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**Sentinel surveys 1995-2010: Catch per  
unit effort (CPUE) in NAFO  
Subdivision 3Ps**

**Relevés sentinelles 1995-2010 : prises  
par unité d'effort (CPUE) dans la sous-  
division 3Ps de l'OPANO**

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## **ABSTRACT**

Unstandardized catch rates for sentinel surveys in NAFO Subdiv. 3Ps are updated for 2009 and preliminary results are given for 2010. Gillnet catch rates (weekly average number of fish per net) in the most recent years remained low compared to 1996-98 catch rates. Catch rates in small mesh gillnet remained low. Length frequencies of cod caught in small mesh gillnet showed fewer fish at the two size modes (36-44 cm and 52-56 cm) that this gear catches since 2000. Linetrawl catch rates (weekly average number of fish per 1000 hooks) increased from 2000 and showed an increase in the number of fish at the 44-54 cm size range from 2002 to 2004. Linetrawl catch rates have been lower than those in 1995-97 since 2000, but have shown a slightly increasing trend.

Trends in liver and gutted body condition showed a seasonal cycle, with condition declining over the winter and early spring, and increasing again over the summer once spawning has occurred. Annually, trends in condition have varied over the time series, but since 2007 have been declining. Both length and weight at age have declined in fish age 4 and older since the early part of the time series.

## **RÉSUMÉ**

Les taux de prise non normalisés des relevés sentinelles effectués dans la sous-division 3Ps de l'OPANO sont mis à jour pour 2009, et des résultats préliminaires sont fournis pour 2010. Les taux de prise au moyen de filets maillants (nombre moyen hebdomadaire de prises par filet) est resté faible au cours des dernières années par rapport aux taux de 1996 à 1998. Les taux de prise au moyen de petits filets maillants sont également restés faibles. Selon les fréquences de longueur des morues pêchées au moyen de petits filets maillants, le nombre de poissons des catégories de 36 à 44 cm et de 52 à 56 cm est en baisse par rapport à 2000. Les taux de prise à la palangre (nombre moyen hebdomadaire de poissons par 1 000 hameçons) ont augmenté depuis l'année 2000, de même que le nombre de poissons de la catégorie de 44 à 54 cm, par rapport aux années 2002 à 2004. Depuis 2000, les taux de prise à la palangre ont été inférieurs à ceux enregistrés dans les années 1995 à 1997, mais ils affichent une légère tendance à la hausse.

Les tendances en ce qui a trait à l'état du foie et à au poids après éviscération montrent un cycle saisonnier, l'état s'affaiblissant au cours de l'hiver et au début du printemps, et s'améliorant à nouveau au cours de l'été, une fois la période de fraie terminée. D'une année à l'autre, les tendances au niveau de l'état ont varié dans la série chronologique, mais depuis 2007, elles sont en baisse. Tant la longueur que le poids selon l'âge ont diminué chez le poisson âgé de 4 ans ou plus depuis la première partie de la série chronologique.

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## **INTRODUCTION**

Sentinel survey projects were formally announced by the Minister of Fisheries and Oceans Canada in October 1994. The sentinel surveys in the Newfoundland and Labrador Region of the Department of Fisheries and Oceans (DFO) are an extension of the index fishermen's project from the Northern Cod Science Project Program with modifications to allow for science activities achievable only under a fishing moratorium. Sentinel data collection continued during the commercial/index fisheries that occurred from 1998-2002, and in 2006-10.

The sentinel survey has the following objectives:

1. To develop a catch rate series for use in resource assessments.
2. To incorporate the knowledge of inshore fish harvesters in the resource assessment process.
3. To describe the temporal-spatial distribution of Atlantic cod in the inshore area over a number of years through, for example, the use of catch rate information, tagging studies, by-catch information and participant's observations.
4. To gather length frequencies, sex and maturity data and sample ages for use in resource assessment.
5. To establish a long-term physical oceanographic and environmental monitoring program of the inshore areas.
6. To provide a source of biological material for other researchers. For example, tissue for genetic, physiological and toxicological analyses, cod stomachs for food and feeding studies, and by-catch information.

## **MATERIALS AND METHODS**

### **PARTICIPANTS**

The primary collectors of data in the sentinel survey are inshore fish harvesters. Through consultation with inshore fisher harvesters and fisheries organizations, traditional inshore fishing grounds have been identified and mapped.

Fish harvesters from communities within the boundaries of the identified coastal areas and who met eligibility criteria were invited to apply to participate in the survey. Where more than one application was received from an area, the project partner conducted a draw or lottery to select the participant. While there was considerable interest in the project in most areas, there were many sites from which only one application was received and others where additional canvassing was required to enlist participants. Selected participants were required to complete a six-week course designed by the Marine Institute of Memorial University, in consultation with DFO. Topics covered included scientific sampling methods and equipment, computer use, resource assessment basics and presentation skills.

In order to minimize inter-annual enterprise effects on data collection, participants are expected to remain with the survey over a number of years. It is also expected that most of the sampling activities will continue once commercial fishing operations resume, and the sentinel participants will form a core of index fish harvesters.

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## SITES

In 2009 and 2010, thirteen enterprises participated in Sentinel activities in NAFO Subdiv. 3Ps. The specific location of each site was chosen after consultation between DFO scientists, fish harvesters, the Fish, Food and Allied Workers Union (FFAW), and the Fogo Island and Petty Harbour Cooperatives (for Fogo Island and Petty Harbour). Site selection was based on the need to survey throughout inshore areas and targeted historical fishing areas and historical gear use patterns.

## SAMPLING STRATEGY

Table 1 gives the homeports of participants in the sentinel surveys in 1995-2010; showing the number of sets completed in each year and the number of enterprises participating in the survey. The timing of sampling was determined after discussions with fish harvesters but was targeted for seasonally appropriate times based on historical fishing patterns.

Gillnets and linetrawls were used to survey inshore areas in Subdiv. 3Ps. Cod traps were used to varying degrees from 1998 to 2002 to sample fish, but are no longer used in the sentinel survey. Hand lines were used mostly in conjunction with nets or trawls as a means of determining the presence of cod for tagging purposes, or when nets were not catching fish. Hand lines were used to sample cod in several locations and information from this survey was used mainly for biological sampling as catch rate information from hand lining is difficult to interpret.

Hook and line crews fished two tubs of baited linetrawl (approximately 500 hooks per tub) each fishing day. Gillnet crews fished a maximum of six fifty-fathom, 5½ inch monofilament gillnets. Nets were rigged 2-3 to a fleet and up to three fleets were fished per fishing day. In addition, selected sites fished one small mesh gillnet (3¼ inch monofilament) tied to one 5½ inch gillnet at least one day per week. All fish caught in gillnets and on hooks were landed and measured. If catches were too large to sample effectively, the number of nets in a fleet (or number of hooks in the linetrawls) was reduced after consultation with DFO scientists. However, consideration was given to bottom topography and gear performance when decreasing the amount of gear. Other measures were considered if fish were particularly abundant in an area and catches appeared to be excessive; even with minimal amounts of gear.

Prior to the start of the survey in 1995, a fixed (i.e., control) location on the fishing grounds was established for each site, and will remain fixed for the duration of the Sentinel project. On each fishing day, up to half of the gear was set at the control site. The remainder of the gear (i.e., experimental) was set at one or two other locations on the fishing grounds at the discretion of the participants. The location of each fishing set was plotted on a nautical chart. Start time of the set and soak time for the gear were recorded. Environmental observations were also recorded, including wind direction and speed, percent cloud cover, tide conditions; presence of invertebrates and other fish species in the area (e.g., bait), marine mammals, sea birds and any other variables that might have influenced fishing behaviour were also noted. For several years selected sites were equipped with a CTD device which measures water temperature and salinity at depth. At these locations, CTD casts were conducted in the vicinity of fishing sets each fishing day. CTD locations were fished for subsequent years when possible.

When gear was retrieved, catches from control and experimental gear were kept separate and sampled on shore. All fish from gillnet, hand line and linetrawl, and a sample of the catch from traps, were measured for total length and sex. Otoliths were sampled on a fish length-stratified

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basis and stored in manila envelopes labeled with relevant information. Selected participants collected a sample of up to 100 frozen fish on a biweekly basis for detailed biological sampling at DFO's Northwest Atlantic Fisheries Center. Detailed weight analysis measurements were taken on these samples and condition indices were calculated using:

$$\begin{aligned}\text{Fulton's condition factor (K}_s\text{)} &= \text{gutted weight (g)} \times \text{length (cm)}^3 \\ \text{Hepatosomatic Index (HSI)} &= \text{liver weight (g)} \times \text{gutted weight (g)}^{-1} \times 100 \\ \text{Gonadosomatic Index (GSI)} &= \text{gonad weight (g)} \times \text{gutted weight (g)}^{-1} \times 100.\end{aligned}$$

Other biological samples were collected when requested. Since 2005, species other than cod have been recorded and measured as well, and this by-catch information is presented as number of fish caught per day (control and experimental sets combined).

## RESULTS

Table 2 and Fig. 1 summarize sentinel activity by gear type and NAFO Division from 1995 to 2010; including the number of sets of gear in each Division (Nhaults), the total number of fish caught (Nmeas) and the number of sets with no fish (Nzero). The number of gillnet sets declined in 2003, but has remained relatively stable since then. Linetrawl effort in Subdiv. 3Ps declined from 1995 to 1999 and has varied between 180 and 400 sets per year since.

Thirteen enterprises continued to collect information in 2009 and 2010. Each enterprise involved surveyed for 9 weeks in most recent years. Survey timing varied at each location as per traditional fishing seasons.

Figures 2-7 show catch per unit effort (CPUE) in scaled symbols from every set in 2009 and 2010 of 3¼ inch gillnet, 5½ inch gillnet, and linetrawl. Control sites were generally consistent from year to year but shifts in location may have resulted due to weather or tide conditions or competition for sites by commercial activity. In general, linetrawl is used to survey in areas west of the Burin peninsula, while gill nets are used to survey within Placentia Bay.

Figure 8 shows overall average CPUE from 1995 to 2010 for the three main gear types used in Sentinel activity. Gillnet (5½ inch) catch rates were highest in 1997, declined rapidly to 2000 and have been stable at a lower level since. Small mesh (3¼ inch) gillnet catch rates were also stable over the time series since 1998, and although it is more difficult to determine trends, a decreasing trend from 1996 to the early 2000s is apparent. The gear's ability to catch two distinct size ranges of fish could mask trends in either size group from year to year. Linetrawl catch rates were more variable, but in general, catch rates decreased from 1996-2000 then gradually increased to 2006 and have again declined slightly to 2010.

Figures 9-11 give annual average CPUE for gillnet (number of cod per net) and linetrawl (number of cod per 1000 hooks) with participants' communities listed. All locations surveyed (control and experimental) are included in the yearly averages. For small mesh gillnet (Fig. 9), Little Harbour East and North Harbour showed the highest catch rates in the early part of the time series, but those catch rates declined to 2000 and in North Harbour, have remained lower since. Catch rates there are now similar to levels in other small mesh locations. In 5 ½ inch gillnet sites (Fig. 10) North Harbour again had the highest catch rates from 1995-1999 and other locations also had the highest catch rates in their respective time series during this time. Since then, catch rates have remained lower. Linetrawl (Fig. 11) catch rates were also higher in some sites in 1995-1997 than in subsequent years, although trends are not as obvious as in gillnet. In

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Burgeo and Ramea however, catch rates trended downward from 1996-2000, but since then have been variable and have shown some of the highest catch rates in the time series.

Figures 12-14 present weekly average catch rates (number of fish per net or 1000 hooks) by year and gear. Week 23 corresponds to June 1 in most years (week 22 in 2001-02, and 2006-07). From 1995-1998, when catch rates in 5 ½ inch gillnet were highest in the series, the highest catches were taken in the fall and winter (from week 44 - week 2 or 3; Fig. 13). These higher fall and winter catches have not been observed since 2000. Linetrawl (Fig. 14) catch rates were more variable from week to week and year to year. Although trends are less obvious, catch rates seem to be higher in the fall.

Length frequencies are shown in Fig. 15 as proportion at length by gear type and NAFO division. The 5 ½ inch gillnet frequencies show the narrowest range of size selectivity (about 50-80 cm). Given the highly selective nature of this gear, frequencies are generally the same shape from year to year. Small mesh gillnet (3¼ inch mesh) caught primarily smaller fish (in the 35-48 cm range) but also picked up a second mode of fish in the 50-65 cm range. Changes in size distribution were difficult to detect in this gear due to its limited selection pattern. Linetrawl had the widest range of size selection of the three gear types used in the sentinel survey, targeting fish from about 30-70 cm. Changes in size distribution of fish were detected in this gear more readily and a shift toward larger fish from 2003 to 2006 and then smaller fish were more evident in 2007 and 2008.

At several locations in 3Ps, fish were sampled for detailed biological information. Data on body condition ( $K_s$ ), liver condition (HSI), gonad condition (GSI), length and weight at age were compiled for monthly and annual trends. Liver (hepatosomatic index; HSI) and gutted body condition (Fig 16) cycled seasonally, as did the gonadosomatic index (GSI) for both males and females. GSI increased from January to June, in females, as the ovaries enlarged in preparation for spawning, and decreased over the spawning season (April-October) to a low value in October. Both liver and body condition were lowest in April/May and were highest from September to December.

Mean length and weight at age (bias corrected for sampling stratification) for cod sampled from the Sentinel Survey are plotted in Figs. 17-20. Both length and weight at age have declined in fish age 4 and older since the early part of the time series. Although trends were similar, cod sampled from linetrawl showed a lower weight and length at age than those sampled from gillnets (Figs. 18 and 20). These differences may be related to gear selectivity or geographic differences in gears used (as linetrawl is used predominantly to the west of the Burin Peninsula) but may also point to growth differences between subcomponents of the 3Ps stock.

By-catch information was presented as total number of fish caught incidentally in sentinel gear for each year. In gillnet, American plaice, winter flounder and redfish were the main by-catch species, while linetrawl caught a wider range of species including mainly plaice, redfish, wolfish, skate, pollock and haddock.



## DISCUSSION

This document summarizes the catch rate trends and length frequency data for sentinel surveys in NAFO Subdiv. 3Ps in 1995-2010. Given the large spatial coverage of the survey and the differences in timing of the survey between locations, relating observations on catch rate to changes in population dynamics of Atlantic cod requires standardizing the data for time and location effects. These analyses were undertaken and reported in Healey et. al. (in press), and in the Science Advisory Report for Subdiv. 3Ps (DFO, 2010). In general, trends in the unstandardized data were in agreement with results from the analyses that took time and location into account.

*Table 1. Number of sentinel survey sets (all gears) 1995-2008. Data collection for 2010 is ongoing.*

Community	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
St. Bride's	163	88	70	80	2	54	63	80	59	50	61	64	70	63	49	24
Placentia		41														
Fox Hr	146	88	72	72	36	48	60	60	48	54	54	54	60	60	60	12
Little Hr East	163	36	57	48	10	46	67									
Fairhaven								73								
Arnold's Cove	153	63	69	27	8	42										
North Hr	118	74	70	50	20	54	55	43	46	30	57	52	55	52	47	21
Monkstown	148	69	72	72	36	51	60	60								
Little Paradise	52	38	44	39	35	44	63	64	42	58	52	56	66	70	64	48
Red Hr	31	30	29	31	21	29	30	61	22	33	36	34	41	35	32	24
Lawn		57	69	71	36	64	78	80	36	72	70	72	59	54	40	8
Lord's Cove	47	39	40	48	36	48	60	84	47	70	72	69	80	80	80	56
Grand Bank							60	60	38	44	44	42	42	46	46	30
Rencontre East	180	96	71	74	35	54	72	60	20	32	48	36	36	36	36	
Hr Breton	158	39	27	28	32	29	31	54	34	30	34	40	30	45	36	6
Seal Cove	204	71	44	42	33	54	46	48	9							
Francois	181	66	74	69	18	30	36	30	25	10	42	38	28	32	22	16
Ramea	206	46	96	60	38	82	92	82	46	36	44	44	50	50	48	16
Burgeo		46	60	62	26	32	64	46	36	24	32	44	40	36	41	8
Number of weeks allocated	30*	12	12	12	6	8	10	10	6	9	9	9	9	9	9	9

\* Includes 15 week pilot project

Table 2. Set details for Senetinel Survey activity in NAFO subdivision 3Ps from 1995-2010. Nhauls=number of sets; NZero=number of sets with no fish; Nmeas=number of fish measured. Data for 2010 are preliminary.

Gillnet 3 1/4"			
Year	Nhauls	Nzero	Nmeas
1995	2	0	34
1996	10	0	1421
1997	22	1	2544
1998	29	1	1829
1999	6	1	233
2000	48	6	1393
2001	62	6	1831
2002	88	8	1913
2003	47	1	687
2004	60	6	1351
2005	60	8	723
2006	61	5	1067
2007	63	3	664
2008	54	1	848
2009	46	7	674
2010	44	1	894
Gillnet 5 1/2"			
Year	Nhauls	Nzero	Nmeas
1995	760	216	37776
1996	412	10	40221
1997	459	5	44771
1998	525	14	31163
1999	234	16	6329
2000	424	64	5578
2001	497	37	5720
2002	499	64	4958
2003	246	37	1648
2004	303	33	2560
2005	330	50	2556
2006	327	30	2823
2007	360	25	4027
2008	317	27	3695
2009	313	60	2682
2010	255	41	2593
Linetrawl			
Year	Nhauls	Nzero	Nmeas
1995	1147	55	74813
1996	555	4	61839
1997	467	4	36548
1998	315	4	20521
1999	194	13	9536
2000	407	25	19148
2001	376	28	18274
2002	385	13	21224
2003	214	14	11612
2004	179	6	9301
2005	235	3	11341
2006	254	6	19470
2007	232	5	13295
2008	259	7	15979
2009	237	8	12241
2010	109	13	4840

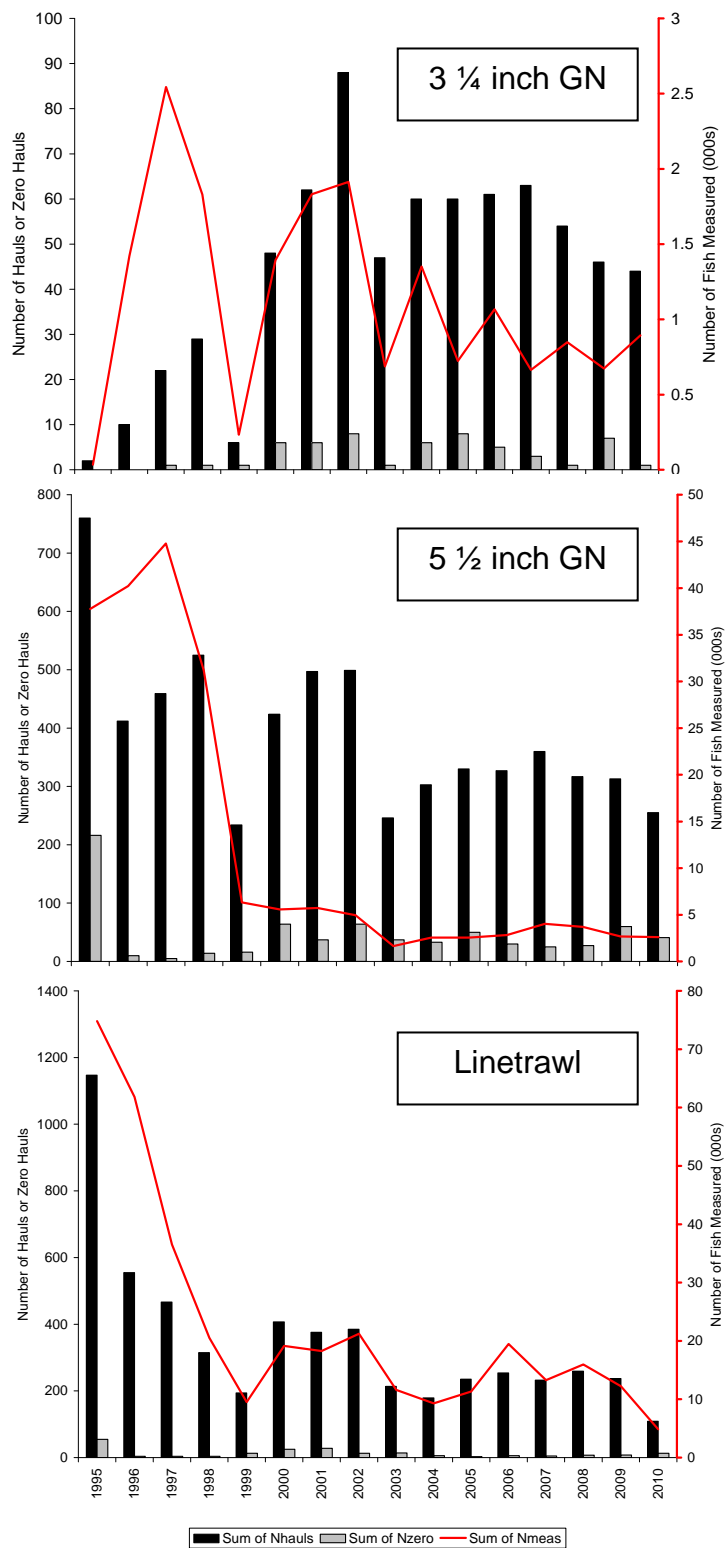


Figure 1. Summary information for sentinel survey activity in NAFO Subdivision 3Ps from 1995 to 2010. Nhails= number of sets; Nzero= number of sets with no fish; Nmeas= number of fish measured. Data for 2010 are preliminary.

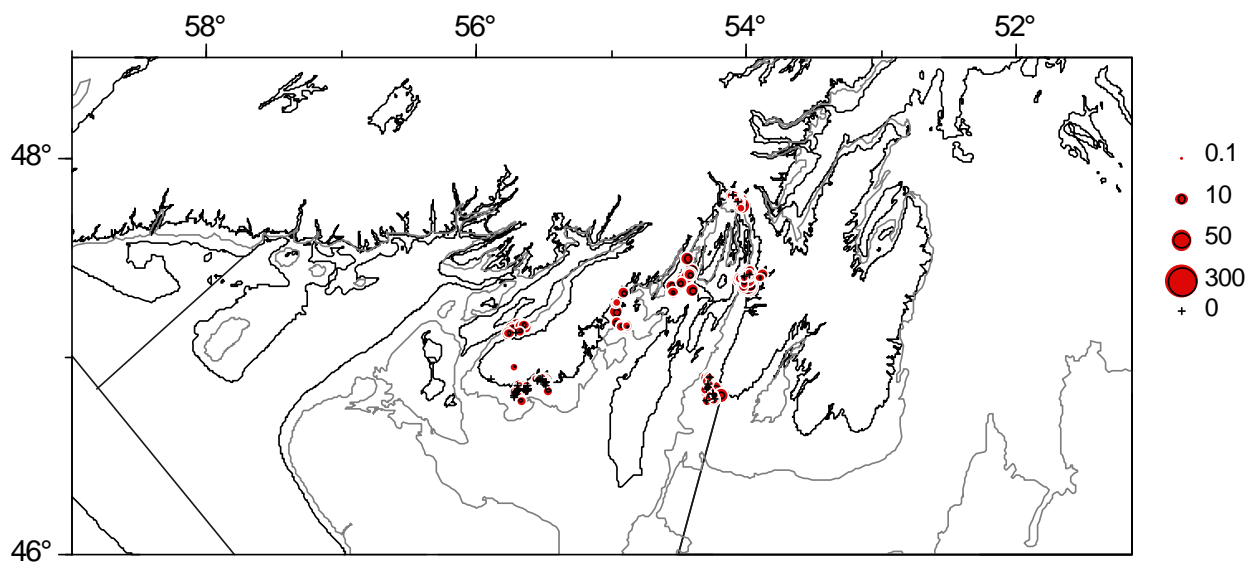


Figure 2. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for 5½ inch gillnet in NAFO Subdivision 3Ps for 2009.

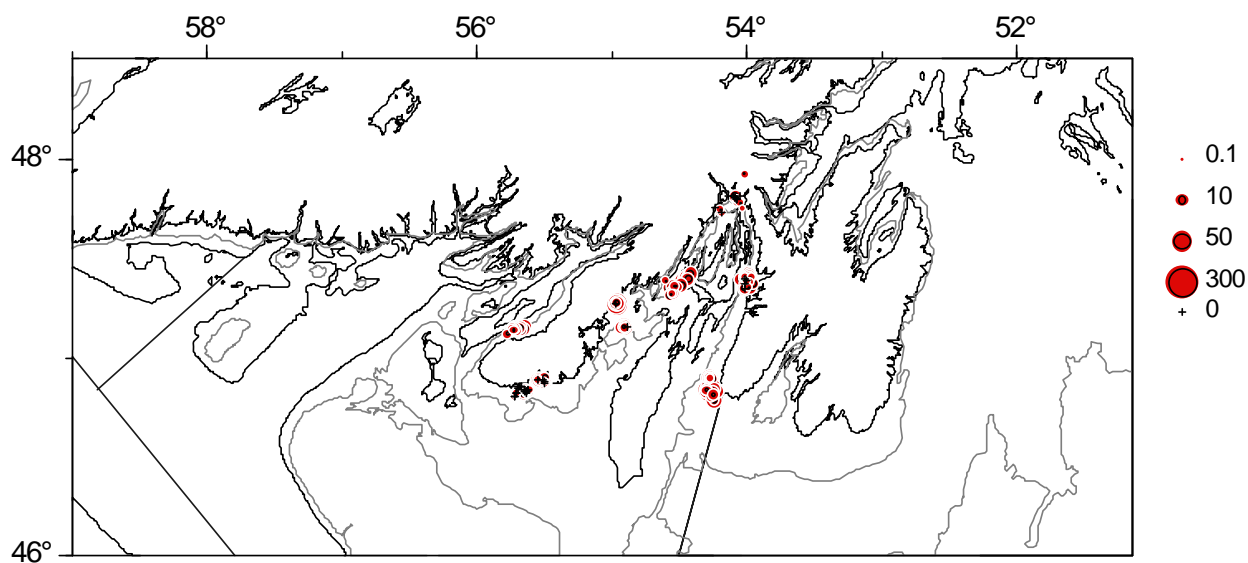


Figure 3. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for 5½ inch gillnet in NAFO Subdivision 3Ps for 2010 (data are preliminary).

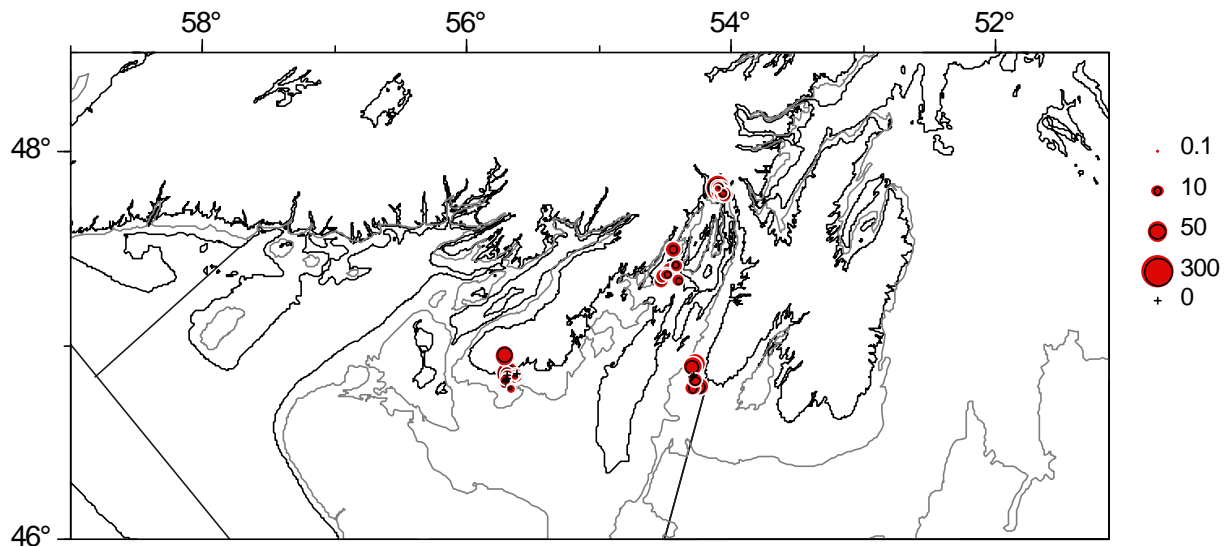


Figure 4. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for 3 1/4 inch gillnet in NAFO Subdivision 3Ps for 2009.

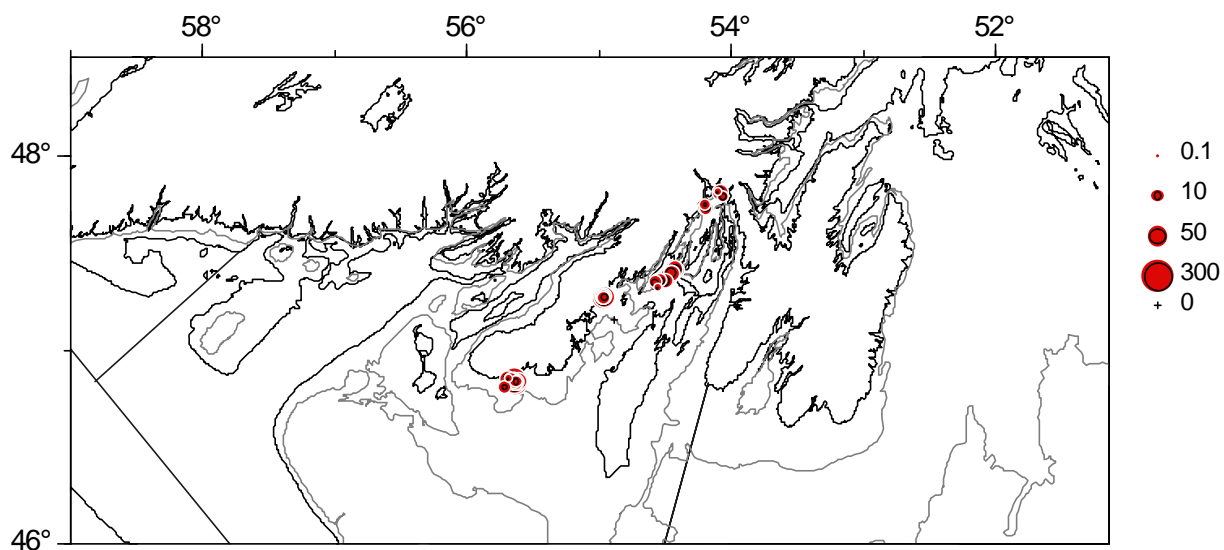


Figure 5. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for 3 1/4 inch gillnet in NAFO Subdivision 3Ps for 2010 (data are preliminary).

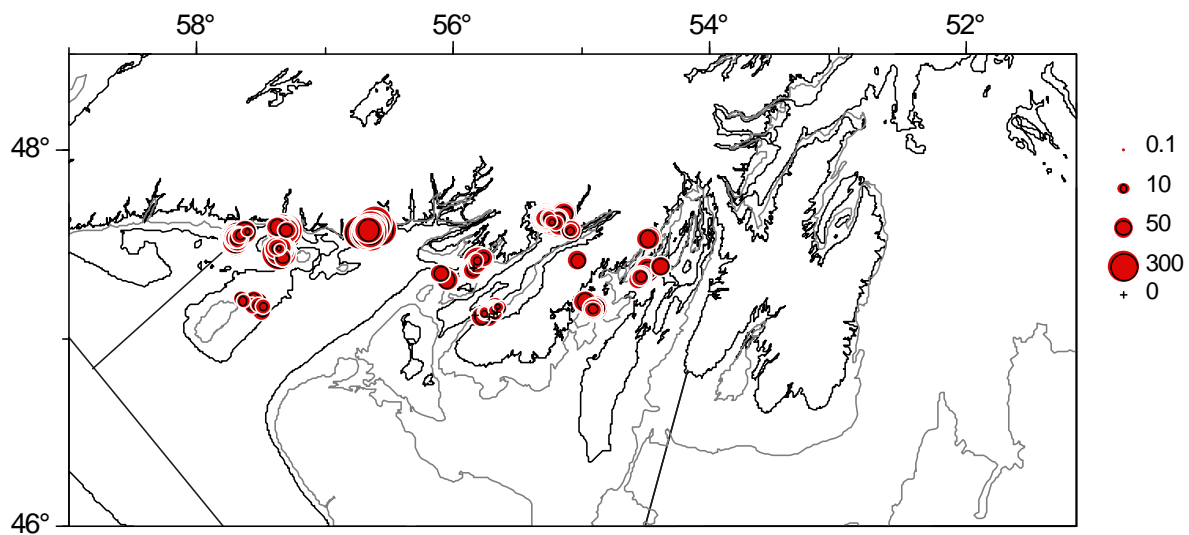


Figure 6. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for linetrawl in NAFO Subdivision 3Ps for 2009.

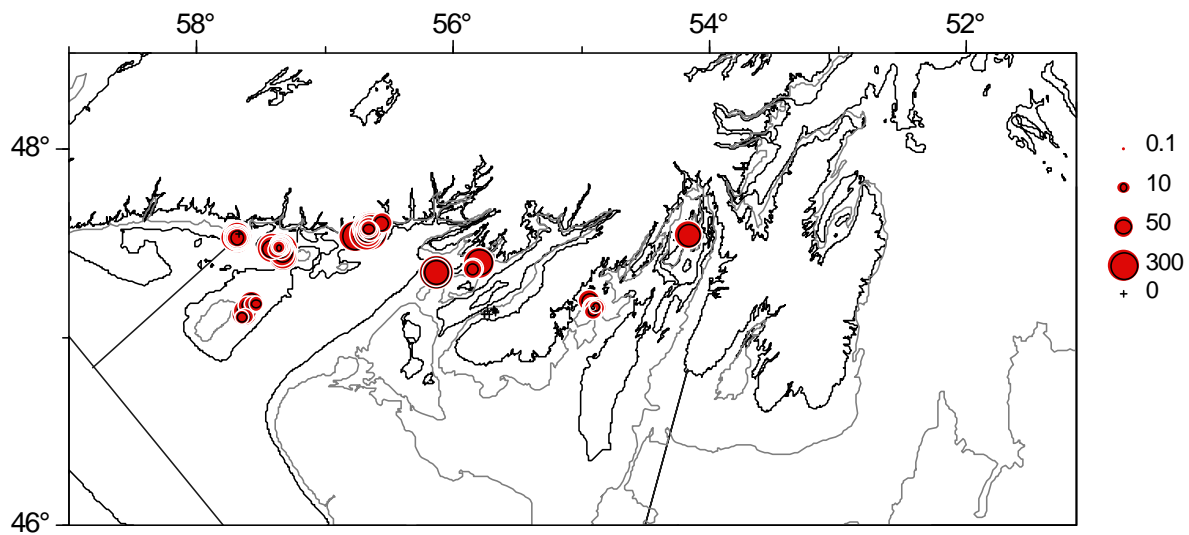
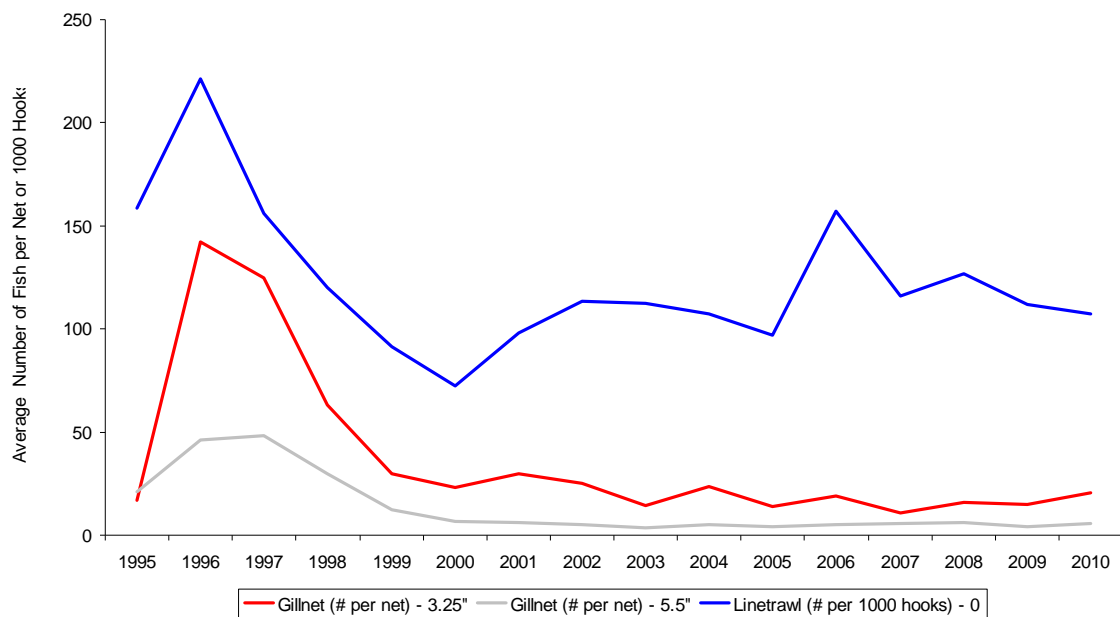


Figure 7. Sentinel survey scaled symbols showing catch per unit effort (number of fish per net) for linetrawl in NAFO Subdivision 3Ps for 2010 (data are preliminary).



*Figure 8. Average number of fish per net or 1000 hooks caught in sentinel surveys for NAFO Subdivision 3Ps 1995-2010. Data for 2010 are preliminary.*

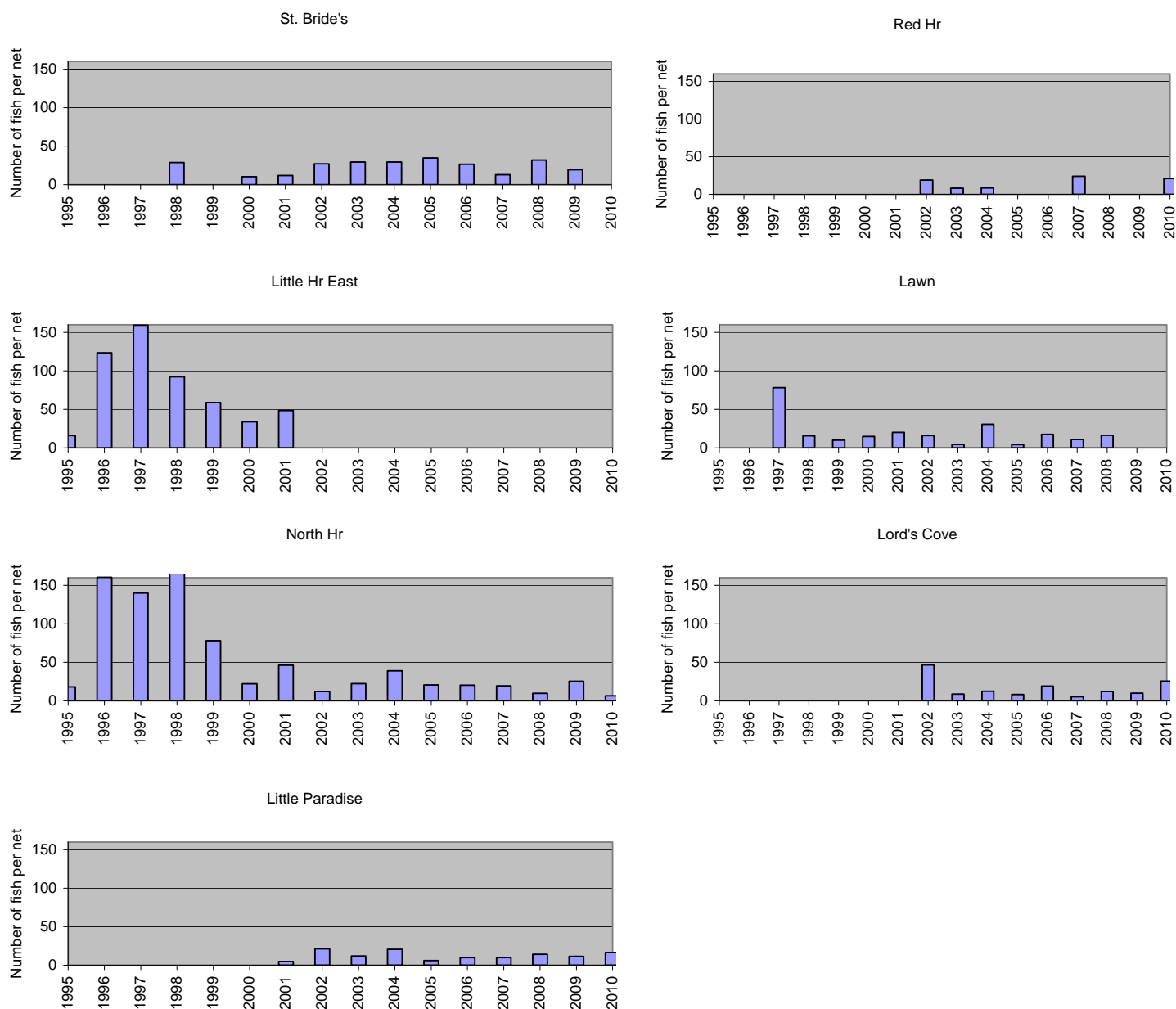


Figure 9. Yearly average number of fish per 3 1/4 inch gillnet caught in sentinel surveys by site for NAFO Subdivision 3Ps.



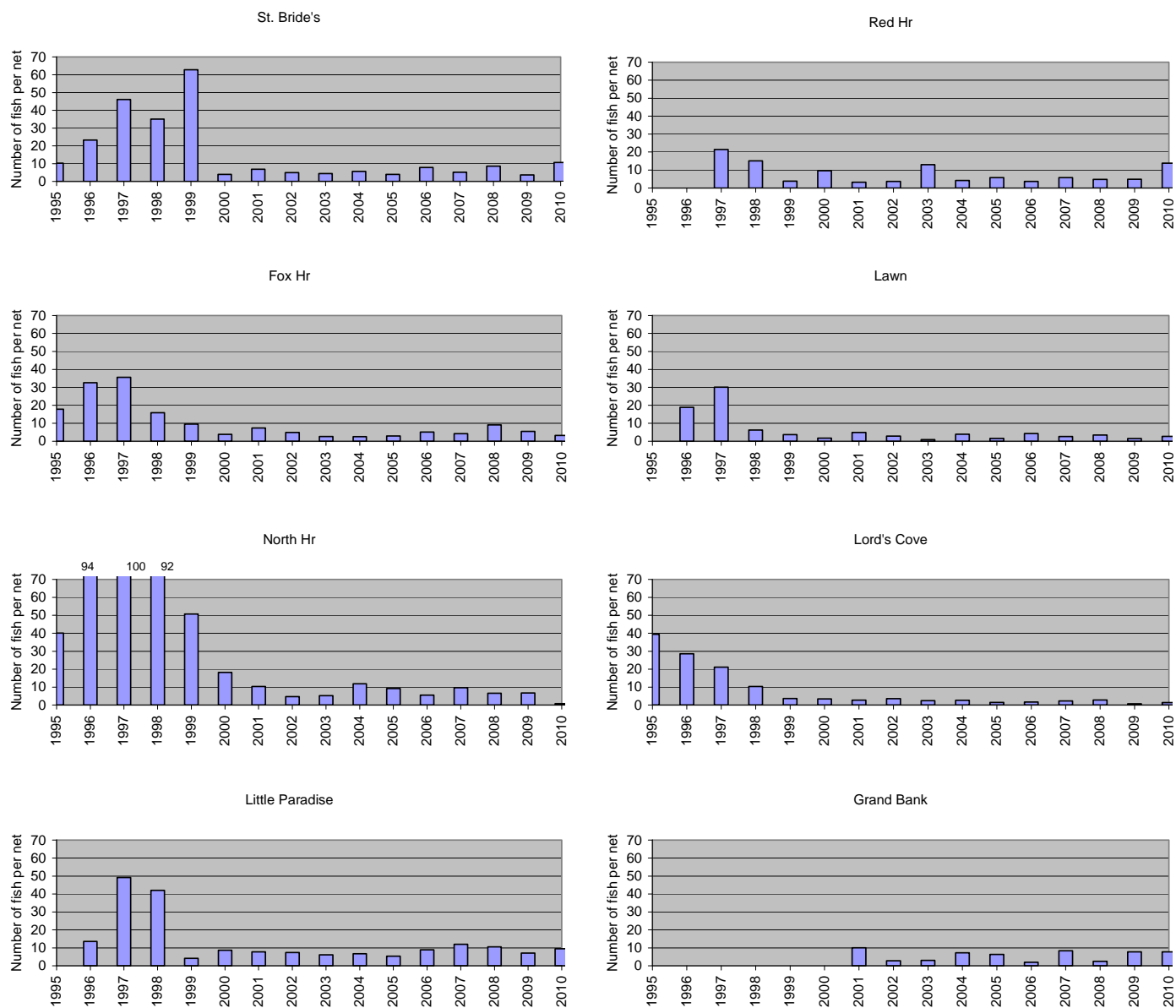


Figure 10 .Yearly average number of fish per 5½ inch gillnet caught in sentinel surveys by site for NAFO Subdivision 3Ps.

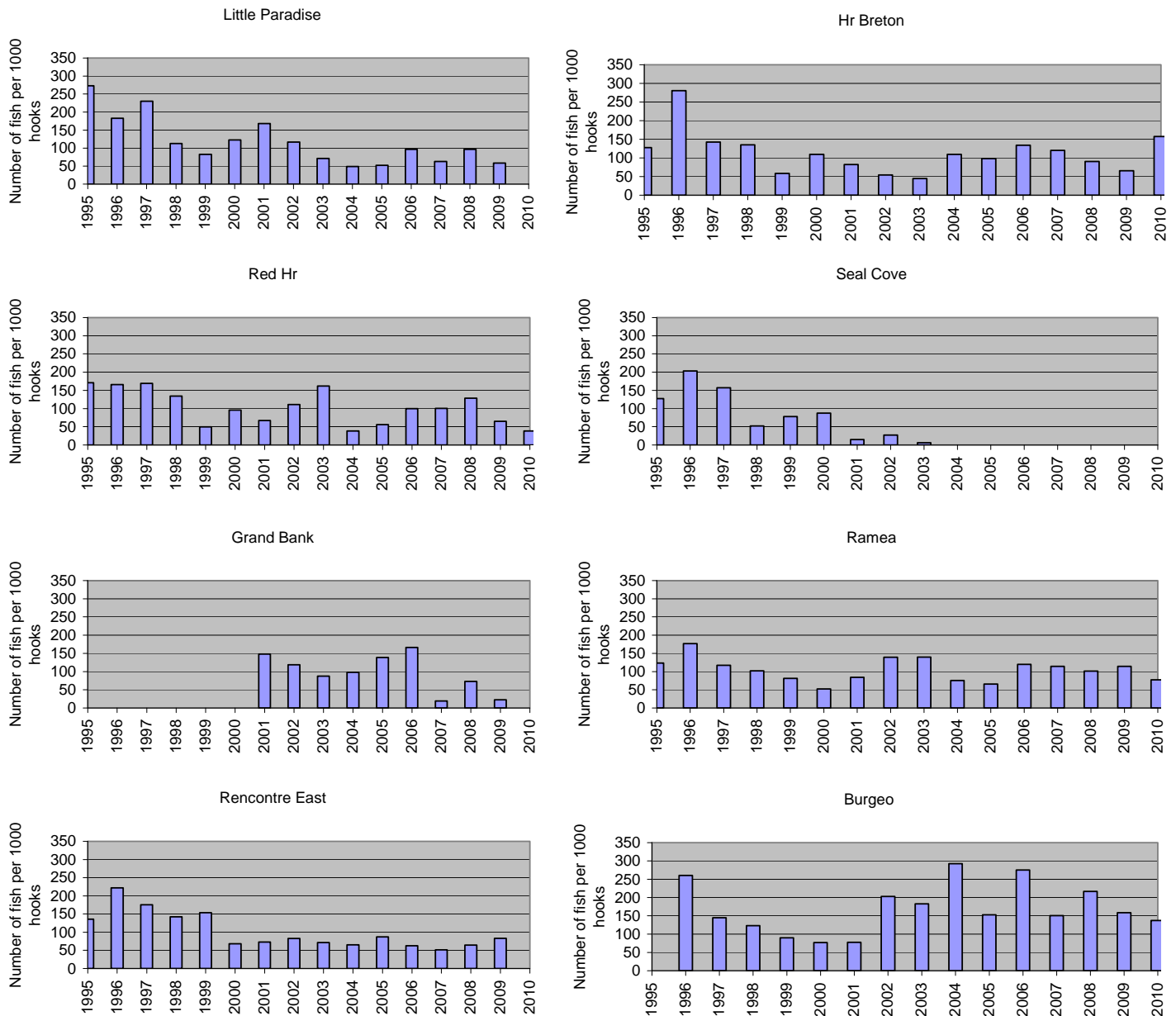


Figure 11. Yearly average number of fish per 1000 linetrawl hooks caught in sentinel surveys by site for NAFO Subdivision 3Ps.

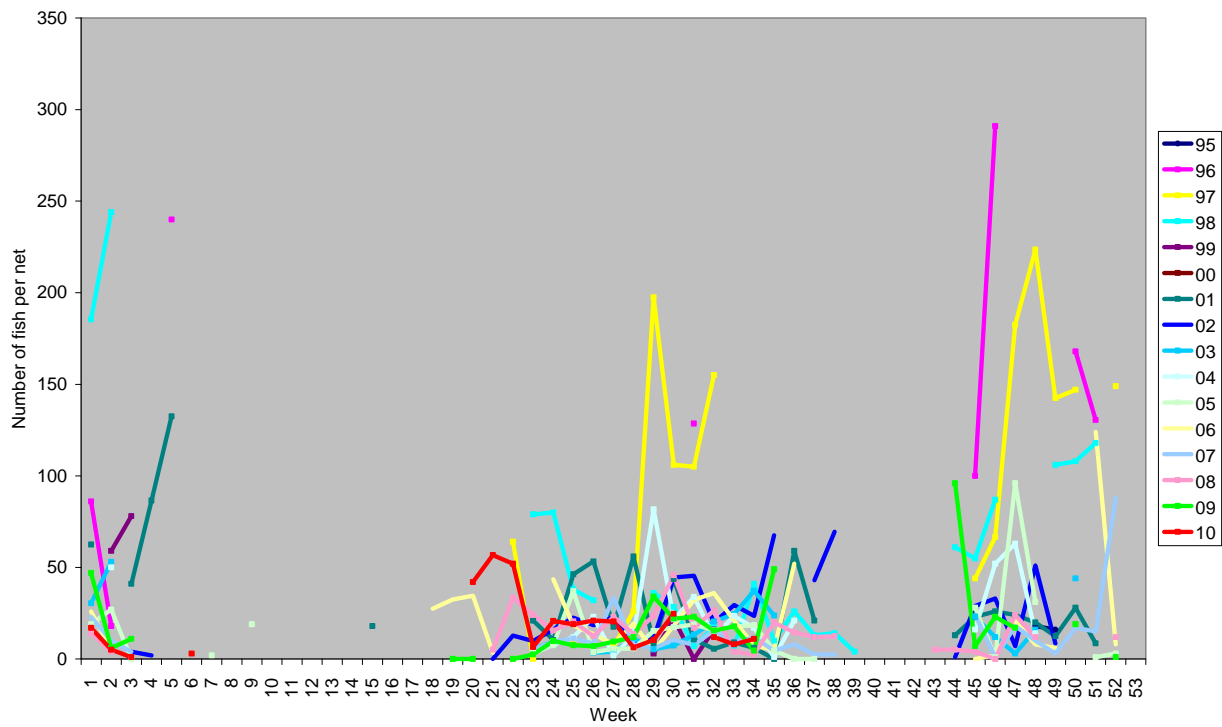


Figure 12. Sentinel small mesh gillnet (3¼ inch) in Subdivision 3Ps: average catch per unit effort by week (number of fish per net) in 1996-2010.

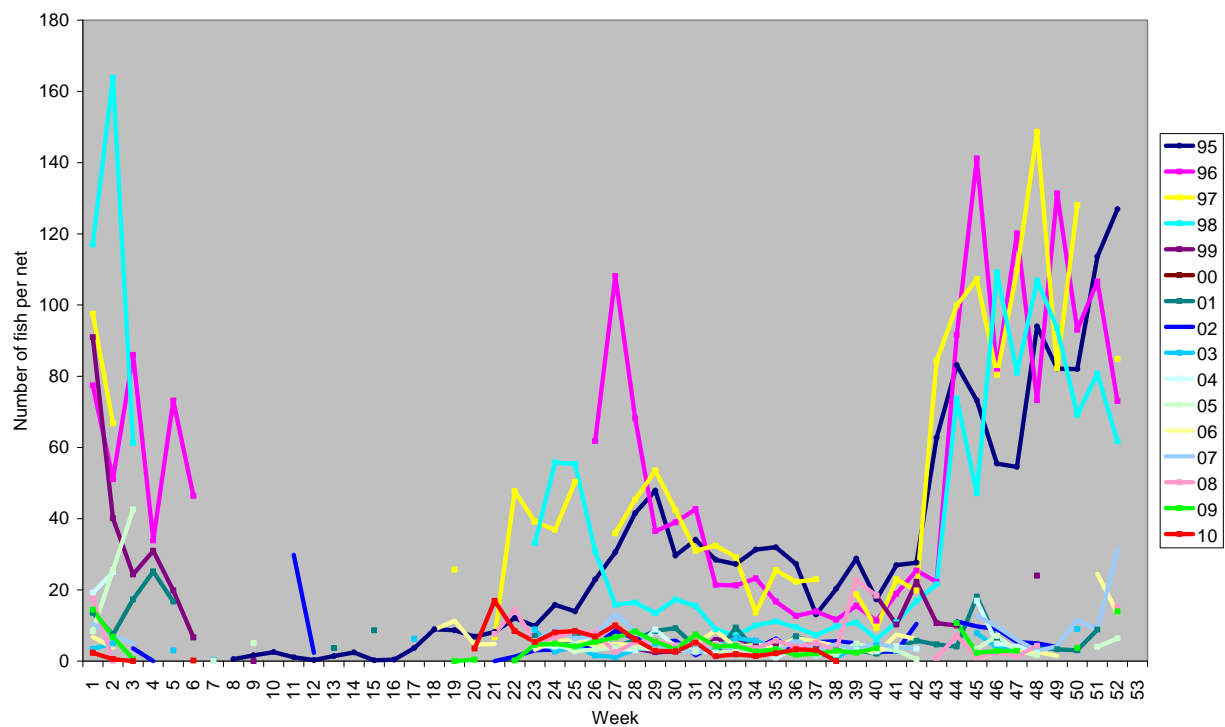


Figure 13. Sentinel gillnet (5½ inch) in Subdivision 3Ps: average catch per unit effort by week (number of fish per net) in 1996-2010.

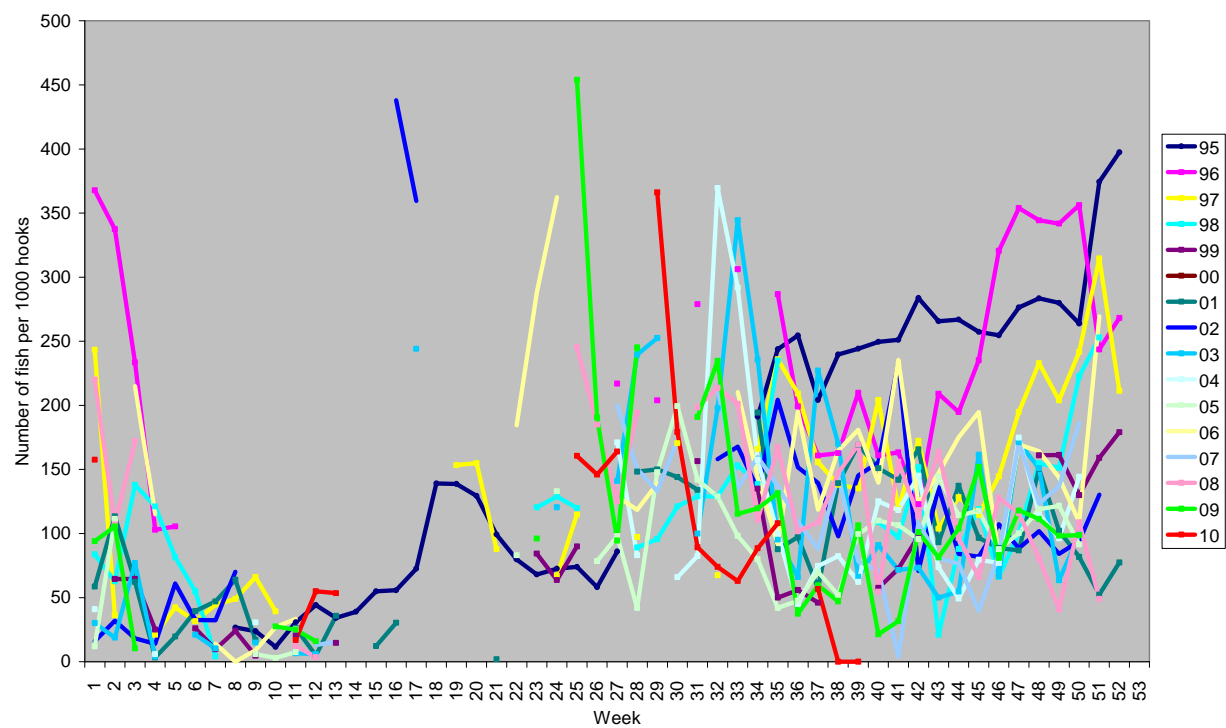


Figure 14. Sentinel linetrawl in Subdivision 3Ps: average catch per unit effort by week (number of fish per 1000 hooks) in 1996-2010.

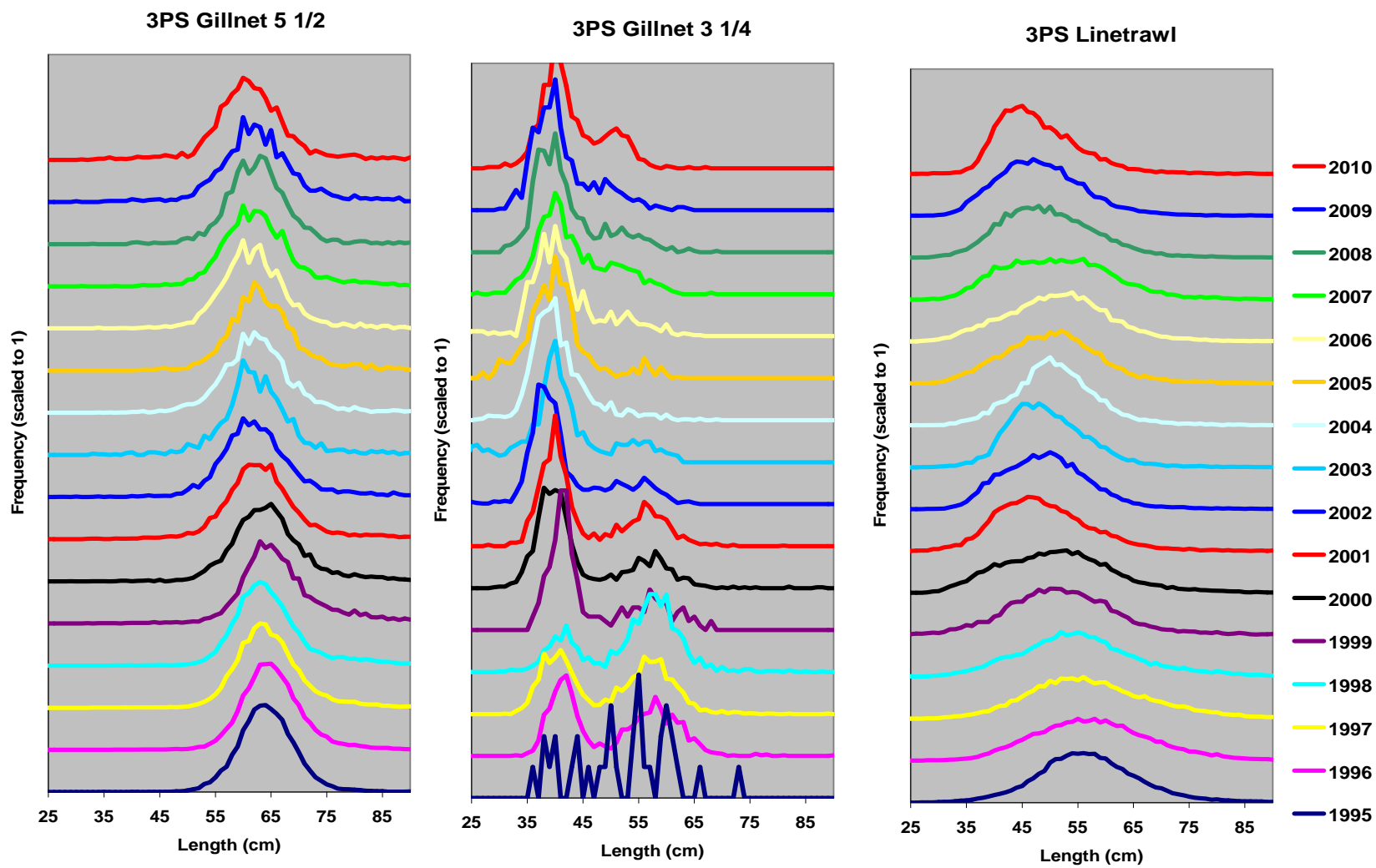


Figure 15. Length frequencies (number at length scaled to 1) of cod caught in Sentinel surveys from 1995 to 2010 in NAFO Subdivision 3Ps.

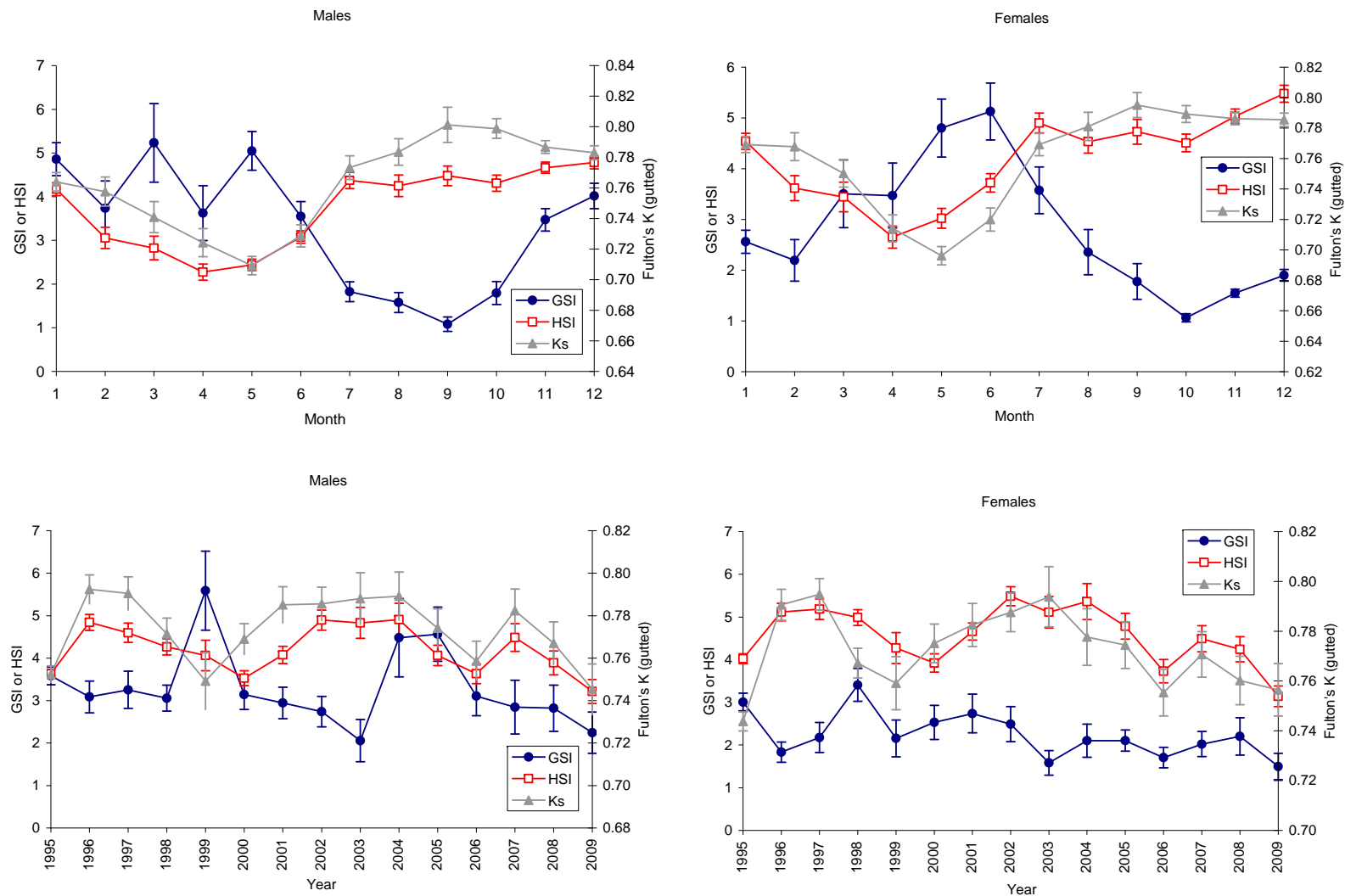


Figure 16. Gonadosomatic Index (GSI), hepatosomatic index (HSI) and Fulton's gutted condition factor (Ks) by month and year for cod sampled in Sentinel surveys in NAFO subdivision 3Ps.

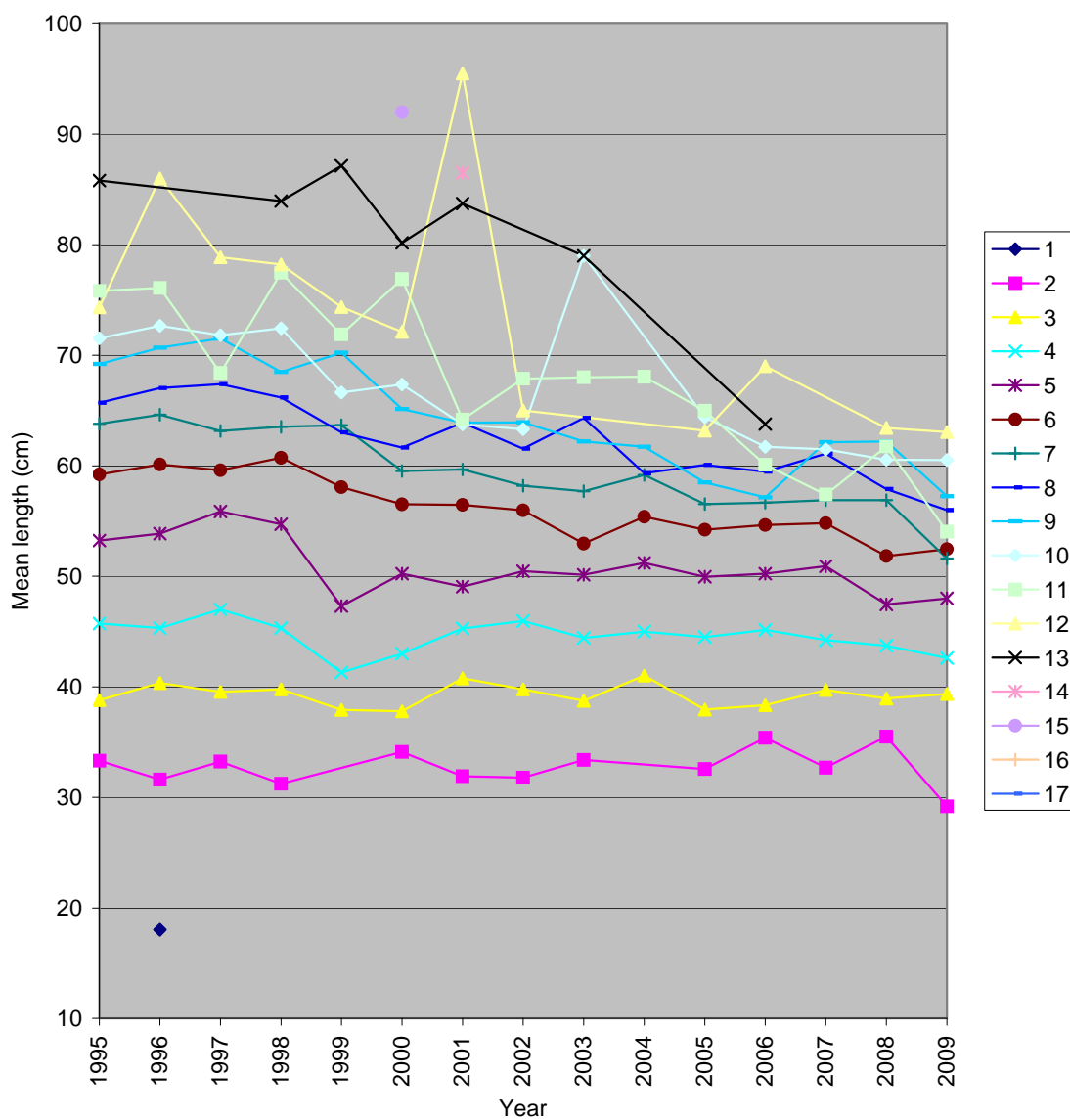


Figure 17. Mean length (cm) at age for cod sampled in sentinel surveys in NAFO Subdivision 3Ps, 1995-2009. Means are corrected for sampling bias.



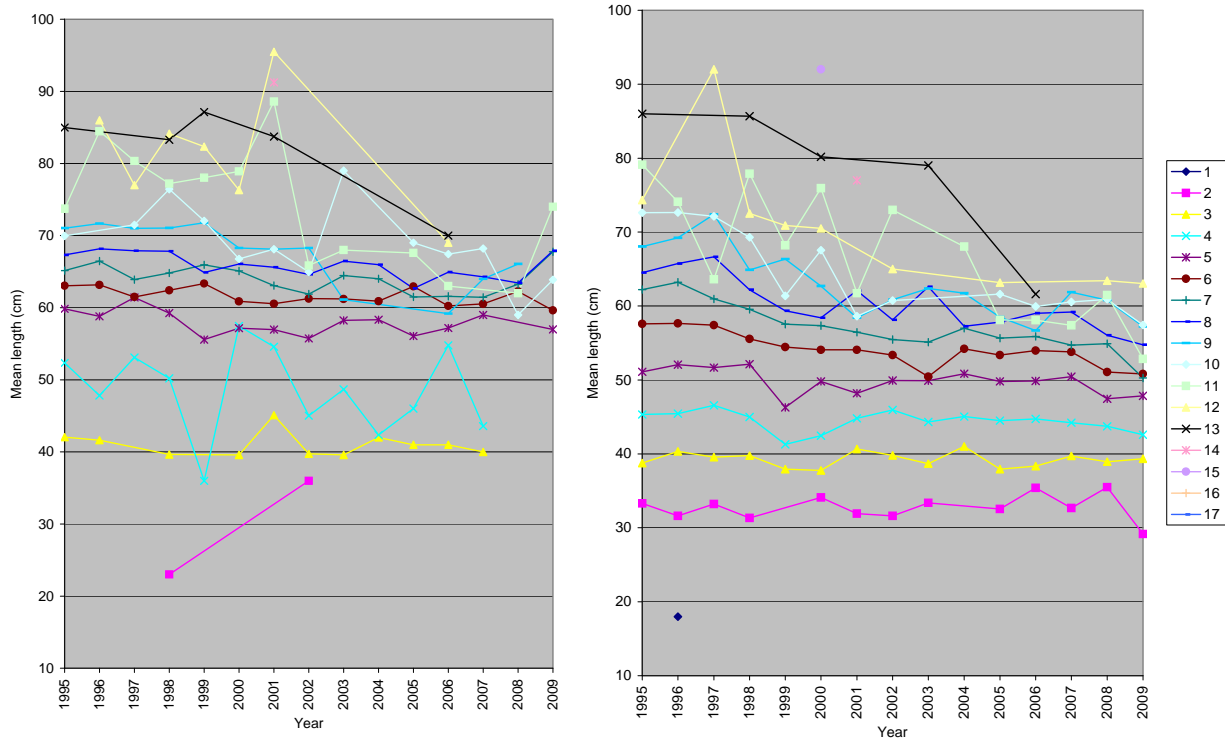


Figure 18. Mean length (cm) at age for gillnet (left panel) and linetrawl (right panel) for cod sampled in sentinel surveys in NAFO Subdivision 3Ps, 1995-2009. Means are corrected for sampling bias.

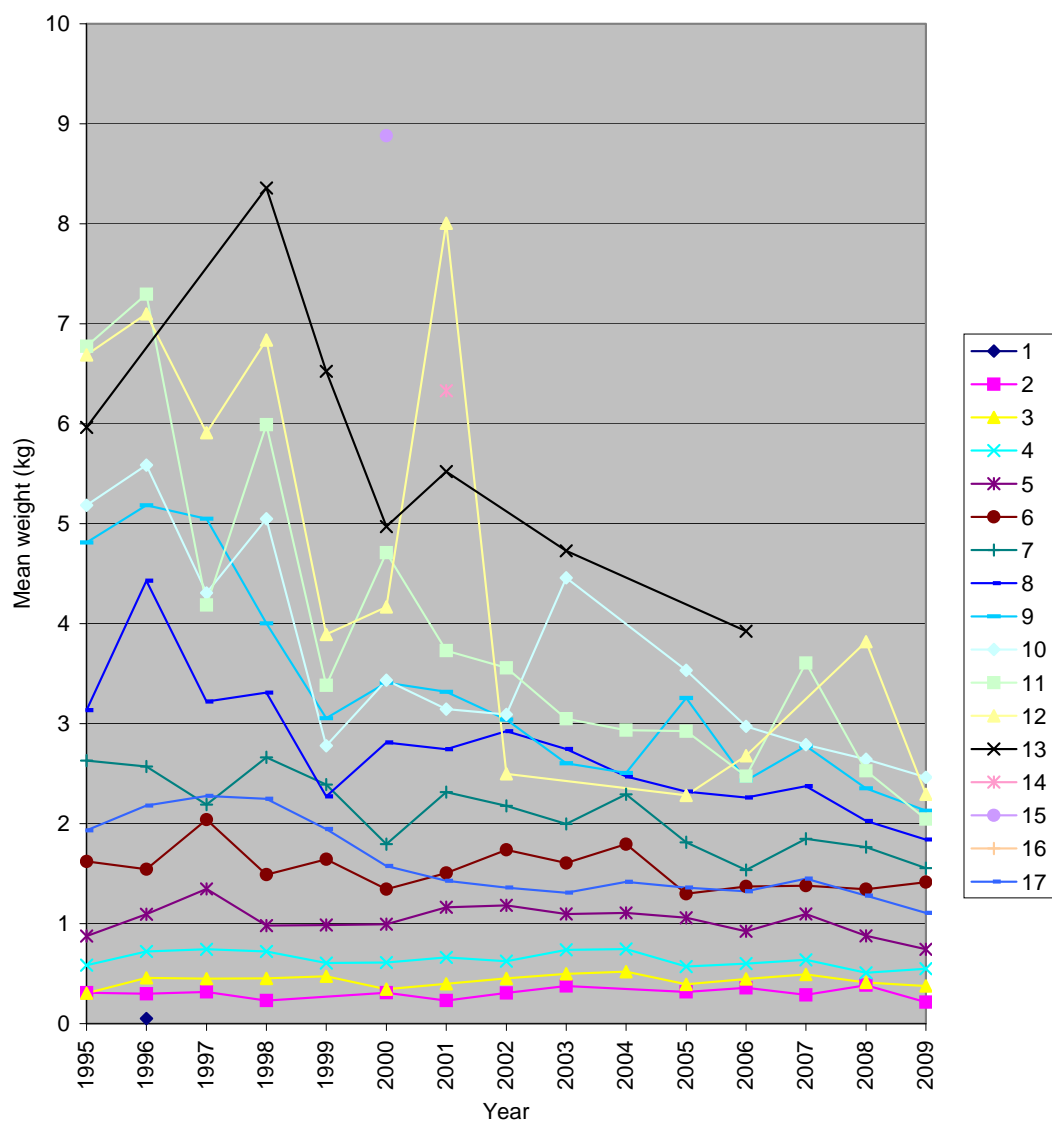


Figure 19. Mean weight (kg) at age for cod sampled in sentinel surveys in NAFO Subdivision 3Ps, 1995-2009. Means are corrected for sampling bias.

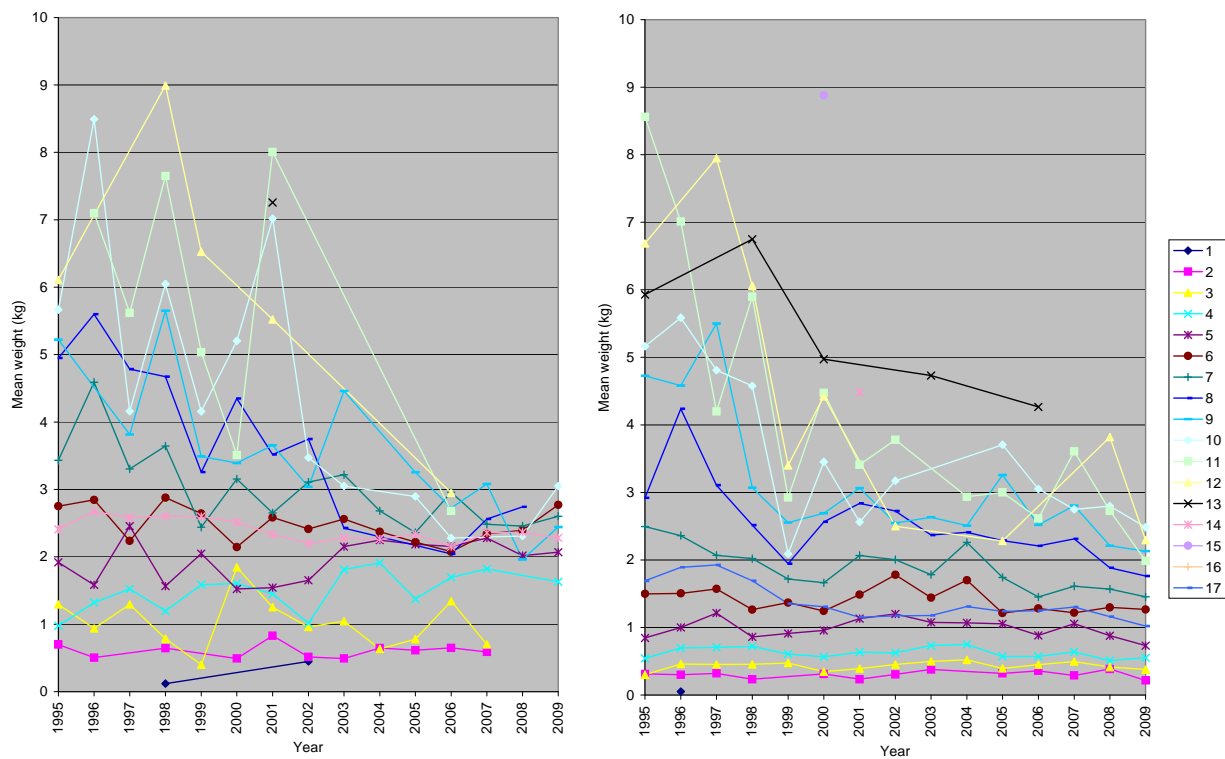


Figure 20. Mean weight (kg) at age for gillnet (left panel) and linetrawl (right panel) for cod sampled in sentinel surveys in NAFO Subdivision 3Ps, 1995-2009. Means are corrected for sampling bias.

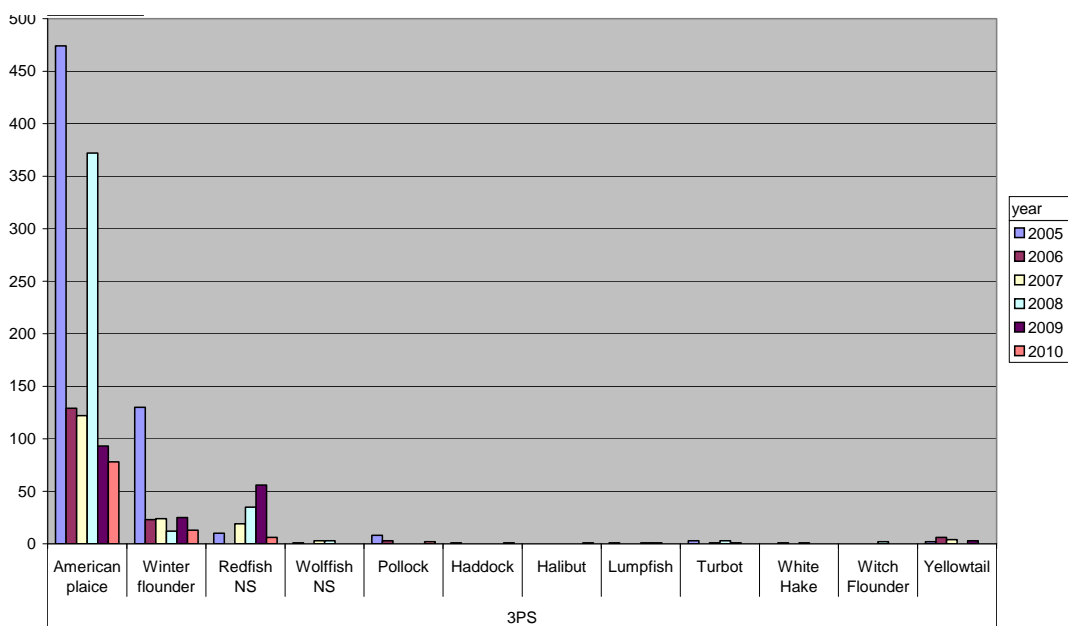


Figure 21. Total annual numbers of by-catch species caught in sentinel gillnets in NAFO Subdivision 3Ps from 2005 to 2010.

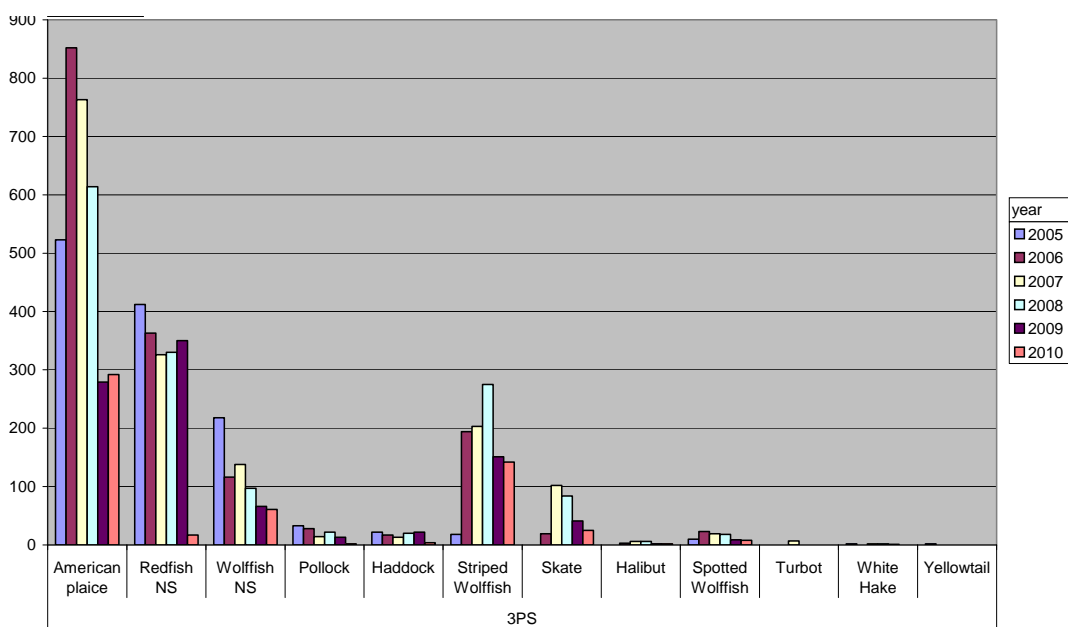


Figure 22. Total annual numbers of by-catch species caught in sentinel linetrawl in NAFO Subdivision 3Ps from 2005 to 2010.