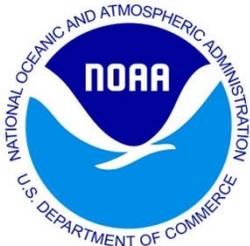# Northeast Multispecies Fishery Management Plan Resource Guide: Witch Flounder (Glyptocephalus cynoglossus)
Bibliography

Hope Shinn, Librarian, NOAA Central Library

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
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Table of Contents

Background & Scope

The Northeast Multispecies Fishery Management Plan (FMP) was implemented in 1986 to reduce fishing mortality of heavily fished groundfish stocks and to promote rebuilding to sustainable biomass levels. Thirteen species are managed through plan amendments and framework adjustments to the original plan, including: Atlantic cod, haddock, yellowtail flounder, American plaice, witch flounder (grey sole), winter flounder (black back), Acadian redfish, white hake, Pollock, windowpane flounder, ocean pout, Atlantic halibut, and the Atlantic wolffish. This bibliography focuses on witch flounder, and is intended as a primer and reference resource for staff of the National Marine Fisheries Service, Greater Atlantic Regional Fisheries office. It is organized into four sections: Biology (life history), Ecology (interaction with the environment), Fisheries, and Management.

Section I – Biology

Section one is intended to provide an overview of the life history of witch flounder. The research in this area is a compilation of basic facts including diet, lifespan and habitat as well as current research on witch flounder biology.

Section II – Ecology

Section two is intended to provide an overview of how witch flounder interacts with the environment. The citations in this area focus on how temperature, food resources, and other environmental factors impact witch flounder.

Section III – Fisheries

Section three is intended to provide an overview of the witch flounder fishery. It covers reports on fish stock status over the last fifteen years. This section also includes one older source covering the history of flatfish fisheries on the Scotian Shelf.

Section IV – Management

Section four is intended to provide an overview of the management of witch flounder. It includes news articles and research concerning plans and policies intended to protect witch and other flounder stocks.

Sources Reviewed

Along with a web search for news items and other relevant materials the following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded, LexisAdvance, ProQuest's Science and Technology, and JSTOR. Only English language materials were included. There was no date range specification in order to cover any relevant research, although priority was given to publication in the last twenty years.

Section I: Biology
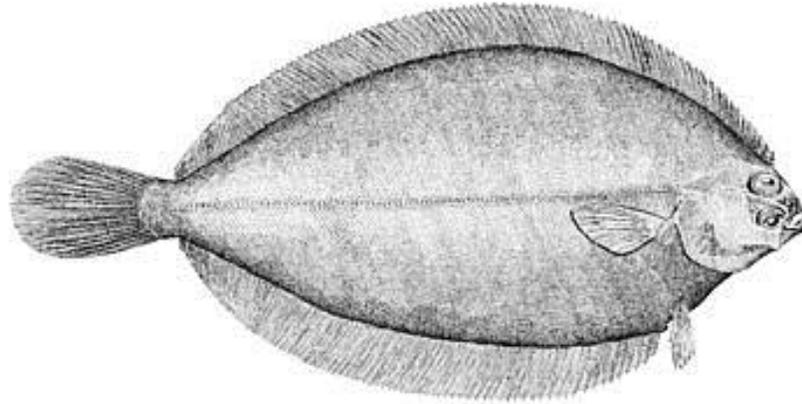
Also known as: Grey sole.

Region: Witch flounder are found in the Atlantic from Cape Hatteras, North Carolina, to Labrador, Canada. In United States waters, they are most common in the Gulf of Maine off Cape Ann, Massachusetts, and tend to be found in the deeper parts of the Gulf.

Habitat: The witch flounder is a deep water fish inhabiting depths down to approximately 1500 m. Most are caught between 110 and 275 m and prefer mud or sandy-mud bottoms.

Size: Adults may be up to 78 cm with an average length of 30-51 cm. They may weigh up to 2 kg.

Physical Description: Witch flounder are a flatfish with both eyes on the right side of the body, and the mouth points to the right.

Lifespan: Witch flounder are a slow-growing, late-maturing fish. They may live up to 30 years. Females reach maturity later than males, at 5-6 years. Spawning occurs in late spring and summer.

Diet: Most witch flounder eat polychaetes, which may be 70% of their diet, as well as crustaceans, echinoderms, and mollusks. In Southern New England, witch flounder may also eat squid.
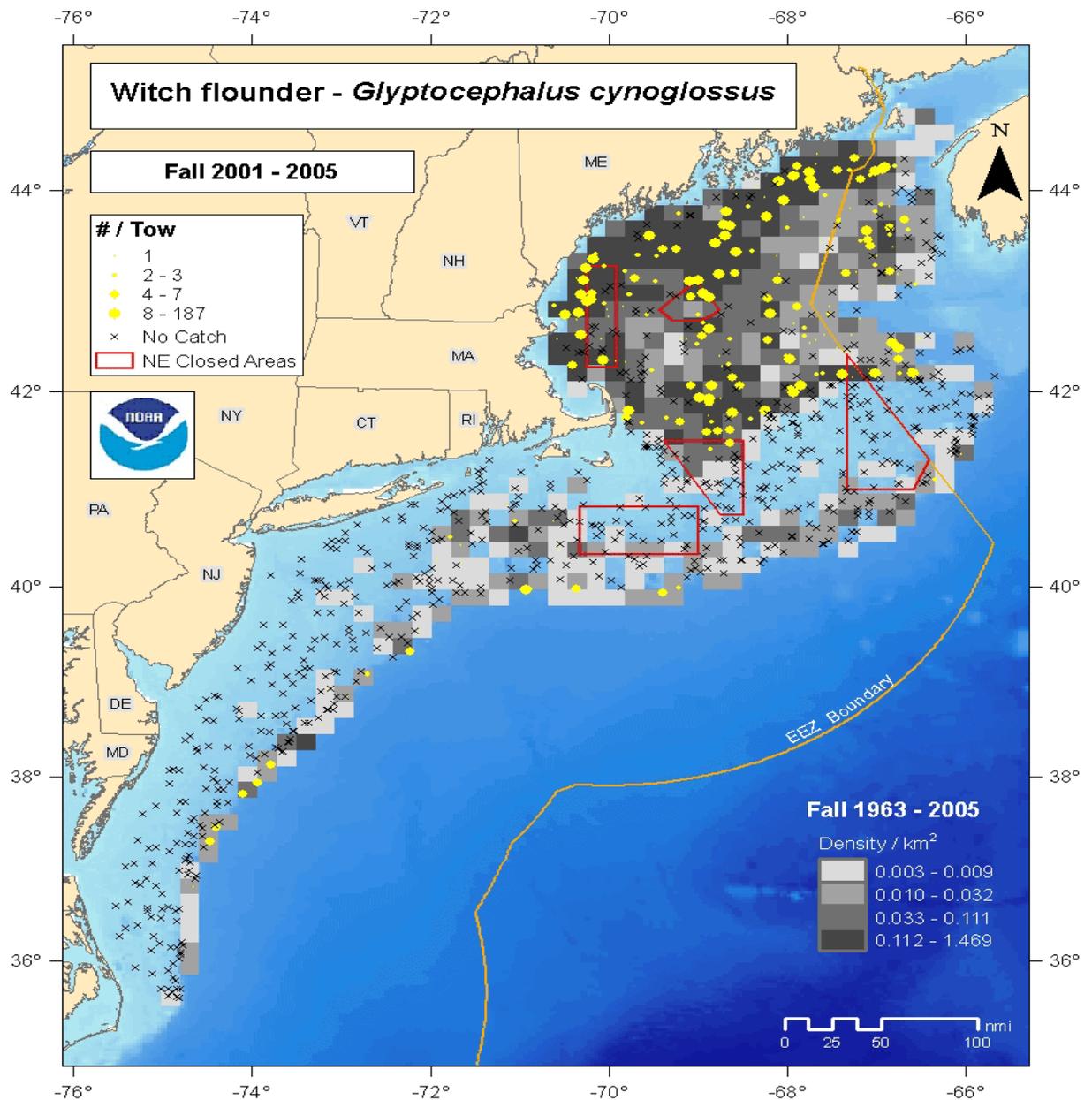
Relative species abundance and distribution from NEFSC bottom trawl survey by time block and relative species density for the full time series.

Image from Wigley, S. and L. Col (2006, December 2006). "Witch Flounder - Status of Fishery Resources off the Northeastern US." Retrieved from https://www.nefsc.noaa.gov/sos/spsyn/fldrs/witch/.

Bidwell, D. A. and W. H. Howell (2001). "The Effect of Temperature on First Feeding, Growth, and Survival of Larval Witch Flounder Glyptocephalus cynoglossus." *Journal of the World Aquaculture Society* 32(4): 373-384.
http://dx.doi.org/10.1111/j.1749-7345.2001.tb00463.x

Witch flounder Glyptocephalus cynoglossus has recently been identified as a candidate species for aquaculture in the northeastern United States and the Canadian Atlantic Provinces. This study investigated the optimal temperatures for witch flounder larval first feeding and for long term larval culture from hatching through metamorphosis. Maximum first feeding occurred between 15.0 and 16.2 C. Larvae did not survive beyond first feeding when reared at mean temperatures of 5.1, 10.4, or 19.5 C and were unable to initiate feeding at mean rearing temperatures below 6.0 C. At a rearing temperature of 15.0 C in 16-L tanks, mean larval survival to 60 days post hatch (dph) was 14.1%. Mean overall length-specific growth rate for larvae reared to 60 dph at 15.0 C was 3.5%/d and mean absolute growth was 0.62 mm/d. Subsequent larval growth at 15.6 C began to taper off towards 70 dph at the onset of weaning which overlapped with larval metamorphosis. Growth plateaued at 85 dph, followed by a rebound between 90 and 95 dph. Survival was 100% when weaning onto a dry, pelleted diet was initiated at 70 dph with a 10-d live diet co-feeding period. These results are favorable and encourage the further pursuit of commercial witch flounder culture.

Wigley, S. E., et al. (2001). "Preliminary estimates of biological and yield characteristics of deep-water witch flounder (Glyptocephalus cynoglossus) in the Georges Bank - southern New England Region." NAFO Scientific Council Research Document 01(114): 17. Retrieved from
https://archive.nafo.int/open/sc/2001/scr01-114.pdf

The existence of a deep-water (greater than 366 meters) resource of witch flounder (Glyptocephalus cynoglossus) along the northeastern U.S. continental slope and adjacent abyssal plain is suggested by several lines of evidence including: 1)egg and larval distribution patterns; 2) by-catch rates in deep-water surveys for red crab (Chaceon quinquedens) and monkfish (Lophius americanus); and 3) various special deep-water studies conducted as far south as Virginia. Nothing is known regarding the abundance, biology, and production rates of these fish nor their affiliation to witch flounder in shallower shelf waters. Recent opportunistic sampling at depths ranging from 367-914 meters has provided a limited number of samples for the preliminary estimation of growth and maturation rates. When compared to witch flounder of the shallower regions of the Gulf of Maine and Georges Bank, growth rates for deep-water fish are considerably lower and maturation occurs at an older age. Production rates (yield per recruit) are calculated for deep-water witch flounder and compared with those for the exploited Gulf of Maine resource (NAFO Division 5Y). Implications for the management of a potential future fishery for currently unexploited deep-water witch flounder are discussed.

Cargnelli, L. M., et al. (1999). *Essential Fish Habitat Source Document: Witch Flounder, Glyptocephalus cynoglossus, Life History and Habitat Characteristics.* Department of Commerce. Woods Hole, Massachusetts, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Retrieved from
https://www.nefsc.noaa.gov/nefsc/publications/tm/tm139/

The witch flounder, Glyptocephalus cynoglossus, is a right-eyed, small-mouthed flounder of the family Pleuronectidae which occurs on both sides of the Atlantic Ocean. In U.S. waters, it is common throughout the Gulf of Maine and occurs in deeper areas on and adjacent to Georges Bank and along

the continental shelf edge as far south as Cape Hatteras, North Carolina. Witch flounder are managed under the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (NEFMC 1993). This Essential Fish Habitat source document provides information on the life history and habitat requirements of witch flounder inhabiting U.S. waters.

Bowering, W. R. (1978). "Fecundity of Witch Flounder (Glyptocephalus cynoglossus) from St. Pierre Bank and the Grand Bank of Newfoundland." *Journal of the Fisheries Research Board of Canada* 35(9): 1199-1209. https://doi.org/10.1139/f78-191

The fecundity of witch flounder from the Grand Bank and St. Pierre Bank was correlated to length, age and weight. In all cases a log–log fit best described the relationship between fecundity and all three variables. However, variations in fecundity were best described in terms of size rather than age. Significant variations in fecundity occurred between the three areas discussed. Significant differences between samples from different years occurred for the Grand Bank areas but not for St. Pierre Bank. A comparison of witch flounder fecundity for the East and West Atlantic indicated that the rate of egg production is generally the same in both areas but the number of eggs produced at each length group in East Atlantic witch flounder is higher than those in West Atlantic.

Burnett, J., et al. (1992). "Several Biological Aspects of the Witch Flounder." *Journal of Northwest Atlantic Fishery Science* 12: 15-25. Retrieved from http://journal.nafo.int/Volumes/Articles/ID/162/Several-Biological-Aspects-of-the-Witch-Flounder-Glyptocephalus-cynoglossus-L-in-the-Gulf-of-Maine-Georges-Bank-Region

Witch flounder (Glyptocephalus cynoglossus) collected in the Gulf of Maine-Georges Bank region during Northeast Fisheries Center bottom trawl surveys in 1980-83 were used to describe growth, length-weight relationships, fecundity, maturation, spawning and distribution. Size-at-age data provided the following von Bertalanffy growth parameters: Linf = 58.05 cm (total length), K = 0.15 and to = -0.01 for males, and 61.99 cm, 0.15, and 0.05, for females. Median length at maturity, estimated from probit analysis, was 27.6 cm for males and 33.5 cm for females. Estimates of fecundity, ranging from 48 800 eggs for a 31 cm fish to 508 300 eggs for a 60 cm fish, were comparable to those for fish from Canadian waters. Two areas of concentrated spawning activity in the western and northern portions of the Gulf of Maine were identified. Juvenile and adult witch flounder appeared to be segregated by depth, but the relative position of the life stages with respect to depth varied seasonally.

Section II: Ecology

Methratta, E. T. and J. S. Link (2006). "Associations between surficial sediments and groundfish distributions in the Gulf of Maine-Georges Bank region." *North American Journal of Fisheries Management* 26(2): 473-489. https://doi.org/10.1577/m05-041.1

The delineation of essential fish habitat is an important element of contemporary fisheries management. Although local-scale species-habitat relationships have been established for some managed species, we lack an understanding of these associations at the synoptic spatial scales on which fish populations and their associated fisheries operate. Interest in habitat delineations has been elevated further by an increased awareness of ongoing habitat degradation caused by mobile fishing gears and by the advancement of spatial management tools. Here we examine the associations between surficial sediment grain size and groundfish distributions in the Gulf of

Maine-Georges Bank region. The mean abundances for 58 demersal fish species were determined for a spatial cell grid (185.2 km(2) per cell), which was subsequently joined to a spatially referenced sediment database in a geographical information systems environment. Multivariate statistical methods were then used to examine how fish distribution and abundance varied with substrate grain size. Of the 58 species examined, 12 were consistently associated with particular substrate types. Atlantic cod Gadus morhua, longhorn sculpin Myoxocephalus octodecemspinosus, sea raven Hemitripterus americanus, and winter flounder Pseudopleuronectes americanus were consistently abundant in large-grained substrate types, whereas white hake Urophycis tennis, goosefish Lophius americanus, red hake U. chuss, silver hake Merluccius bilinearis, witch flounder Glyptocephalus cynoglossus, and American plaice Hippoglossoides platessoides were consistently abundant in fine-grained substrates. Little skate Leucoraja erinacea was most abundant in sediments of intermediate grain size. Although broadly distributed, spring dogfish Squalus acanthias consistently distinguished assemblages in fine-grained sediments. Given that we were able to detect even weak associations and that these relationships were consistent with local-scale studies, we recommend using these relationships to further refine essential fish habitat and that they be given more weight in this and similar temperate ecosystems.

Brodziak, J. and L. O'Brien (2005). "Do environmental factors affect recruits per spawner anomalies of New England groundfish?" *ICES Journal of Marine Science* 62(7): 1394-1407. https://doi.org/10.1016/j.icesjms.2005.04.019

We evaluated the influence of environmental factors on recruits per spawner (RS) anomalies of 12 New England groundfish stocks. Nonparametric methods were used to analyse time-series of RS anomalies derived from stock-recruitment data in recent assessments. The 12 stocks occur in three geographic regions: the Gulf of Maine (cod Gadus morhua, redfish Sebastes fasciatus, winter flounder Pseudopleuronectes americanus, American plaice Hippoglossoides platessoides, witch flounder Glyptocephalus cynoglossus, and yellowtail flounder Limanda ferruginea), Georges Bank (cod. haddock Melanogrammus aeglefinus, and yellowtail flounder), and Southern New England (summer flounder Paralichthys dentatus, yellowtail flounder, and winter flounder). Randomization tests were applied to detect years when RS anomalies were unusually high or low for comparison with oceanographic conditions such as the 1998 intrusion of Labrador Subarctic Slope water into the Gulf of Maine region. Randomization methods were also used to evaluate the central tendency and dispersion of all RS anomalies across stocks. Average RS anomalies were significantly positive in 1987 across stocks and regions, indicating that environmental forcing was coherent and exceptional in that year. Responses of RS values of individual stocks to lagged and contemporaneous environmental variables such as the North Atlantic Oscillation (NAO) index, water temperature, windstress, and shelf water volume anomalies were evaluated using generalized additive models. Overall, the NAO forward-lagged by 2 years had the largest impact on RS anomalies, This apparent effect is notable because it could provide a leading indicator of RS anomalies for some commercially exploited stocks. In particular, the three primary groundfish stocks on Georges Bank (cod, haddock, and yellowtail flounder) all exhibited positive RS anomalies when the NAO(2) variable was positive.

Rabe, J. and J. A. Brown (2001). "The behavior, growth, and survival of witch flounder (Glyptocephalus cynoglossus) larvae in relation to prey availability: adaptations to an extended larval period." *Fishery Bulletin* 99(3): 465-474. Retrieved from http://fishbull.noaa.gov/993/rab.pdf

Foraging behavior and prey abundance are significant factors determining the survival success of fish during the larval stage. Witch flounder (Glyptocephalus cynoglossus) are reported to have the longest pelagic stage of any northwest Atlantic flatfish. We used laboratory experiments to investigate the behavior and performance of witch larvae in relation to prey availability during this important life history stage. In one experiment, larvae were reared at a range of prey densities (2000, 4000, and 8000 prey per liter) and their growth and survival were monitored for 12 weeks after hatching. In a second experiment the foraging behavior of larvae was recorded during feeding trials at a range of prey densities (250, 500, 1000, 2000, 4000, 8000, and 16,000 prey per liter) during weeks 2-8 after hatching. The larval search strategy for prey appeared to change from one that was saltatory to one that was cruising, and the foraging behavior was not strongly affected by variation in prey availability. The growth rate was rapid (0.53 mm-d) and was unaffected by changes in prey density as was survival. Witch flounder larvae likely have low prey requirements compared with yellowtail flounder and Atlantic cod reared under similar laboratory conditions The ability to forage effectively when prey is abundant or scarce and the low prey requirements of this species may be an adaptive response to the extended larval period.

Sulak, K. J. and S. W. Ross (1996). "Lilliputian bottom fish fauna of the Hatteras upper middle continental slope." *Journal of Fish Biology* 49: 91-113. https://doi.org/10.1111/j.1095-8649.1996.tb06069.x

Submersible data from two areas along the Carolina-Virginia continental slope reveal a Hatteras upper middle slope (HMS) (35 degrees 30' N, 74 degrees 50' W) demersal fish fauna remarkable for diminutive size of individuals within and across species, a fauna which is accordingly termed 'Lilliputian'. Contrast of HMS submersible data with Virginia trawl and submersible data support this finding. The four top-ranking HMS fishes, Lycenchelys verrillii, Glyptocephalus cynoglossus, Myxine glutinosa and Nezumia bairdii, are all significantly smaller than on the Virginia upper middle slope. Also peculiar to the HMS is the dominance of sedentary benthic species, rarity of active benthopelagic foragers, and markedly elevated fish population density. Species composition of the HMS fauna differs from that of the general Middle Atlantic Eight Fauna; notably absent are species of otherwise continuous distribution along the U.S. East Coast (e.g. Synaphobranchus affinis, Nezumia aequalis). Since HMS megafaunal and macrofaunal invertebrate communities are also anomalous, the Lilliputian phenomenon among HMS bottom fishes provides a characteristic biotic signature of a pervasively re-structured benthic boundary layer community. The authors hypothesize that the HMS faunal anomaly reflects a limiting factor, episodic sediment surface hypoxia, peculiar to this region of high particulate organic carbon flux from surface waters. Results indicate that substantial changes in fish faunal composition and structure can occur on a small geographic scale on the open soft-substrate continental slope.

Markle, D. F. (1975). "Young Witch Flounder, Glyptocephalus cynoglossus, on the Slope off Virginia." *Journal of the Fisheries Research Board of Canada* 32(8): 1447-1450. https://doi.org/10.1139/f75-166

Young witch flounder, Glyptocephalus cynoglossus, 11–25cm TL, are abundant on the continental slope off Virginia. The Virginian slope may be a major nursery area for 1- to 3- or 4-yr-old witch flounder spawned by one or more northern stocks. Shelf water circulation patterns are considered as a possible mechanism for the passive dispersal of larvae.

Section III: Fisheries

Northeast Fisheries Service Center (2017). 62nd Northeast Regional Stock Assessment Workshop (62nd SAW) Assessment Report. Woods Hole, MA, NOAA Fisheries Service. Retrieved from https://www.nefsc.noaa.gov/publications/crd/crd1703/

This assessment of witch flounder in the Gulf of Maine-Georges Bank region and southward presents a benchmark analytical assessment for the 1982-2015 period, estimates 2015 fishing mortality and spawning stock biomass for stock status, updates biological reference points, and provides short-term projections of median catch corresponding to the Overfishing Limit (OFL) for 2017-2019.

Hare, J., et al. (2016). "Empirical estimates of maximum catchability of Witch Flounder Glyptocaphalus cynoglossus L. on the Northeast Fisheries Science Center Fall bottom trawl survey." Witch Flounder Working Group Working Paper, Northeast Fisheries Science Center. Retrieved from https://www.nefsc.noaa.gov/groundfish/operational-assessments-2017/working-papers/sweep-study-working-paper.pdf

For fisheries research surveys the catchability coefficient (q) defines the relationship between a survey index and population size. Typically, catchability is estimated within a stock assessment model. However, in any situations an empirical estimate of survey gear catchability can provide important information to scale population size during an assessment. We used a gear comparison study with a twin trawler to develop an estimate of maximum catchability of Witch Flounder on the Northeast Fisheries Science Center bottom trawl survey. On average, catch rates in the experimental chain sweep gear were about 4-fold the catch rates of the rockhopper sweep gear used on the standard survey. Both day:night differences and length-specific differences were evident in relative catch efficiencies of the two sweeps. Two separate analytical techniques (betabinomial models & bootstrapping) provided very similar results, indicating that on a relative scale, the chain sweep was more efficient than the rockhopper sweep during daylight hours and at catching small individuals. Age-specific maximum catchability for the rockhopper survey gear was developed on the assumption of 100% efficiency of the chain sweep between the wings. An asymptote of maximum catchability for the NEFSC survey was reached at age 7 and at a value of 0.291 if survey data is entered into a stock assessment model as Bigelow swept area biomass or 0.056 if entered as Albatross swept area biomass.

Beutel, D., et al. (2008). "Bycatch reduction in the Northeast USA directed haddock bottom trawl fishery." *Fisheries Research* 94(2): 190-198. https://doi.org/10.1016/j.fishres.2008.08.008

We investigated the performance of a large mesh faced (upper and lower wings, side panels, first bottom belly) bottom trawl designed to capture haddock (Melanogrammus aeglefinus) while reducing the bycatch of cod (Gadus morhua) and other species. This experimental net, named the Eliminator Trawl (TM), was tested using two vessels, F/V Iron Horse and F/V Sea Breeze, in side-by-side catch comparison hauls with the currently regulated net. A total of 100 successful comparison tows were completed. All species captured were weighed for total weight. Haddock, cod, and the majority of the flounders were measured. The Eliminator Trawl (TM) significantly reduced the catch of stocks of concern including cod, yellowtail flounder (Limanda ferruginea), winter flounder (Pseudopleuronectes americanus), witch flounder (Glyptocephalus cynoglossus), and American plaice (Hippoglossoides platessoides). Other species such as monkfish (Lophius

americanus) and skate (unclassified) also showed a significant decrease in catch in the Eliminator Trawl (TM). In addition, the catch of haddock, the target species, did not differ significantly between nets. The results of this study indicate that the Eliminator Trawl (TM) would be an efficient tool in gaining access to closed areas and used in recovery programs to exploit more abundant fish species. Examples in the Northeast USA include a B Days-at-Sea Program (DAS) as well as a Special Access Program (SAP) where the Eliminator Trawl (TM) appears to meet the minimum bycatch requirements to be considered for both these programs.

Wigley, S. and L. Col (2006, December 2006). "Witch Flounder - Status of Fishery Resources off the Northeastern US." 2018, from https://www.nefsc.noaa.gov/sos/spsyn/fldrs/witch.

Witch flounder spawning stock biomass has increased since the mid-1990s from 3,901 mt in 1996 to 21,175 mt in 2004; the stock is currently slightly below SSBMSY (25,248 mt). Fully recruited fishing mortality declined from 1.1 in 1996 to 0.20 in 2004, indicating that F is at or just below all the F reference points (F0.1 = 0.196; Fmsy = 0.23; Fmax = 0.545). Thus, the stock is not in an overfished condition and overfishing did not occur in 2004.

Wigley, S. E., et al. (2003). A report of the 37th Northeast Regional Stock Assessment Workshop : assessment of the Gulf of Maine and Georges Bank witch flounder stock for 2003. Department of Commerce. Woods Hole, MA. Retrieved from https://repository.library.noaa.gov/view/noaa/5358

The 2003 analytical assessment for witch flounder in USA waters, covering the period 1982-2002, estimates 2002 fishing mortality and spawning stock biomass for stock status, and provides short-term projections of median landings, discards and spawning stock biomass for various fishing mortality scenarios. USA commercial landings increased during the 1960's from 1,200 mt to about 3,000 mt, then fluctuated between 2,000 and 3,000 mt until 1983 through 1985 when landings abruptly increased to about 6,000 mt. Landings subsequently declined to 1,500 mt in 1990. Since the early 1990s, landings have fluctuated between 2,000 and 3,000 mt. In 2002, USA commercial landings totaled 3,186 mt, a 5% increase over 2001; and 117% higher than in 1990, the lowest value since 1964. Research survey indices of abundance and biomass remained fairly stable from 1963 until the late 1970s; autumn indices declined during the early and mid-1980s, reaching record low levels in late 1980s and early 1990s. Abundance sharply increased in 1993 and has continued to increase to near record high levels in 2002; however, the age composition still remains truncated. The VPA indicates that fishing mortality (ages 8-9, unweighted) increased from 0.26 in 1982 to 0.67 in 1985, declined to 0.22 in 1992, increased to 1.13 in 1996, then declined to 0.41 in 2002. Spawning stock biomass declined from 16,897 mt in 1982 to about 3,800 mt in 1996. With recent increases in recruitment and declines in fishing mortality, SSB has increased to 18,296 mt in 2002 . Since 1982 recruitment of age 3 has ranged from approximately 3 million fish (1984 year class) to 67.6 million fish (1997 year class). Over the 1982-2002 period, average recruitment of age 3 fish (the 1979-2000 year classes) was 19.6 million (the geometric mean equaled 14.4 million fish). The 1995-1999 year classes appear to be above average, and the 1997 year class is the largest in the VPA time series. In addition to the VPA, an alternative model, a statistical catch at age model (SCAA) was also conducted. The SCAA generally confirmed trends in the VPA results. The biological reference points were updated by applying the approach used to estimate MSY proxies for witch flounder. Fmsy is approximated as F40% (0.23), the SSBmsy proxy is 25,248 mt, the product of 40%MSP (1.2882 kg spawning biomass) and average long-term recruitment (19.6 million). The MSY proxy is 4,375 mt, the product of yield per recruit at F40% (0.2232 kg) and average

recruitment. Based on the ADAPT VPA, the witch flounder stock was not overfished, but overfishing was occurring in 2002. Fully recruited fishing mortality in 2002 was 0.41, nearly double Fmsy (0.23), and spawning stock biomass was estimated to be 18,296 mt in 2002, 72% of SSBmsy (25,248 mt). Recent year classes appear to be above average. Although the spawning stock biomass has increased, the age structure still remains truncated. Fishing mortality should be reduced to Fmsy or below to allow the age structure to rebuild.

Halliday, R. G. (1973). "The flatfish fisheries of the Scotian Shelf." *ICNAF Redbook* 1973(III): 79-99. Retrieved from https://www.nafo.int/ICNAF/library/docs/1973/res-102.pdf

There are six species of the family Pleuronectides fished commercially on the Scotian Shelf (ICNAF Divisions 4Vn, 4Vs, 4W, 4X) - witch flounder [Glyptocephalus cynoglossus (L.)], American plaice [Hippoglossoides platessoides (Fabricius)], Atlantic halibut [Hippoglossus hippoglossus (L.)], yellowtail flounder [Limanda ferruginea (Storer)], winter flounder [Pseudopleuroneates americanus (Walbaum)], and Greenland halibut [Reinharditus hippoblossoides (Walbaum)]. The Atlantic halibut and its fishery are not considered in this document. The nature of the halibut fishery in SA4, prosecuted mainly by longline, and the high value of the species set it apart from the other flounder species.

Section IV: Management

Chiaramida, A. (2017). Flounder catch limit hike to help local fleet. *The Daily News of Newburyport*. Newburyport, MA. Retrieved from LexisAdvance.

Starting in May, there could be more locally caught flounder available. A recent decision by fishing regulators doubled the permitted catch limit for witch flounder, also known as grey sole. The move is considered a victory for the local inshore dayboat fleet and came at a New England Fishery Management Council meeting held in Portsmouth last week. When adjusted for management uncertainty, the decision will result in a 2017 annual catch limit of 839 metric tons, nearly twice the 2016 annual catch limit of 441 metric tons.

(2016). "Floundering about: a 'compromise' for witch flounder." TalkingFish.org. 2018. Retrieved from https://www.talkingfish.org/2016/newengland-fisheries/floundering-about-a-compromise-for-witch-flounder

NOAA's Greater Atlantic Regional Fisheries Office released Framework Adjustment 55 for public comment this week, which proposes a suite of changes to the Northeast Groundfish Fishery Management Plan, including establishing 2016-2018 annual catch limits for its 20 managed groundfish species. A species at the center of the discussion at the Council level and within Framework 55 is witch flounder.

Wigley, S. E. (1999). "Effects of First-time Spawners on Stock Recruitment Relationships for Two Groundfish Species." *Journal of Northwest Atlantic Fishery Science* 25: 215-218. Retrieved from http://journal.nafo.int/Volumes/Articles/ID/320/Effects-of-First-time-Spawners-on-Stock-Recruitment-Relationships-for-Two-Groundfish-Species

Recent experimental studies suggest that first-time spawning fish may not be as reproductively fit as repeat spawners. Traditional stock-recruitment models consider all mature fish as equivalent contributors to the spawning stock biomass. In this study we examine the effects of discounting first-time spawners on the stock-recruitment relationship of two species with varying life histories: Georges Bank haddock (Melanogrammus aeglefinus), a fast maturing gadoid, and Gulf of Maine witch flounder (Glyptocephalus cynoglossus), a slow maturing pleuronectid. Proportions of first-time spawning haddock ranged from 3 to 62 percent of the spawning stock biomass during 1963-96. Exclusion of all first-time spawners from spawning stock biomass improved the Ricker stock-recruitment relationship by 39 percent. For witch flounder, proportions of first-time spawners were less variable, never exceeding about 30 percent. Adjusting the spawning stock biomass for first-time spawners did not improved the overall relationship for witch flounder.

Fairbairn, D. J. (1981). "Which Witch is Which? A Study of the Stock Structure of Witch Flounder (Glyptocephalus cynoglossus) in the Newfoundland Region." Canadian Journal of Fisheries and Aquatic Sciences 38(7): 782-794. http://doi.org/10.1139/f81-107

Genetic variability at two protein loci (phosphoglucomutase and superoxide dismutase) was assessed both within and among three major management areas for witch flounder (Glyptocephalus cynoglossus) in the Newfoundland region. The genetic analysis revealed population subdivision within each of the major management areas, giving a total of six subpopulations or stocks. These genetically defined stocks also differed with respect to population structure, time of spawning, individual growth rate, and temperature and depth of capture. These results suggest that witch flounder in the Newfoundland region exist in relatively small, independent subpopulations with little inter-stock migration. This population structure is at odds with current practices of managing witch flounder as large homogeneous stock units.