Fisheries and Oceans Canada | Pêches et Océans Canada
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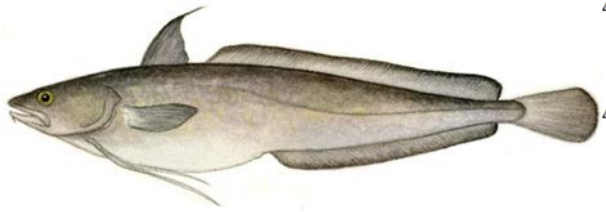
Canadian Science Advisory Secretariat
Newfoundland and Labrador Region **Science Advisory Report 2016/009**

STOCK ASSESSMENT OF NAFO SUBDIVISION 3PS WHITE HAKE (*UROPHYCIS TENUIS*)



White Hake (Urophycis tenuis, Mitchill 1815)

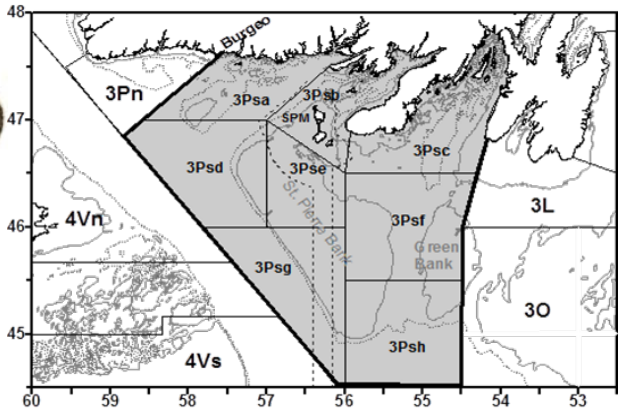


Figure 1. 3Ps management area (shaded), unit areas (solid lines), and economic zone around the French islands of St. Pierre et Miquelon (SPM; dashed line).

Context:

This assessment was requested by Fisheries Management to provide the Minister with advice that will inform management decisions for the 2016 fishing season. The specific request was to:

- *Provide an ecosystem overview (e.g., environment, predators, prey) of the stock.*
- *Assess and report on the status of the stock based on commercial fishery statistics (overall landings distribution, breakdown by fishing gear and directed species) and biological data resulting from the commercial sampling program (size structure).*
- *Analyze historical data from DFO research surveys up to 2015 (abundance and biomass indices, recruitment, size structure and geographical distribution of catches).*
- *Identify B_{lim}, or a proxy for B_{lim}, for this stock and report on the current spawning stock biomass relative to B_{lim}.*
- *Provide annual projections to 2018 based on the assessment of trends in the abundance index, biomass index and other stock indicators, including associated risk analyses. Specifically, these analyses will include an assessment of the trends in the stock and in the risks compared to B_{lim}.*
- *Perspectives for 2016 based on available indicators.*
- *Establish a full assessment review period as well as interim-year guidance.*
- *Provide guidance on inter-framework review activities, including the procedure and frequency of providing fisheries management advice, and events that would trigger an earlier-than-scheduled assessment.*

This Science Advisory Report is from the October 20-22, 2015 3Ps White Hake Stock Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Since 2009, the Northwest Atlantic Fisheries Organization (NAFO) reported landings from Subdivision (Subdiv.) 3Ps averaged 310 tonnes (t) annually, while Newfoundland and Labrador (NL)-Zonal Interchange File Format (ZIFF)-reported landings averaged 243 t and were predominantly from White Hake-directed gillnet (71%) and longline (25%) fisheries.
- Using the past three years as status quo, current landings from Subdiv. 3Ps are below historic levels. In Subdiv. 3Ps, status quo landings was 261 t (195.5-328.5 t, range ± 25%), while the status quo was 18 t (13.5-22.5 t, range ± 25%) for Subdiv. 3Pn.
- Biomass of this stock increased in 2000-03, generated by the large recruitment in previous years. Subsequently, the biomass index has declined.
- Recruitment in 2000 was very large, but no large year class has been observed since then. Recruitment was higher in 2011, but not comparable to the very high recruitment observed in 2000.
- Relative fishing mortality (Relative *F*) has fluctuated, but increased considerably in 2003-05. Current estimates of Rel. *F* are near average.
- Available evidence suggests that current White Hake productivity, like other piscivores, may be hindered in Subdiv. 3Ps, therefore it is advised that higher than usual risk-aversion be considered in the management of these stocks.
- If White Hake in Subdiv. 3Ps is to recover, it will be due to favourable changes in environmental conditions that allow successive years of good recruitment. The most effective way to assist in rebuilding the White Hake population is to conserve as much spawning biomass as possible.

INTRODUCTION

White Hake (*Urophycis tenuis*, Mitchill 1815) is a highly fecund gadoid species distributed in the Northwest Atlantic from Cape Hatteras to southern Labrador. Present knowledge of its biology for the Grand Banks and southern Newfoundland has been summarized in previous assessments of this species in Newfoundland waters (Han and Kulka 2007; Simpson et al. 2012)

For management purposes, White Hake in Div. 3NO and Subdiv. 3Ps are assessed separately by NAFO, despite the fact that hakes in both areas constitute one biological stock. This paper presents an assessment of White Hake in Division (Div.) 3P (Fig. 1), which includes Subdivisions 3Ps and 3Pn, and focuses on available commercial fisheries data and Fisheries and Oceans Canada (DFO)-NL research survey information.

History of the Fisheries

The status of White Hake in Subdiv. 3Ps was first assessed in 1996 (DFO 1996), then in 1998 (DFO 1998) and 2002 (DFO 2002). Following a June 2004 assessment of this species in Div. 3LNO and Subdiv. 3Ps for NAFO Scientific Council (Kulka et al. 2005), White Hake in Div. 3NO came under NAFO quota regulation in September 2004. NAFO Fisheries Commission decided that a Total Allowable Catch (TAC) of 8,500 t be established for Div. 3NO for 2005-07. This fishing allocation was between Canada at 2,500 t, the European Union (EU) at 5,000 t, Russia at 500 t, and remaining NAFO member countries at 500 t. No quota was implemented for Div. 3L, nor did Canada implement a TAC for Subdiv. 3Ps within its Exclusive Economic Zone (EEZ). The TAC in Div. 3NO was maintained at 8,500 t for 2008-2009. In September

2009, NAFO Fisheries Commission reduced the TAC of White Hake in Div. 3NO from 8,500 t to 6,000 t for 2010-11. This TAC was further reduced to 5,000 t for 2012, and to 1,000 t for 2013 with a *caveat*: the TAC in 2013 can be increased in-season to 5,000 t, based on evidence of an "exceptional" increase in the availability of White Hake. For 2016, the TAC remains at 1,000 t, with the increase under exceptional conditions lowered to 2,000 t.

This species has not been assessed domestically since implementation of:

1. A NAFO TAC for Div. 3NO;
2. A two-year schedule for the full assessment of Div. 3NOPs White Hakes at NAFO Scientific Council; and
3. A NAFO interim monitoring report required for non-assessment years.

Furthermore, these NAFO documents always include analyses of Subdiv. 3Ps White Hakes, due to the prevailing understanding that Div. 3NO and Subdiv. 3Ps fish constitute a single population (Simpson et al. 2015*a*).

Commercial fisheries removals of White Hake in Div. 3P were examined for 1960-2014, using three data sources: the NAFO STATLANT-21A landings data (1960-2014), which were reported by NAFO member countries; DFO-NL ZIFF landings data (1985-2014), as recorded in logbooks by Canadian fishers operating in Canada's EEZ; and Canadian At-Sea Fisheries Observers' catch and discards data (1978-2013), collected at sea on a set-by-set basis in a standardized format. It must be noted that Canadian At-Sea Observers constitute the only reliable source of data on total catch by species, and discarding at sea.

NAFO-reported landings of White Hake in Div. 3P were largely attributed to fishing by Canadian fleets. Since 1989, only France (St. Pierre and Miquelon) has reported landings in Div. 3P; all of which were taken in Subdiv. 3Ps. Historically, Spain (1965-72) and Russia (1971-76) conducted fisheries in Div. 3P. In addition, other countries (e.g., Ireland, Japan, Poland) occasionally reported landings in Div. 3P during the 1960s and 1970s.

Overall, NAFO-reported landings of White Hake in Div. 3P were mainly from Subdiv. 3Ps (Fig. 2). During the 1960s, annual landings in Subdiv. 3Ps averaged 266 t, then increased significantly in 1971 and averaged 1,608 t over 1971-78. Landings were variable throughout 1979-93, but remained relatively high (averaging 1,044 t). During 1994-99, landings declined to an average of 517 t, then significantly increased to 1,241 t on average over 2000-08. In 2009-14, landings averaged 310 t (i.e., comparable to those reported in the 1960s). NAFO-reported landings from Subdiv. 3Ps were 191 t in 2013, and 383 t in 2014. Landings from Subdiv. 3Pn averaged 173 t during the 1970s, with a maximum of 295 t in 1972. Throughout the 1980s and 1990s, landings averaged 88 t annually. NAFO-reported landings from Subdiv. 3Pn then averaged 38 t over 2004-11, and 18 t in 2012-14.

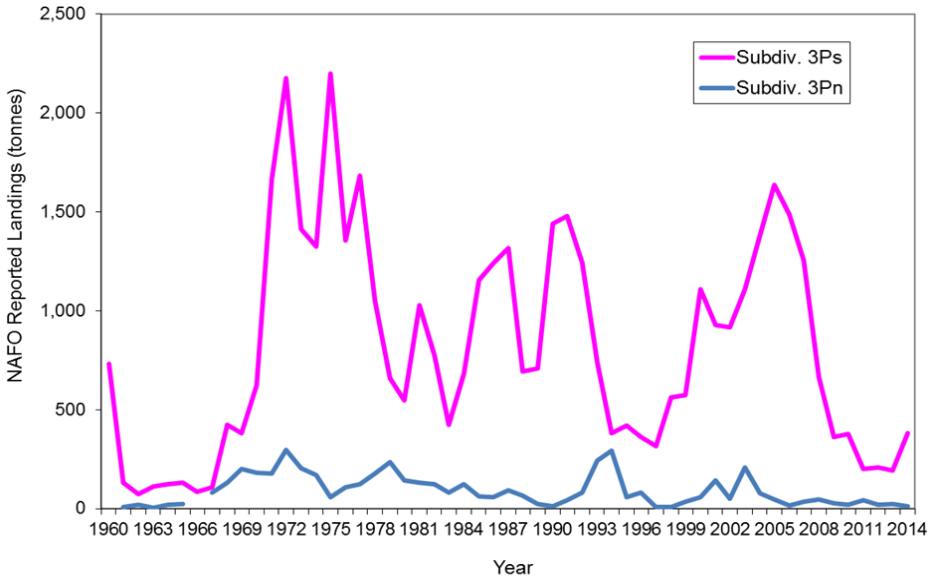


Figure 2. NAFO-reported landings (tonnes) of White Hake by member countries in Subdiv. 3Ps and 3Pn, 1960-2014 (STATLANT-21A).

ZIFF-reported annual landings of White Hake in Div. 3P also showed a majority from Subdiv. 3Ps, with none reported from Subdiv. 3Pn after 2003 (Fig. 3). However, most of the reported landings from Subdiv. 3Ps during the mid-1980s to early 90s should be interpreted with caution, as landings of Atlantic Cod (*Gadus morhua*) by Canadian longline fisheries during this period were misreported as White Hake. In 2000-08, ZIFF-reported landings of White Hake from Subdiv. 3Ps averaged 1,031 t annually, and 243 t in 2009-14.

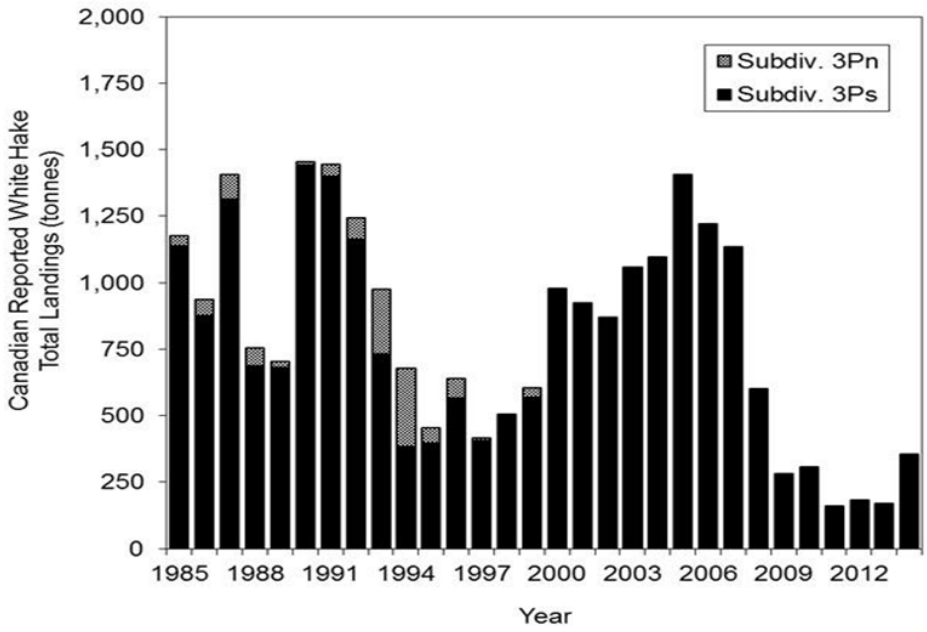


Figure 3. DFO-NL ZIFF-reported landings (tonnes) of White Hake in Subdiv. 3Ps and 3Pn, 1985-2014.

ZIFF data indicated that White Hakes in Subdiv. 3Ps over 2003-14 were primarily landed from gillnets (71% on average), secondarily from longlines (25% ave.), and a small proportion from otter trawls (4% ave.; Fig. 4, top panel). This species was landed predominantly from Subdiv. 3Ps directed fisheries and also as bycatch. In Subdiv. 3Pn, White Hakes were primarily reported from longlines (62% on average), secondarily from otter trawls (22% ave.), and from gillnets (15% ave.; Fig. 4, bottom panel), while almost all were reported as bycatch in other groundfish fisheries.

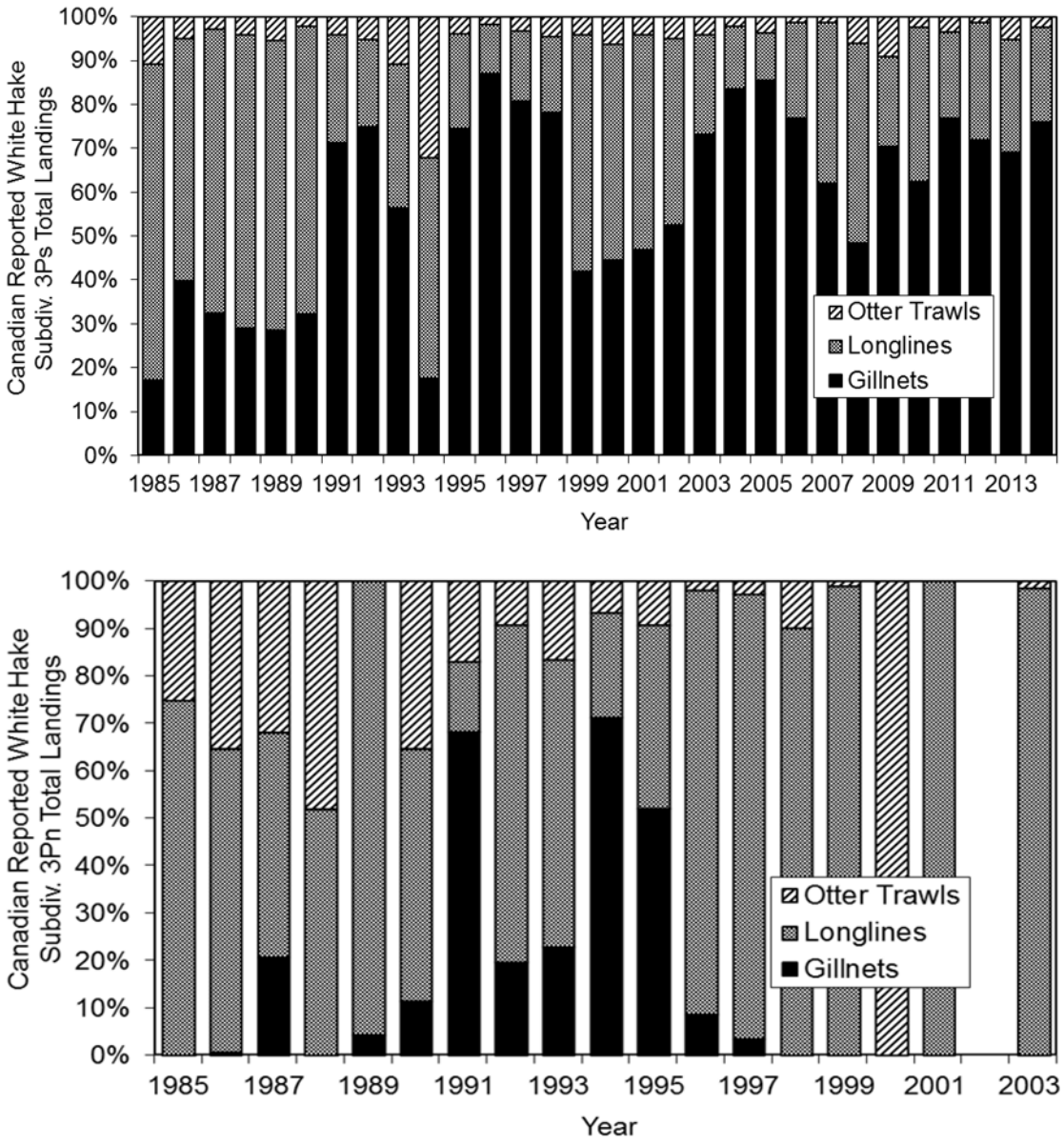


Figure 4. DFO-NL ZIFF-reported landings of White Hake by gear in Subdiv. 3Ps (top panel) and 3Pn (bottom panel), 1985-2014. Note that no landings were reported from Subdiv. 3Pn after 2003.

Subdiv. 3Ps bycatch of White Hake in 1998-2014 was landed mainly from gillnet fisheries targeting Atlantic Cod (62% on average) and redfish (*Sebastes* spp.; 33% ave.), with a small proportion from the Monkfish (*Lophius americanus*) fishery (5% ave.; Fig. 5, top panel). White

Hake bycatch over 1998-2014 also occurred in Atlantic Cod (75% on average) and Atlantic Halibut (*Hippoglossus hippoglossus*; 25% ave.) longline fisheries, and in otter trawl fisheries targeting Atlantic Cod, redfish, and Witch Flounder (*Glyptocephalus cynoglossus*; 33% on average for each directed species; Fig. 5, middle and bottom panels, respectively). In White Hake-directed fisheries, bycatch of other commercially important species occurred, such as Atlantic Cod, Atlantic Halibut, American Plaice (*Hippoglossoides platessoides*), Haddock (*Melanogrammus aeglefinus*), and Monkfish.

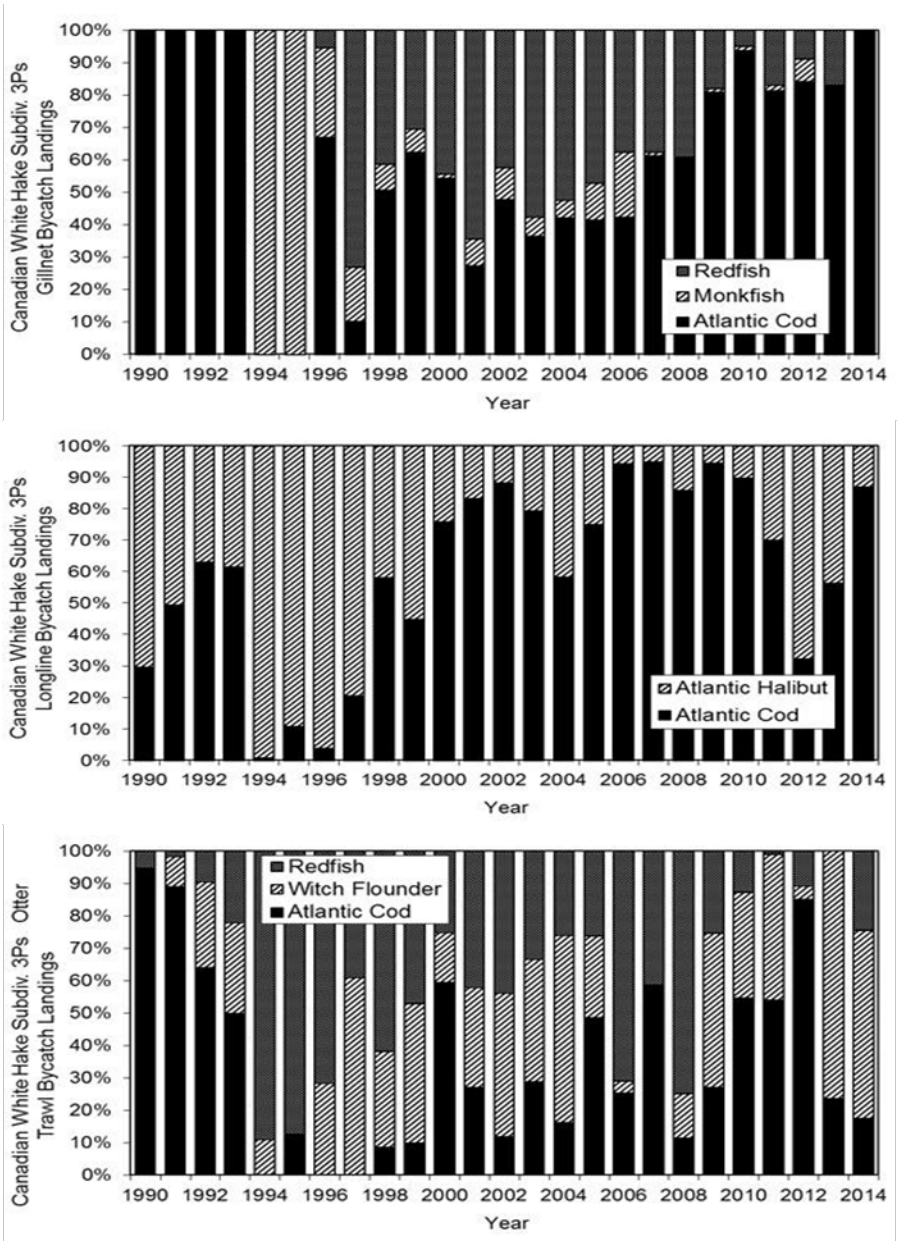


Figure 5. DFO-NL ZIFF-reported landings of White Hake bycatch by gear and directed species in Subdiv. 3Ps, 1990-2014.

To estimate annual total catch of White Hake (i.e., landings + discards at sea) in gillnet and longline fisheries directing for this species in Div. 3P, a method based on Campana et al. 2011 was used with the Canadian At-Sea Fisheries Observer database for 1985-2013 (see Simpson

and Miri 2013 for detailed methodology). However, catch estimates were dependent on the percentage of actual Observer coverage of each fishery in each year, as well as whether the DFO-NL ZIFF database contained reported landings of this species for each year of Observer coverage. Combined estimates for both gears peaked at 1,130 t in 2005, although most catches occurred in the White Hake-directed gillnet fishery during this period (Fig. 6, top panel). Annual catch estimates for Div. 3P remained below 69 t since 2009.

Annual estimates of bycatch of White Hake in other Div. 3P groundfish fisheries over 1997-2008 suggested that the Atlantic Cod longline fishery averaged 219 t annually, the redfish gillnet fishery 216 t, the Atlantic Cod gillnet fishery 152 t, the Atlantic Halibut longline fishery 63 t, the redfish otter trawl fishery 29 t, the Monkfish gillnet fishery 15 t, and the Witch Flounder otter trawl fishery 11 t (Fig. 6, bottom panel). Combined bycatch estimates peaked in 2008. Furthermore, combined annual bycatch estimates for White Hake in 2009 12 have not exceeded 500 t, and were primarily from the longline fishery directing for Atlantic Cod (250 t average annually), while the Atlantic Halibut longline and Atlantic Cod gillnet fisheries annually averaged 25 t and 40 t (respectively); although a bycatch estimate for the latter fishery suggested 730 t of White Hake in 2013.

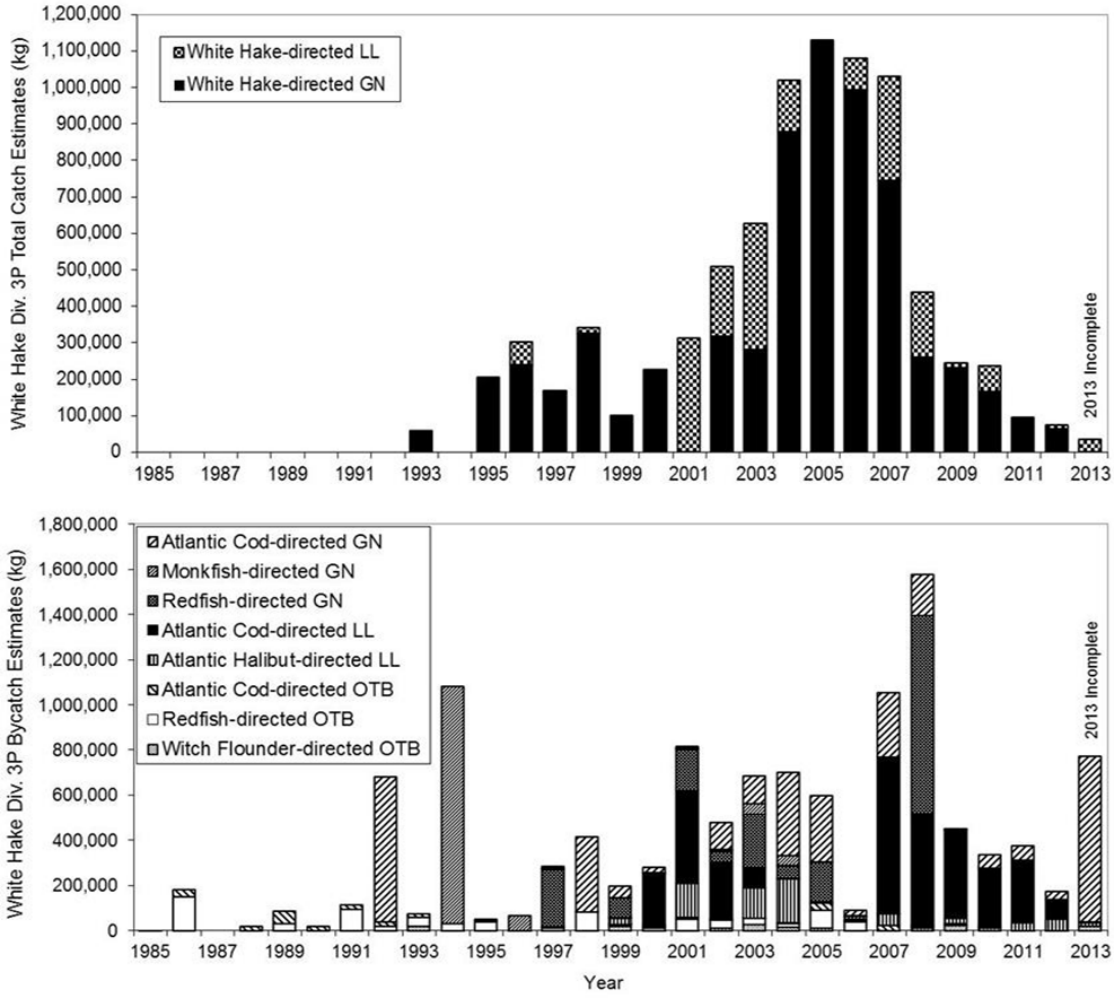


Figure 6. Estimated annual total catch (kg) of White Hake in directed (top panel) and bycatch (bottom panel) fisheries using gillnets (GN), longlines (LL) and otter trawls (bottom; OTB) in Div. 3P, 1985-2013. Data are from Canadian At-Sea Fisheries Observers and DFO-NL ZIFF in comparable years.

Species Biology and Ecology

Han and Kulka (2007) investigated dispersion and survival potential of White Hake eggs, larvae, and small pelagic juveniles with a three-dimensional regional ocean circulation model. These early life stages passively inhabit the upper water layer, where they develop and are dispersed by ocean currents for two to three months (depending on water temperature) before resultant juveniles settle on the bottom (Markle et al. 1982; Lang et al. 1996). Modelling results suggested that a weak along-slope current and strong on-bank flow increase juvenile retention on the southern Grand Banks. In addition, spawning below the surface Ekman layer in late spring maximizes chances for White Hake juveniles to settle on the southern Grand Banks in autumn.

White Hake larvae and small pelagic juveniles consume plankton (Coates et al. 1982). Diet analysis of demersal juveniles collected from the Mid-Atlantic Bight to the southern Scotian Shelf indicated that White Hake prey almost exclusively on crustaceans, such as shrimp, isopods, amphipods, and crabs; however, polychaetes are also consumed (Bowman 1981). Although adult White Hakes prey heavily on small fish, including juveniles of their own species (Langton et al. 1994), shrimp and other crustaceans are still important in their diet (Langton and Bowman 1980). Diet analysis of White Hakes collected from the southwest slope of the Grand Bank and St. Pierre Bank indicated that the following fish species were their most common prey: Atlantic Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*) , flatfishes, sand lances, Capelin (*Mallotus villosus*), argentines, and grenadiers, followed by planktonic crustaceans, such as shrimp (Petrov 1973). Benthic molluscs (e.g., clams, scallops) and echinoderms (e.g., sea urchins, sea stars) do not appear to be important prey for White Hake in Newfoundland and Labrador waters (Petrov 1973), or elsewhere (Collette and Klein-MacPhee 2002).

White Hake are cannibalistic, and are also consumed by Porbeagle Shark (*Lamna nasus*), Blue Shark (*Prionace glauca*), and Bluefin Tuna (*Thunnus thynnus*; Aasen 1961; Compagno 1984; Scott and Scott 1988). Off of the coast of Maine (USA), Atlantic Puffins (*Fratercula arcitca*) and Arctic Terns (*Sterna paradisaea*) prey on pelagic juvenile White Hakes in surface waters (Fahay and Able 1989). In the Gulf of St. Lawrence, White Hake constitutes a large part of the diet of both Grey Seals (*Halichoerus grypus*) and Harp Seals (*Phoca groenlandica;* Hammill and Stenson 2002; Hammill et al. 2014). Benoit et al. (2011) suggested that predation by Grey Seals on White Hake in the southern Gulf of St. Lawrence has elevated adult natural mortality to the extent that it is responsible for a decline in White Hake abundance.

White Hakes in Newfoundland waters prefer bottom temperatures warmer than 4°C, and are found mostly along the continental shelf slope of the southwestern Grand Bank (Div. 3O), and in the Laurentian and Hermitage Channels (Div. 3P; Kulka and Mowbray 1998; Kulka et al. 2005; Simpson et al. 2012). In addition to water temperature, inshore eelgrass beds constitute an important nursery habitat for small demersal juveniles to avoid detection by larger predators (Fahay and Able 1989; Heck et al. 1989; Gregory et al. 1997; Ings et al. 1998; Collette and Klein-MacPhee 2002; Lazzari and Stone 2006).

ASSESSMENT

The spring biomass index for White Hake on the Grand Banks in Div. 3NOPs increased rapidly in 1999-2000 to approximately 26,000 t, but then declined steeply, and is presently at low levels compared to earlier estimates in the Campelen time series. During the DFO-NL spring survey of 2000, the estimated abundance of about 117,000,000 fish was 10 times greater than that observed in either the first years of the Campelen series or during recent years, due to the very large 1999 year-class. In 2011, the abundance index increased from low levels to about

27,000,000 fish (3 times the 2007-09 average), primarily due to a moderate 2010 year-class. Average spring abundance estimates were 16,110,814 White Hakes in 2013 -15.

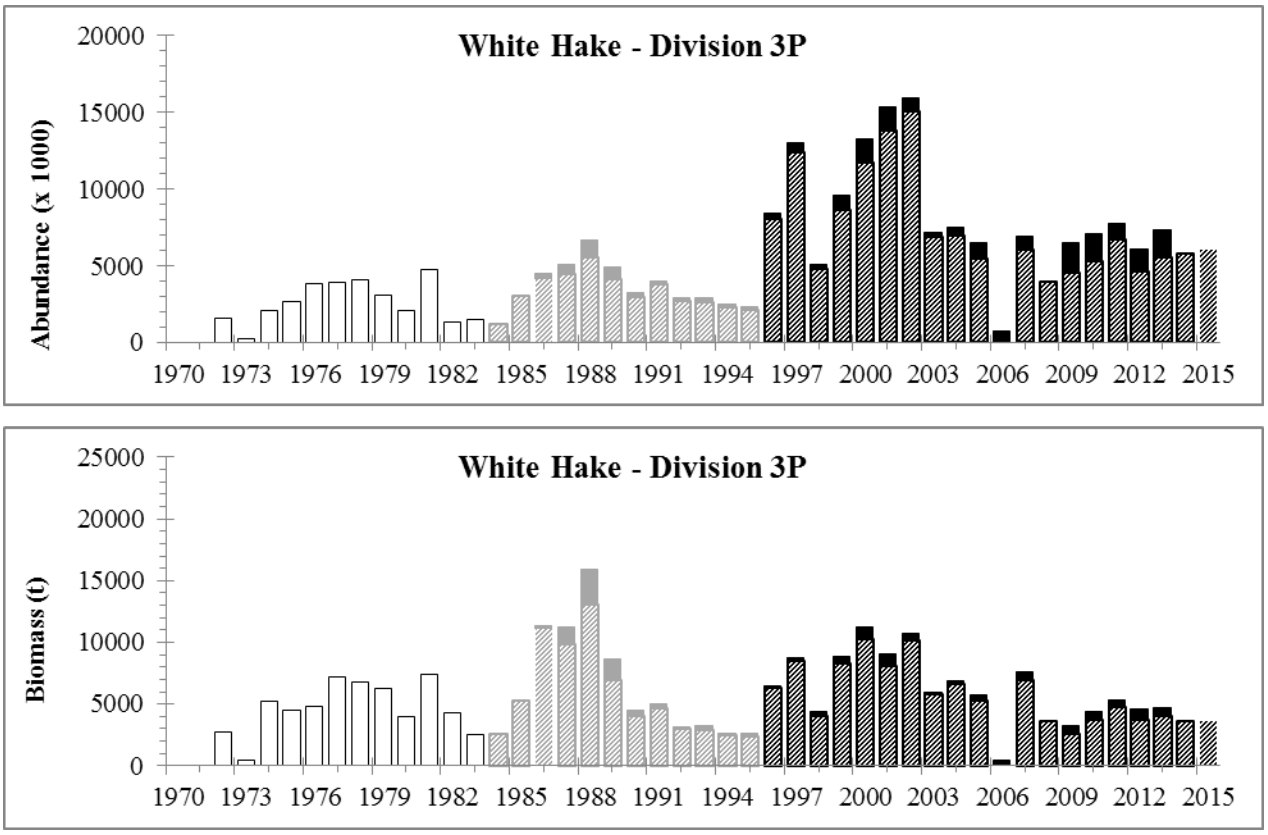


Figure 7. Annual estimates of abundance and biomass for White Hake from DFO-NL spring research surveys in Subdiv. 3Ps (open column and diagonal lines) and 3Pn (solid color). Note that there is no conversion factor between Yankee (open columns), Engel (grey columns), and Campelen (black columns) time-series. Note that most of Subdiv. 3Ps was not surveyed in spring 2006, due to Canadian research vessels' mechanical difficulties.

White Hake abundance and biomass estimates from spring surveys indicate that the majority of the Div. 3P stock component is consistently found in Subdiv. 3Ps, ranging from approximately 0.25 to 15 million fish and 467-13,000 t; and from 0.19 to 2 million fish and 170-2,900 t in Subdiv. 3Pn. Temporal trends in stock size were similar in both Subdivisions, despite a difference in the magnitude of estimates (Fig. 7). White Hake abundance and biomass increased through the first half of the Yankee and Engel time-series. In Subdiv. 3Ps, abundance and biomass peaked in 1981 (4.7 million fish; 7,500 t) and 1988 (5.5 million fish; 13,000 t), then declined towards the end of each time-series; while estimates for the Campelen time-series increased through the late 1990s and peaked in 2002 (15 million fish; 10,000 t), with a sharp decline thereafter. Estimates of abundance and biomass ranged from 4 to 7 million fish, and 2,600-7,000 t (respectively) between 2003 and 2015.

Estimates of mean number and mean weight per tow from spring surveys in Subdiv. 3Ps ranged from 0.5 to 7.1 fish/tow and 0.9-12.4 kg/tow, with almost no differences between Engel and Campelen time-series; whereas these estimates tended to be higher and more variable (i.e. larger Confidence Intervals or CIs) for the Yankee time-series (Fig. 8). Catch rates increased through the mid-1970s then declined until the early 1980s; similar trends occurred from the 1980s until the mid-2000s, when catch rates stabilized at very low levels. Mean

number and mean weight per tow ranged from 1.1 to 9.3 fish/tow and 0.8-23.5 kg/tow, respectively, in Subdiv. 3Pn, and the precision of mean number per tow was generally lower when compared to catch rates in Subdiv. 3Ps. Catch rates followed a similar pattern to those in Subdiv. 3Ps: peaking in the late 1980s, then declining over subsequent years.

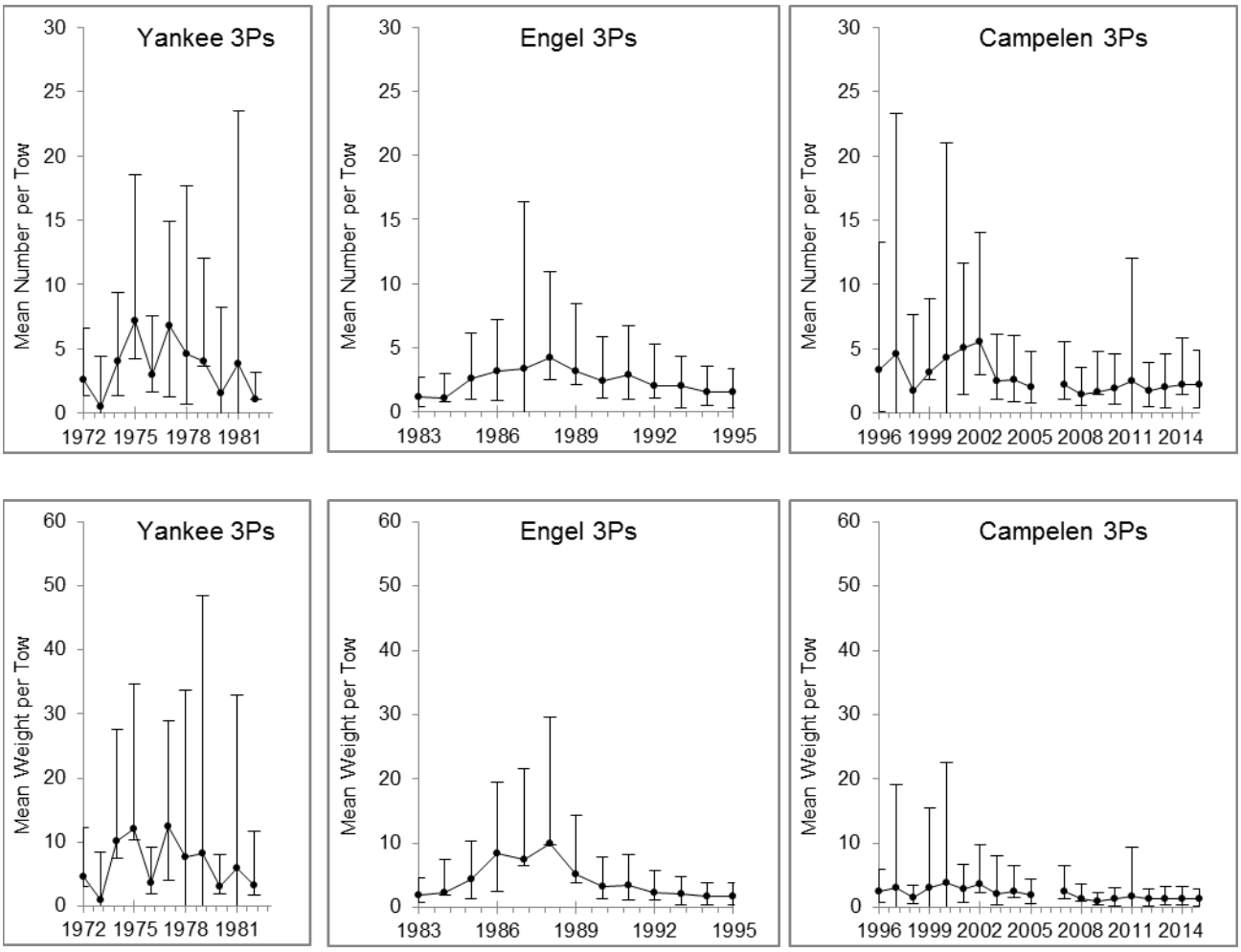


Figure 8. White Hake mean numbers (top panels) and mean weights (kg; bottom panels) per tow (+/-95% CI) from DFO-NL spring research surveys in Subdiv. 3Ps, 1972-2015. Yankee, Engel, and Campelen time series are not standardized, and thus are presented on separate panels. Note that most of Subdiv. 3Ps was not surveyed in spring 2006, due to Canadian research vessels' mechanical difficulties.

Sources of Uncertainty

White Hake age data are not available from commercial fisheries or DFO-NL research surveys. In addition, data on length, weight, and maturity of White Hakes in DFO-NL survey catches are incomplete. Furthermore, estimates of total commercial removals are dependent on Canadian At-Sea Observer coverage, which is minimal or non-existent in some fisheries; thereby underestimating fishery impacts on this Div. 3P component of the population.

Limit reference points for White Hake in Div. 3P have not been defined. Previous investigations of limit reference points for this species were conducted (Simpson et al. 2015*c*) for the stock area Div. 3NOPs using a Bayesian surplus production model, Catch-resilience models (Martell and Froese 2013), and empirical methods based on Canadian research survey indices of

biomass. During its June 2015 Meeting, NAFO Scientific Council concluded that none of the assessment models were acceptable in capturing the episodic character of this White Hake population and, therefore, the resulting limit reference points were not accepted (Simpson et al. 2015*b*, 2015*c*).

Predation by seals in Newfoundland waters may contribute to low levels of White Hake abundance, but studies using larger sample sizes (as compared to Hammill et al. 2007) are necessary to quantify any effects of seal predation on White Hake abundance in Div. 3P.

Recruitment of Div. 3NOP White Hake remains unpredictable, and has been extremely low since the very large 1999 year-class.

CONCLUSIONS AND ADVICE

Using the past three years as status quo, current landings from Subdiv. 3Ps are below their historic levels. In Subdiv. 3Ps, status quo landings were 261 t (195.5-328.5 t, range ± 25%), while the status quo was 18 t (13.5-22.5 t, range ± 25%) for Subdiv. 3Pn. It must be noted that, without a recruitment pulse such as that seen for White Hake in 1999-2000 (thereby supporting high landings over 2003-07), higher catch rates are not sustainable. At current removal levels, the biomass of White Hake in Subdiv. 3Ps has been stable.

If White Hake in Subdiv. 3Ps is to recover, it will be due to favourable changes in environmental conditions that allow successive years of good recruitment. The most effective way to assist in rebuilding the White Hake population is to conserve as much spawning biomass as possible.

Age-structured assessment of this population is currently not feasible. However, population abundance at length estimates from Canadian spring research surveys suggest that no significant recruitment has occurred for White Hake over the past fifteen years.

Given that good recruitment rarely occurs and remains unpredictable for this White Hake population, commercial fishing pressure should be regulated in Div. 3P by a TAC set at a level that will allow survival and growth to maturity of larger year-classes. This strategy (with the appropriate enforcement) is crucial to rebuilding the population; especially given that the drastic decline in White Hake biomass following the large recruitment event of 1999-2000 was attributed to fishing (Kulka and Miri 2007).

Regulations that limit the amount of White Hake bycatch for other directed fisheries in Canada's EEZ could also be implemented.

A five-year assessment schedule is recommended with interim updates using the Canadian Science Advisory Secretariat's Science Response Reports, based on the biennial Div. 3NOPs White Hake stock assessments and interim monitoring reports (i.e., for non-assessment years) produced for NAFO Scientific Council. A full assessment is warranted if the major population indicator (i.e., DFO spring survey biomass index) statistically declines or increases more than two standard deviations. This re-assessment may result in revised catch advice for White Hake-directed and bycatch fisheries.

SOURCES OF INFORMATION

This Science Advisory Report is from the October 20-22, 2015 3Ps White Hake Stock Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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