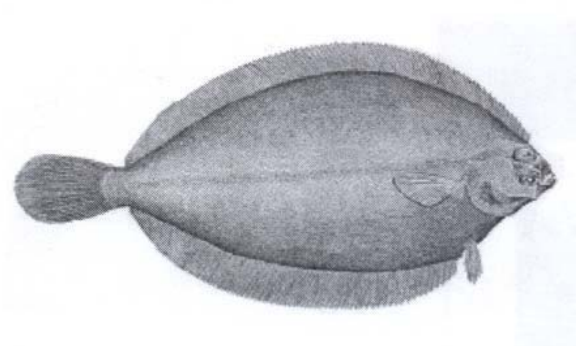
ASSESSMENT OF WITCH FLOUNDER (*GLYPTOCEPHALUS CYNOGLOSSUS*) IN THE GULF OF ST. LAWRENCE (NAFO DIV. 4RST)



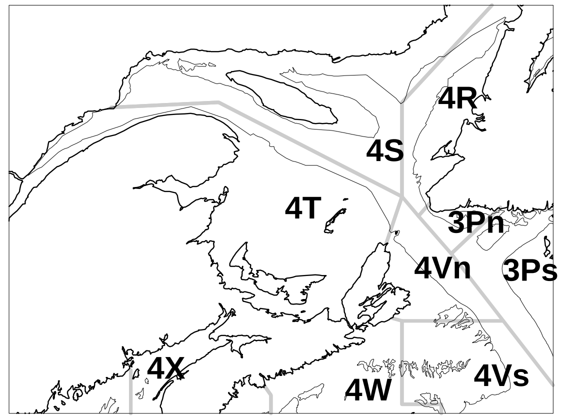


Figure 1: Gulf of St. Lawrence and adjacent areas showing NAFO Divisions.

Context

*Commercial fisheries for witch flounder (*Glyptocephalus cynoglossus*) developed rapidly in the 1940s with the introduction of otter trawling to Newfoundland. Stocks in the Gulf of St. Lawrence became exploited in the 1950s when Danish seiners in Fortune Bay, Newfoundland (NAFO Division 3Ps) motivated by declining stocks, moved their effort to St. George's Bay in 4R . A small directed fishery for witch flounder developed in St. George's Bay during the summertime, with offshore winter catches as bycatch in cod- and redfish-directed fisheries gaining in importance. The witch flounder fishery expanded from St. George's Bay during the 1970s to the Esquiman Channel and the northern shores of Cape Breton Island.*

Witch flounder in the northern Gulf of St. Lawrence (NAFO Division 4RS) came under quota management in 1977, with a quota of 3,500 t. In 1979, the Total Allowable Catch (TAC) in NAFO Div. 4RS was increased to 5,000 t to remove an old and slow-growing component of the stock. This measure succeeded in reducing the age composition of the stock; however, landings declined and by 1982, the TAC was reduced to 3,500 t. The first detailed assessment of 4RS witch flounder was conducted in 1978 and continued yearly until 1981. During the 1980s,landings from NAFO Div. 4T increasingly dominated the Gulf of St. Lawrence witch flounder landings; however, the management unit remained as 4RS. Stock assessments resumed in 1991 and following the recommendation of the Fisheries Resource Conservation Council in 1994, the management unit was extended to 4RST in 1995. The most recent full assessment of the status of this stock was conducted in 2006 (Swain et al. 2006; DFO 2006).

SUMMARY

- In 2011-2012, the total allowable catch (TAC) remained at 1,000 t. Landings in 2011 were 442 t (318 t in 4R and 124 t in 4T).
- The fishery for witch flounder is now primarily a directed fishery, with most of the catch taken by seines. Fishing effort by seines dropped sharply in 2010.

- Size distribution in the landings has contracted, the proportion of large fish (40+ cm) in the landings decreased from 67-80% in the 1970s to 10% in 2011.
- Witch flounder are slow growing and late maturing. Because of this low productivity, they are vulnerable to overexploitation.
- The 4RST research vessel (RV) survey index of commercial biomass (30+ cm), available since 1987, declined sharply in the early 1990s and remains at a relatively low level.
- The 4RST sentinel survey index of the biomass of fish 30 cm and longer, available since 2003, was at its lowest level in 2011.
- Size distribution in the survey catches has also contracted over time. The proportion of fish 40 cm and longer in the catches of the 4T RV survey, available since 1971, declined from 73% in the 1970s to 14% in the 2000s. Fish 40 cm and longer comprised 21% of the 4RST survey catches in 1987-1990 but only 4.5% of the catches in 2005-2011.
- Recruitment has been relatively strong in the 1990s and 2000s but has not resulted in improved abundance of 40+ cm fish, consistent with high mortality at commercial sizes.
- Population models indicate a 90% decline in commercial biomass since 1961.
- The limit reference point (LRP) for this stock, set at 40% of the biomass producing the maximum sustainable yield (B_{MSY}), is estimated to be 10,700 t of 30+ cm fish.
- The estimate of the biomass of fish 30 cm and longer in 2011 is 5,000 t, about half the LRP. Based on the uncertainties in the estimates of both the 2011 biomass and the LRP, the probability that biomass is below the LRP in 2011 is 93%.
- The maximum removal reference in the healthy zone (the exploitation rate at MSY) is estimated to be 0.07 for this stock. The estimated exploitation rate in 2011 was 0.09.
- Biomass is expected to increase with annual catches of 300 t and decrease with catches of 850 t (the average level in 1998-2008). However, even with no catch, there is a 62% probability that biomass will remain below the LRP in five years.
- A strong year-class is now approaching commercial sizes. Protecting this year-class by keeping catches as low as possible for the next decade may promote rebuilding of the 40+ cm size group.

BACKGROUND

Species Biology

Witch flounder (*Glyptocephalus cynoglossus* L.) are found in the deeper waters of the North Atlantic. In the Northwest Atlantic, witch flounder range from the lower Labrador coast to Cape Hatteras, North Carolina. Relative to other flounders, witch flounder is slow-growing and long-lived. Spawning occurs from spring to late summer, depending on the region. In the Gulf of St. Lawrence (NAFO Division 4RST), spawners aggregate in the lower Esquiman Channel and the eastern Laurentian Channel in January and February. Spawning in the Gulf is believed to occur in deep water in spring. The females are highly fertile, releasing as many as 500,000 eggs in a single spawn. In the late 1970s and early 1980s, 50% of females reached maturity at lengths of 40-45 cm (9-14 years of age) and 50% of males matured at lengths of 30-34 cm (5-8 years of age) (Bowering and Brodie 1984). The fertilized eggs float and hatching occurs after several days, followed by a lengthy pelagic stage that may last a year. Juveniles eventually settle to the bottom in deep waters. In northern areas of their range, including the Gulf of St. Lawrence, witch flounder move into deep water during winter months and cease feeding. Witch flounder grow faster in the Gulf of Maine and Georges Bank, where water temperature is higher and feeding occurs year-round.

The Fishery

Landings of witch flounder in NAFO Divs. 4RST exceeded 3,000 t in most years from 1960 to 1980 (Fig. 2). Landings declined to near 1,000 t in the early 1980s, increasing to near 2,500 t in the late 1980s (Table 1). Landings again declined in the 1990s, falling to less than 500 t in the mid 1990s. Following an increase to a level between 700 and 1,000 t from 1998 to 2008, landings fell below 300 t in 2010. Landings have been roughly equally split between divisions 4R and 4T in most years. Landings in 2011 were 442 t (318 t in 4R and 124 t in 4T).

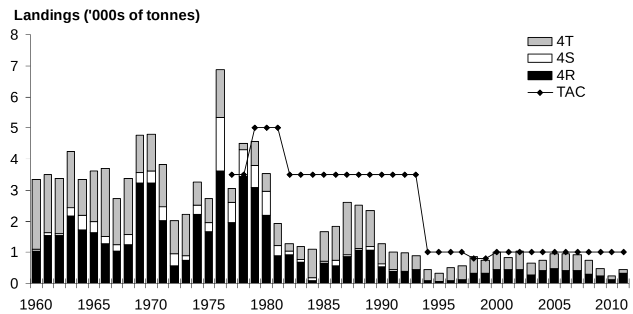


Figure 2. Landings and TAC of witch flounder in NAFO Divs. 4RST.

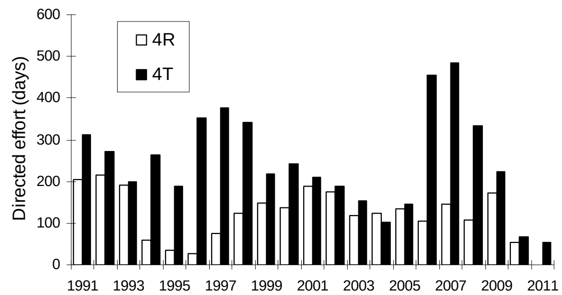


Figure 3. Fishing effort (days) by seines directing for witch flounder; 4R data not available in 2011.

Table 1. Landings, (thousand tonnes), total allowable catch (TAC; thousand tonnes), and seine effort (days) for the witch flounder fishery.

Year	Average 1981-90	Average 1991-95	Average 1996-2000	Average 2001-2005	2006	2007	2008	2009	2010	2011[1]
TAC[2]	3.7	2.5	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Landing	1.8	0.7	0.7	0.8	0.9	0.9	0.7	0.5	0.2	0.4
Seine effort (days)	N/A	388	409	309	560	629	441	393	120	54[3]

1 Landings for 2011 are preliminary
2 TAC in 2000 to 2011 is applied for May 15 to May 14 of the following year
3 Seine effort for 2011 is for 4T only

Since the mid-1980s, landings have been mostly by seiners directing for witch flounder between May and October in St. George's Bay, Newfoundland (4Rd) and off the west coast of Cape Breton Island (4Tf and 4Tg). The lower landings in 1994-1997 are the result of a large decrease in fishing effort in 4R (Fig. 3). Fishing effort in 4R increased again in the late 1990s, as did the landings. Fishing effort (days fished) increased sharply in 4T in the late 2000s. This increase was less evident in terms of hours fished, reflecting more but shorter fishing trips during this period. The sharp decline in landings in 2010 corresponded to a sharp decline in fishing effort.

The size of witch flounder caught in the fishery decreased from the 1970s and 1980s to the 2000s in both 4R and 4T (Fig. 4). The proportion of fish 40 cm and longer declined from 67% -

80% in 1970-1979 to 20% in 2006-2011. In 2011, only 10% of the fish in the landings were estimated to be 40 cm or longer.

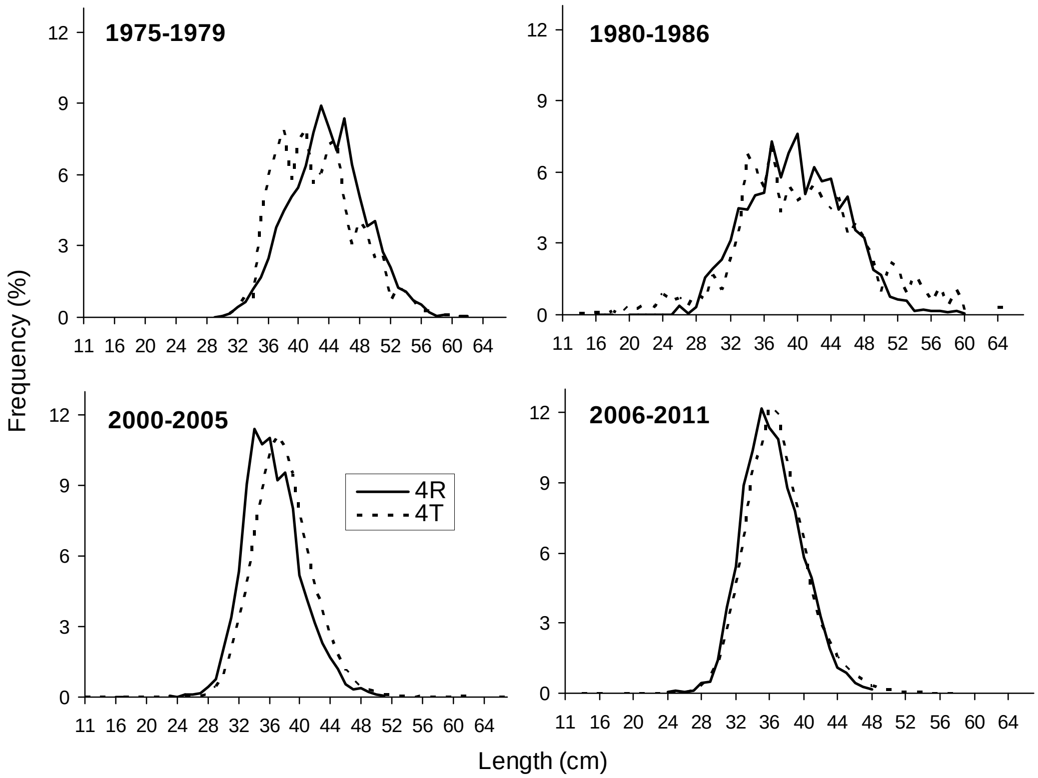


Figure 4. Length distribution (%) of witch flounder in landings from 4R (solid line) and 4T (dashed line) in recent years (2000-2005, 2006-2011) compared to those in the mid 1970s and early 1980s.

ASSESSMENT

Sources of information

A biomass index for commercial sizes (30+ cm) of witch flounder in 4RST was calculated for 1987-2011 by combining data from annual research vessel (RV) surveys conducted in the southern Gulf each September and in the northern Gulf each August. Adjustments are made for changes in vessel or gear based on comparative fishing experiments (except for the 2003 September survey which was conducted by an uncalibrated vessel). The adjusted index (the catch per tow expanded to the area surveyed) should reflect changes in witch flounder biomass over time but should not be taken as a measure of the actual biomass present in the area. Data from the 1971-1986 September surveys were also used to provide a longer term perspective on changes in biomass, size composition and geographic distribution in the 4T portion of the stock area.

Stratified random sentinel surveys have been conducted in the northern Gulf of St. Lawrence in July since 1995 and in the southern Gulf in August beginning in 2003. These surveys provide a second view of witch flounder distribution and relative abundance over most of the management unit, though they do not cover the estuary portion west of about 67°W, an area where RV catch rates are often high. A biomass index (30+ cm) was calculated for 2003-2011 combining data from the two surveys.

Landings data from 1960 to 2011 were also used in the population models.

Biological information

Witch flounder is a species characterized by low productivity. Growth is very slow and maturation is at a late age. Based on ageing of samples collected during the 1974-1981 September surveys, the mean length at an age of 12 years is 40 cm for males and 41 cm for females. Based on the same data, the estimated lengths and ages at 50% maturity were 38.6 cm and 10.4 years for females and 33.2 cm and 7.5 years for males. Data collected in January 1978-1981 in the northern Gulf produced similar estimates. These life-history characteristics make this stock particularly vulnerable to overexploitation.

Data collected in the 2000s suggest that maturation is now earlier, with 50% of females and males mature at lengths of about 28 and 25 cm, respectively. Earlier maturation is an expected evolutionary response to increased mortality at larger sizes, such as that imposed by fishing. Maturation at a smaller size could also reflect slower growth.

Stock trends

Biomass trends

A sharp decline in witch flounder biomass occurred in the Gulf (4RST) from 1990 to 1993 (Fig. 5). The index of biomass remained at a low level from 1993 to 1998. It increased to an intermediate level in 1999 and 2000 but has decreased since then. Since 2001, biomass of fish 30 cm and longer has fluctuated at a level about 40% of the 1987-1990 level. Biomass of fish 40 cm and longer has shown no increase from the decline in the early 1990s, fluctuating at a level less than 20% of the 1987-1990 level since 2004.

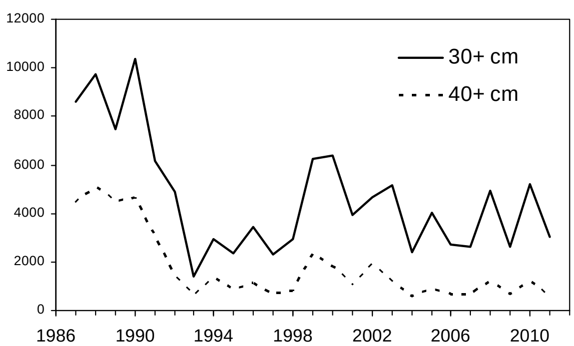


Figure 5. RV biomass index for two size groups of witch flounder.

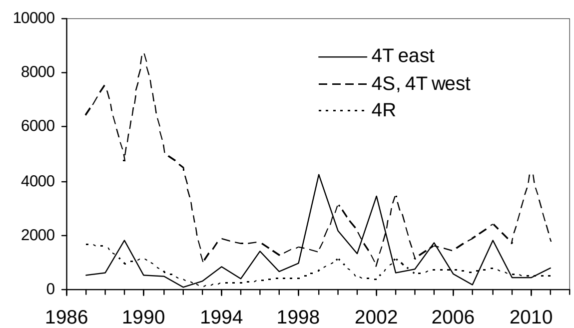


Figure 6. RV biomass index of witch flounder 30 cm and longer in three regions of the Gulf of St. Lawrence.

Changes in biomass have not occurred uniformly throughout 4RST (Fig. 6). The decline in biomass in the early 1990s occurred primarily in the 4R and 4S/western 4T areas. There has been little increase of 30+ biomass in 4S and western 4T. In 4R, 30+ biomass has increased somewhat from the very low values of the early to mid 1990s, averaging 37% of the 1987-1990 levels in 2009-2011. In eastern 4T, 30+ biomass increased to a relatively high level in the late 1990s and early 2000s but has since declined, averaging 64% of the 1987-1990 level in 2009-2011.

The size-aggregated biomass index from the July sentinel survey of the northern Gulf declined slightly from the mid 1990s to the early 2000s and then increased back to the mid 1990s level (Fig. 7). The size-aggregated index from the August sentinel survey of the southern Gulf declined after 2006, with the 2011 value the lowest in the 9-year time series. The combined biomass index for sizes 30+ and 40+ cm both also declined after 2006 (Fig. 8).

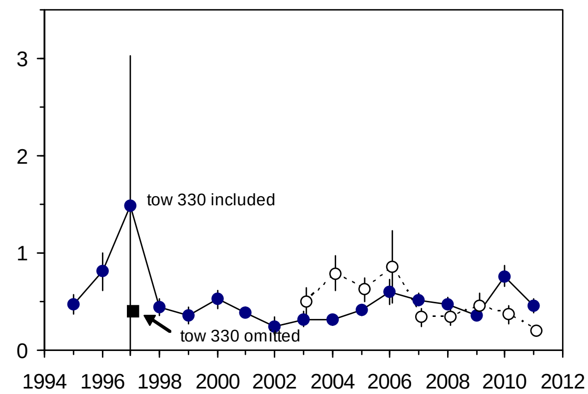


Figure 7. Mean catch rates (kg/tow) of witch flounder in the July sentinel survey of the northern Gulf (closed circles) and the August sentinel survey of the southern Gulf (open circles). Vertical lines are ± 1 standard error.

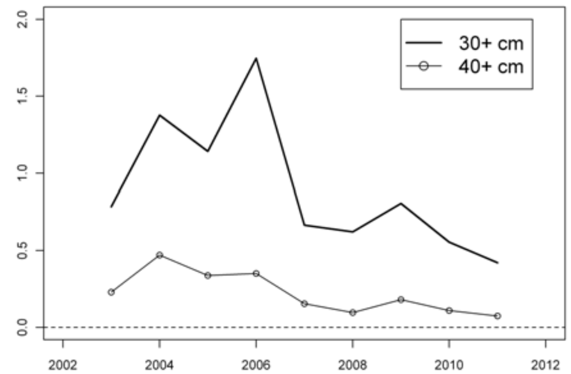


Figure 8. Sentinel biomass indices (kg/tow) for 4RST witch flounder combining the July and August sentinel data.

The September RV survey provides a longer term perspective on biomass trends in the southern Gulf portion of the stock area. The biomass of pre-commercial sizes (< 30 cm) of witch flounder in the southern Gulf increased in the early to mid 1990s, and has been at a high level since then (Fig. 9a). However, the southern Gulf survey covers only a small portion of the area occupied by these small fish. Biomass of commercial-sized witch flounder was relatively high in the southern Gulf in the 1970s but declined to a lower level in the early 1980s (Fig. 9b). Following an increase in the late 1980s, biomass declined again in the early 1990s and following a brief increase in the late 1990s, the biomass has been at a low level since the mid 2000s. The increases in biomass followed periods of low landings (Fig. 2) whereas the declines in biomass followed increases in landings.

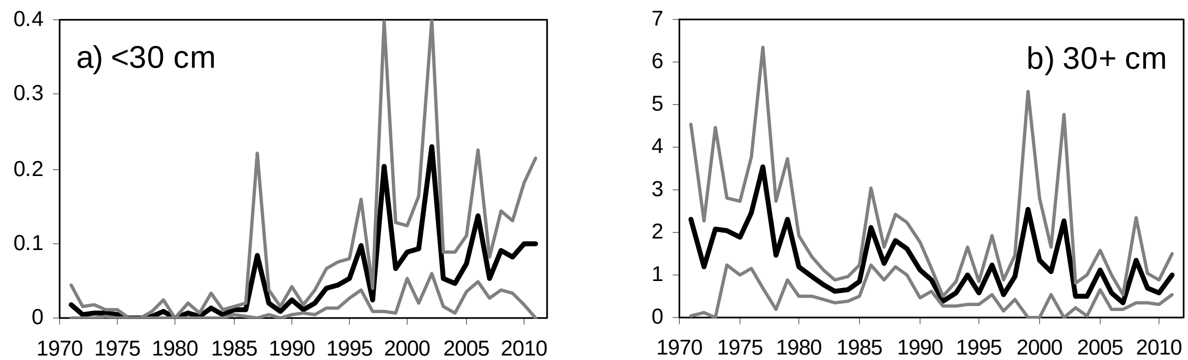


Figure 9. Biomass indices (kg/tow) for two size classes of witch flounder in the September survey of the southern Gulf. Grey lines show ± 2 standard error.

Geographic distribution

Pre-commercial sizes of witch flounder are distributed in the estuary and throughout the deep channels in the northern Gulf (Fig. 10). High densities of these small fish were more widespread in the 1990s and 2000s than in the late 1980s. The larger commercial sizes tend to move up onto the shelves during the summer feeding season. In the 1987-1990 period, these larger fish penetrated deeply into the western Magdalen Shallows, a pattern also typical of earlier years in the 1970s and 1980s. High densities of these fish also occurred in the Cape Breton Trough, in the estuary and the northwestern Gulf and along the west coast of Newfoundland. Densities of commercial-sized fish declined in the 1990s, most notably on the western Magdalen Shallows and in the northwestern Gulf. In the 2000s, high densities of these commercial sizes were mostly restricted to the estuary, the Cape Breton Trough, the southern slope of the Laurentian Channel and the shelf off western Newfoundland. The distribution of witch flounder catches in the sentinel surveys resembled the distributions described here based on the RV survey catches.

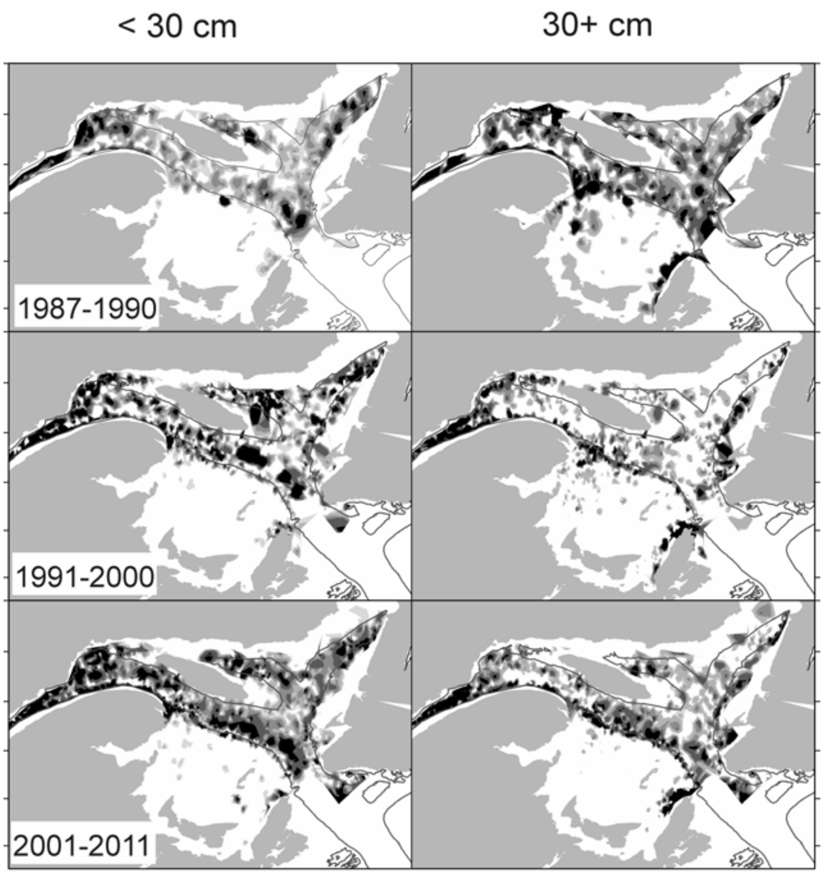


Figure 10. Geographic distribution of two length groups of witch flounder in the summer RV surveys of the Gulf of St. Lawrence. Darker shading corresponds to high densities.

Length composition

Abundance of large fish (30+ cm) in the RV survey catches dropped sharply from the 1987-1990 period to the 1991-1997 period (Fig. 11). In contrast, abundance of smaller fish was much higher in 1991-1997 than in 1987-1990. Although there has been some improvement in abundance at the smaller commercial sizes (30-39 cm), there has been no increase in the abundance of fish 40 cm and longer, despite high abundance at small sizes. Fish 40 cm and longer comprised 21% of the survey catches in 1987-1990 but only 4.5% of the catches in 2005-2011.

A longer term perspective is available for the portion of the stock occurring in the southern Gulf in September (Fig. 12). In the 1970s, 73% of the witch flounder caught in the September survey were 40 cm or greater in length, and 14% were 50 cm or greater. By the 2000s, this had declined to 14% and 0.2%, respectively. The size composition in commercial catches (Fig. 4) suggests that the loss of large fish from the northern Gulf over this period has been similar in magnitude. In contrast to large fish, small fish have increased in abundance in the September survey catches from the 1970s to the 2000s.

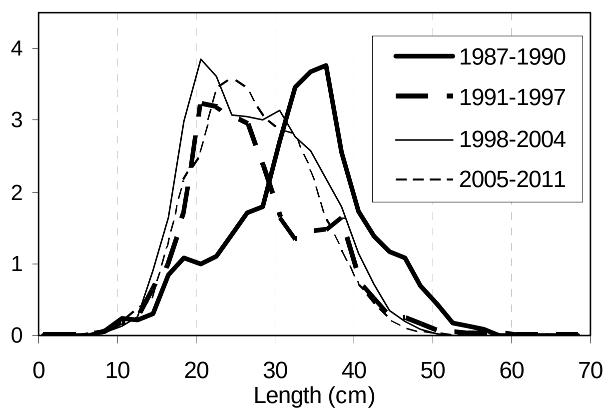


Figure 11. Length composition of witch flounder catches (trawlable abundance, millions) in the summer RV surveys of the southern and northern Gulf.

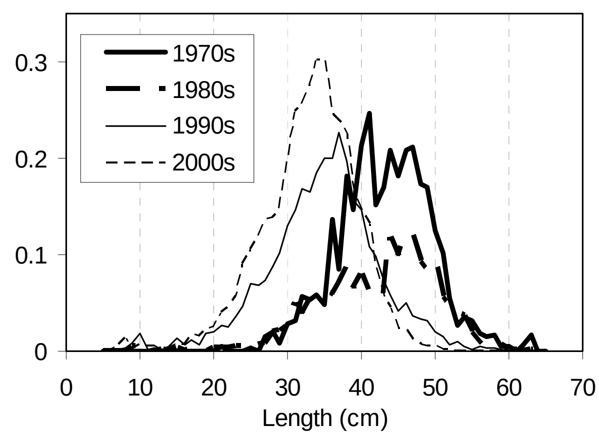


Figure 12. Length composition of witch flounder catches (mean number per tow) in the September RV survey of the southern Gulf.

The relatively high abundance of pre-commercial sizes of witch flounder in RV survey catches in the 1990s and 2000s (Fig. 11 and 12) suggests that recruitment has been strong during this period. A number of strong year-classes are evident at lengths below 30 cm in the survey catches, including one now approaching commercial sizes (Fig. 13). Despite this strong recruitment there has been no increase in the abundance of 40+ cm fish. This is consistent with high mortality at commercial sizes.

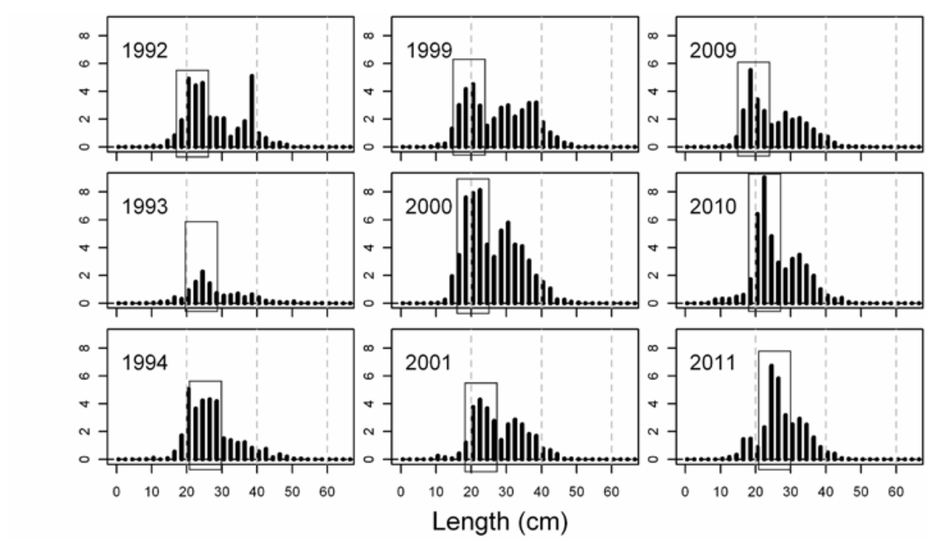


Figure 13. Length distributions of witch flounder in catches in the summer RV surveys in selected years. Boxes mark modes that suggest the growth of strong year-classes through these distributions.

Current status

The population model used in this assessment was a state-space Schaefer production model adjusted using a Bayesian approach. Inputs were the reported landings from 1960 to 2011 and three indices of 30+-cm biomass: the 4RST RV index (1987-2011), the 4RST sentinel index (2003-2011) and the 4T RV index (1971-1992). Use of the 4T index requires the assumption that there is no time trend in the proportion of the total stock occurring in the September survey area. Supplementary information on geographic distribution and changes in stock abundance in the 1970s and 1980s supported this assumption. However, this index was used only up to 1992 because the proportion of the stock occurring in the September survey area increased as the stock declined in the early 1990s. Several models were examined, differing in initial conditions (the prior distribution on biomass at the start of the model period), the time period modeled (starting in 1961 or 1971) and the biomass indices used (including or excluding the 4T index), but all led to similar conclusions regarding current status. A model allowing for changes in productivity regimes (by allowing decadal variation in the intrinsic rate of population increase) was also examined; this model did not indicate any significant changes in productivity regime for this stock and was not examined further.

The estimated biomass of commercial-sized (30+ cm) witch flounder in the 4RST stock in 2011 was 5,000 t, less than 10% of the biomass in 1961 and about 20% of the biomass producing the maximum sustainable yield (B_{MSY}) (Fig. 14). Based on guidance from the DFO policy (DFO 2009), 40% of B_{MSY} was chosen as the Limit Reference Point (LRP; B_{lim}). Below the LRP, there is a high probability that stock productivity has been so impaired that serious harm to the stock has occurred. The median estimate of 30+ cm biomass in 2011 is about half of B_{lim}, with a 93% probability that the stock is below B_{lim}.

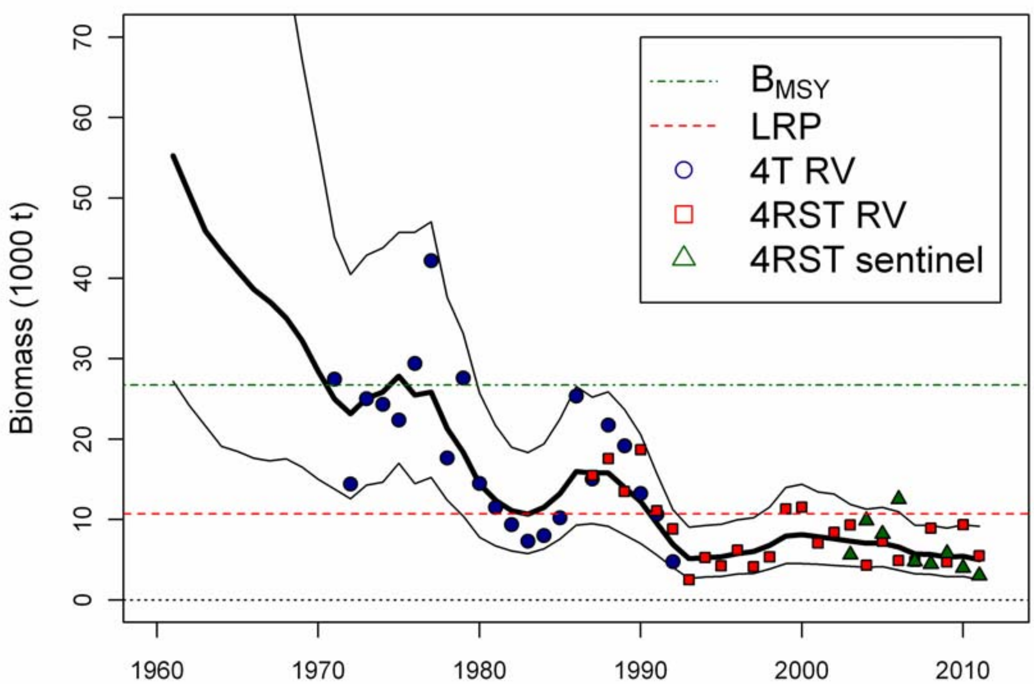


Figure 14. Estimated biomass of 4RST witch flounder 30 cm and longer based on the preferred population model. The heavy line is the median estimate and light black lines show the 2.5th and 97.5th percentiles. Symbols show the catchability-corrected biomass indices from the various surveys. The median estimates for the biomass at maximum sustainable yield (B_{MSY}) and the Limit Reference Point (LRP or B_{lim}, 40% of B_{MSY}) are also shown.

Estimates of several quantities of management interest are in the following table.

	Median	80% credible limits
K (carrying capacity) (kt)	53.5	31.4 – 166.3
B_{MSY} (kt)	26.7	15.7 – 83.2
LRP (kt)	10.7	6.3 – 33.3
Catch at MSY (kt)	1.988	1.097 – 5.149
F_{MSY}	0.072	0.046 – 0.100
2011 Biomass (kt)	5.0	3.2 – 7.5
2011 Biomass / LRP	0.45	0.14 – 0.91

The estimated history of exploitation and biomass of 4RST witch flounder is shown in Figure 15. In the 1960s, landings were high but so was estimated biomass, thus the exploitation rate was relatively low. Nonetheless, biomass declined because the population was estimated to be near carrying capacity and thus yielded little surplus production. By the mid to late 1970s, biomass was estimated to be near B_{MSY} but exploitation rates had risen to high levels, well above F_{MSY}, and estimated biomass declined further. Since then exploitation rates have generally remained high (relative to stock productivity), and further declines in biomass have occurred. Biomass was estimated to improve after temporary reductions in exploitation rates in the mid 1970s, mid 1980s and mid 1990s. However, in each case, exploitation rate subsequently increased again and declines in biomass resumed. The estimated exploitation rate in 2011 was above the F_{MSY} level.

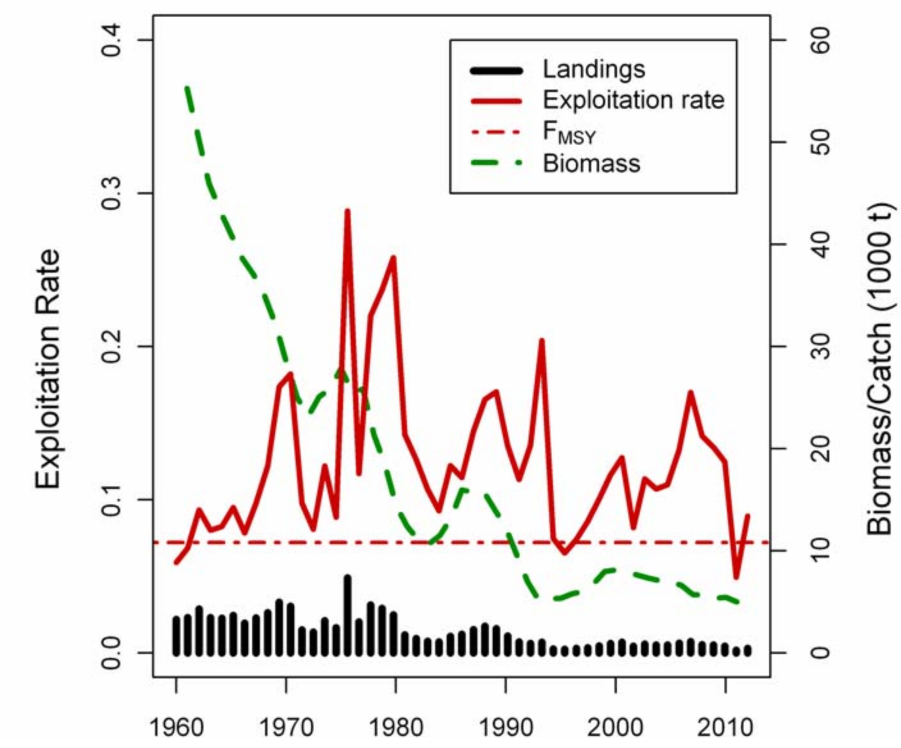


Figure 15. History of landings, exploitation rate and 30+ cm biomass of 4RST witch flounder.

Stock projections

Five-year projections were made at three levels of catch: 0, 300 and 850 t (the average level in 1998-2008). Median estimates of 30+ cm biomass increase over the 5-year period at catch levels of 0 and 300 t and decrease at catches of 850 t (Fig. 16). Even with no catch, the median estimate of 30+ cm biomass remains below the LRP in 2016. The probability of remaining below the LRP in 2016 was estimated to be 62%, 71% and 86% at catch levels of 0, 300 and 850 t. These probabilities are lower than the estimate for 2011 (93%) even for the case where biomass has declined further (catch = 850 t) because uncertainty in the biomass level increases greatly in the projection period.

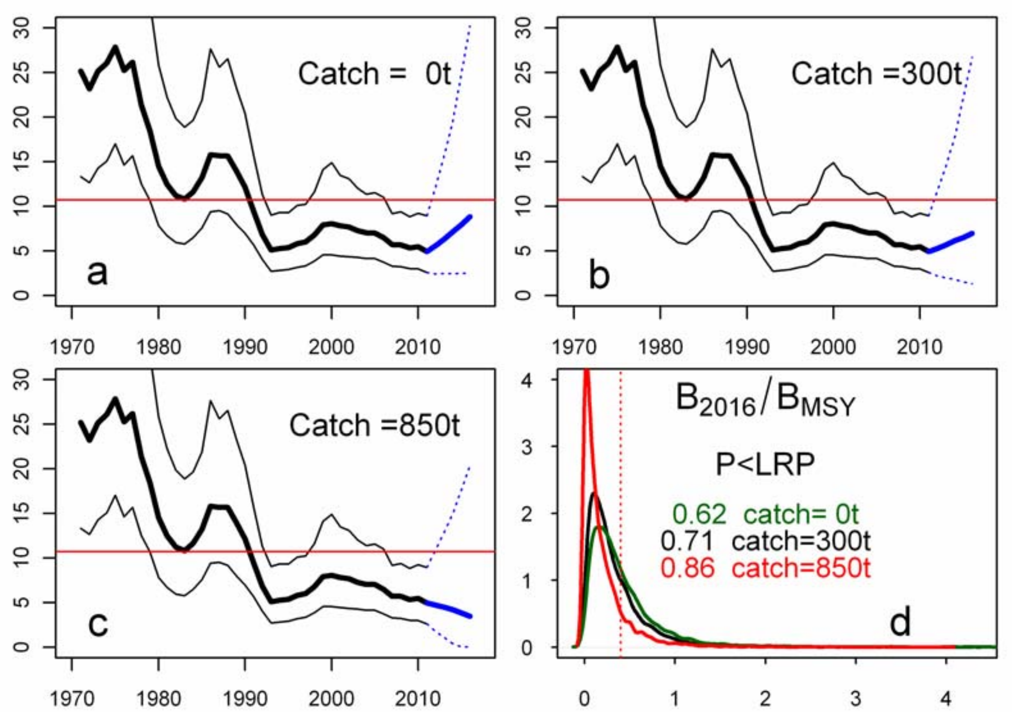


Figure 16. Projected 30+cm biomass (X 1000 t) of 4RST witch flounder at catch levels in 2012-2016 of 0 t (panel a), 300 t (panel b) and 850 t (panel c) and estimated biomass in 2016 as a proportion of B_{MSY} (panel d). In panels a-c, heavy lines are median estimates and light lines the 2.5th and 97.5th percentiles; blue lines are projected estimates. Red horizontal (a-c) or vertical (d) lines show the LRP.

Sources of uncertainty

For the research vessels (RV), fishing efficiency for witch flounder varies substantially between day and night. Efficiencies also vary among the vessels and gears used to conduct the summer and fall research surveys. Adjustments have been made for these changes in fishing efficiency using calibration factors estimated from comparative fishing experiments. However, there is uncertainty around these estimated factors.

The sentinel index shows a stronger decline in 30+ cm biomass over the 2003-2011 period than does the RV index. The reasons for this difference are unknown, though lower catchability of small flounder to the sentinel index and differences in spatial coverage may contribute to this difference. The estuary portion of the Gulf of St. Lawrence, west of about 67°W, is not covered in the sentinel index, an area where RV catch rates are often high.

The inclusion of the 4T index in the model assumes that there is no time trend in the proportion of the stock occurring in the 4T September survey area over the 1971 to 1992 period. Information on geographic distribution and changes in stock abundance in the 1970s and 1980s are consistent with this assumption, but its validity remains uncertain. Excluding this index results in a more severe decline in estimated biomass between 1961 and 2011.

There is no information on growth and age-at-maturation that is more recent than the early 1980s. Thus the extent to which the decline in size at maturation since the early 1980s reflects a response to high mortality versus an effect of slower growth is uncertain. Likewise, it is uncertain whether a decline in growth explains some of the observed loss of 40+ cm fish from the population.

The Schaefer production models do not provide support for changes in productivity regime for this stock. However, in these models, the intrinsic rate of population increase integrates recruitment, growth and natural mortality. Thus, it is possible that there have been counter-acting changes between the components of productivity. For example, a decline in growth rate or an increase in natural mortality rate could be obscured in the modeling by an increase in recruitment rate.

Stock structure is a source of uncertainty for this resource. It is possible that the dynamics of witch flounder in the Gulf, particularly those in eastern 4T, are linked to those of witch flounder in NAFO Div. 4VW.

CONCLUSIONS AND ADVICE

Witch flounder are characterized by slow growth and late maturation. Because of these life-history characteristics, they are vulnerable to overexploitation. The size composition of the 4RST witch flounder stock has undergone a severe contraction over the past 40 years. In the 1970s and early 1980s, fish 40 cm and longer dominated the commercial catch as well as the RV survey catch in 4T (the only area with survey indices prior to 1987). In contrast, this size group comprised only 10% of the landings in 2011 and 14% of the 4T RV catches in the 2000s. Despite strong recruitment in the 1990s and 2000s, no increase in the abundance of 40+ cm fish has been observed. This is consistent with high mortality at commercial sizes.

The RV index of biomass at commercial sizes (30+ cm), available only since 1987, declined sharply in the early 1990s and has shown little increase since then despite annual landings less than 1,000 t. Over the longer term, population models indicate a 90% decline in commercial biomass since 1961 when, shortly after the start of directed fishing for witch flounder, biomass was estimated to have been near carrying capacity.

The limit reference point (LRP) for this stock is estimated to be 10,700 t of 30+ cm biomass. The median estimate of 30+ cm biomass in 2011 is 5,000 t, about half of the LRP. The probability that 30+ cm biomass is below the LRP in 2011 is estimated to be 93%. Below the LRP, there is a high probability that a stock has suffered serious harm due to impaired productivity (DFO 2009). Based on 5-year projections, median estimates of 30+ cm biomass are expected to increase with annual catches of 300 t and decrease with catches of 850 t or more. However, despite high uncertainty in projected biomass, the probability that biomass will remain below the LRP in five years is 62% even with no catch.

A number of strong year-classes have appeared in the RV survey length frequency distributions in the 1990s and 2000s. These year-classes have not resulted in a rebuilding of biomass at lengths greater than 40 cm, because fishery catches are unsustainable at the current low stock level. Another strong year-class, evident in the 2009-2011 survey data, is now approaching commercial sizes. Protecting this year-class by keeping catches as low as possible for the next decade may promote rebuilding of the 40+ cm size group.

SOURCES OF INFORMATION

This Science Advisory Report is from the regional peer review meeting of February 22, 2012 on the Assessment of stock status of witch flounder (*Glyptocephalus cynoglossus*) from the Gulf of St. Lawrence, NAFO Divisions 4RST. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Bowering, W.R., and W.B. Brodie. 1984. Distribution of witch flounder in the northern Gulf of St. Lawrence and changes in its growth and maturity patterns. North Am. J. Fish. Manag. 4: 399-413.

DFO. 2006. A harvest strategy compliant with the precautionary approach. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/023.

DFO, 2007. Stock assessment of witch flounder in the Gulf of St. Lawrence (NAFO Div. 4RST). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/004.

DFO. 2009. A fishery decision-making framework incorporating the Precautionary Approach. http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm (2009-03-23).

Swain, D.P., and R.B. Morin. 2006. Status of witch flounder in NAFO Divisions 4RST, February 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/005.

FOR MORE INFORMATION

Contact: Doug Swain
Fisheries & Oceans Canada
Gulf Fisheries Centre
P.O. Box 5030, Moncton
New Brunswick, E1C 9B6
Tel: (506) 851 6237
Fax: (506) 851 2620
E-Mail: doug.swain@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Gulf Region
Fisheries and Oceans Canada
P.O. Box 5030
Moncton, NB
E1C 9B6

Telephone: 506 851 6253
Fax: 506 851 2620
E-Mail: csas-sccs@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2012. Assessment of witch flounder (*Glyptocephalus cynoglossus*) in the Gulf of St. Lawrence (NAFO Div. 4RST). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/017.