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Northeast Multispecies Fishery Management Plan Resource Guide: Pollock (Pollachius virens)

Bibliography

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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 pollock 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), Fishery, and Management.

Section I - Biology

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

Section II – Ecology

Section two is intended to provide an overview of how pollock interacts with the environment. The citations in this area focus on how temperature, food resources, open ocean aquaculture, and parasites affect wild pollock.

Section III – Fishery

Section three is intended to provide an overview of the pollock fishery. It is divided into two sections: Modern and Historical. The Modern section contains both policy documents and scientific publications about the current state of the pollock fishery. The Historical section contains statistics on global capture production for pollock from 1950 to 2014.

Section IV – Management

Section four is intended to provide an overview of the management of the pollock. It includes research concerning plans and policies intended to protect and maintain the pollock population.

Sources Reviewed

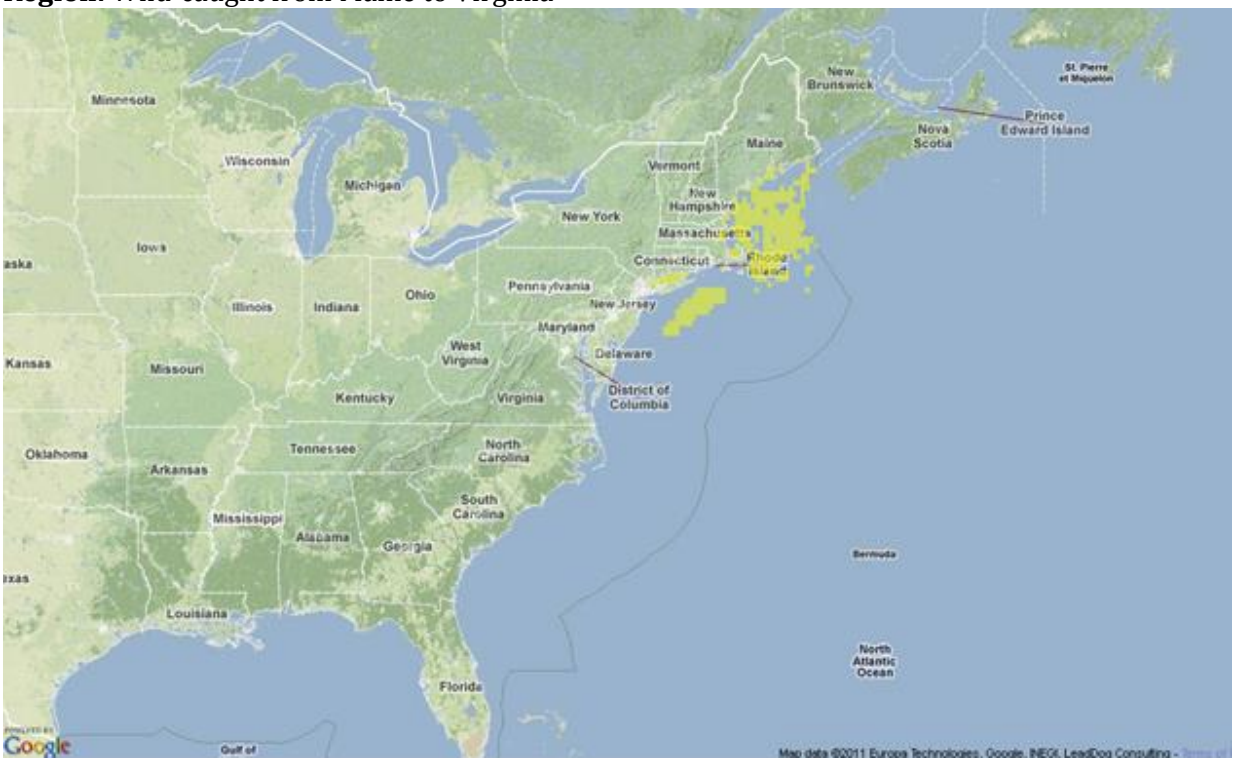
Along with a web search for news items and other relevant materials the following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded, ProQuest Earth Atmospheric & Aquatic Science Database, ScienceDirect, and JSTOR. Only English language materials were included. Only English language materials were included and there was no date range specification.

Section I: Biology

Image from http://www.fishwatch.gov/profiles/atlantic-pollock

Also known as: Saithe, Coalfish, Coely, Green cod, Boston bluefish

Region: Wild-caught from Maine to Virginia



https://www.fishwatch.gov/profiles/atlantic-pollock

Habitat: Pollock eggs and larvae are found in the water column. Juveniles are found inshore and move offshore as they grow older. When in inshore waters, juvenile Pollock school in the open water at low tide, then scatter at high tide and hide in intertidal seaweed beds Adults live offshore near the ocean floor over a wide variety of ocean bottom habitats including sand, mud, rocks, and vegetation. Atlantic pollock swim in schools and are believed to travel extensively between the

Scotian Shelf and Georges Bank and, to a lesser extent, between the Scotian Shelf and the Gulf of Maine

Size: over 3.5 feet long and 35 pounds when fully grown

Physical Description: Atlantic pollock are brownish-green on the back and slightly pale on the belly. They have a small chin barbel, like the whiskers on a catfish. They are a member of the cod family but can be distinguished by their greenish hue and darker flesh

Lifespan: Up to 23 years

Diet: Smaller pollock in inshore waters feed on small crustaceans and small fish. Larger pollock mainly prey on fish.

Source: NOAA. (10/25/2017). FishWatch U.S. seafood facts: Atlantic Pollack. Retrieved from https://www.fishwatch.gov/profiles/atlantic-pollock

Homrum, E. Í., Hansen, B., Steingrund, P., & Hátún, H. (2012). Growth, maturation, diet and distribution of saithe (Pollachius virens) in Faroese waters (NE Atlantic). Marine Biology Research, 8(3), 246-254. https://doi.org/10.1080/17451000.2011.627921

Saithe (Pollachius virens) in Faroese waters is a stock that is very important for the Faroese economy. Previous studies have provided information on juvenile saithe, but only sporadic information on the general biology of adult saithe is available in the published literature. Here, we present the basic biology of Faroe saithe based on data from Faroese groundfish surveys. Spawning appears presently to occur earlier in the year than in the early twentieth century, and the main spawning seems to occur on the eastern part of the Faroe Plateau. There is a gradual movement of saithe into deeper water with increasing size, which may well reflect a shift in diet with age. Together with changes associated with maturation, this may explain the change observed in the growth pattern around the age of 4 years.

Bolle, L. J., Rijnsdorp, A. D., van Neer, W., Millner, R. S., van Leeuwen, P. I., Ervynck, A. . . . Ongenae, E. (2004). Growth changes in plaice, cod, haddock and saithe in the North Sea: a comparison of (post-) medieval and present-day growth rates based on otolith measurements. *Journal of Sea Research, 51*(3), 313-328. https://doi.org/10.1016/j.seares.2004.01.001

Fishing effort has strongly increased in the North Sea since the mid-19th century, causing a substantial reduction in the population size of exploited fish stocks. As fisheries research has developed simultaneously with the industrialisation of the fisheries, our knowledge of population dynamics at low levels of exploitations is limited. Otoliths retrieved from archaeological excavations offer a unique opportunity to study growth rates in the past. This study compares historical and present-day growth rates for four commercially important demersal fish species. A total of 2532 modern otoliths (AD 1984–1999) and 1286 historical otoliths (AD 1200–1925) obtained from archaeological excavations in Belgium and Scotland were analysed. Comparison of the growth patterns between eras revealed a major increase in growth rate of haddock, whereas growth changes were not observed in saithe and only in the smaller size classes of plaice and cod. Comparison of our results with literature data indicates that the observed growth rate changes in plaice and cod occurred within the 20th century. Apparently the onset of industrialised fisheries has not greatly affected the growth of plaice, cod and saithe populations in the North Sea.

DFO. (1999). Subdivision 3PS Pollock. *DFO Science Stock Status Report, A2*(07). http://www.dfo-mpo.gc.ca/csas/Csas/status/1999/A2-07e.pdf

Pollock occur on both sides of the North Atlantic, on the North American side from southern Labrador around Newfoundland into the Gulf of St. Lawrence, and south to Cape Hatteras. Pollock is a member of the cod family (Gadidae), but unlike most members spends little time near the bottom. They are voracious eaters and often congregate in large numbers. As pelagic larvae they feed mainly on copepods, but as they settle and move inshore, crustacea, mainly amphipods, are the preferred food. As they increase in size, euphausiids, shrimp and small fish become part of the diet. In the offshore areas sand lance, herring, silver hake, redfish and lanternfish become more important in the diet. Pollock are a cold water fish preferring waters from 0 degree C to 10 degree C, however maturation of sex organs and incubation of eggs requires temperatures in the upper range. This fact places Newfoundland waters at the bottom end of pollock range. Research on pollock in the Newfoundland area shows that mature fish occur along the slopes of St. Pierre Bank and the slopes of the southern Grand Bank. In summer months schools of young pollock are occasionally found in harbours along Newfoundland's south coast. Pollock do not generally occur in Newfoundland waters in sufficient numbers to support a major fishery. Historically warm periods have coincided with higher abundance of pollock in the area. In 1999 survey biomass was estimated at 5 700 metric tons. This estimate is largely the result of two large sets in two strata.

Fortier, L., & Quinonez-Velazquez, C. (1998). Dependence of survival on growth in larval pollock Pollachius virens and haddock Melanogrammus aeglefinus: a field study based on individual hatchdates. *Marine Ecology Progress Series, 174*, 1-12. https://doi.org/10.3354/meps174001

The hatchdate frequency distributions (HFD) of pollock and haddock larvae sampled at monthly intervals west of Sable Island (Scotian Shelf, northwest Atlantic) in 1992 and 1993 were reconstructed for different age intervals (0-20, 21-40, 41-80 d) and corrected for aliasing due to sampling discontinuity and mortality-dispersion. The ratio of the HFD at a given age to the HFD at an earlier age was used as an index of the relative survival of larvae grouped into 5 d hatchdate cohorts. Pollock hatched from November to March and haddock from February to June. In pollock, seasonal variations in relative survival of the cohorts over the 21-40 and 41-80 d age intervals were correlated to strong variations in growth. In haddock, growth varied little over the hatching season and there was no significant Link with survival. For pollock, slow growth invariably resulted in low survival but fast growth resulted in either low or high survival, indicating that fast growth is a necessary but not sufficient condition for survival. Increased predation pressure late in the hatching season of both species could explain the decoupling of growth and survival in cohorts hatched in spring and early summer

Smith, G. W., Glass, C. W., Johnstone, A. D. F., & Mojsiewicz, W. R. (1993). Diurnal patterns in the spatial relationships between saithe, Pollachius virens, schooling in the wild. Journal of Fish Biology, 43, 315-325. https://doi.org/10.1111/j.1095-8649.1993.tb01195.x

Six saithe, length 35 to 43 cm, were tagged with acoustic transmitters and individuals tracked for between 9 and 508 h during May 1989. The tagged fish were members of a schooling group and during the study, pairs of tagged fish were tracked simultaneously for periods ranging from 9 to 139 h. These data have been used to investigate the spatial relationships between individuals schooling in the wild. Distances between individuals showed a distinct diel pattern. Tagged fish were generally closer together

during the day, than either at night or the periods of dawn and dusk. Those circumstances under which pairs of tagged fish could be shown to school together were investigated by analysing the differences in their swimming directions. Schooling was generally evident during the hours of daylight, although the degree to which fish schooled varied between pairs. The degree to which the fish schooled was also dependent upon distance between the tagged individuals. Schooling could be demonstrated for saithe within 20 m of each other during the day and within 10 m in two out of three pairs at night.

Section II: Ecology

Ottera, H., & Skilbrei, O. T. (2014). Possible influence of salmon farming on long-term resident behavior of wild saithe (Pollachius virens L.). Ices Journal of Marine Science, 71(9), 2484-2493. https://doi.org/10.1093/icesjms/fsu096

The culture of Atlantic salmon is one of the most developed aquaculture industries in the world. The production from smolt to market size usually takes place in sea cages in open waters, and these structures tend to attract wild fish, as they do for other farmed species. For salmon farming, saithe (*Pollachius virens*) is one of the most-frequently observed species around sea cages. An important question is whether the large concentration of salmon farms in some areas might alter the natural behaviour and migration pattern of wild saithe. We conclude that the aquaculture industry is influencing the local saithe distribution. Large-scale population effects are more difficult to prove, but it is possible that the dynamic relationship between the coastal and oceanic phases has been altered.

Homrum, E. I., Hansen, B., Jonsson, S. P., Michalsen, K., Burgos, J., Righton, D. . . . Joensen, J. S. (2013). Migration of saithe (Pollachius virens) in the Northeast Atlantic. Ices Journal of Marine Science, 70(4), 782-792. https://doi.org 10.1093/icesjms/fst048

Saithe (Pollachius virens) stocks in the Northeast Atlantic intermingle as a result of migration among stock areas. The extent of migration has been poorly quantified. Here, we estimate measures of the migration based on existing tagging data from Icelandic, Faroese and Continental (Scotland, North Sea and Norway) waters. Saithe tagged in Icelandic waters were seldom caught outside Icelandic waters (, 1% of tag returns), whereas 42% of adult saithe tagged in Faroese waters were recaptured outside Faroese waters. Of adult saithe tagged in Norwegian waters 6.6% were recaptured outside Continental waters. In broad terms, there was a net migration of saithe towards Icelandic waters. The distance between tagging and recapture increased with increasing size and age, with saithe tagged in Norwegian waters moving the longest distances. The results demonstrate significant, but variable, migration rates of adult saithe in the Northeast Atlantic. More detailed studies are needed to clarify the mechanisms behind the migration and what causes the differences among the areas.

Bagdonas, K., Humborstad, O.-B., & Løkkeborg, S. (2012). Capture of wild saithe (Pollachius virens) and cod (Gadus morhua) in the vicinity of salmon farms: Three pot types compared. Fisheries Research, 134-136, 1-5. https://doi.org/10.1016/j.fishres.2012.06.020

Large numbers of wild members of commercially important fish species tend to congregate around fish farms. This effect is in conflict with the interests of fishermen because wild fish cannot be harvested close to fish farms due to the fishery exclusion zone, which is intended to prevent fishing gear from damaging the cages. We studied the potential for harvesting wild fish around a Norwegian salmon farm using three different types of pots. Our video observations showed that large quantities of wild fish, in particular saithe (Pollachius virens), aggregated in close vicinity of the cages. Pots set underneath salmon cages produced 17 times higher catches of saithe and five times higher catches of cod (Gadus

morhua) than pots set at a distance of 100 m from the cages. The pots set underneath cages also caught larger cod. Large rigid pots were shown to be more efficient than smaller flexible pots. The stomach content of small cod was dominated by pellets, while large cod were feeding mainly on saithe. We suggest that dense aggregations of saithe and small cod beneath fish cages were associated with the supply of waste feed, whereas larger cod were attracted by the saithe. We conclude that pots have great potential for harvesting gadoids beneath salmon cages, but catches decline dramatically with the distance from cages.

Tyrrell, M. C., J. S. Link, H. Moustahfid, and B. E. Smith. (2007). The Dynamic Role of Pollock (Pollachius Virens) as a Predator in the Northeast US Continental Shelf Ecosystem: A Multi Decadal Perspective. Journal of Northwest Atlantic Fishery Science, 38, 53-65. http://dx.doi.org/10.2960/J.v38.m605

The Northeast US continental shelf ecosystem has been subject to heavy fishing pressure and other anthropogenic influences that have directly and, through food web interactions, indirectly affected the abundance of fish and invertebrates. The role of pollock (Pollachius virens) as one of the key groundfish predators in this ecosystem has changed accordingly over the last three decades. We utilized a thirty-three year food habits database with over 5500 pollock stomachs to examine relative removal of commercially valuable fish and invertebrate prey by pollock. Pollock diet composition has substantially shifted through time and appears closely tied to the relative availability of prey. Pollock diet shifted from euphausiids, squid and sandlance early in the time series to decapod shrimp, herrings and hakes in recent years. Both small and large size classes of pollock have shown an increased proportion of fish in the diet through time. Pollock has, at times, exerted notable predatory removals on squid, and to a lesser extent, on herring and mackerel. The implications of pollock consumption on prey population dynamics is discussed in light of the recent trend of its increasing biomass.

Carruthers, E. H., Neilson, J. D., Waters, C., & Perley, P. (2005). Long-term changes in the feeding of Pollachius virens on the Scotian Shelf: responses to a dynamic ecosystem. *Journal of Fish Biology, 66*(2), 327-347. https://doi.org10.1111/j.1095-8649.2004.00594.x

The diet and feeding ecology of pollock Pollachius virens from the Scotian Shelf and Bay of Fundy in the north-west Atlantic changed over the last few decades, which was associated with decreases in euphausiid abundance. Stomach contents data for 2078 pollock collected during the 1958-1967 period and for 1230 pollock collected during the 1996-2002 period indicated that pollock diet contained fewer euphausiids and feeding activity decreased. During the early period. euphausiids were present in 65% of the pollock stomachs that contained food and only 9% of these stomachs in the recent period. The decrease of euphausiids was not wholly offset by an increase in piscivory, since there was little increase in the frequency of fish prey in the diet or in the fullness index for this prey type. Empty stomachs were significantly more common in the recent period during both the winter and summer. The decreased occurrence of euphausiids in stomach samples coincided with a significantly decreased abundance of this prey, suggesting that the near-absence of euphausiids in recently collected pollock stomachs reflected prey abundance. Concurrent with changes in diet and feeding intensity, the condition or 'plumpness' of pollock significantly declined from the early to the late sampling periods

McClure, C. A., Hammell, K. L., Dohoo, I. R., & Gagne, N. (2004). Lack of evidence of infectious salmon

anemia virus in pollock Pollachius virens cohabitating with infected farmed Atlantic salmon Salmo salar. *Diseases of Aquatic Organisms, 61*(1-2), 149-152. https://doi.org10.3354/dao061149

The infectious salmon anemia (ISA) virus causes lethargy, anemia, hemorrhage of the internal organs, and death in farmed Atlantic salmon Salmo salar. It has been a cause of disease in Norwegian farmed Atlantic salmon since 1984 and has since been identified in Canada, Scotland, the United States, and the Faroe Islands. Wild fish have been proposed as a viral reservoir because they are capable of close contact with farmed salmon. Laboratory studies have shown that brown trout and sea trout Salmo trutta, rainbow trout Oncorhynchus mykiss, and herring Clupea harengus tested positive for the virus weeks after intra-peritoneal injection of the ISA virus. Pollock Pollachius virens are commonly found in and around salmon cages, and their close association with the salmon makes them an important potential viral reservoir to consider. The objective of this study was to determine the presence or prevalence of ISA virus in pollock cohabitating with ISA-infected farmed Atlantic salmon. Kidney tissue from 93 pollock that were living with ISA-infected salmon in sea cages were tested with reverse transcription-polymerase chain reaction (RT-PCR) test. Results yielded the expected 193 bp product for positive controls, while no product was observed in any of the pollock samples, resulting in an ISA viral prevalence of 0%. This study strengthens the evidence that pollock are unlikely to be an ISA virus reservoir for farmed Atlantic salmon.

Rangeley, R. W., & Kramer, D. L. (1998). Density-Dependent Antipredator Tactics and Habitat Selection in Juvenile Pollock. *Ecology, 79*(3), 943-952. https://doi.org/10.2307/176591

Juvenile pollock (Pollachius virens) school in open water at low tide and disperse in beds of intertidal algae at high tide. The goal of the present study was to determine whether both aggregation and use of algal habitat represent alternative antipredator tactics for pollock, and whether their occurrence depended on the number of fish present and the amount of algal habitat available. We systematically varied fish density and algal availability in large (8-m2) arenas and examined distributions before and after exposure to an avian predator model, a stuffed cormorant (Phalacrocorax auritus). Pollock preferred the algal habitat, and the proportion of fish in the algae increased as the amount of algal habitat increased. When density of fish in the arena increased, the number of fish in the algal habitat increased, but the proportion decreased. Following exposure to the predator model, the proportion of fish in the algae increased. Fish in the open were aggregated most of the time, but there was a trend toward increased aggregation of those fish remaining in the open following exposure to the predator. Thus, the use of two alternative antipredator tactics can produce very dynamic spatial distributions. Because the benefits of aggregations are positively density dependent while those of refuges are likely negatively density dependent, species that use both tactics are likely to show dramatic shifts in habitat distribution with changes in population size and refuge availability.

Shaw, R., & Opitz, M. (1996). Abundance of the Parasitic Copepod Caligus elongatus on Wild Pollock near Commercial Salmonid Net-Pens. *Journal of Aquatic Animal Health, 8*(1), 75-77. https://doi.org/10.1577/1548-8667(1996)008<0075:AOTPCC>2.3.CO;2

Between July and December 1993, wild pollock Pollachius virens collected near salmonid net-pens on the Atlantic coast of Maine in the United States were examined for parasitic copepods of the family Caligidae to determine the role of pollock as host reservoirs. Only Caligus elongatus was

detected on 1,456 pollock sampled. Most pollock (97.39%) had two or fewer sea lice per fish. A maximum prevalence (percent of fish infested) of 50%, an abundance (average number per fish) of 0.9, and an intensity (average number per infested fish) of L79 were recorded. Only one larval C. elongatus was found. No seasonal or geographic trends in infestation statistics were observed.

Section III: Fishery

Modern: Population is above target level, fishing range is at recommended level. The 2016 commercial landings of Atlantic Pollock totaled more than 5.7 million pounds and were valued at $6.5 million. Pollock is growing in popularity with recreational anglers that have traditionally targeted other groundfish like cod and haddock. Fishing occurs year-round, peak landings are from November through January.

Source: NOAA. (10/25/2017). FishWatch U.S. seafood facts: Atlantic Pollack. Retrieved from https://www.fishwatch.gov/profiles/atlantic-pollock

National Marine Fisheries Service. (12/20/17) Federal Recreational Fisheries Regulations for the Greater Atlantic Region. Retrieved from https://www.greateratlantic.fisheries.noaa.gov/sustainable/RecFishing/regs/index.html#ven

As of December 20, 2017 there is no catch limit for pollock 19 inches or larger.

Pol, M. V., Herrmann, B., Rillahan, C., & He, P. (2016). Selectivity and retention of pollock Pollachius virens in a Gulf of Maine trawl fishery. *Fisheries Research, 184*, 47-53. https://doi.org/10.1016/j.fishres.2015.07.029

Measuring the size selectivity of pollock, or saithe, Pollachius virens, has been challenging due to the patchy, elusive nature of the species. By using data collected opportunistically during a redfish Sebastes fasciatus selectivity study, selectivity of three sizes of mesh opening (114, 140 and 165 mm double 5 mm twine diamond) for pollock was determined using a commercial fishing vessel fishing off Provincetown, Massachusetts, USA. Fifty-six tows were completed in March and April 2013; 21 included sufficient catches of pollock to estimate size selectivity. Robust, simple models for the mean L50s (50% selection length) and SR (selection ranges), and confidence intervals, were developed for all three tested codends, incorporating both within and between haul variability. Selection parameters and selection ranges were determined for codends with nominal mesh sizes of 114 mm (L50: 34.8 cm; SR: 2.4 cm), 139 mm (L50: 45.6 cm; SR: 3.1 cm), and 165 mm (L50: 52.4 cm; SR: 3.6 cm). All measures of model validity were positive, indicating robust and reliable findings that can be used to provide guidance to fishery managers, stock assessment scientists, and fishermen on size-dependent retention of pollock by codend mesh size.

Roth, B., & Rotabakk, B. T. (2012). Stress associated with commercial longlining and recreational fishing of saithe (Pollachius virens) and the subsequent effect on blood gases and chemistry. *Fisheries Research, 115-116*, 110-114. https://doi.org/10.1016/j.fishres.2011.05.003

The stress associated with commercial and recreational fishing of saithe (Pollachius virens Linnaeus) was investigated on fish caught with a rod and reel at the pier < 10 s or 4–5 min at 100 m depth and after 6–12 h of soaking on a longline or chased to exhaustion for 15 min. Results show that hooking caused an acute stress reaction accompanied by accumulating blood lactate and pCO2 levels accompanied by the acidification of the muscle. After 6–12 h of soaking, the longlined had a significant increase in blood glucose levels, Na+, K+, hemoglobin content and hematocrit values. During soaking the longlined fish had restored their acid–base balance, having significant higher blood pH and HCO3 − levels, reflecting hyperventilation. Only one case of hypoxia was observed. None of the 767 investigated fish that was hauled onboard had died during soaking. We conclude that angling causes a long and short term stress effect on P. virens, but survival is related to animal capability to restore acid–base balance during soaking.

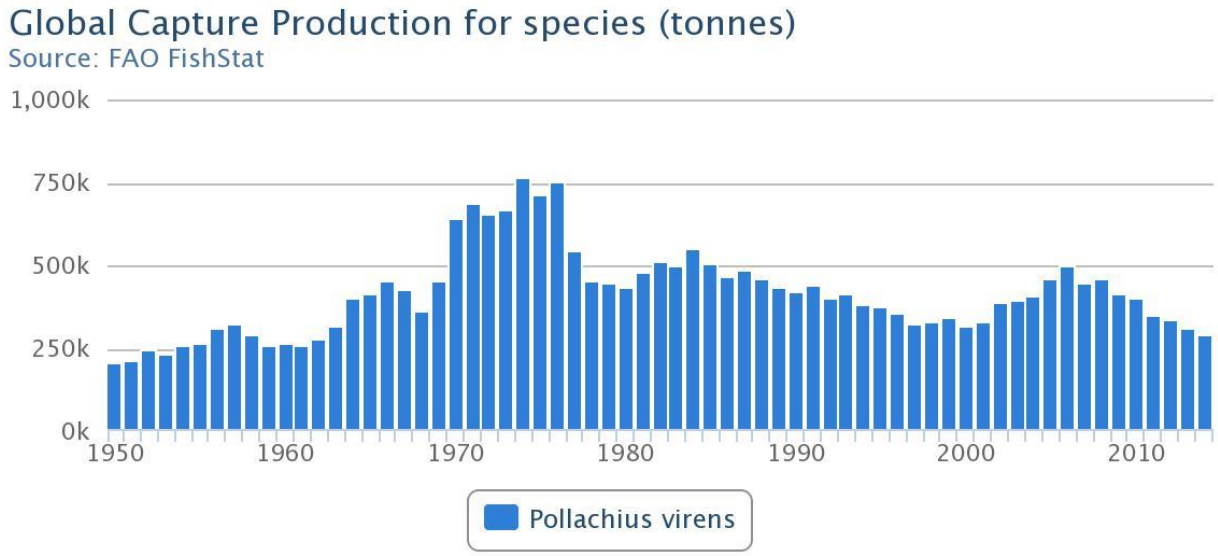
Neilson, J. D., Stobo, W. T., & Perley, P. (2006). Pollock (Pollachius virens) stock structure in the Canadian Maritimes inferred from mark-recapture studies. *Ices Journal of Marine Science, 63*(4), 749-765. https://doi.org/10.1016/j.icesjms.2005.12.006

The current management unit for pollock on the Canadian Atlantic coast is large compared with other gadoid resources, and includes the Scotian Shelf, the Bay of Fundy, and the Canadian portion of Georges Bank. Based on an analysis of mark-recapture studies conducted in the Canadian Maritimes and off southwestern Newfoundland and a review of other published studies providing data relevant to stock identification, the stock structure of pollock in Canadian Atlantic waters was re-assessed. The analysis also includes a novel method for using the spatial distribution of standardized fishing effort to predict the distribution of tag returns. It is concluded that three stocks co-occur within the current management unit. The larger population components exist in the western Scotian Shelf (including the eastern Bay of Fundy) and on the eastern Scotian Shelf. There is a coastal population in the western Gulf of Maine that overlaps into Canadian waters, but its size? is likely to be relatively small. There is a need to revise the current management unit boundaries to protect the eastern Scotian Shelf stock, which on the basis of growth rate data, appears to be the least productive component of the pollock resource in Canadian Atlantic waters.

Beacham, T. D. (1982). Growth of pollock (pollachius virens) on the scotian shelf in the northwest Atlantic ocean. Retrieved from Nanaimo, B.C., Canada: https://search.proquest.com/docview/13611239?accountid=28258

Size and age composItIons of pollock (Pollachius virens) in the landings of commercial fishery, as well as variability in pollock growth rates, were investigated on the Scotian Shelf and Georges Bank. Mean lengths-at-age for pollock derived from ground fish surveys indicated that linear regressions adequately described pollock growth up to age 8, with a growth rate of about 8 cm/yr. Pollock in NAFO Div. 4X were larger than those in Div. 4W. Instantaneous growth rates of pollock were generally above 0.30 for ages 5 and under, and these ages comprised about 70% of the landings of otter trawlers in the Canadian pollock fishery in the 1970s. Pollock in Divs. 4W and 4X had different growth histories, which may suggest that they are from different stocks.

Historical: Global Captures Production has increased since 1950, but peaked in the 1970s.



Source: Food and Agriculture Organization of the United Nations (2018). Pollachius virens. *Species Fact Sheets.* Retrieved from http://www.fao.org/fishery/species/3016/en

Section IV: Management

O'Neill, F. G., Graham, N., Kynoch, R. J., Ferro, R. S. T., Kunzlik, P. A., & Fryer, R. J. (2008). The effect of varying cod-end circumference, inserting a 'flexi-grid' or inserting a Bacoma type panel on the selectivity of North Sea haddock and saithe. *Fisheries Research, 94*(2), 175-183. https://doi.org/10.1016/j.fishres.2008.06.007

A comprehensive set of experiments using the twin trawl technique were conducted in the North Sea to assess the selectivity of haddock (Melanogrammus aeglefinus), cod (Gadus morhua) and saithe (Pollachius virens) in 120 mm mesh cod-ends with (i) 100, 80 and 60 meshes in circumference; (ii) a 35 mm 'flexi-grid' mounted in the extension; (iii) a 110 mm 'Bacoma' style square mesh panel. For haddock, cod-end type and catch size had a significant impact on 50% retention length (L50) and only cod-end type influenced selection range. Reducing the number of meshes in circumference from 100 to both 80 and 60 increased the L50 of haddock. The Bacoma panel gave a similar selection for haddock to the 60 mesh round cod-end, while no difference was found between the 'standard' 100 meshes round cod-end and the trawl with the flexi-grid fitted. For saithe, the cod-end with 60 meshes in circumference was significantly more selective than the codend with 100 meshes around. The cod-end with 80 meshes in circumference had an estimated selectivity between that of the cod-ends with 60 and 100 meshes in circumference, although it did not differ significantly from either. Catch size was not found to influence the selectivity of any of these three cod-ends. Insufficient data were obtained to estimate either the selectivity of saithe in the cod-end with a Bacoma panel or grid. A stock predictive model was used to illustrate the possible long-term effects of improving gear selectivity on the biomass, yield and discarding of haddock in the North Sea

Neilson, J. D., D. Clark, G. D. Melvin, P. Perley, and C. Stevens. (2003). The Diel-Vertical Distribution and Characteristics of Pre-Spawning Aggregations of Pollock (Pollachius Virens) as Inferred from Hydroacoustic Observations: The Implications for Survey Design. *Ices Journal of Marine Science, 60*(4), 860-871. http://dx.doi.org/10.1016/S1054-3139(03)00068-7

The characteristics of pollock (the synonymous European common name is saithe) pre-spawning aggregations were described at two locations with contrasting bathymetric features on the Scotian Shelf, off the Canadian Maritimes. The data were collected using a split-beam echosounder onboard a research vessel, augmented with periodic, bottom-trawl samples. Pollock form aggregations each fall that persist at the same location over time. Such aggregations appeared to be associated with spawning. Hydroacoustic information indicates that pollock become more densely aggregated at night. This could reflect movement away from the study area during the day, or changes in the proportion of pollock in the acoustic dead zone over the 24-h period. The hydroacoustic information indicates that while pollock can occur up to 30m off bottom, the greatest proportion remains within 1-5m off bottom during both day and night. The length composition of the pollock aggregations differed between the two sites, with larger fish found at the site further offshore. Within an aggregation, there was spatial heterogeneity with respect to fish size, with larger fish found primarily within the core area of aggregation as shown by the hydroacoustics. An appropriate survey design for obtaining an index of abundance for pollock would reflect both the contagious (patchy) distribution as they prepare to spawn, and the diel differences in the availability of the fish to the hydroacoustic-sampling gear.

Salthaug, A., & Aanes, S. (2003). Catchability and the spatial distribution of fishing vessels. Canadian Journal of Fisheries and Aquatic Sciences, 60(3), 259-268. https://search.proquest.com/docview/219320926?accountid=28258

A central problem when using commercial catch per unit effort (CPUE) as an index of fish stock abundance is that fishing vessels search for concentrations of fish. For a given stock abundance, CPUE may become high if the vessels succeed in finding patches of fish and low if the vessels distribute their catching operations more randomly. In this work, the relationship between catchability and two measures of the degree of spatial concentration of a trawl fleet (the fleet's spatial extent and the fleet's degree of spatial patchiness) is investigated for four different fish stocks. The catchability of northeast Arctic cod (Gadus morhua) is strongly related to the fleet's degree of spatial concentration, but the relationship is weaker for northeast Arctic haddock (Melanogrammus aeglefinus), and no relationships appear for two saithe (Pollachius virens) stocks. Our findings suggest that adjusting CPUE with a measure of the fleet's average degree of concentration relates CPUE more strongly with abundance for migratory stocks

Neilson, J. D., L. Annis, P. Perley, A. Clay, C. Croft, and M. O'connor. (2002). Seasonal Aggregations of Canadian East Coast Pollock as Inferred from the Commercial Fishery and Hydroacoustic Observations. *Journal of Fish Biology, 61*(5), 1067-1084. doi:http://dx.doi.org/10.1006/jfbi.2002.2100

Data from an otter trawler fleet fishing on the Scotian Shelf combined with year-round hydroacoustic data indicated that the locations of aggregations of pollockPollachius virens did not change appreciably from month to month. The proportion of pollock mass compared with total catch mass in individual trawl catches, however, tended to be higher from September to February. The period of highest catch rates was shown to be the December to January period. This period

coincided with the period when pollock had the least affinity with the seabed based on information from hydroacoustic observations, a behavioural consideration for acoustic survey design. Based on these observations, it was concluded that the optimal time to conduct an acoustic survey was during the December to January period.