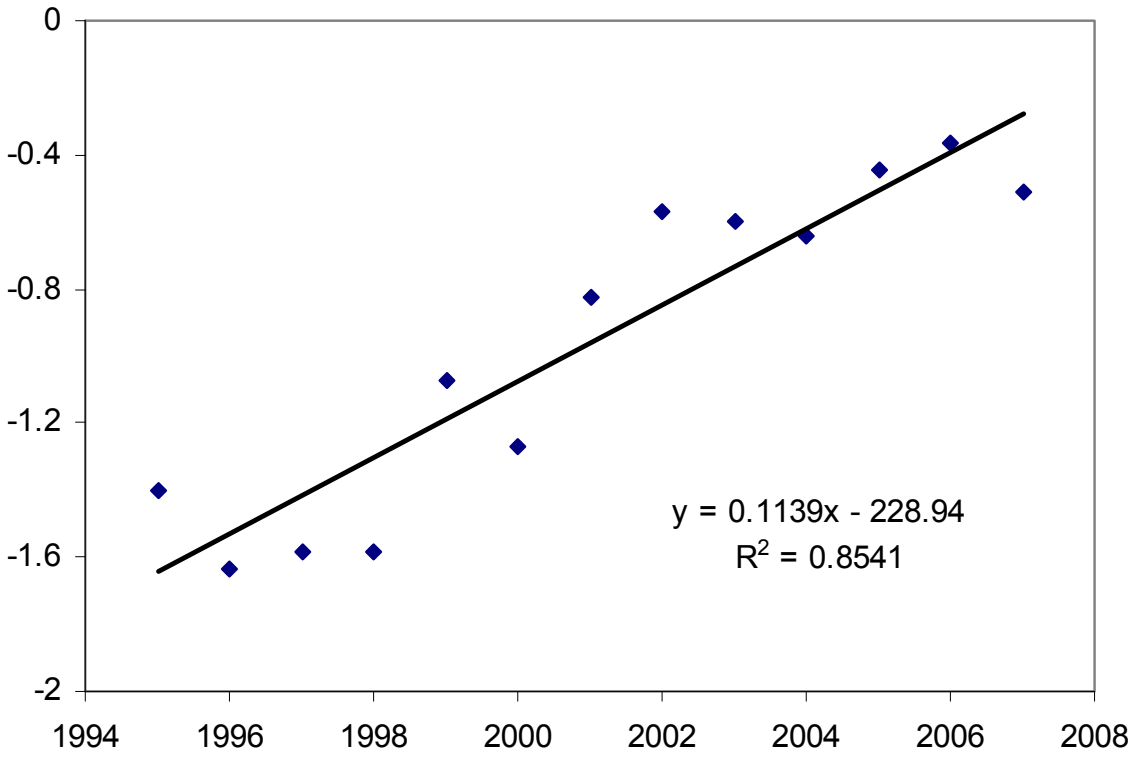


Figure 28. Log transformed (total number) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the entire US Fall RV survey, 1995-2007.

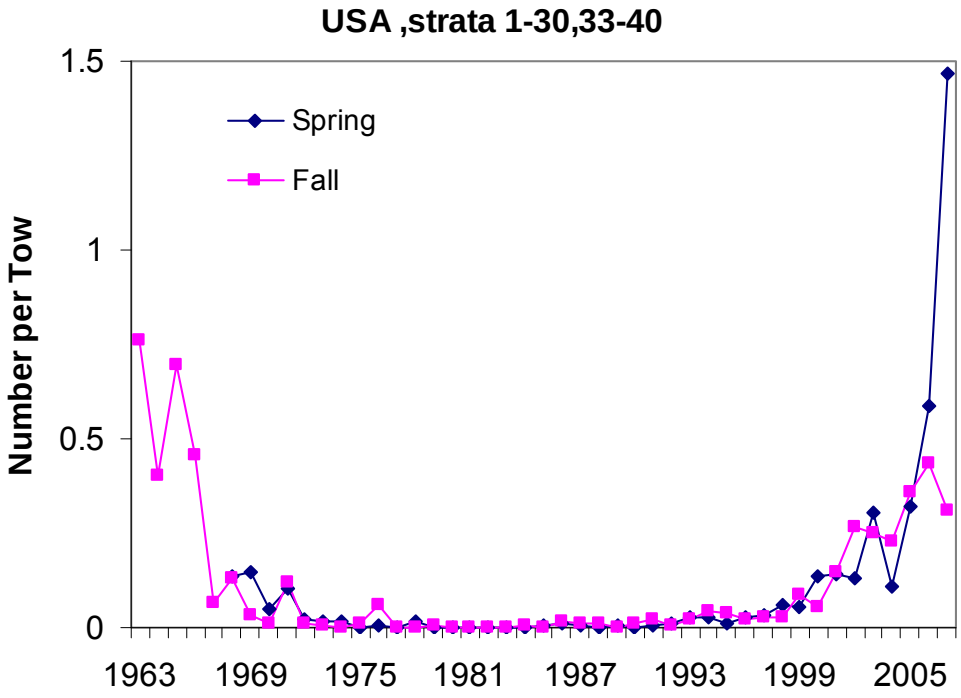


Figure 29. Stratified mean number of Barndoor Skate per tow as indicated by the US Spring and Fall RV surveys in strata 1-30 and 33-40.

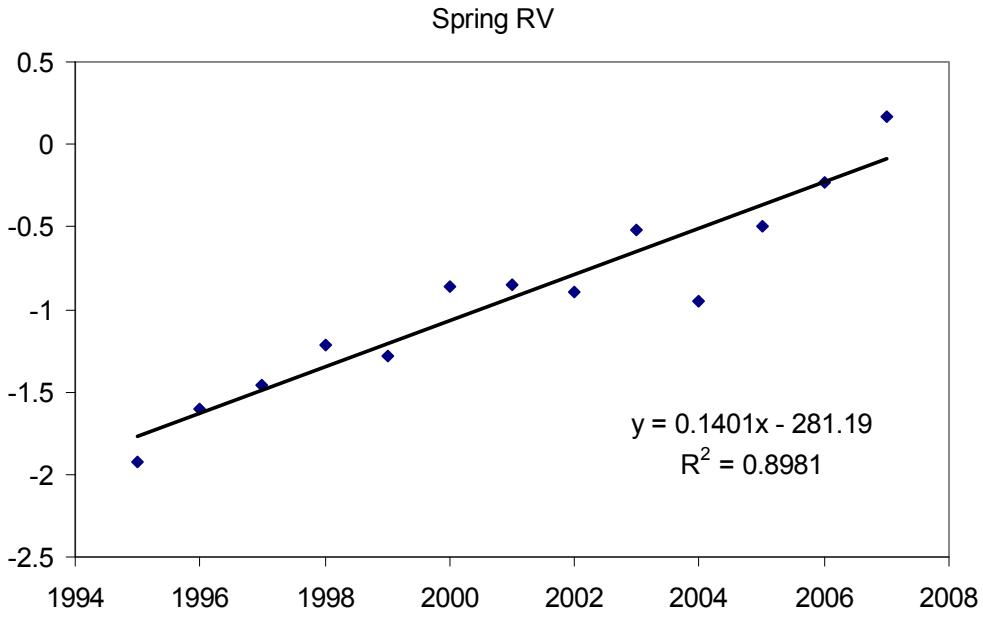


Figure 30. Log transformed (total number) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the entire US Spring RV survey, 1995-2007.

Abundance trends from a subset of the US RV survey strata which approximate the portion of the survey in Canadian waters were similar to those observed for the entire survey area, but precise total abundance estimates for the Canadian portion are not available because many of the US strata are bisected by the international boundary (Figure 31). The annual increases in the US Spring and Fall RV surveys were 11 and 10%, respectively.

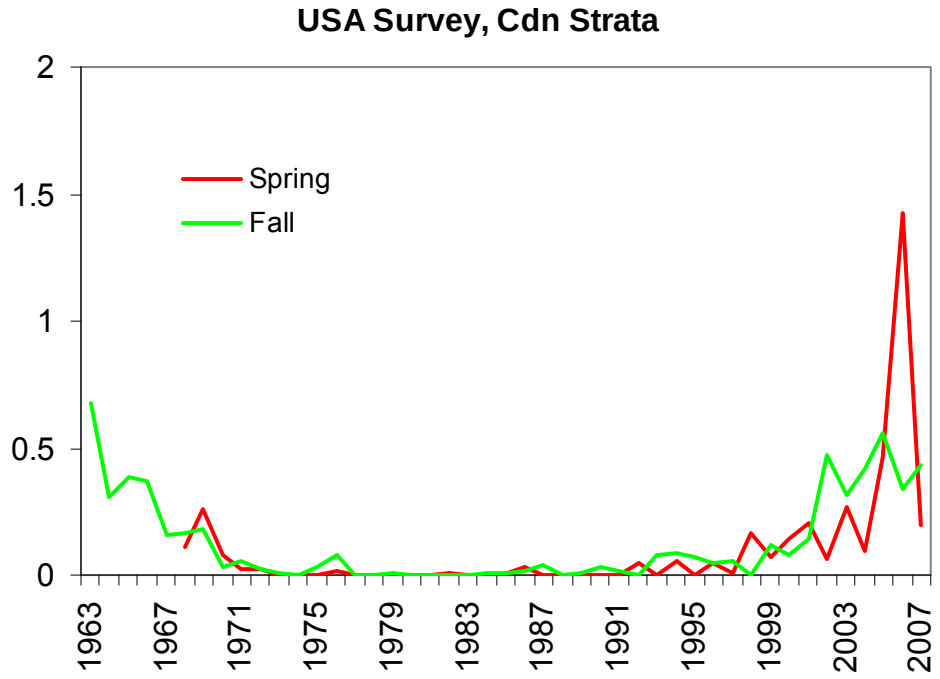


Figure 31. Abundance (#/tow) of Barndoor Skate caught in the US Spring and Fall RV surveys from strata which approximate the portion of the survey in Canadian waters. Note that many of the strata straddle the international boundary and, as a result, estimates include some data from the US side of the border.

Canada

Georges Bank, Div. 5Z

The annual rate of increase from 1986 to 2008 for the Canadian Georges Bank RV survey was 6.0% for the entire bank (Figure 32), but there was no clear trend in the data over this time period for the Canadian portion of Georges Bank alone (Figure 33). If only the last generation is considered (1996-2008), then there is an annual rate of decline of 18.3% in the Canadian zone. As stated above, the US Spring RV survey for approximately the same area, one month later, shows an annual increase of 11%.

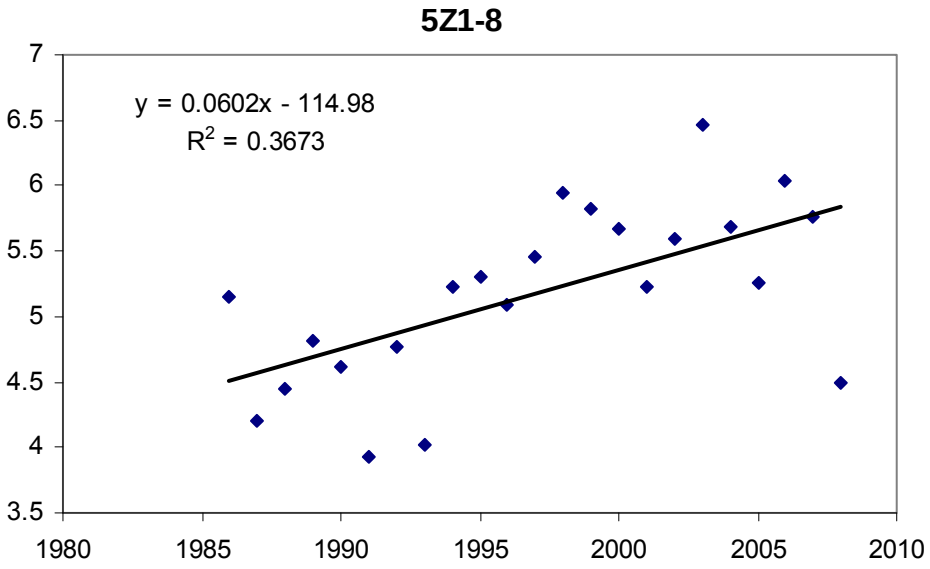


Figure 32. Log transformed (total number) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the Canadian RV survey of Georges Bank, 1986-2008.

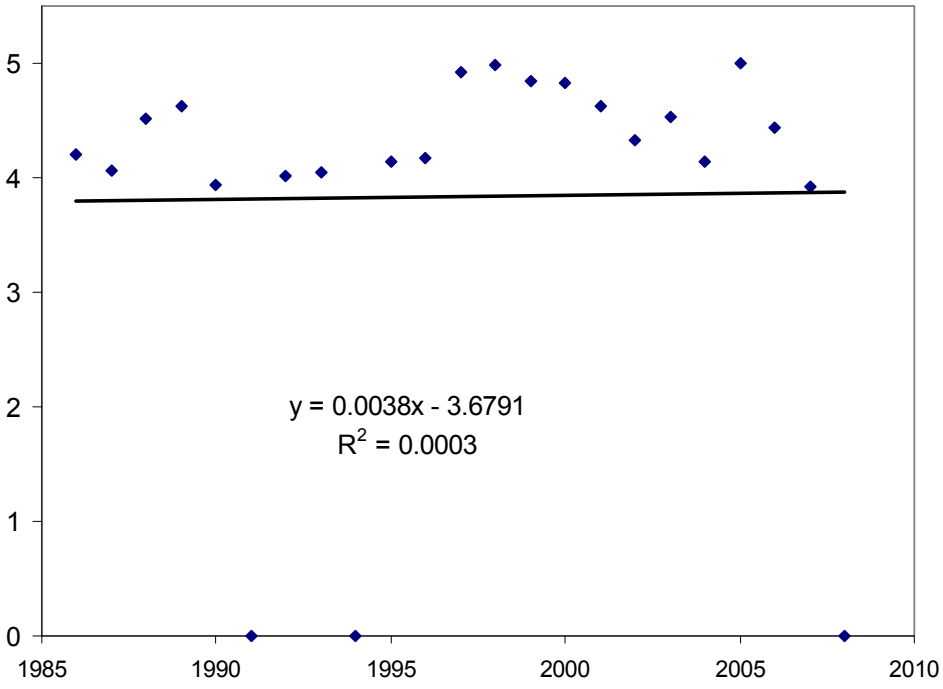


Figure 33. Log transformed (total number) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the Canadian RV survey of Georges Bank, Canadian side only, 1986-2008.

Inter-annual changes in total abundance for the US Fall and Spring RV surveys (Figures 24 and 26) appear to be significantly less than those seen in the Canadian survey on Georges Bank, especially within the Canadian zone (Figures 30 and 31). These differences in inter-annual abundance may not be biologically feasible and suggest that this indicator may not be suitable to track changes in population abundance in such a small geographic area. The international boundary is an arbitrary delimiter of a larger ecosystem, and the Canadian zone may be too small an area to track overall population changes in this ecosystem. Area occupied, which has less inter-annual variability than total abundance, may be a better indicator of changes in the population.

Scotian Shelf, Div. 4VWX

The annual rate of increase for the Scotian Shelf from 1996 to 2008 was 8.9% for all size classes (Figure 34).

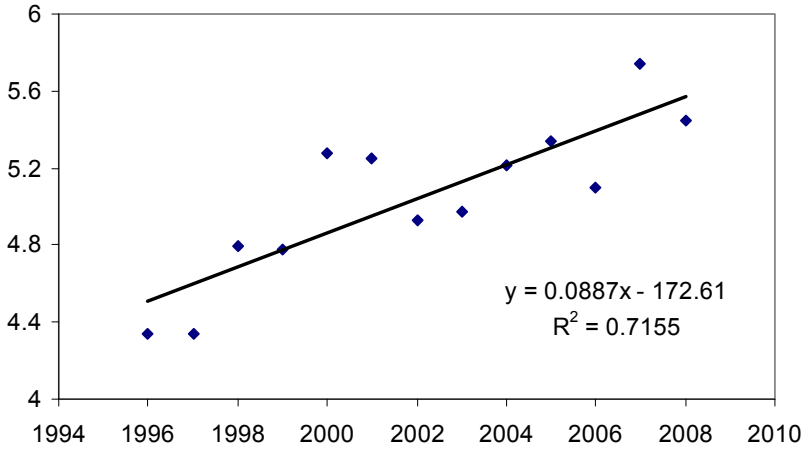


Figure 34. Log transformed (total number) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the Canadian Summer RV survey in Div. 4VWX, 1996-2008.

Indices of abundance and annual rates of increase were calculated for the three industry surveys. The stratified mean catch (number and weight per tow) from the core strata of the Div. 4VsW Sentinel Survey increased from less than one fish per tow to seven fish per tow during 1996-2007 (Figure 35). The annual rate of increase corresponding to this time period was 11.8% (Figure 36). The stratified mean catch (kg) per tow from the Halibut Survey increased from 2 to greater than 15 kg of Barndoor Skate per tow from 1998 to 2007 (Figure 37). This corresponds to an annual rate of increase from 1998 to 2007 of 7.4 % (Figure 38). The mean catch per tow from the ITQ survey increased from less than 0.1 kg to 0.7 kg per tow in Div. 4X from 1996 to 2006. In 2007 and 2008, abundance fell to values observed during the first two years of the survey (Figure 39). The annual rate of increase for the entire ITQ series was 3.2% (Figure 40).

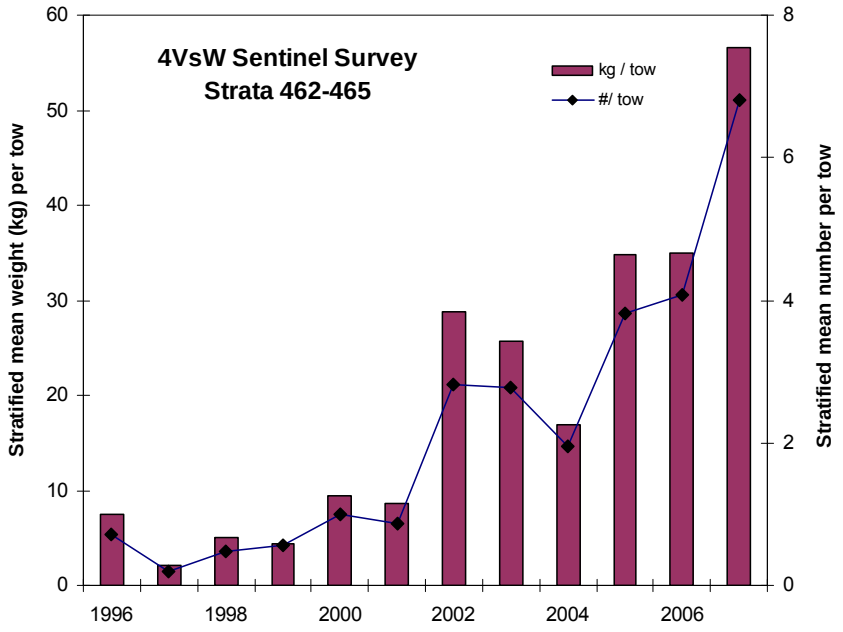


Figure 35. Stratified mean catch rate of Barndoor Skate in the core strata (462-465) of the Div. 4VsW Sentinel Survey, 1996-2007. Note that skate were not identified to species in 1995 and no length frequencies were taken by the participants.

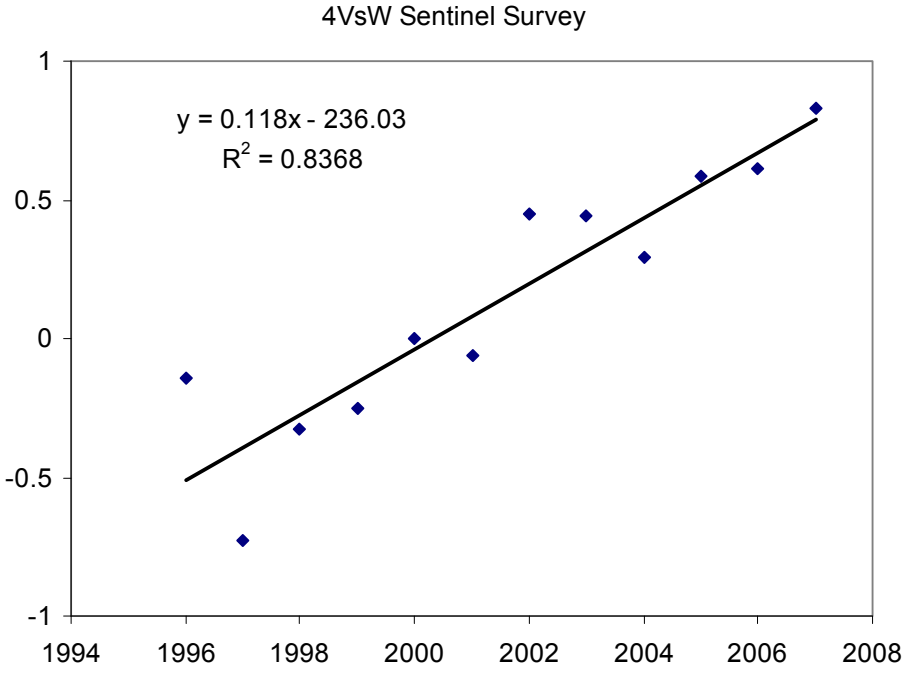


Figure 36. Log transformed (number per tow) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the longline Div. 4VsW Sentinel Survey.

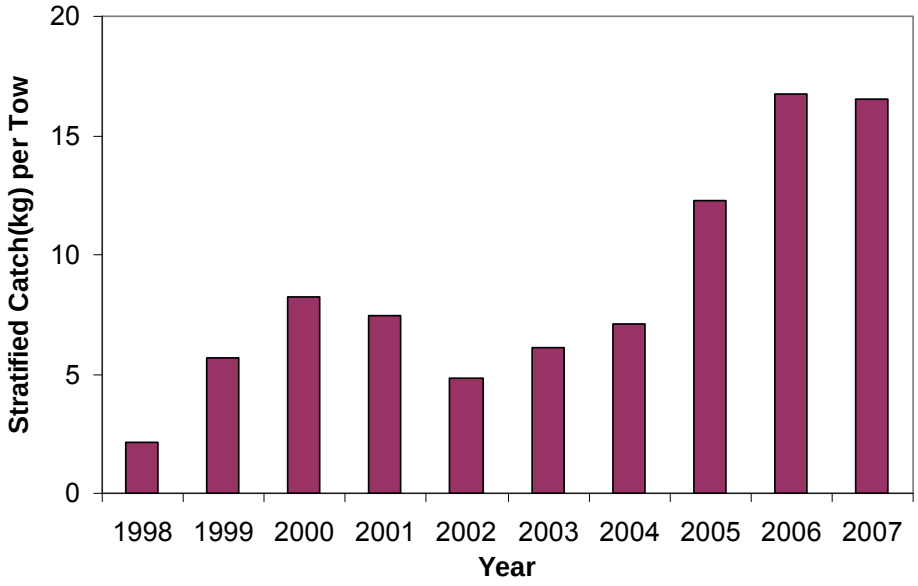


Figure 37. Stratified mean catch (kg) per tow of Barndoor Skate as indicated by the fixed station sets in the Halibut Industry Survey in Divs. 3NOP4VWX.

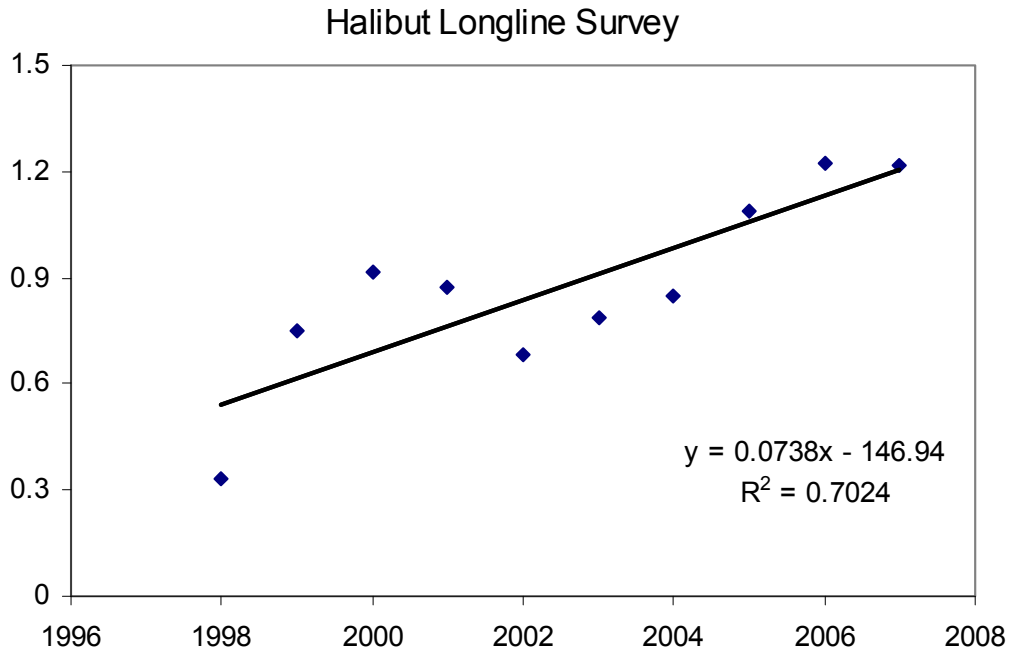


Figure 38. Log transformed (kg per tow) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the fixed station sets of the Halibut Industry Survey in Div. 3NOP4VWX.

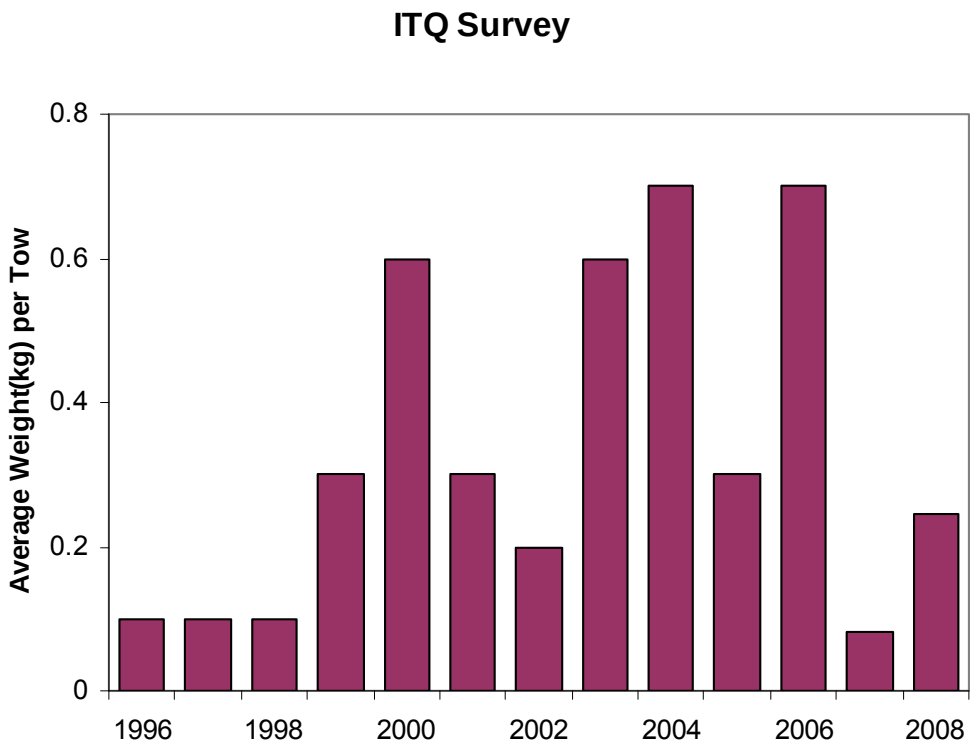


Figure 39. Average catch (kg) per tow of Barndoor Skate from the otter trawl ITQ Industry Survey in Div. 4X, 1996-2008.

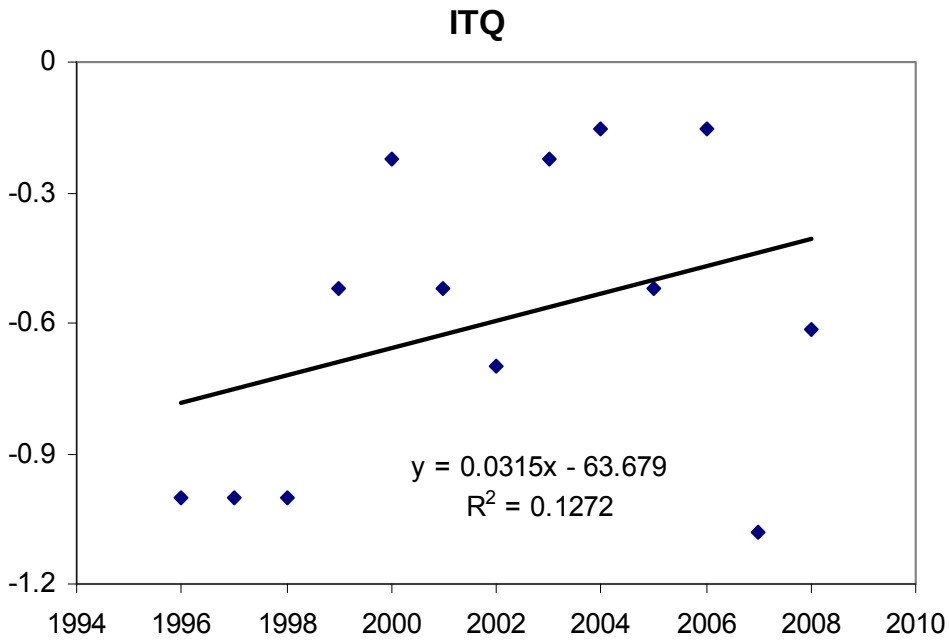


Figure 40. Log transformed (kg per tow) and corresponding linear regression of the catch rate of all sizes of Barndoor Skate from the otter trawl ITQ Industry Survey in Div. 4X.

Rescue effect

An examination of the trends in RV abundance suggests that the abundance of Barndoor Skate began to slowly increase on Georges Bank (Div. 5Ze) beginning in the late 1980s (Figures 24, 26). Subsequently the species began to reappear in the RV Survey in Div. 4X in 1993 (Figure 27) with abundance increasing dramatically in both areas beginning in the late 1990s. In Div. 4W, Barndoor Skate reappeared in the RV Survey in the western portion of Div. 4W in 2002 after an apparent absence of 23 years. Whether the species was always present in all areas but at very low levels and is now being encountered more frequently as abundance increases is unclear. The results from the 4VsW Sentinel Survey would suggest the species has been present in Div. 4W prior to 2002, but not detected in the RV survey (Figure 35). The capture of a Barndoor Skate in 2004 in Subdiv. 4Vn during the Summer RV Survey was the first record in that area since 1980.

Collectively these data suggest that the distribution of Barndoor Skate in Canadian waters is continuous with that in US waters. As abundance increased on Georges Bank a rescue effect onto the Scotian Shelf may have occurred with the species now more common as far east as Div. 4W. Whether this possible rescue effect continues eastward and the species recovers to re-occupy the remainder of its former range in Div. 4V and Div. 3Ps is unknown.

HABITAT

Habitat requirements

Barndoor Skate have been found on soft mud, sand, and gravel bottoms (MacEachern 2002).

Habitat trends

The life history and habitat characteristics of Barndoor Skate in US waters were reviewed by Packer *et al.* (2003). They reported the species to be widely distributed throughout its range with no difference in distribution between juveniles and adults (based on a maturity length of 102 cm; Packer *et al.* 2003).

In Canadian waters, distribution plots for juveniles and adults were produced using data from the Maritimes Regional RV surveys with life history characteristics observed by Gedamke (2005, 2006) and the limited observations by Simon *et al.* (2002). In this instance, 114 cm was used to separate juveniles and adults. In addition, distribution plots were produced for individuals less than 40 cm in length (a proxy for fish ages 0 and 1) to approximate location of nursery areas.

Essential Habitat

Distribution patterns across the Scotian Shelf and Georges Bank do not provide sufficient information to identify more detailed information on habitat associations for this species. Juveniles and adults on both the Canadian and US sides of Georges Bank appear to occupy the same geographic areas (Figure 4). Juveniles appeared to be widespread on the western Scotian Shelf to Sable Island but adults were concentrated in the Fundian Channel (Figure 4).

When considering only fish less than 40 cm in length, their distribution on Georges Bank (Figure 41) is similar to that of other size ranges, while on the Scotian Shelf (Figure 42), this size category has only been observed four times since 1970. Gedamke (2006) considered Barndoor Skate not fully recruited to the trawl gear until they reached 55 cm.

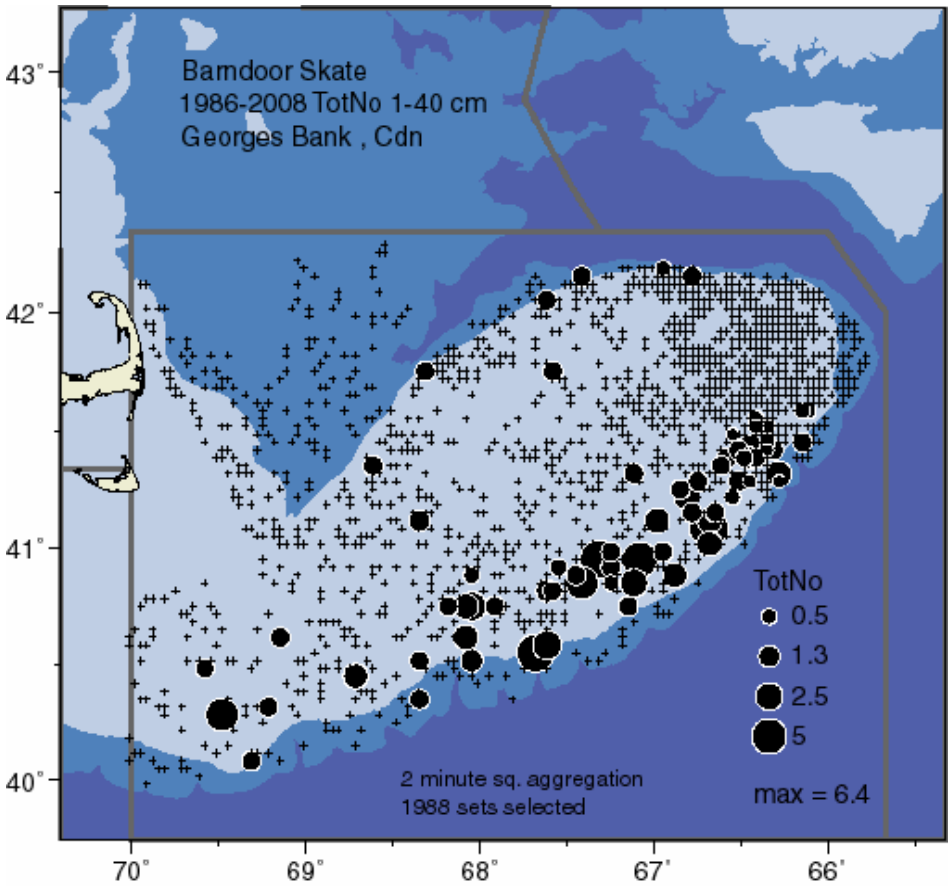


Figure 41. Distribution of Barndoor Skate measuring 1-40 cm in length from the Canadian Georges Bank RV survey (Div. 5Z).

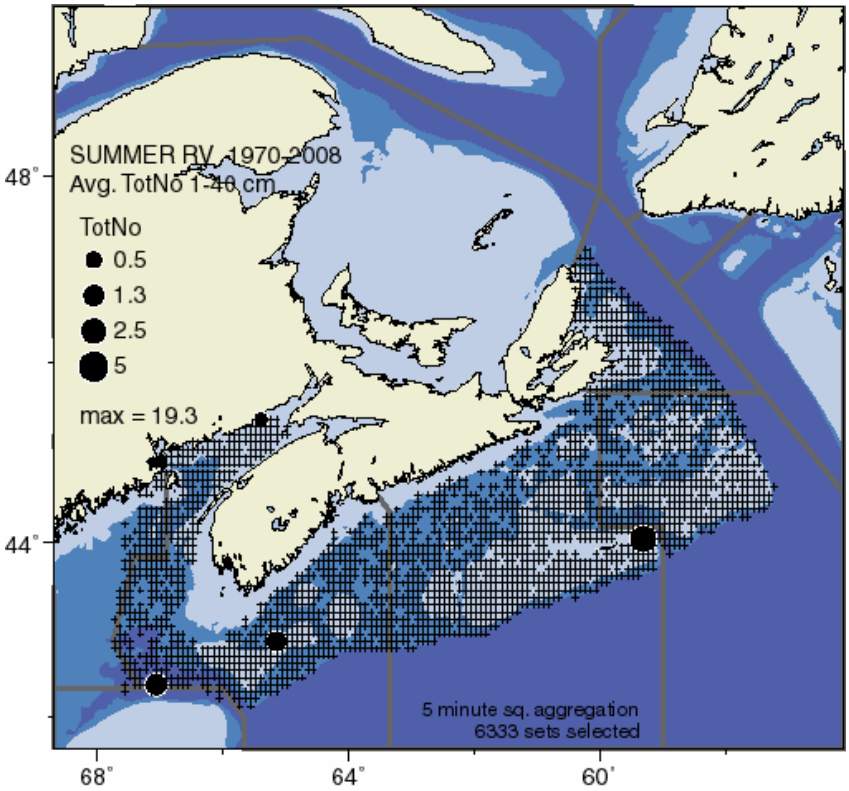


Figure 42. Distribution of Barndoor Skate measuring 1-40 cm in length from the Canadian Summer RV survey on the Scotian Shelf (Div. 4VWX).

No distributional information for Barndoor Skate purses could be located for the present status report. Vladykov (1936) reported females containing fully developed eggs in December and January, both near Sable Island and in Kennebecasis Bay, NB. As well, a single female with almost complete purses was sampled from the Sentinel Survey in Div. 4W but no positional information was recorded. As part of the annual Scotian Shelf surveys in Div. 4VWX, the authors have requested that all skate purses be retained for the last three years. A species identification key for skate purses was created based on Vladykov's (1936) observations with updated photographs. No Barndoor Skate purses have been observed during the last three years' RV surveys and prior to these surveys there were not requirements to record skate purses at all.

Length frequency data from the Halibut Survey were compared to length frequency data from the Summer RV survey. Barndoor Skate from the fixed station portion of the halibut survey had a length range similar to fish caught during the Summer RV survey. In both surveys, juveniles less than 114 cm were primarily captured. Maximum length was 139 cm in the halibut survey and 136 cm in the Summer RV survey. Barndoor Skate from the commercial index portion of the halibut survey, which is concentrated at depths greater than those covered by the DFO RV surveys, captured a higher percentage of adults with a maximum length of 163 cm (Figure 43). This may indicate that adults are more prevalent in waters deeper than those sampled by the RV survey but may reflect seasonal differences or be an artifact of the survey design.

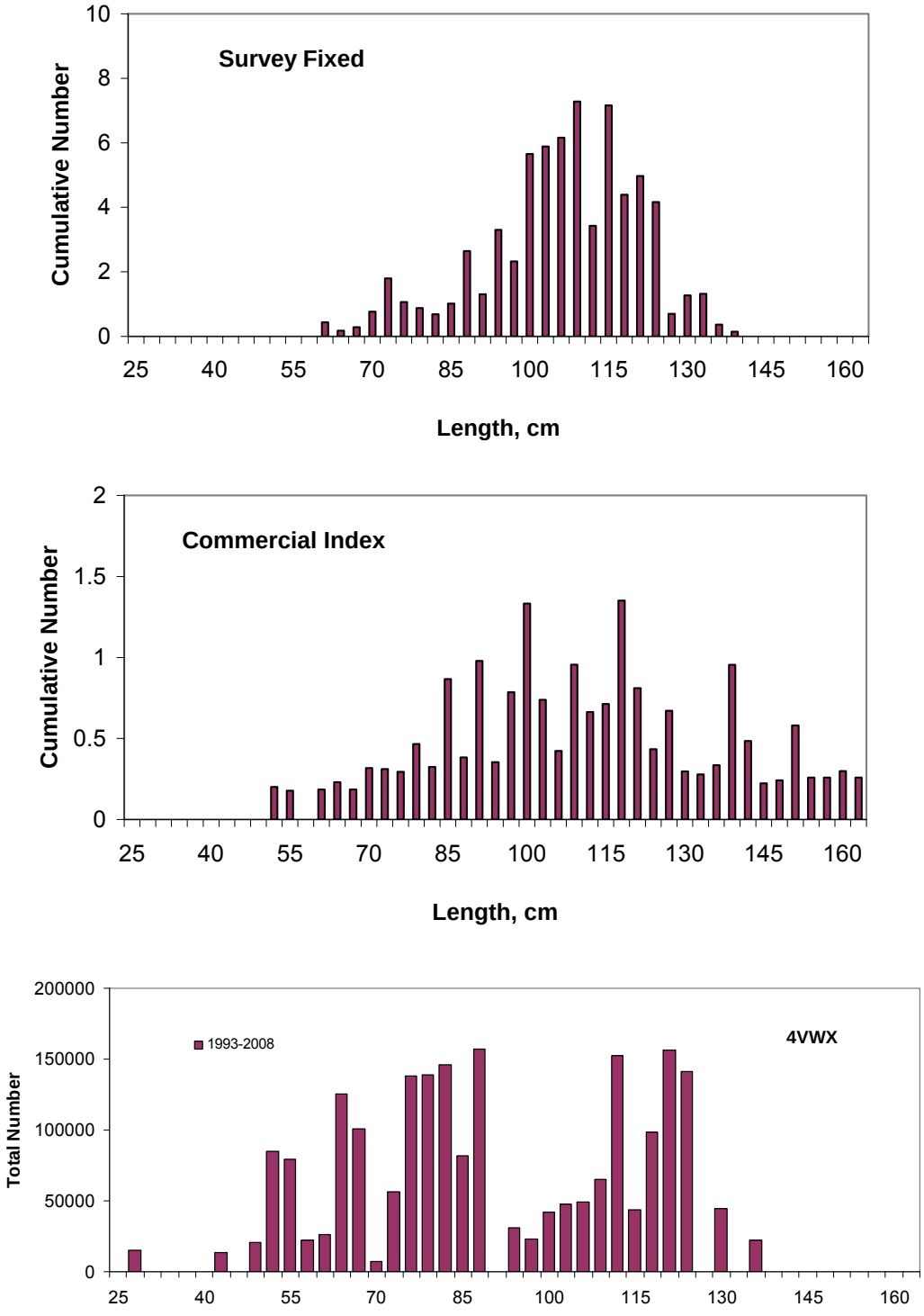


Figure 43. Length frequency distributions of Barndoor Skate caught in the fixed sets of the Halibut Industry Survey in Div. 3NOP4VWX (top panel), the commercial index sets of the Halibut Industry Survey in Div. 3NOP4VWX (middle panel), and the Summer RV survey in Div. 4VWX, 1993-2008 (bottom panel).

Temperature and Depth Preferences

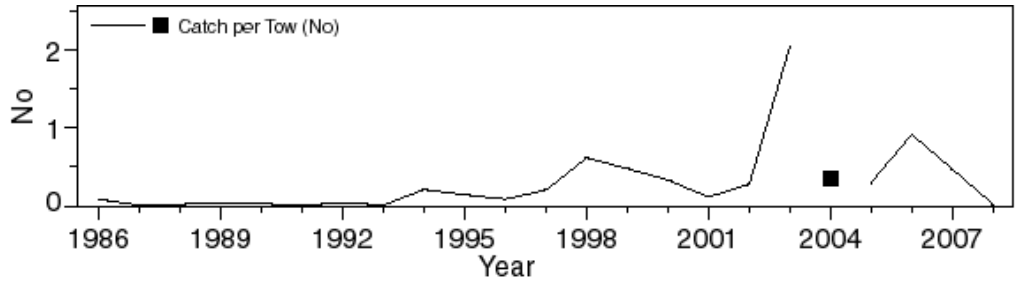
Barndoor Skate are widespread from 38 to 351 m in Div. 5Z but have been reported from the shoreline to 750 m (Packer et al. 2003). Preferred temperature range from US RV surveys is 3-18ºC for the Gulf of Maine to Cape Hatteras with a reported peak of 20ºC off Cape Hatteras. Salinity preference range is 32-36 ppt in the same areas. No differences were found between adults or juveniles (Packer et al. 2003).

Temperature and depth preferences were calculated from the DFO RV surveys on Georges Bank and the Scotian Shelf. On Georges Bank, the species has been primarily caught in 50 m with a temperature range of 3-13ºC (Figure 44). On the Scotian Shelf, Barndoor Skate have been reported from 24-375 m and were primarily caught in 50-150 m (Figure 45). Temperature range on the Scotian Shelf is 2-11ºC with a preference for 3-9ºC (Simon et al. 2009). Off Newfoundland, they have been recorded as deep as 1174 m (Simon et al. 2009). In the Gulf of St. Lawrence, they have been recorded at temperatures as low as 1.2ºC (Packer et al. 2003).

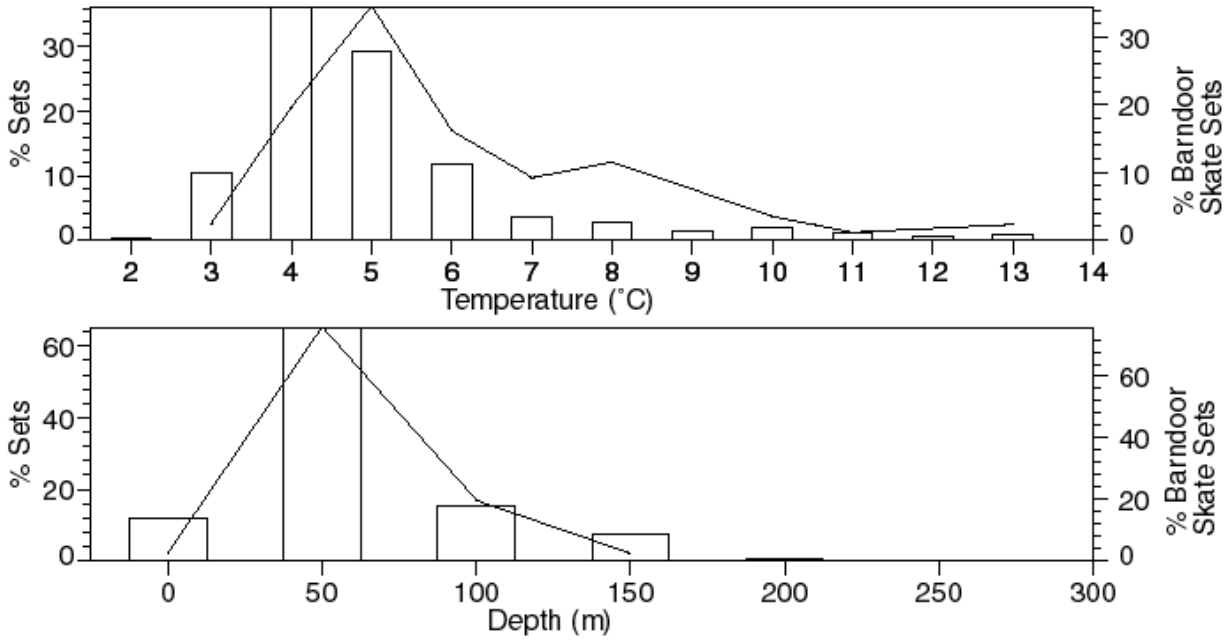
Habitat protection

The distribution of Barndoor Skate overlaps The Gully (Figure 17 and 18) Marine Protected Area (MPA) on the outer portion of the Scotian Shelf. Regulations prohibit the disturbance, damage, destruction or removal of any living marine organism within it. However, an area of this size only represents a small fraction of the Barndoor Skate's distribution and abundance in Canadian waters.

In Div. 4W, an area has been closed to groundfish trawling since 1987 to protect juvenile Haddock. Longline fishing continued in this area until 1993 at which time all directed fishing for Cod and Haddock was closed in Div. 4VW. Barndoor Skate has been observed to be abundant within the 'Haddock box' based on the 4VsW Sentinel survey and the species was recently recorded there by the RV survey.

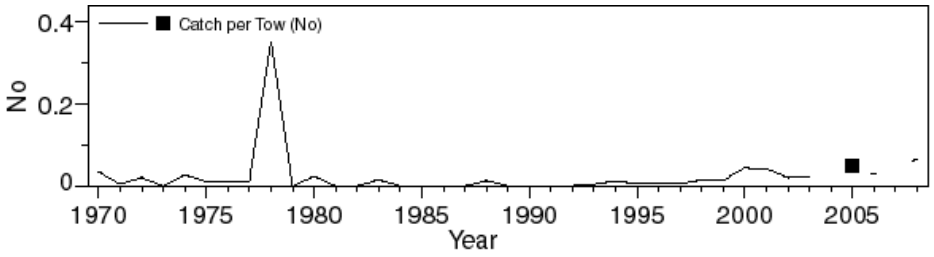


Barndoor Skate stratified mean number caught per tow from the GEORGES Ecosystem surveys. The catch for 2004 was sampled using the MV Teleost. It has not been calibrated, and should not be compared to the earlier time series.

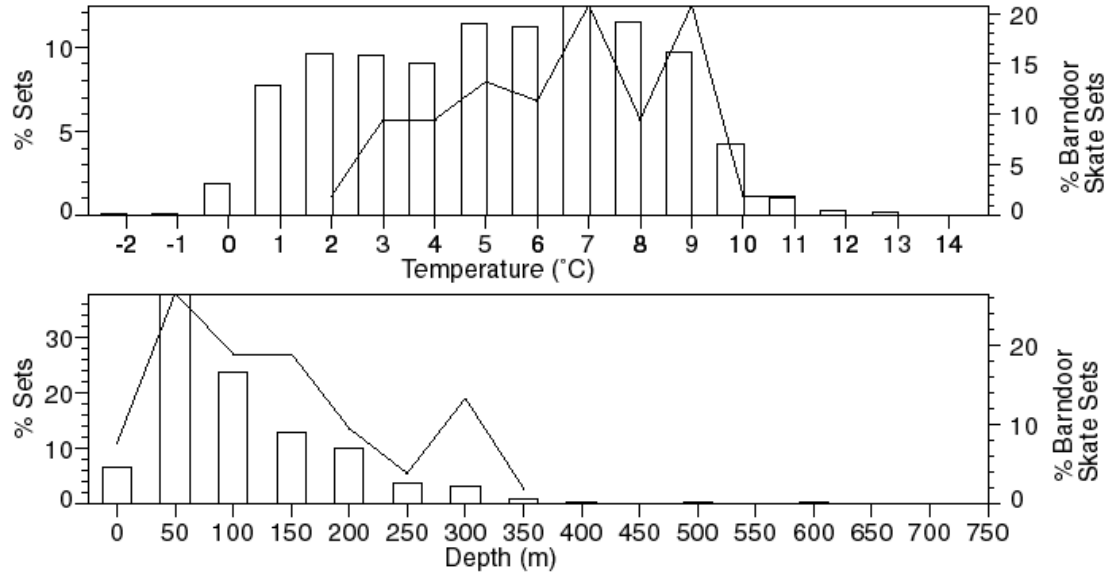


Temperature and depth distribution of Barndoor Skate captured from the GEORGES Ecosystem surveys 1986-2008. Shown for each variable is percentage of sets with Barndoor Skate within given temperature or depth intervals (line) and percentage of all sets within different temperature or depth intervals (bar graph).

Figure 44. Temperature and depth preferences from the Canadian Georges Bank RV survey.



Barndoor Skate stratified mean number caught per tow from the SUMMER Ecosystem surveys. The catch for 2004 was sampled using the MV Teleost. It has not been calibrated, and should not be compared to the earlier time series.



Temperature and depth distribution of Barndoor Skate captured from the SUMMER Ecosystem surveys 1970-2008. Shown for each variable is percentage of sets with Barndoor Skate within given temperature or depth intervals (line) and percentage of all sets within different temperature or depth intervals (bar graph).

Figure 45. Temperature and depth preferences from the Summer RV survey in Div. 4VWX.

LIMITING FACTORS AND THREATS

Information on potential threats to Barndoor Skate is limited. Given their large size, it is likely that adults may only be preyed upon by large sharks and marine mammals. An examination of the DFO Maritimes stomach data base revealed only one instance of Barndoor Skate being consumed by another fish (cod; Simon *et al.* 2009). Predation on egg cases by gastropods has been observed for skate species in other areas but no data exist for Barndoor Skate. The only potential threat for which there are quantitative data is mortality from groundfish fisheries. The survivorship of Barndoor Skate captured as bycatch and discarded is unknown.

Casey and Myers (1998) suggested that Barndoor Skate populations were reduced to extremely low levels because they were taken as bycatch in other major fisheries (Figure 46); however, no supporting data were provided. Pre-COSEWIC documents (Simon *et al.* 2004; Kulka *et al.* 2006) on Winter Skate and Smooth Skate have attempted to estimate removals by these fisheries since 1977 by using limited observer reports. To fill in the gaps in the data, the percentage of skate by species from the research vessel surveys was sometimes used in the Gulf of St. Lawrence and on the Scotian Shelf. Both of these methods rely on having enough records of species-identified skate to prorate skate unspecified observations by species. Given the very few reports of Barndoor Skate since the observer program began in 1977, it was felt that neither method could be used to estimate removals from the fishery.

To address this issue, the total reported landings of all groundfish species by all countries were summarized annually from Div. 5Z, 4X, 4VW, and 3Ps in which Barndoor Skate were reported to be near extinction by Casey and Myers (1998). These landings were intended to be a proxy for effort which was not available for all areas or years (Simon *et al.* 2009). Landings were then compared with the RV survey trends where possible. No attempt was made to extend the RV data series prior to the beginning of the standard surveys.

On Georges Bank (all of Div. 5Z), total removals of all groundfish was almost 100,000 t in 1960. Removals increased to greater than 600,000 t by 1965 and remained greater than 200,000 t until the mid-1970s. By 1977 and the extension of jurisdiction by the US and Canada to 200 miles, total landings had decreased to 125,000 t and have generally been below 100,000 t since 1985 (Figure 47). The precipitous decline in abundance of Barndoor Skate in this area was coincident with the sharp increase in landings for the area in the mid-1960s. In 1994, an area closed to groundfish dragging was created on the US side of the international boundary but it was reopened to limited scallop fishing in 1999 (Gedamke 2006). The effect of this closure is unknown but it will provide a measure of protection near the centre of distribution on the bank. There has not been any significant change in total landings since the mid-1990s when the RV abundance trend increased sharply (Figure 48).

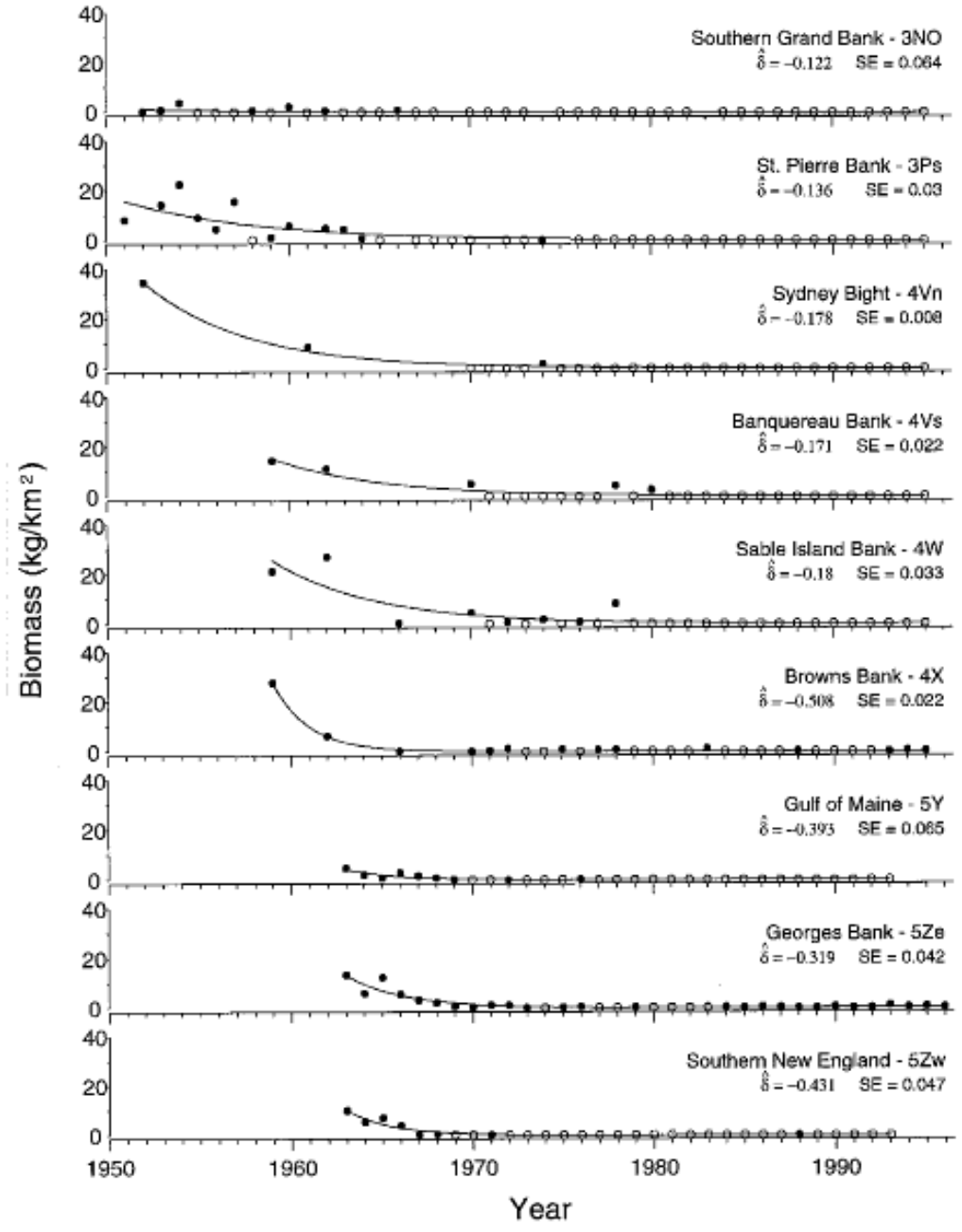


Figure 46. Estimates of absolute biomass for Barndoor Skate calculated by Casey and Myers (1998). The figure and following text are reproduced from Casey and Myers (1998): Open circles are zero catches. An exponential decay curve ($Ne^{-\delta t}$) was fit to the data with nonlinear least squares, where N is the population size in the first year of the surveys and t is the time since the first year. The estimated rate of population decline (δ) was lowest in the northern regions and highest in the southern regions. If only data since 1960 are considered, the population decline on St. Pierre Bank, Sydney Bight, and Banquereau Bank is similar to that in the southernmost regions (that is, Gulf of Maine, Georges Bank, and southern New England). The standard error (SE) of (δ) is provided.

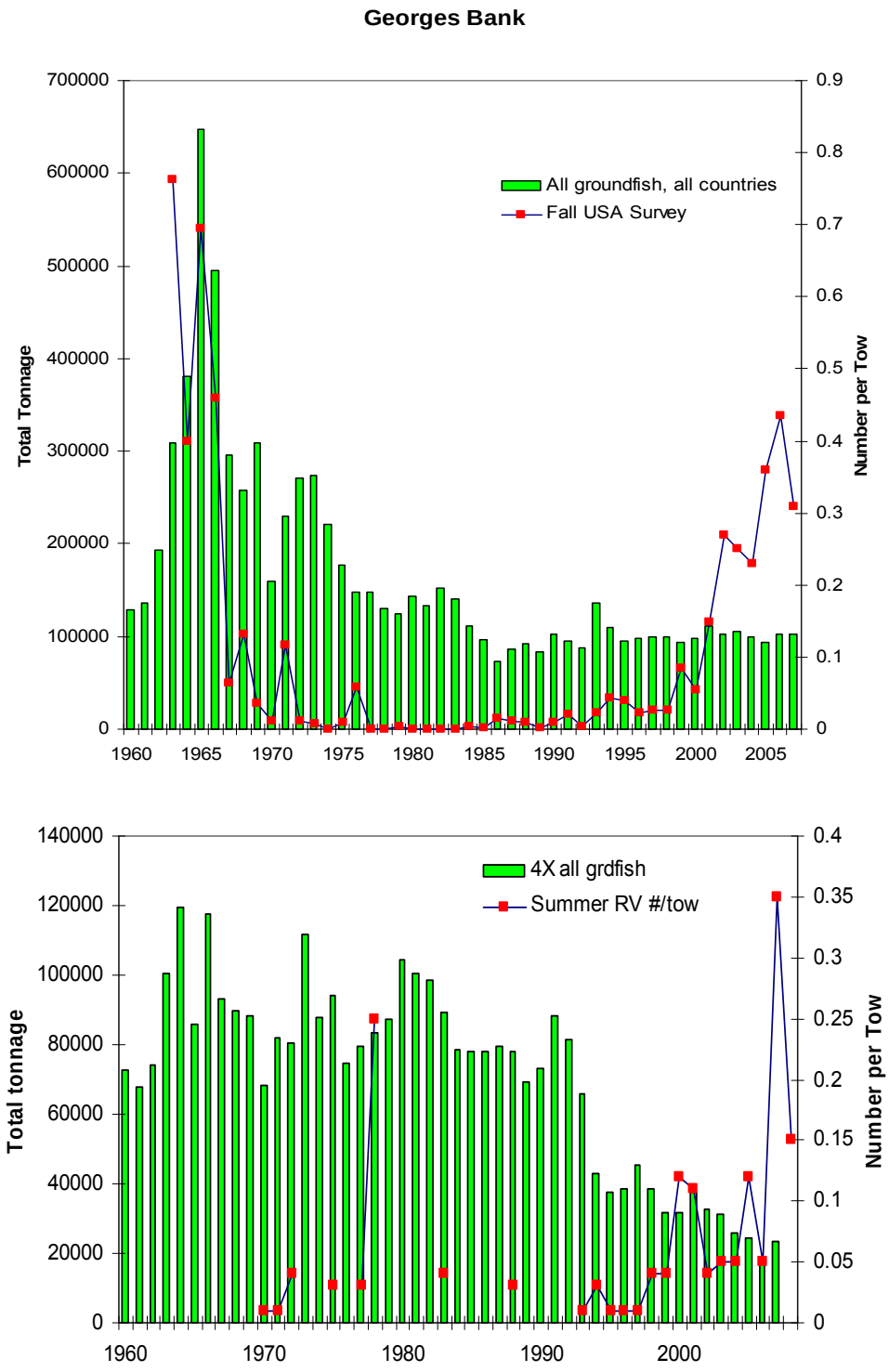


Figure 47. Total reported landings (t) of all groundfish from all countries (based on NAFO statistics) in Div. 5Z (top panel) and Div. 4X (bottom panel) and the corresponding catch rates (number per tow) from the US Fall RV surveys (Div. 5Z) and Canadian Summer RV surveys in Div. 4X.

In Div. 4X, the spike in landings noted in Div. 5Z was not evident. Landings prior to 1994 were generally between 60,000 and 90,000 t. In 1994, landings decreased sharply to 45,000 t and have continued to decrease to approximately 20,000 t in 2007 (Figure 48). Seasonal closures exist to protect spawning haddock on Brown's Bank but no large permanent closures exist in this area. Unlike Div. 5Z, the decline in skate abundance in the mid-1970s does not appear to be coincident with a significant change in landings.

In Div. 4VW, landings have been variable ranging from 150,000 t in the early 1960s to greater than 300,000 t in the early 1970s. Landings averaged approximately 150,000 t in the 1980s. A haddock nursery area was created in 1987 in Div. 4W to provide protection for juvenile fish – draggers were restricted from this area in 1987 and longline gear was excluded in 1994. Since 1994, directed fisheries for cod and haddock have been closed in Div. 4VW and total landings have been below 20,000 t (Figure 48). However, there have been no restrictions on the use of scallop gear within the Haddock nursery area. There appears to be no relationship between fishing effort (landings) and the decline in skate abundance in this area. The recent increases in Barndoor Skate abundance in the Summer RV survey (since 2000) are occurring at a time of very low fishing effort.

In Subdiv. 3Ps, total landings have been variable ranging from approximately 60,000 t to 115,000 t in the 1960s. Landings peaked at around 120,000 t in 1970 and fell to approximately 45,000 t by the early 1980s. Landings since the mid-1990s have ranged between 5,000 and 35,000 t (Figure 48). The decline in Barndoor Skate abundance in this area during the 1960s that was noted by Casey and Myers (1998) is coincident with the highest reported landings for the series, but it is unclear whether these landings were the cause of the decline in Barndoor Skate abundance in this area.

Examination of trends in skate removals alone for these NAFO Divisions (Figure 49) revealed high levels of skate removals from Div. 4VWX and Div. 5Z from the late 1960s to the mid-1970s primarily by foreign countries. However, it has been suggested that these landings were actually other groundfish species that were misreported, but this cannot be confirmed (Simon et al. 2009). In Subdiv. 3Ps, there has been a general increase in landings over the entire series.

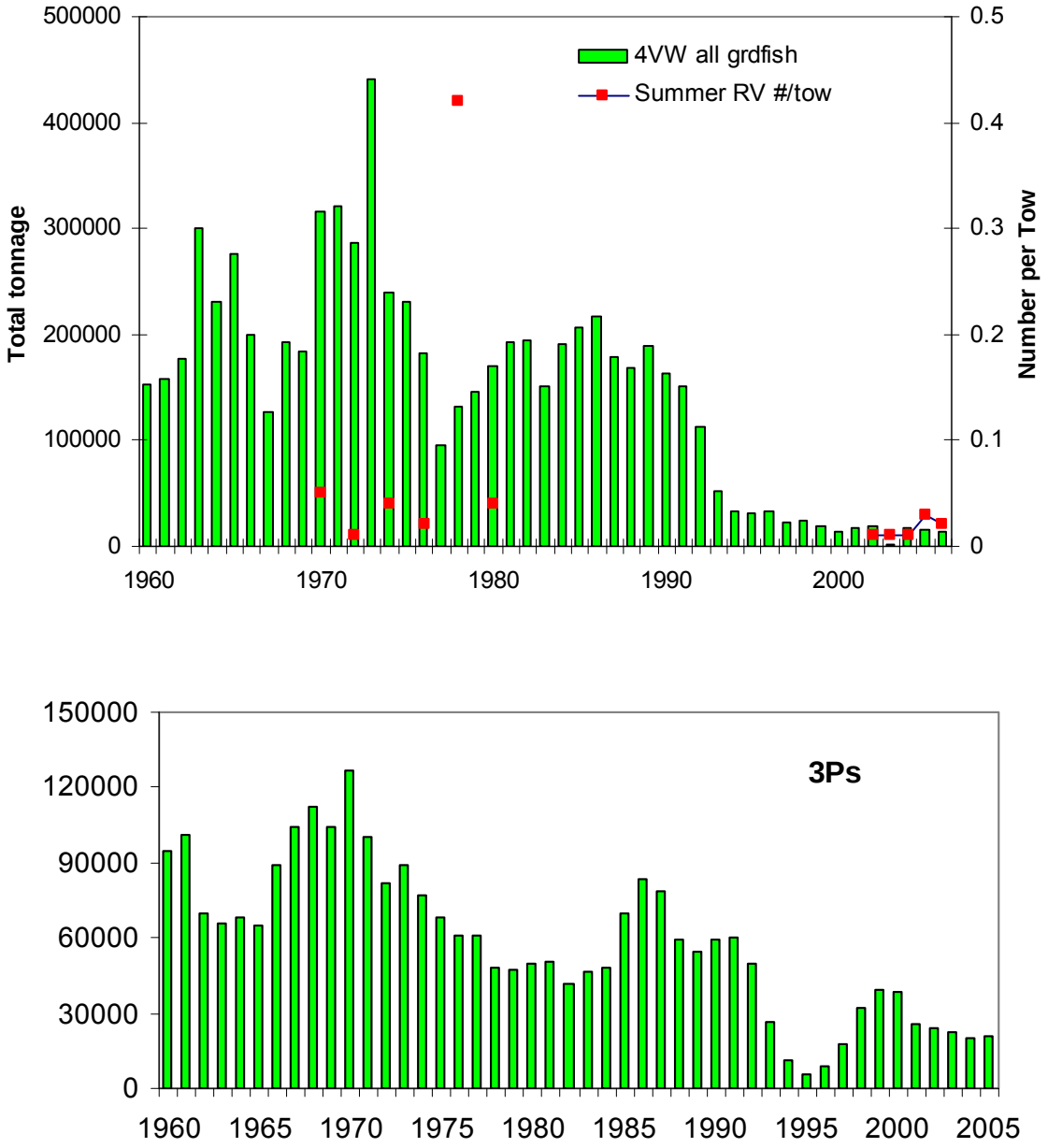


Figure 48. Total reported landings (t) of all groundfish from all countries (based on NAFO statistics) in Div. 4VW (top panel) and Subdiv. 3Ps (bottom panel) and the corresponding catch rates (number per tow) from the Canadian Summer RV surveys in Div. 4VW.

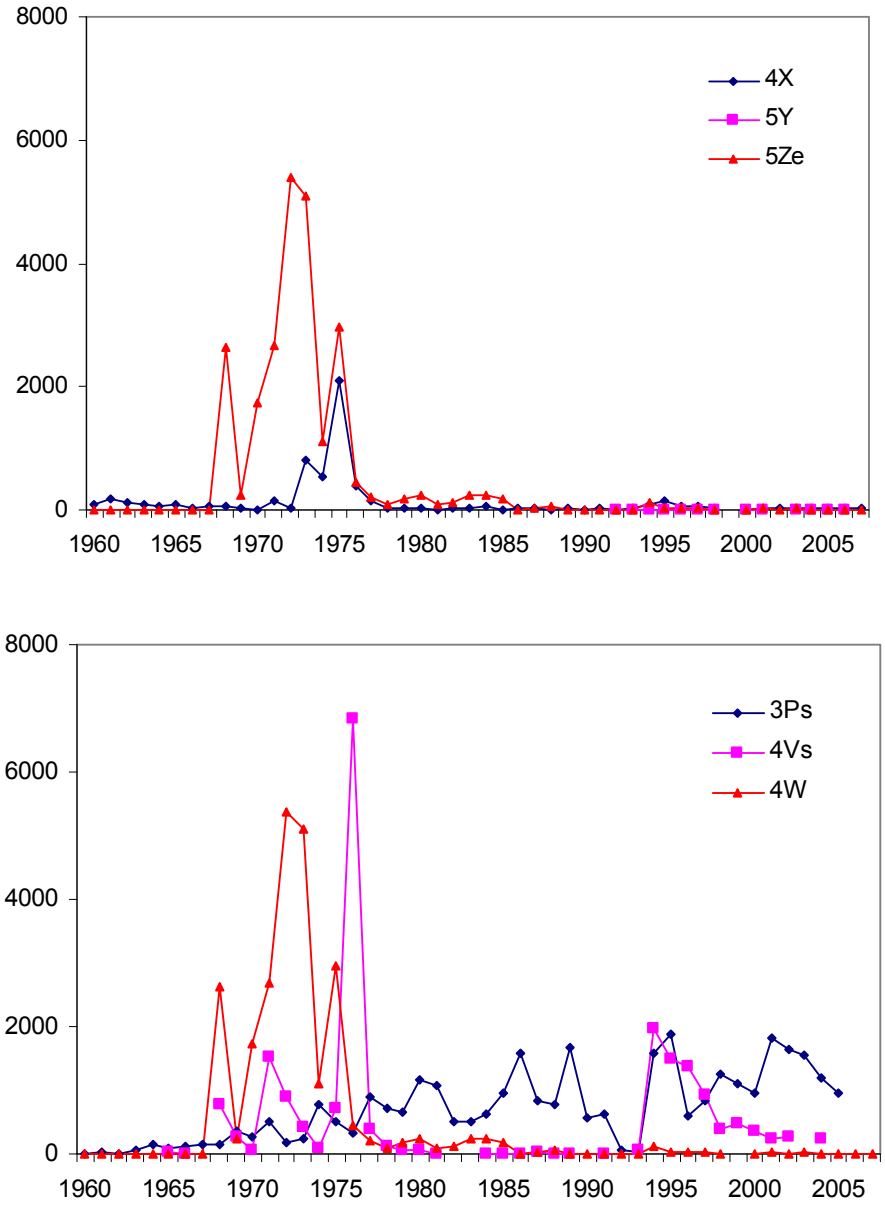


Figure 49. Reported skate landings (t) from Div. 5Z, 5Y, and 4X (top panel), and Div. 4Vs, 4W, and 3PS (bottom panel).

Since 1994, all skate landings have come from the Canadian directed skate fisheries. In Subdiv. 3Ps, the fishery directs on thorny skate (Kulka et al. 2004) while on the Scotian Shelf, the directed fishery focused on winter skate with a small bycatch of Thorny Skate. In both fisheries, reports of Barndoor Skate bycatch were negligible although these fisheries have occurred during a time of very low abundance of Barndoor Skate.

An examination of observer reports from Div. 5Zc (Canadian zone only) and Div. 4X was used to estimate total annual bycatch since 1986 (Table 1; S. Gavaris pers. com.), There is a high degree of uncertainty in these estimates due to low observer coverage. Where fisheries were not listed, it means there was no observer coverage or there was no recorded bycatch. Survival of discarded Barndoor Skate is unknown but the mortality of other skate species was estimated to be greater than 50% in the Gulf of St. Lawrence (Benoit 2006).

In Subdiv. 5Zc, bycatch estimates were calculated for the yellowtail flounder and the combined Cod, Haddock, and Pollock otter trawl (OT) fisheries. As well, estimates were available from the combined cod and haddock longline (LL) fishery and the scallop fishery. The highest rate of Barndoor Skate bycatch occurred in the yellowtail flounder fishery (1.05%), while the lowest rate occurred in the scallop fishery (0.07%) within this area. Total removals were highest in the scallop fishery (15 to 40 t). Total annual bycatch estimates from all fisheries combined for Subdiv. 5Zc ranged from 26 to 100 t from 1986 to 2007 (Table 1).

In Div. 4X, the highest recorded bycatch rate was from the combined Cod and Haddock LL fishery (0.65%) with the lowest reported rate from the Redfish fishery (0.05%). Total annual bycatch from all fisheries combined ranged from 25 to 115 t from 1986 to 2007 (Table 1).

Table 1. Estimated bycatch of Barndoor Skate in Div. 5Z and 4X from various fisheries that were observed to have caught Barndoor Skate. OT = otter trawl, LL = longline gear. % bycatch on the top line refers to the percent of Barndoor caught by weight in each one of the listed fisheries for the period 1986-2007. For example, Barndoor was 1.05% by weight of the catch of Yellowtail Flounder between 1986 and 2007 in the 5Z Cdn OT Yellowtail fishery.

Fishery, 5Z Cdn	Yellowtail Flounder OT	CHP (Cod, Haddock, Pollock) OT	CH (Cod, Haddock) LL	Scallop	Total Bycatch,t	Fishery, 4X	Redfish OT	CHP(Cod, Haddock, Pollock) OT	CH (Cod, Haddock) LL	Halibut LL	Total Bycatch,t
Bycatch rate(%)	1.05	0.12	0.80	0.07		Bycatch rate(%)	0.05	0.07	0.65	0.52	
1986	0.1	12.2	21.6	27.2	61.0	1986	2.7	20.8	64.0	2.2	89.8
1987	0.0	15.2	34.1	39.5	88.7	1987	2.3	21.6	67.0	2.0	93.0
1988	0.1	17.3	40.0	25.2	82.5	1988	1.6	20.9	66.0	2.6	91.2
1989	0.0	5.7	42.4	27.2	75.3	1989	1.0	17.6	53.1	1.9	73.5
1990	0.0	13.6	48.4	30.3	92.3	1990	1.0	14.8	74.0	1.7	91.5
1991	0.1	13.9	48.1	33.7	95.8	1991	0.8	22.5	89.8	1.3	114.5
1992	0.1	12.3	46.9	35.7	95.0	1992	1.1	19.8	93.1	1.3	115.2
1993	1.4	12.7	26.9	36.0	77.0	1993	2.4	12.5	51.9	1.3	68.2
1994	13.7	7.0	23.2	29.1	73.0	1994	2.5	8.0	39.6	1.6	51.7
1995	4.1	3.1	7.4	11.5	26.0	1995	2.3	7.2	32.6	1.0	43.0
1996	4.4	5.3	15.2	17.4	42.3	1996	1.8	8.5	34.9	1.3	46.4
1997	8.4	4.7	16.3	24.7	54.1	1997	2.7	10.7	36.7	1.5	51.6
1998	12.2	5.0	14.6	23.2	55.0	1998	2.7	11.1	35.3	1.0	50.1
1999	20.7	4.7	14.1	21.5	61.1	1999	2.1	6.7	28.6	1.0	38.4
2000	29.5	6.5	15.3	39.6	90.9	2000	2.2	6.0	30.7	1.0	40.0
2001	30.3	8.3	21.6	39.9	100.2	2001	2.0	7.7	27.8	1.2	38.7
2002	27.6	8.0	17.6	38.6	91.8	2002	2.3	8.2	27.2	1.4	39.2
2003	21.7	7.9	19.9	35.9	85.4	2003	1.5	9.4	25.6	1.5	37.9
2004	1.0	12.0	21.3	21.6	55.9	2004	1.0	8.2	15.5	1.5	26.2
2005	0.3	16.8	21.4	15.6	54.2	2005	1.5	7.5	14.3	1.7	25.1
2006	0.2	13.6	19.8	23.8	57.3	2006	1.3	4.8	19.9	2.4	28.4
2007	0.1	13.0	19.9	25.6	58.6	2007	1.4	7.1	22.5	2.0	33.0

SPECIAL SIGNIFICANCE OF THE SPECIES

Skates are targeted by commercial fisheries for their pectoral fins (wings) and, typically, large skates such as winter skate and Barndoor Skate would be preferred over smaller skates in American markets. It is possible that the wings of Barndoor Skate have been marketed as Winter Skate in the past but their possession has been prohibited in US fisheries since 2004 and it would not have been possible to market any Canadian landings in the US since this time.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The 1999 stock assessment of the skate complex in the US concluded there was no cause to list Barndoor Skate as endangered but recommended that the species remain on the candidate list (NEFSC 2000). Following that assessment, a Fisheries Management Plan (FMP) was developed by the New England Fishery Management Council (NEFMC) when they were informed that Barndoor Skate were overfished. This FMP was implemented in September 2003 and prohibited the possession of Barndoor Skate (NEFSC 2007). Internationally, New England Barndoor Skate was proposed as an addition to the IUCN Red List as “critically endangered” in 2003 (Dulvy 2003).

The federal *Fisheries Act* provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries. Since 2007, when the Atlantic Fishery Regulations were amended, skate in the Gulf Region are to be returned to the water, and if alive, in a manner that causes them the least harm. In the Maritimes Region regulations are similar in that skate are to be returned alive if possible when discarded, but skate can be landed as a bycatch in other fisheries, and there is no requirement to record them to the species level. There is also no requirement for fishers in both regions to record discarded skate in their logbooks. In the NL Region the >65' fleets are authorized to release skate but must record them in their logbook, whereas the <65' fleets are not authorized to release skate and must land whatever they catch. In neither fleet is there a requirement to record skate to the species level. In the managed skate fisheries in the NL Region, management conditions are in place that require minimum mesh sizes, hook size, limits on the quantity of gear, and there is an annual quota. They are not required to record skate landings to the species level; however, some observer coverage is required in this fishery and there have not been any records of Barndoor Skate since the fishery began.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The report writers thank Adam Cook, Mark Simpson, Carolyn Miri, Hugues Benoît, and Diane Archambault for providing data and background information. Todd Gedamke provided additional insight into the biology of the species. An earlier draft of this work was reviewed by the Stock Assessment Working Group in the Population Ecology Division at the Bedford Institute of Oceanography (BIO) and valuable input was provided by individuals at the National Assessment Process review of this species, which was held at BIO in 2008. Funding for the preparation of this report was provided by Environment Canada.

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