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Report of the Study Group on the Bycatch of Salmon in Pelagic Trawl Fisheries (SGBYSAL)

8–11 February 2004

Bergen, Norway

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Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

1.1 Main Tasks

At its 2004 Statutory Meeting, ICES resolved (C. Res. 2ACFM25) that a Study Group on Bycatches of Salmon in Pelagic Fisheries [SGBYSAL] (Chair: Marianne Holm, Norway) will meet at the Institute of Marine Research, Bergen, Norway, 8–11 March 2005 to consider questions posed to ICES by the North Atlantic Salmon Conservation Organisation (NASCO). The terms of reference and sections of the report in which the answers, where possible, are provided, are as follows:

	SECTION
Work with the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy, HAWG, and WGNPBW as well as national laboratories to make available disaggregated data on the commercial catches of mackerel and herring in the Norwegian Sea (ICES Divisions IIa and Vb), the Northern North Sea (Division IVa), and the west of Ireland and Scotland (Divisions VI a & b; VII b,c,j & c) by ICES Division and standard week 16-36; Data provided by a number of countries.	2.1; 2.3
Work with the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy, HAWG and WGNPBW well as national laboratories to make available disaggregate data on the number of boats and gear types used in the commercial fishery of mackerel, herring and horse mackerel in the Norwegian Sea (ICES Divisions IIa and Vb), the Northern North Sea (Division IVa), and the west of Ireland and Scotland (Divisions VI a & b; VII b,c,j & k) by ICES Division and standard week 16–36;	2.2¸ 2.4
Explore new data available for estimating bycatches of Atlantic salmon in the pelagic fisheries in the north East Atlantic and where possible give an assessment of their reliability	2.4 , 2.5 & 5
Explore analytical methods to allow catch rates of salmon in research surveys to be extrapolated to catch rates in commercial fisheries	3
Review methods used for intensive screenings of pelagic research hauls for the presence of postsmolt (small salmon in their first year at sea, generally < 45 cm) and older salmon	4

The Study Group considered data presented at the meeting or submitted by electronic mail from members of the HAWG, WGMHSA and WGNPBW or their colleagues; other references cited in the report are given in Appendix 1.

1.2 Participants

Belikov, S.	Russia
Boyd, J.	Ireland
Crozier, W.	UK (Northern Ireland)
Graham, N.	Norway
Holm, M. (Chair)	Norway
Iversen, S.	Norway
Jacobsen, J.A.	Faroes
Ó Maoiléidigh, N.	Ireland
Prusov, S.	Russia
Shamray, E.	Russia

A full address list for the participants is provided in Annex 2

1.3 Background

Reports of salmon being taken during pelagic fishing operations for a number of fish species in the eastern north Atlantic have been circulating for some years, but these have been spo-

radic and often anecdotal in nature and did not provide evidence of any potentially significant bycatch of salmon in these fisheries.

Since 1998, large numbers of Atlantic salmon postsmolt have been taken together with large numbers of mackerel in a Norwegian research surveys for salmon in the Norwegian Sea. These surface trawl catches (Holm *et al.*, 2000), indicated that there could be coincidence in time and space, which may give rise to a potential for salmon to be taken as bycatch in the mackerel fishery. As information on the distribution of salmon at sea has improved, this has also raised the possibility of interactions between salmon and other pelagic fisheries, such as herring. Accordingly, in 2002 NASCO asked ICES to *"provide an estimate of the bycatch of salmon postsmolts in the pelagic fisheries based on the scientific information currently available"*.

ICES reviewed the available information on the catch rates of salmon and of mackerel from surveys carried out in the Norwegian Sea during salmon research cruises in 2001–2002 (ICES, 2002). An approach was made to estimate post-smolt bycatches in the commercial mackerel fishery in the Norwegian Sea (area IIb and IVb) and in areas west of Ireland and Great Britain (IVa, VI and VII) (ICES, 2003a). Estimates of potential bycatch ranging from only a few specimens to a range of 608 000–950 000 postsmolt, depending on method applied, were produced. There are no reliable estimates of the smolt production of the NEAC salmon countries, but the estimated pre fishery abundance of this stock complex is approximately 3.5 million fish (ICES, 2003a).

Due to the extremely wide range of estimates found in the ICES review, including very high ones, a specific Study Group on *Bycatches of Salmon in Pelagic Fisheries (SGBYSAL*) was convened in March 2004, with the task of collating and analysing available information on this topic and providing an estimate of the bycatch of salmon in pelagic fisheries. A summary of the 2004 report is given in section 1.4.

1.4 Summary of the first SGBYSAL report in 2004.

The major pelagic fisheries in the Norwegian Sea, the North Sea and areas west and south of UK and Ireland were described and potential areas of interaction were identified based on time (quarters) space (ICES statistical rectangles) and gear type in use in the various fisheries (ICES, 2004c). Information on salmon movements at sea were used to indicate that the period of potential overlap in the Norwegian Sea mackerel fishery was probably limited to a relatively short period, centred around the latter half of June and early July, confirming the need for access to weekly disaggregated catch data to fully assess potential by catch. Disaggregated data for landings to the U.K. and Germany enabled a closer study of mackerel and herring fisheries in the western (VIa) and northern North Sea areas (IVa) per week and statistical rectangle. Possible areas of interception were detected also in these areas (ICES, 2004c).

A model for estimating progress in time and space of post smolt cohorts in the Norwegian Sea, based on data on distribution from research surveys was also examined and projected northward with estimated progression speeds of salmon. The Study Group recommended that with further development and using appropriate data, this model could form a useful tool to assess the risk of post smolts being intercepted by commercial fisheries in the area of passage.

A review of available information on detection of salmon during screening of catches by various countries was also carried out, revealing small but consistently occurring bycatches, mainly in various types of trawl fisheries. The advantages and constraints of various methods of screening pelagic catches for bycatch of salmon were evaluated and it was concluded that observer-based onboard screening programmes were the most effective method.

Analytical methods to estimate post-smolt bycatch in commercial fisheries were also explored, using the Norwegian Sea mackerel fishery as the only example where salmon catch

rate data had been obtained. Based on quarterly catch data, the overlap between post smolts and the fisheries in the Norwegian Sea appeared high, but the absence of disaggregated data (by week and statistical rectangle), impeded an assessment of the true overlap of post smolts with the fisheries.

In the absence of data on intercalibration between research catch methods and commercial catch methods, the Study Group concluded that the best method presently available would be based on direct observation on board commercial fishing vessels according to agreed protocols. Thus, estimates would be based on consistent gear types and fishing methods and would not depend on transferability of data from research catches. However, it was stressed that disaggregated catch data for week and standard rectangle for the areas in question was still a priority.

1.5 SGBYSAL 2005 report – limitations

It was not able to accomplish all the tasks requested from ICES/NASCO in 2004 and following further requests from ICES for provision of disaggregated catch data by all countries engaged in pelagic fishing in the NEAC area, SGBYSAL reconvened in February 2005.

The present report is essentially confined to deal with issues that could not be considered in-depth in 2004 either due to the lack of disaggregated data or lack of appropriate expertise in gear technology. *E.g.* descriptions of pelagic fisheries are only included where new data have been available or if the Group felt the previous report needed further clarification on a particular issue. The 2005 report is therefore to be considered as an addendum to the 2004 report (ICES, 2004c) and should be read in association with it.

2 SALMON DISTRIBUTION AND FISHERIES WITH A POTENTIAL TO INTERCEPT THEM

2.1 Distribution of postsmolt and salmon by origin in time and space

2.1.1 Horizontal distribution

Figure 2.1.1 shows the distribution of the post-smolt and adult salmon catches taken in Norwegian research trawls 1990–2004. The figure clearly indicates that the postsmolt are not evenly distributed, but are markedly concentrated in certain areas. The smolts are occurring in association with the warm and saline waters of the North Atlantic Current (NAC) and the dominating currents in the NE Atlantic (Holm *et al.*, 2004). Based on the low smolt ages recorded from the scales (1–2 years dominate), most of these fish are of southern European origin, *i.e.* from Spain to Scotland in range, although some of the 2-year smolts may originate also in west Sweden and south Norway. Most of the recaptures of micro-tagged postsmolts (over 90%) are originating from Ireland, which is not surprising, as the Irish releases of micro-tagged fish constitute the majority of the European micro-tagged fish.

Vertical distribution and salmon behaviour

The behaviour of a fish in relation to the fishing gear will determine whether it will be captured or not. As there are no specific fisheries targeting postsmolts, there are no behavioural studies relating to any gear therefore other sources of information have to be used to infer the likely behaviour of postsmolts in relation to *e.g.* an approaching trawl.

Cruising speed has been reported to be around 1 bl s^{-1} (Holm unpublished and Thorstad *et al.*, 2004) or between 0.25 and 1.9 kt for small and large salmon respectively. Burst speed of~3 ^{to} 4 bl^{-1} is known to be possible.

In the fresh water salmon are adapted to react to avian and fish predators (Bakshtansky *et al*.,1982; Jakobsson and Järvi, 1976; Järvi and Uglem, 1993) and exhibit varying behaviour to predators (*e.g.* birds flying over or encounters with fish predators). In aquaria, young salmon have been observed maintaining their distance from approaching predators. If the predator approaches at a uniform speed than they will react less vigorously than if the predator is rushing towards them (Holm, pers. obs.). It is thought that the "shock wave" created by a rushing predator alerts the smolts while a slowly approaching predator appears less threatening and can progress closer before the smolts react.

Acoustically tagged postsmolts were observed to dive if a boat came close or produced "noise" in the vicinity (Holm, pers. obs.). However, in very shallow water (in troughs) salmon parr have been observed to zigzag at the surface with the body partly out of the water to avoid certain predators (in this case burbot, Jakobsson and Järvi, 1976).

The Study Group considered information on recent recaptures of 4 Data Storage Tags (DSTs) from adult salmon tagged in the Norwegian Sea in April 2004. The depth graphs showed that these adult salmon had performed dives down to at least 280 m in some cases, although the most frequent dives were not deeper than 80–100 m. The amplitude and frequency of the dives changed over time, probably related to where the fish was on its coastward migration. In some cases the salmon stayed in the deep for more than an hour, possibly avoiding predators, but mostly the dives were of shorter duration and were possible an indication of feeding. Preliminary analyses of the data indicate a "cruising depth" for these fish between 5–10 m (Holm *et al.*, unpubl.), which is in accordance with sonic tracking study from the Faroes (Jakupstovu, 1988). Similar diving activity, although with less frequency and with smaller amplitudes (0-40m) have been observed for acoustic tagged postsmolts in fjords (Holm *et al.*, 1984 and unpublished). Both average swimming depth and the diving activity will have implications for the risk to salmon of being intercepted by pelagic fishing gear.

2.2 Description and distribution of the fisheries

An extensive description of the different important fisheries that might overlap with the temporal and spatial distribution of salmon was given in last year's report (ICES, 2004d). The data made available to the Study Group in 2005 (Table 2.2.1) confirm that fisheries for mackerel, herring and blue whiting are the principal fisheries of concern, although fisheries for horse mackerel and capelin, which in some cases were made available but not included in the Study Groups database, should also be considered.

The fleet operating in the North East Atlantic is summarized in Table 2.2.2 for the period 2000–2003. The blue whiting fishery is carried out by trawlers with a small purse seine operating in the Faroes, the capelin fishery by purse seiners, while the mackerel, herring and horse mackerel fisheries are carried out both by trawlers (Denmark, UK, Ireland, France, Germany, Netherlands, Ireland, Russia and Faroes) and purse seiners (Norway, Russia, UK Scotland). The purse seiners might catch salmon if they are mixed with the target species. However, little is known about bycatch of salmon in these fisheries. Most of the Norwegian catches of herring, mackerel and horse mackerel are used for human consumption, which implies that the fish are treated more or less individually at the processing plants. It is recommended that these factories be contacted with a view to establishing if there is a salmon bycatch in these purse seine fisheries or if it would be possible to establish a scanning programme to investigate this. The blue whiting fishery is mainly carried out by trawlers at fishing depths deeper than 50 m. The trawl fishery for herring is carried out deeper than 20 m while the trawl catches of mackerel and horse mackerel often are taken close to sea surface. The salmon is distributed in the surface layer, therefore all fisheries covering this part of the water column are considered to have a potential to intercept the salmon.

Bycatches have been observed in the Russian mackerel fishery in Divisions IIa and Vb (ICES 2003, 2004a). Other fisheries that might have bycatches are indicated below:

WEEKS	16–25	16–25	20–26	20–26	27–36
Area	IVb	VIIj	IVa	Vb	IIa
Mackerel		UK-E&W, UK-SCO, FR, IRL, DE, NL	UK-E&W UK-SCO RUS	RUS	NO, RUS, FO
Horse mackerel	DK	UK E&W, IRL, NL	DK, NOR		
Capelin					ICE, NO, FO

The Russian pelagic fishery in the North-East Atlantic during weeks 16–36 is carried out in the international waters in the Norwegian (IIa) and in the Faroese EEZs (IIa, IVa and Vb). In area IVa the Russian fishery takes place only inside Faroese EEZ, which is the two northwestern rectangles of IVa. The Russian pelagic fishery inside the above mentioned EEZs is regulated by the bilateral Fisheries Commissions which define the quotas and how many vessels that can operate at same time.

In the international waters the Russian fishery is regulated by NEAFC and national rules. All vessels have their own quotas for each species. The vessels change their target species according to the fish behavior, weather conditions and quotas.

Due to the international agreements the total number of vessels targeting mackerel, blue whiting and herring may vary from 1–64 vessels per day in different waters. The size of vessels varies from 55–80 meters and the engine 1000–5000 hp. This fishery is carried out by fishing vessels using similar single pelagic trawls with minimum mesh size of more than 35 mm (NEAFC) or 40 mm (EEZ).

Only 1–3 Russian vessels sometimes use purse seine for fishing herring in the international and the Norwegian waters (IIa) but the total catch is much smaller than that taken by trawlers. These vessels change to trawl when fishing for blue whiting. Purse seines are not suitable for mackerel fishery in the Norwegian Sea during the summer due to the behavior of mackerel.

Due to an agreement between Russia, Norway and Faroes all vessels have to report their catches by each species on a daily basis. According to Russian regulations all cases of salmon bycatch have to be reported to the fisheries and scientific authorities. Since the end of 1990s scientific observers are working onboard the Russian vessels during their herring, mackerel and blue whiting fisheries in the Norwegian Sea. Russian, Norwegian, Faroese and NEAFC authorities inspect the vessels.

The entire Russian commercial catches of mackerel and herring and most of the blue whiting catches are used for human consumption and most vessels freeze and store their products onboard. Consequently all catches are sorted and packed by species in standard boxes that include 3 packs of 8–10 kg whole or filleted fish. Some of the vessels also produce canned fish. A smaller part of the blue whiting catch is used for fishmeal and oil production. In all cases the catch is loaded from the trawl onto an accumulation conveyor in the vessels factory immediately and sorted by the crew, which implies that the fish are handled more or less individually before packing or milling.

2.3 Disaggregated data available to the group

The following data were made available to the Study Group.

Denmark	2000 – 2003 (Mackerel, Herring)
Faroes	2001 – 2002 (Mackerel, Herring, Blue Whiting, Capelin)

Germany	1995 – 2003 (Mackerel, Herring, Blue Whiting)
Ireland	1995 – 2003 (Mackerel, Herring)
Norway	2000 – 2004 (Mackerel, Herring, Blue Whiting)
	Monthly data from 1995 – 1999 (Mackerel, Herring, Blue Whiting)
Russia	2000 – 2003 (Mackerel, Herring, Blue Whiting)
	Monthly data from 1998 – 2003 (Mackerel, Herring, Blue Whiting)
UK (England/Wales)	1990 – 2003 (Mackerel, Herring)
UK (Scotland)	1970 – 2004 (Mackerel, Herring)

Fisheries included all trawl fisheries (single trawls and pair trawls, midwater and pelagic) and purse seines. Some limited information on drift net and bottom trawl catches was also provided. As data were available for most countries for the 2000–2003 period, the Study group created a single database for this period.

Information is available on country, gear, species, ICES areas and rectangles and catch in mt by week. In this instance the "Absolute Week" is mainly used to standardise between areas *i.e.* "An **absolute** week number is the 7 day period that a date falls within, based solely on the first day of the year, regardless of the day of the week. Week 1 is always Jan-1 to Jan-7; week 2 is always Jan-8 to Jan-14, and so on. The absolute week number will always be between 1 and 53. Week 53 will have either one or two days, depending on whether the year is a leap year. *Source http://www.cpearson.com/Excel/Weeknum.htm)*

Given a date in cell A1, the absolute week number can be determined with the following EXCEL® formula:

Week =TRUNC(((B6-DATE(YEAR(B6),1,0))+6)/7) "

The study group used only disaggregated catch data from those years where all nations that had provided data had information, in this case 2000 – 2003 (Table 2.3.1). In terms of information received Table 2.3.1 indicates the number of weekly catch records provided for each fleet and species *i.e.* for each ICES Division there is a weekly landing record in weight of fish and by gear type. While this is not an indication of the volume of fish caught or the effort employed by each fleet, it provides an indication of amount of disaggregated data available to the Study Group for further analyses.

The additional data provided will be used in further studies.

The ICES statistical areas where data available are shown in Table 2.3.2.

As previously noted, Areas IIa and IVa are areas where catch data are most heavily represented relative to the other areas where data are available which suggested further analyses of data from these specific areas for estimating potential bycatch of salmon.

2.4 Gear and fishing methods applied and evaluation for their potential for intercepting salmon

For the capture of any fish, it is necessary that they can come in contact with the gear and with the selection span of the gear. The preferred habitat of post-smolt salmon in the open ocean is principally in the upper 10 m of the water column; although there is evidence of forays into deeper water for short periods, in contrast, adult Atlantic salmon demonstrate a far wider depth profile.

Therefore, any gear that may pose a potential threat to postsmolts must filter or encircle a proportion of the upper layers of water. For the capture of pelagic species, this leaves two candidate gears that could result in bycatches of postsmolts, the pelagic trawl when towed on the

surface or the purse seine (Figure 2.4.1). Table 2.2.1 identifies all the pelagic fisheries in the NE Atlantic, categorised by gear type, ICES area, operating depth of the fishing gear and season. Those fisheries that are known to have reported bycatches of post-smolt Atlantic salmon at some time are shown in bold, while those with a *potential* to take bycatches are shown in italics. Using prior knowledge of smolt distribution and the spatial information of the fisheries and depth profiles, the fishery with the highest probability of capture is the surface pelagic trawl fishery in ICES area IIa.

2.5 Salmon distribution and intercepting fisheries

During some periods of the feeding migration and on their return migration the post-smolt, pre-adult and adult salmon are likely to pass through areas with intensive fishing

Up to 2003 only the international zone west and north of the Vøring Plateau had been identified as a risk area for postsmolts due to the high degree of overlap in time and space between mackerel and post-smolt cohorts from the southern NEAC countries (ICES, 2002, 2003; Holm *et al.*, 2003, 2004). However, there are indications that also other parts of the known post-smolt distribution area may be intercepted (ICES, 2003, 2004a). This will be further explored in section 2.5.1, which reviews the weekly distribution of salmon and pelagic fisheries during weeks 23 – 32. One major drawback for evaluating the potential of salmon being intercepted by pelagic fisheries is that their distribution throughout the year and migration routes in certain areas still are relatively poorly known. The Study Group recommends that the marine ecology of salmon, and particularly the distribution and timing of migration should be further investigated in order to allow a better assessment of the potential for interception by pelagic fisheries.

2.5.1 Areas with overlap between recorded landings from pelagic fisheries and recorded salmon distribution

Background and general considerations

During its first meeting in 2004 the SGBYSAL was provided with very limited disaggregated catch data on the pelagic fisheries in the NE- Atlantic and could therefore not make a detailed assessment of areas and time-periods where post-smolt migration was occurring simultaneously with major pelagic fisheries. As a consequence the overlap between the quarterly catches of pelagic fish and the pooled catches of salmon seemed extensive (ICES, 2004c).

At its 2005 meeting the Study Group was provided with enough disaggregated catch data to make an attempt to map a more realistic overlap in time and space. The Study Group reviewed the database to provide the following guidelines:

a) Only data on pelagic trawl catches on a weekly basis for those years provided by most countries, *i.e.* 2000–2003 would be used (see previous sections in this chapter),

b) Pool the data for post-smolt research captures (1990–2003) as in some individual years the IMR pelagic surveys had insufficient coverage of the salmon distribution either on a temporal or a spatial scale, and very few salmon had been captured, and

c) Note the shortcomings of the post-smolt and salmon research database, which covers only part of the assumed spatial and temporal distribution of salmon, and in some areas is influenced more by the other research priorities than the salmon distribution objective.

In the areas around Ireland and Western UK, and in particular in the North Sea, very little is known of the migrations of the postsmolts. In the beginning of Quarter 2 (week 13 – 20), postsmolts have been recorded in rivers and estuaries either through traps or sightings, but after that few recordings have been made until they turn up in research catches towards the

end of Quarter 2 (ref. weeks 23–24, Figure 2.5.2a–b) around the northern part of the British Isles (ICES, 2004c). Observations made with tracking postsmolts in fjords seem to indicate that the time spent in estuaries and fjords, and even close to the coast is of short duration (Moore *et al*., 1998; Holm *et al.*, 1984, 2003). Thus the overlap of post smolt distribution with the ongoing fisheries in the transition areas may be of relatively short duration.

ICES (2004c) identified an area in the northern Norwegian Sea in the Quarter 3 where the information on the overlap of pelagic fisheries and post smolt salmon distribution was lacking. These areas are in the northernmost parts of ICES area IIa and southern parts of IIb where trawl fisheries for herring are carried out, and from which anecdotal reports of bycatches of salmon exist. However, the possible impacts on salmon stocks are unknown.

2.5.2 Post-smolt and pelagic trawl-catches, distribution in weeks 23–32

Figures 2.5.2 a – j present the results of the mapping exercise based on the disaggregated landings data for 2000–2003 and distribution charts of the pooled (1990–2003) Norwegian research catches of salmon for the corresponding weeks. From these it can be seen that the periods with the highest likelihood of overlap with *e.g.* the trawl fisheries for mackerel in the Norwegian Sea are week 25–28, after which the smolt cohorts seem to have moved more northerly than those fisheries. This time period has been selected by the Study Group as the most appropriate for scaling of recorded bycatches of salmon up to the total commercial catches taken in the corresponding areas. This is a significant step forward from previous assessments and clearly shows the value of the weekly-disaggregated data. However, as the absolute distribution of salmon and their movements between areas is not yet known, the possibility of high catch rates in specific times and other places cannot be ruled out.

The Study Group further recommends that research into the migration patterns of post-smolt and salmon from the coastline of the NE-Atlantic countries into the shelf areas be carried out along with an investigation of migration routes in the North Sea and the northern extension of the summer feeding areas for post-smolt and adult salmon. In particular, surveys in more southerly areas should be undertaken in weeks 20–23 while the northern areas should be covered in weeks 30–34.

TIME	QUARTER 2 WEEKS 16 - 25														
Fishery	IVb			VIa			VIIb			VIIc			VIIj		
	Country	Gear	Depth	Country	Gear	Depth	Country	Gear	Depth	Country	Gear	Depth	Country	Gear	Depth
Mackerel				ENG SCO IRL DE	PT/PPT PT/PPT PT/PPT PT/PPT	D D D D	ENG SCO IRL	PT/PPT PT/PPT PT/PPT	D D D	IRL	PT/PPT	D	*ENG* *SCO* *FR* *IRL* *DE* **NL***	*PT/PPT* *PT/PPT* *PT/PPT* *PT/PPT* *PT/PPT* *PT/PPT*	*0 –50* *0 –50* *0 –50* *0 –50* *0 –50* *0 –50*
Herring				SCO	PT/PPT	20+									
Blue-whiting				NL NO DE	PT/PPT PT/PPT PT/PPT	D D D									
Capelin															
Horse Mackerel	*DK*	*PT*	*0 – 50*										*ENG* *IRL* *NL*	*PT/PPT* *PT/PPT* *PT/PPT*	*0 –50* *0 –50* *0 –50*

Table to be continued.

*Bycatches of "salmon" have been recorded in catches landed in the Netherlands, but according to information provided to the SGBYSAL, the majority and possibly all of these "salmon" are actually sea trout (ICES 2004d; Potter, pers. com.)

Table 2.2.1 The nations (their applied fishing gears and fishing depths) participating in fisheries that might overlap with the distribution of salmon. The fisheries shadowed are fisheries with a potential for catching salmon. Bold type are fisheries with reported bycatches of postsmolts. The fisheries in *Italics* are those with a *potential, but from which there are no bycatch reports*. (Areas refer to ICES fishing areas; Q is the quarter of the year). Further explanations at the end of the continued table

Table 2.2.1 Continued

QUATER	QUARTER 2 (WEEKS 20 – 26)						QUARTER 3 (WEEKS 27 – 36)		
Fishery	IVa			Vb			IIa		
	Country	Gear	Depth	Country	Gear	Depth	Country	Gear	Depth
Makerel	*ENG* *SCO* *RUS*	*PT/PPT* *PT/PPT* *PT*	*0 – 50*	RUS	PT	S	NO RUS FO	PS PT PS	S S S
Herring	RUS	PT	20+	RUS	PT	20+	RUS	PT/PS	20+/S
Blue-whiting	RUS	PT	D	NL NO DE RUS	PT PT PT PT	D D D D	RUS NO FO DE	PT	D
Capelin**							*ICE* *NO* *FO*	*PS* *PS* *PS*	*S* *S* *S*
Horse Mackerel	*DK*	*PT*	*0 – 50*						

**Iceland, East Greenland, Jan Mayen

Depth profiles, relative to depth of headline:
S – surface fishery
0-50 – Top upper layers
20+ - Variable but not shallower than 20 meters
D – Deeper than 50m

Gear codes
PT – Single pelagic trawl
PPT – Pelagic pair trawl
PS – Purse seine

COUNTRY	DETAILS	LENGTH METERS	ENGINE POWER	GEAR TYPE	FISH HOLD	NO. VESSELS
Denmark	Yes Yes	30–40 45–65	900-1500hp >1000hp	Trawl Purse Seine	RSW RSW	35 9
Faroe Islands	Yes Yes	35–90 65–75	515-6468 kW 2208-8000 kW	Trawler Purse Seine/ Trawler	RSW RSW	9 7
France	No					
Germany	Yes	85–125	2400-4950kW	Single MWT	Freezer	4
Iceland	Yes	47–79	441-5520 kW (599-7500 HP)	purseseiners/trawlers		28
Netherlands	Yes Yes	55 88–140	2890hp 4400-10455hp	Pair MWT Single MWT	Freezer Freezer	2 13
Norway	Yes Yes Yes Yes	>7 7–14 14–21 >21		Trawler Purse/Fish nets P. Seine/ Trawler Purse Seine		24 475 90 221
Ireland	Yes	<30 >30<65		Pair Trawl Pair/Single Trawl	Dry Hold/RSW RSW	20 22
Russia	Yes	55–80	1000>5000hp	Single Midwater Trawl	Freezer	58
UK England and Wales	Yes Yes	47.3 92.05	1992 5053.5	Pair Mid Water Trawl Single Mid Water Trawl	RSW Freezer	3 2
Scotland	Yes	35–67		Single Mid Water Trawl	RSW	26
Sweden	No					

Table 2.2.2 Summary of countries and vessels fishing in the areas listed in SGBYSAL (from ICES 2004b, c; ICES 2005).

			Number of weeks of disaggregated data				
Country	Species	Gear	2000	2001	2002	2003	Grand Total
Denmark	Herring	PT	114	89	66	65	334
	Mackerel	PT	12	26	15	4	57
Den Total			126	115	81	69	391
Faroes	BWH	BT	1	10			11
		PS	66	10			76
		PT	159	124			283
	BWH Total		226	144			370
	Cap	PS	51	25			76
	Herring	PS	110	45			155
		PT	4	29			33
	Herring Total		114	74			188
	Mackerel	PS	52				52
		PT	15				15
	Mackerel Total		67				67
Far Total			458				458
Germany	BWH	PT	34	39	35	56	164
	Herring	PT	69	93	83	100	345
	Mackerel	PT	16	32	26	13	87
Ger Total			119	164	144	169	596
Ireland	Herring	PPT	21	25	13	87	146
		PT	42	32			74
	Herring Total		63	57	13	87	220
	Mackerel	PPT	56	61	52	59	228
		PT	15	22	18	1	56
	Mackerel Total		71	83	70	60	284
Irl Total			134	140	83	147	504
Norway	BWH	PS	75	95	20	25	215
		PT	634	810	802	1225	3471
	BWH Total		709	905	822	1250	3686
	Herring	DRFNT			11	7	18
		PS	1486	1455	1171	1809	5921
		PT	174	83	65	68	390
	Herring Total		1660	1538	1247	1884	6329
	Mackerel	DRFNT	4	7	458	502	971
		PS	846	884	1378	900	4008
		PT	115	144	3136	2733	6128
	Mackerel Total		965	1035	4972	4135	11107
Nor Total			3334	3478	7041	7269	21122
Russia	BWH	PT	643	795	826	903	3167
	Herring	PS	37	34	10		81
		PT	245	299	393	494	1431
	Mackerel	PT	404	342	314	364	1424
Rus Total			1329	1470	1543	1761	6103
UK(England and Wales)	Herring	BT	105	95	96	26	322
		PPT	94	118	108	152	472
		PT	357	376	270	291	1294
	Herring Total		556	589	474	469	2088
	Mackerel	BT	163	132	97	60	452
		PPT	173	248	289	299	1009
		PT	1543	1440	1192	1272	5447
	Mackerel Total		1879	1820	1578	1631	6908
UK(England and Wales) Total			2435	2409	2052	2100	8996
UK(Scotland)	Herring	BT				1	1
		PPT	182	199	165	72	618
		PS	94	30	9		133
		PT	250	153	165	195	763
	Herring Total		526	382	339	268	1515
	Mackerel	PPT	4	2			6
		PT	129	14	1	3	147
	Mackerel Total		133	16	1	3	153
UK(Scotland) Total			659	398	340	271	1668
Grand Total			8594	8174	11284	11786	39838

Table 2.3.1 The number of disaggregated weekly catch records provided to the Study Group for each fleet and species *i.e.* for each ICES Division there is a weekly landing record in weight of fish and by gear type. (BWH = Blue Whiting, PT = Pelagic trawl, PPT = Pair Trawl, BT = Bottom trawl, PS = Purse seine, DRFNT = Driftnet)

*** less than 30 weekly catch records ** 30 –100, ***101 -1000,**

	Species			
Division	Blue Whiting	Capelin	Herring	Mackerel
I		*		
IIa	*****	*	*****	*****
IIa			*	
IIb	*		*	
IVa	*		*****	***
IVa			****	
IVb			**	**
IVb			*	
Va	**	**	*	
Vb	***		*	*
Vb1	***			*
Vb2	*			
VIa	***		***	***
VIa			***	
VIb	*			*
VIIa			*	
VIIb	*		*	***
VIIc	*			
VIIe				*
VIIg			**	*
VIIh				*
VIII				*
VIIIa				*
VIIj			*	**
VIIk	*		*	
XIVa		*	*	

******1000 - 3000**

Table 2.3.2 Relative density of disaggregated weekly catch records by ICES Division.

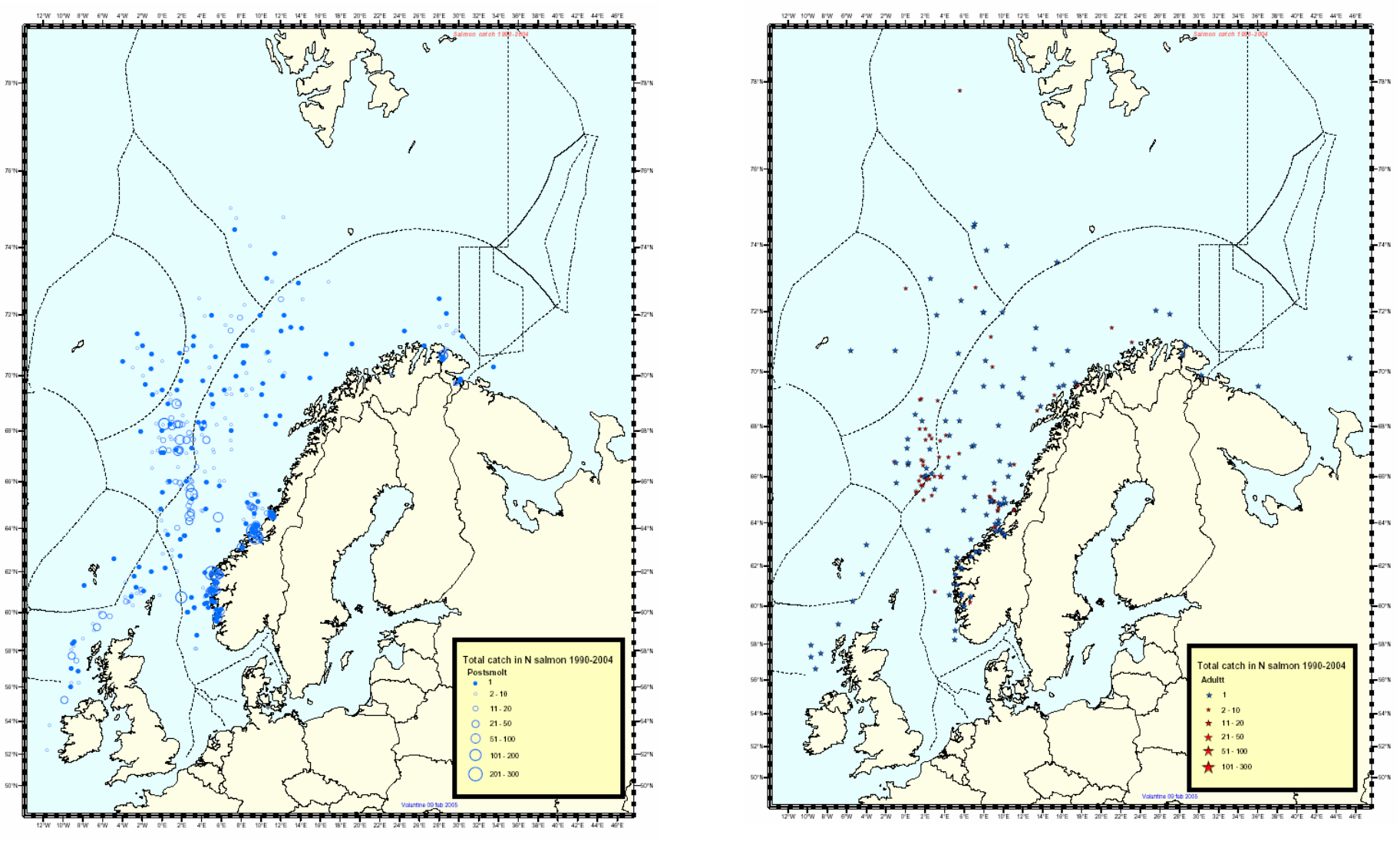

Figure 2.1.1 Distribution of total number of captures of postsmolts (left panel) and adult salmon (right panel) in Norwegian research trawls in 1990 – 2004. Symbol size proportional with number of fish in the catch, legends in figure.

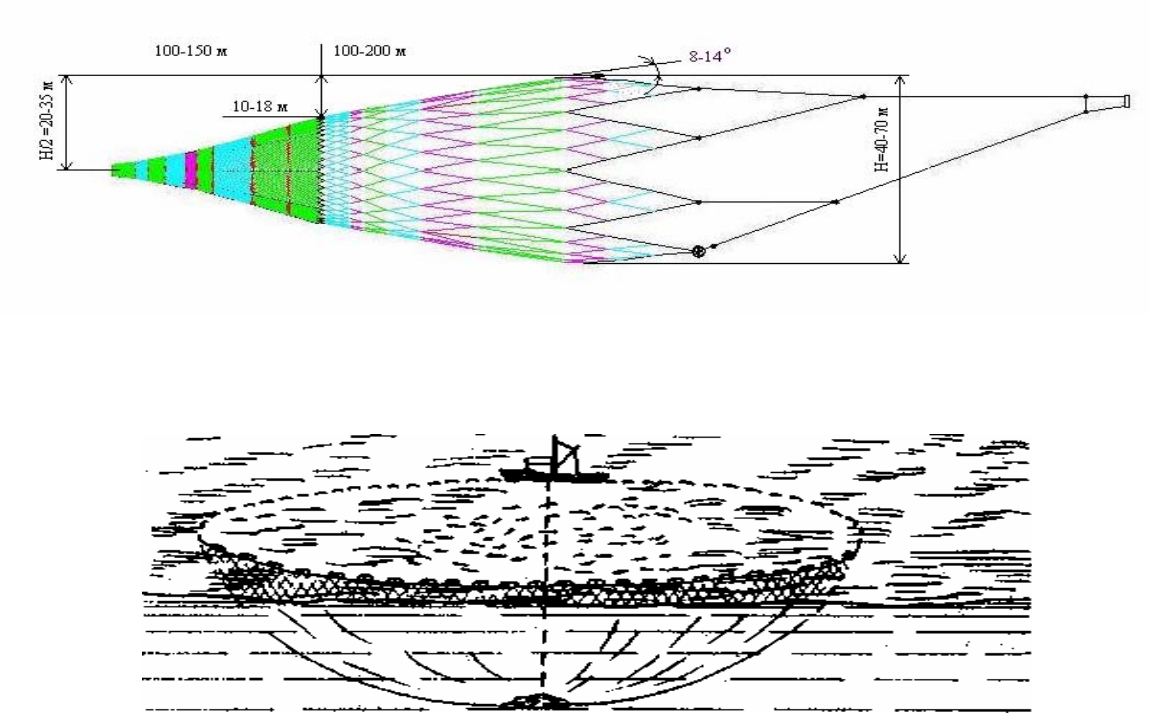

Figure 2.4.1. Two candidate gears for bycatch of post-smolt Atlantic salmon; pelagic trawl towed on the surface (top) and the purse seine (bottom).

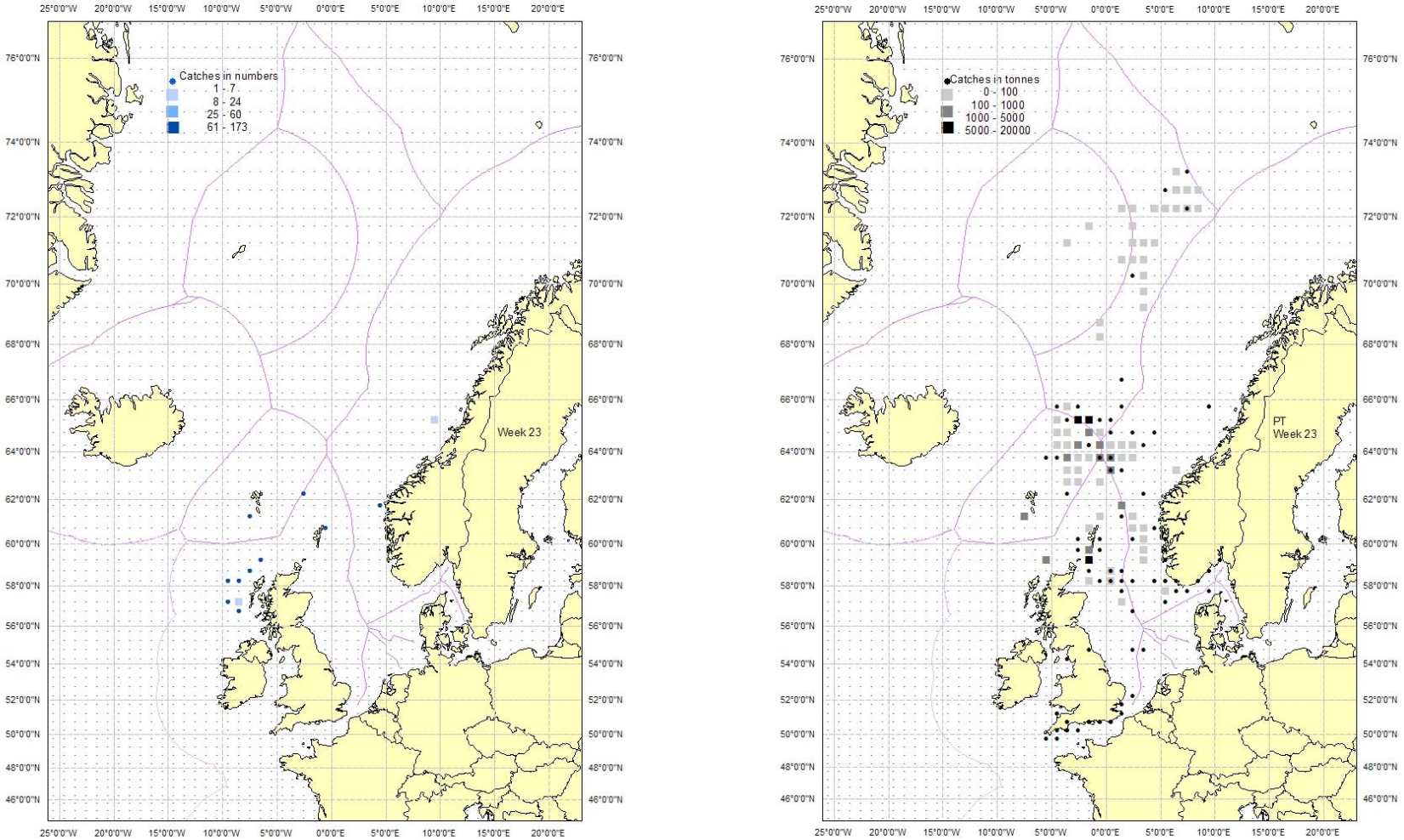

Figure 2.5.2.a Week 23- Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

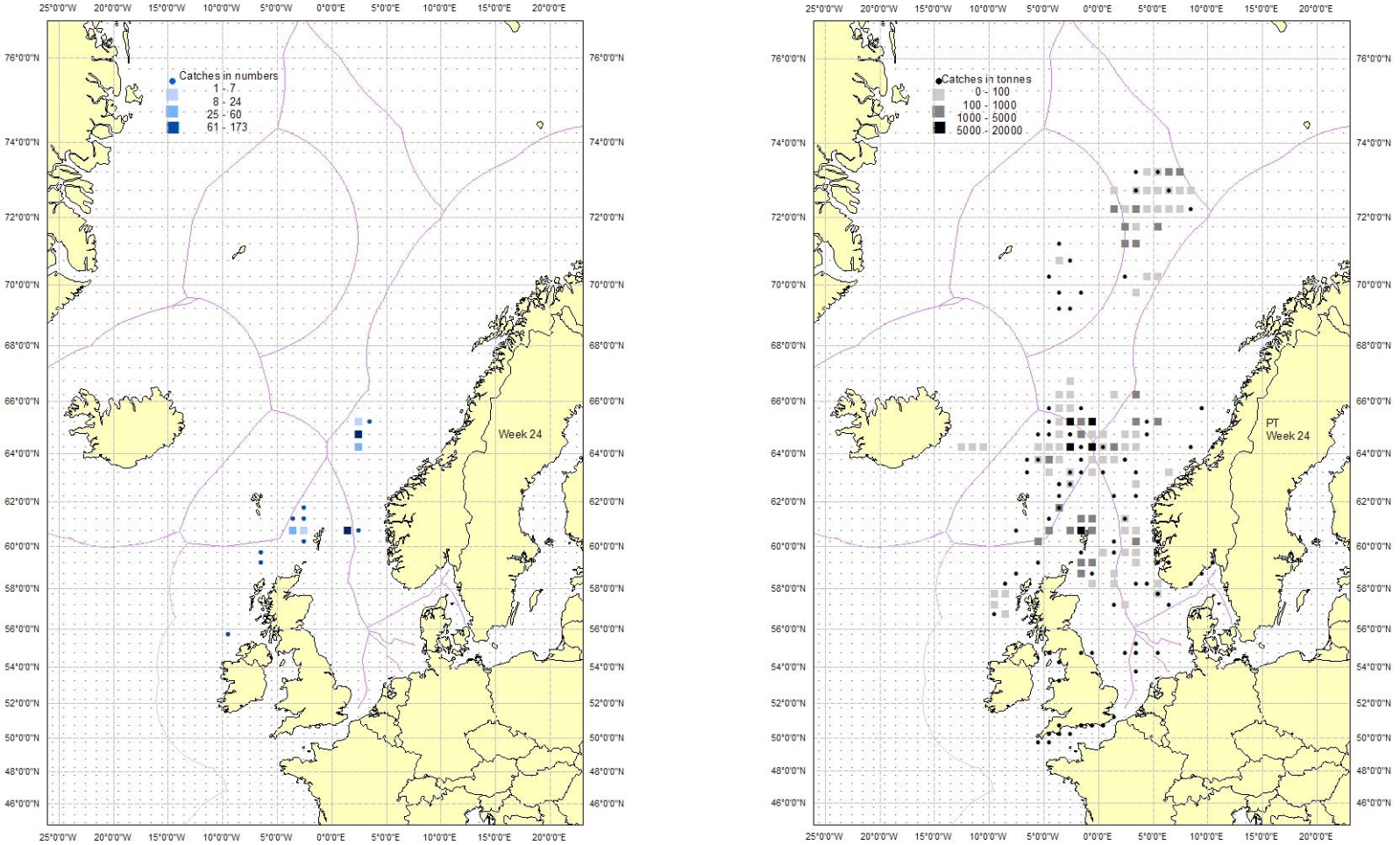

Figure 2.5.2b Week 24 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

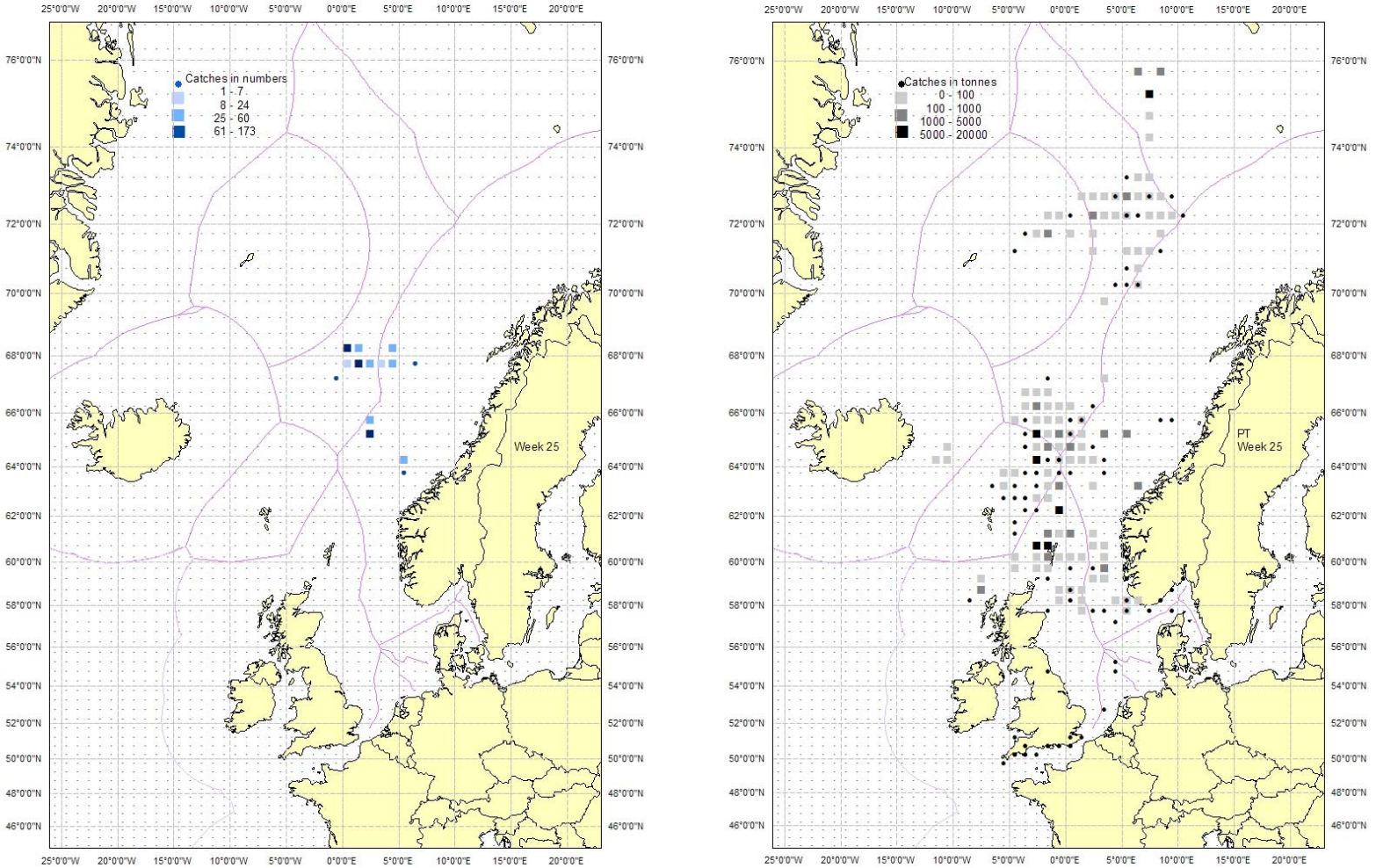

Figure 2.5.2c Week 25 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

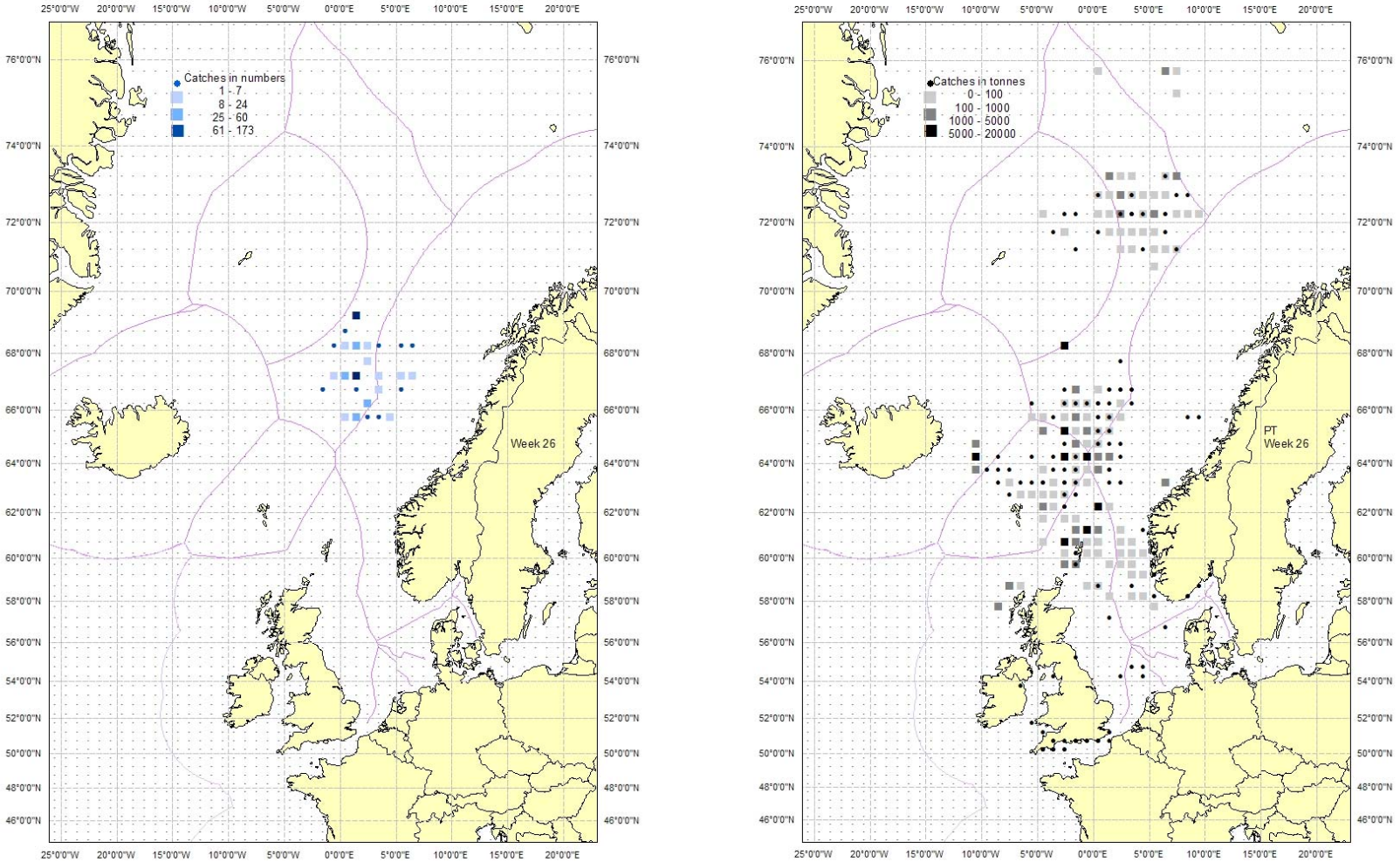

Figure 2.5.2d Week 26 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

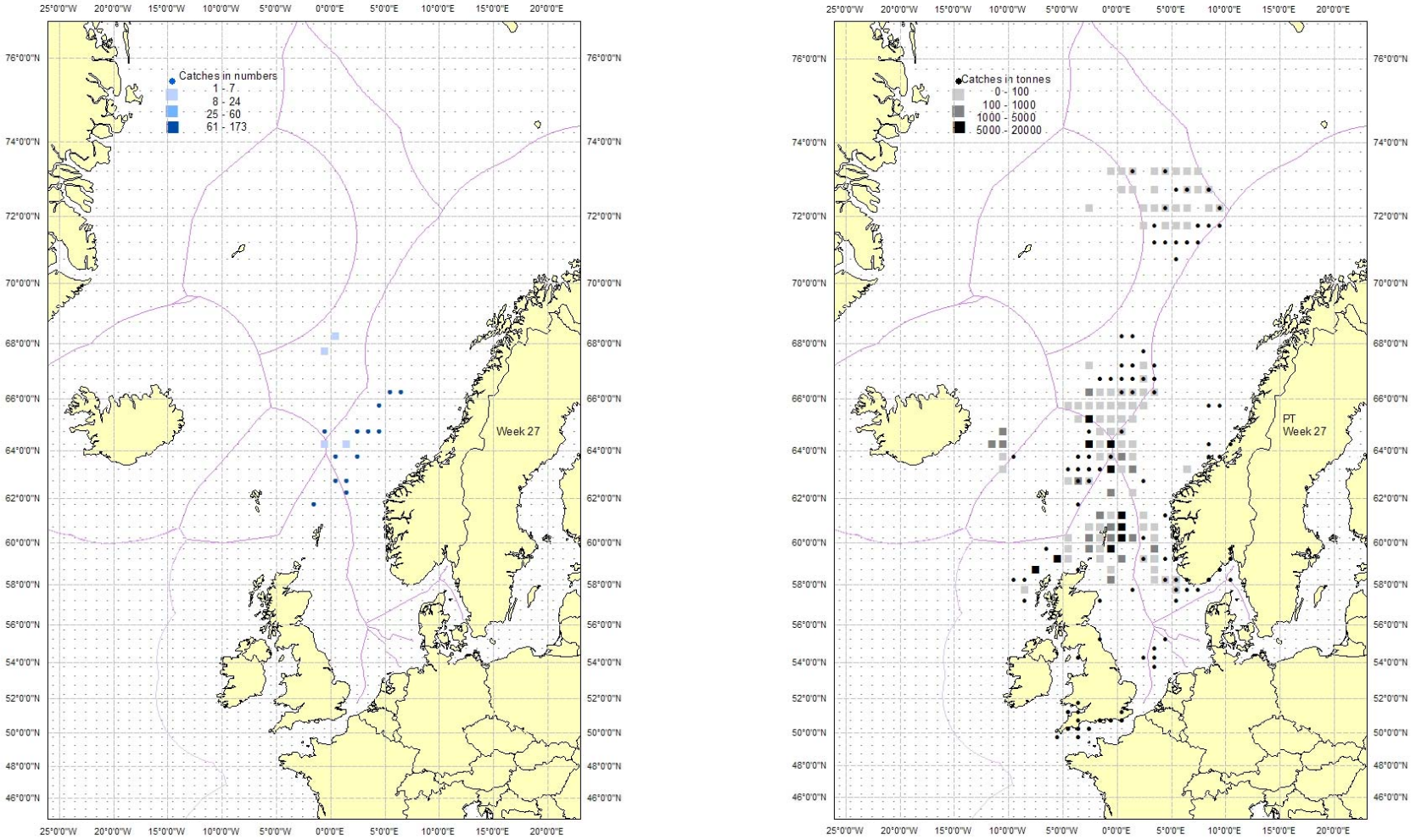

Figure 2.5.2e Week 27 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

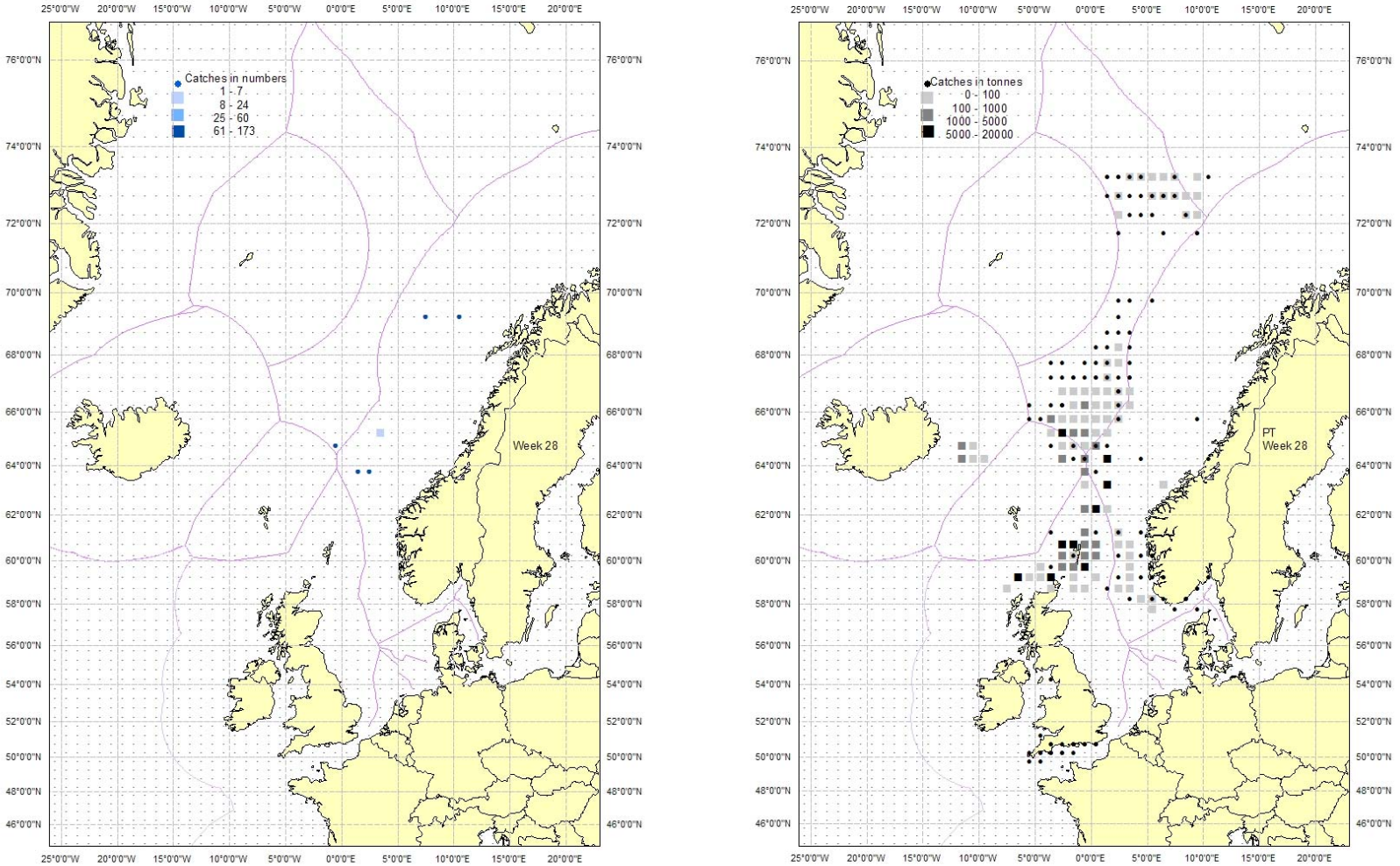

Figure 2.5.2f Week 28 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

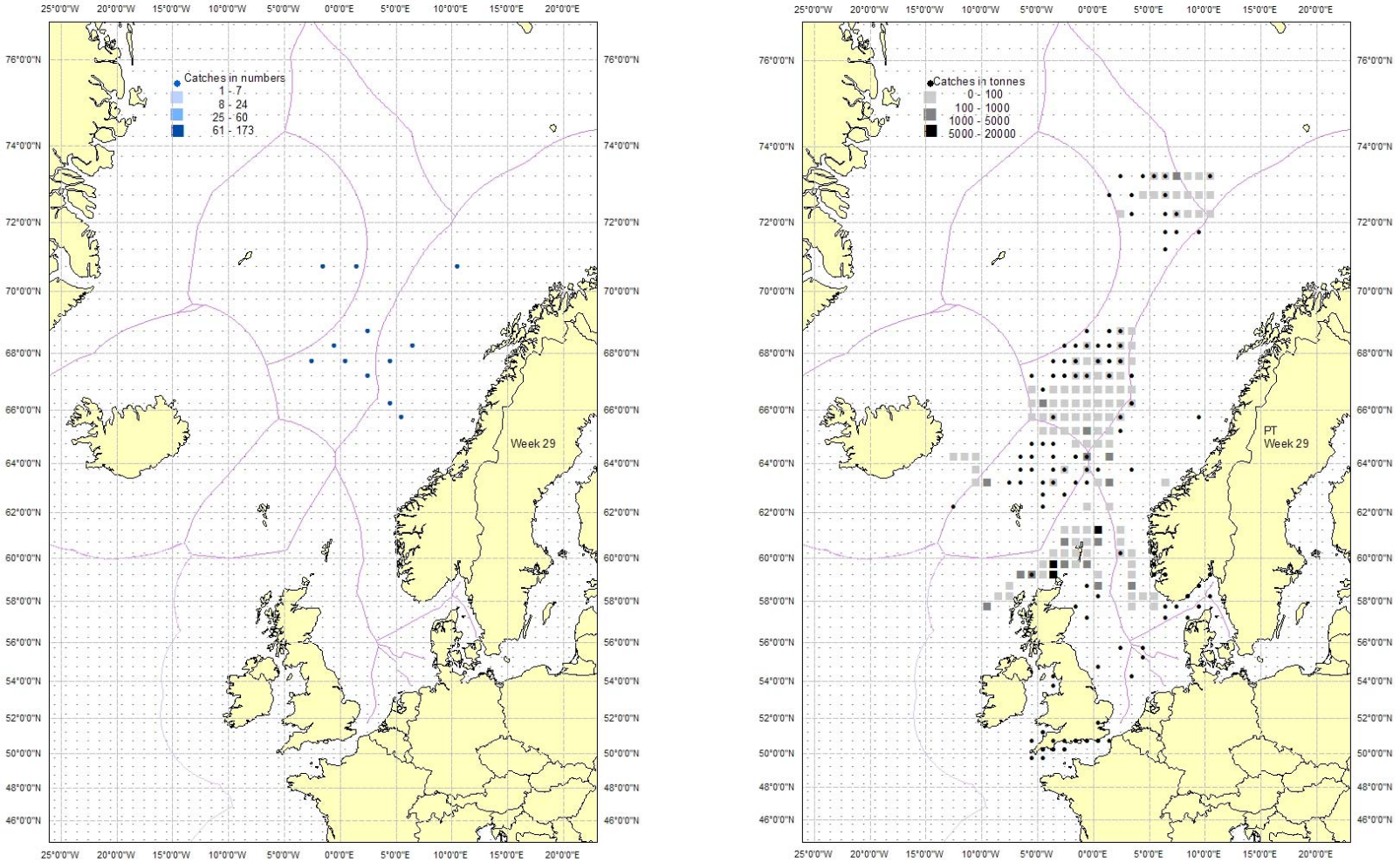

Figure 2.5.2g Week 29 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

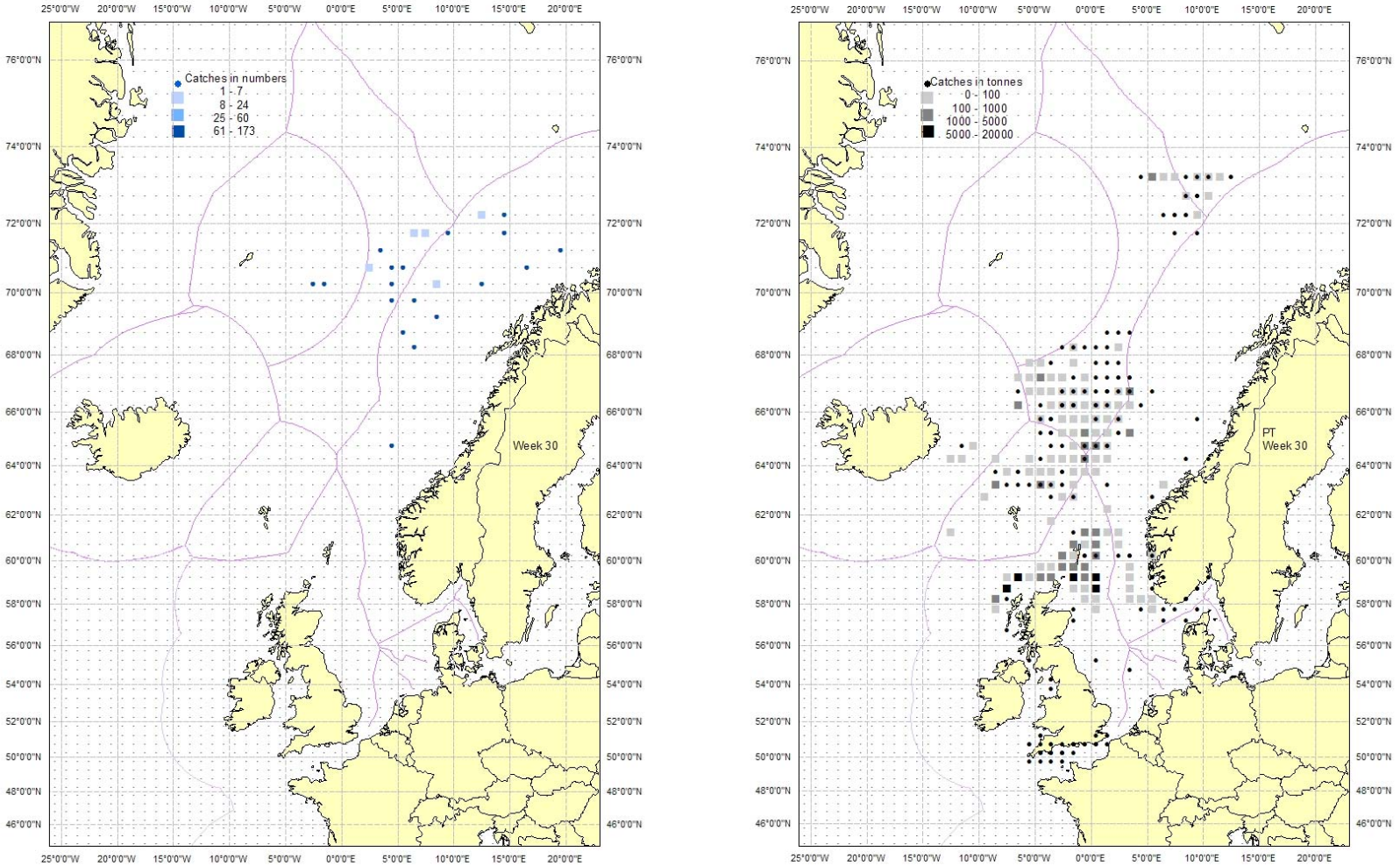

Figure 2.5.2h Week 30 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

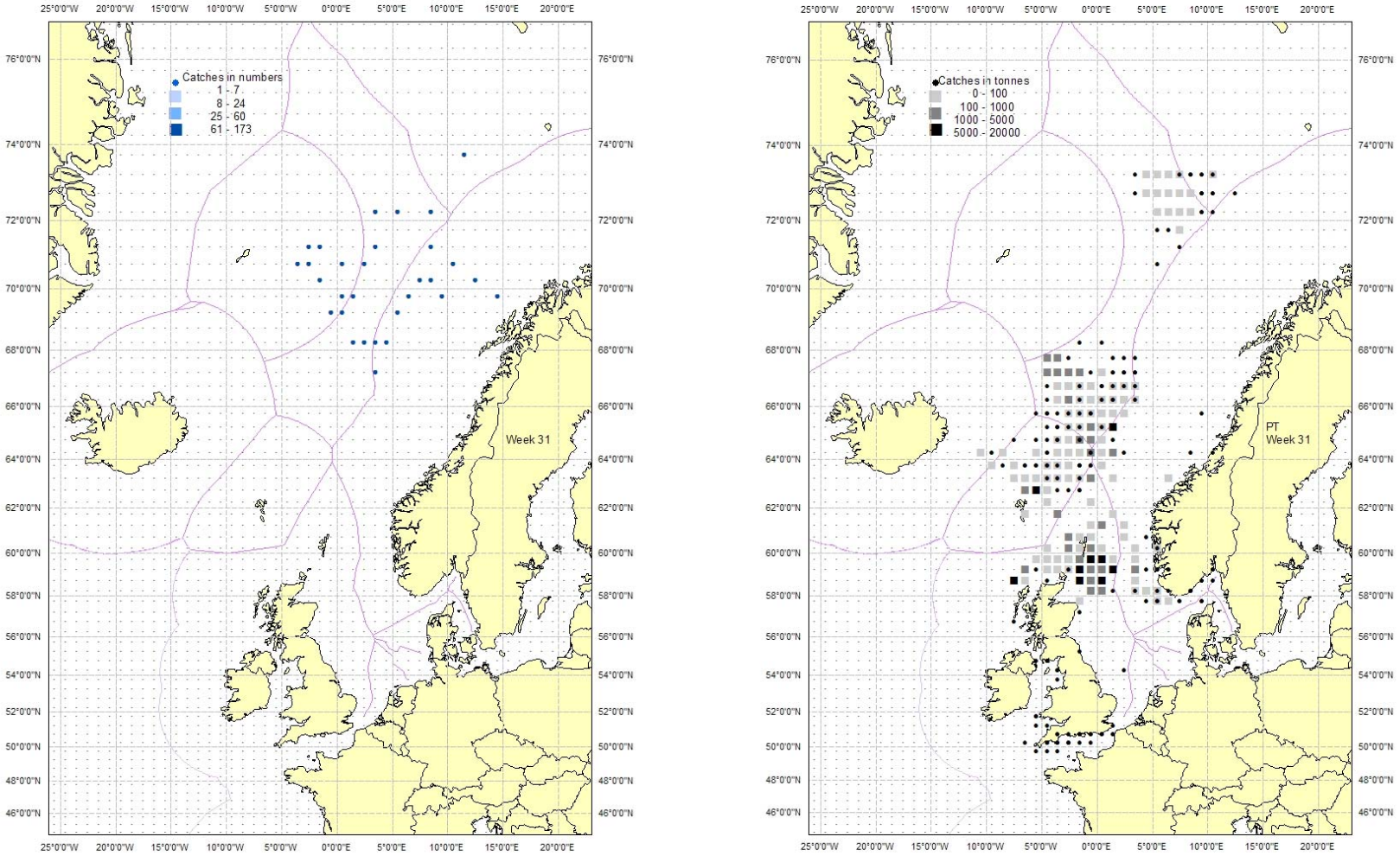

Figure 2.5.2i Week 31 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

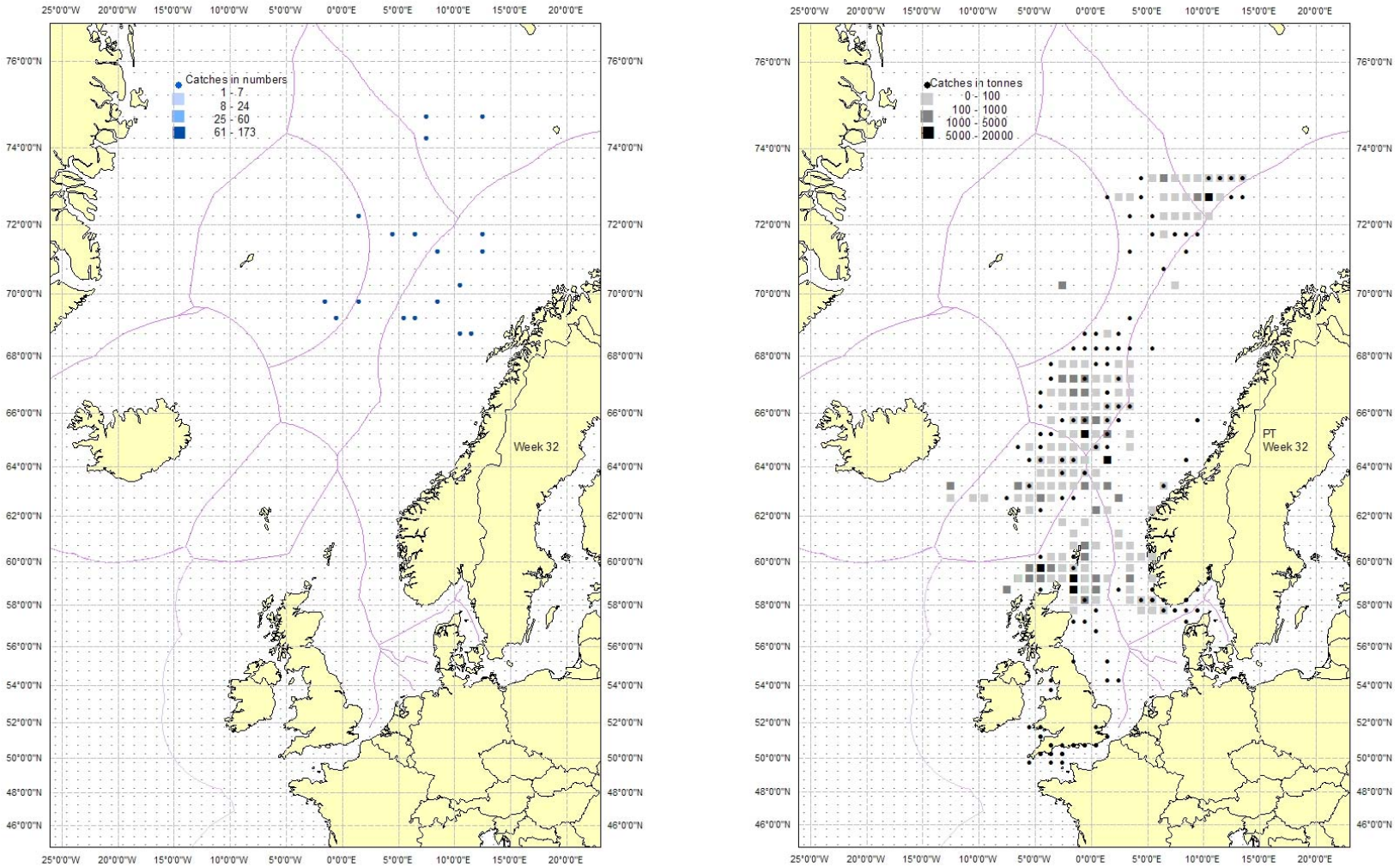

Figure 2.5.2j Week 32 - Distribution of salmon research captures 1990- 2003 (left) and reported landings from pelagic fisheries in 2000-2003 per ICES statistical rectangles (legends in figures).

3 EXTRAPOLATION OF DATA FROM CATCHES

3.1 Background

In order to produce reliable estimates of post-smolt bycatches in the commercial fishery, it is necessary to have a) disaggregated catch data from the fishery, and b) an estimate of the numbers of postsmolts per unit of target species *e.g.* mackerel, herring from either commercial catch screening or from scientific surveys.

In addition to commercial catch screening data from Russian vessels, bycatch and target species catch data are also provided from three scientific surveys, each of which utilise different survey trawls. The scientific surveys are:

i) Surveys for postsmolts using a trawl specifically designed to catch smolts;
ii) Norwegian scientific research cruises for pelagic species;
iii) Russian scientific research cruises for pelagic species.

To use survey data for direct extrapolation, it is essential that the efficiency of survey gears (for both target and non-target species) are representative of commercial gears – the ratio of target to bycatch species needs to be the same for all gears. Failing this, it is necessary to conduct catch comparison (efficiency) trials to obtain conversion factors of the relative efficiency of each compared to trawls typically used by the commercial fleet (see section 2).

3.2 Pelagic trawl design and operation considerations.

There are a number of design and operational differences between the survey trawl and commercial trawls. These are shown in Table 3.2.1 and include the overall size, towing speeds, ratios of width to height and the mesh sizes used in the construction, particularly in the fore part of the nets.

Net plans and schematic diagrams of the main gears are given in Figures 3.2.1–3.2.3

These are not only likely to result in differences in catching efficiency between the survey and the commercial trawls but it is probable that significant differences in efficiency between the survey gears also exist. The salmon survey trawl in particular differs considerably and is designed specifically for the capture of postsmolts. It is likely that this is the main reason for the large variations in bycatch ratios reported earlier (ICES, 2002, 2003, 2004a).

The main design parameter of concern is the differences in mesh sizes used in the front part of the trawl. The mesh sizes range from 0.8 m for the salmon survey trawl up to 50 m for the largest commercial net. The mesh sizes used in the Russian survey trawl are typical of a small-scale commercial net. Post-smolt fish inhabit the upper 10 m of the surface, which is only filtered by the section of the net with the largest meshes (Figure 3.2.3). It is thought that the smolts simply pass through the large meshes, while mackerel tend to dive in response to a vessel and are visually herded by the netting bars. The presence of significant quantities of salmon in the salmon survey trawl, which only covers the top 10 m of the surface, supports this. In addition, the reported catch rates of salmon per unit of target species increased considerably following the introduction of the salmon survey trawl in comparison to the rates reported when using the Norwegian pelagic survey trawl, which has larger meshes (3.2 m) in the fore part of the net.

In the absence of efficiency estimates and considering the substantial differences in design and operation, extrapolation of the bycatch ratios from the Norwegian scientific salmon-surveys to the entire fishery is not recommended.

Only the Russian pelagic survey trawl has similar design properties to the commercial net. In the absence of relative efficiency estimates from the two other survey gears in comparison with the commercial trawl, it is recommended that only the catch data from the Russian survey and commercial trawl should be used for extrapolation purposes. However, it should be noted that the Russian pelagic survey trawl is operated at a different towing speed from the commercial trawl and some times with smaller cod-end mesh size. The effect of towing speed on the catchability of salmon is unknown.

In conclusion, before any direct comparison between the gears is made, it would be necessary to quantify the relative efficiency of each of the gears and that behavioural reactions of post-smolts and adult salmon are evaluated.

	Mesh Size Fore Part (Full Mesh m)	Net Height (m)	Net Width (m)	Minimum Cod- End Mesh Size (mm)	Towing Speed (Knots)
Norwegian Salmon survey trawl	0.8	10	40	20	4.8
Norwegian Pelagic survey trawl	3.2	30	40	22	3.5
Russian Pelagic Survey Trawl	6 – 50	40	50	24, 32, 40	3.5 – 5.0
Russian Pelagic Commercial Trawl	6 –50	50 - 100	100 - 200	35, 40	5.5 – 6.5

Table 3.2.1. Comparison of gear design parameters between trawls used for bycatch data.

3.3 Procedures necessary to estimate trawl efficiency

In the first instance it is necessary to obtain estimates of trawl efficiency based on the ratio of target to non-target species catches. This ratio will depend on the relative abundance of the populations encountered during trawling for each of the species in question and will also be dependant on the relative catchability or susceptibility of capture of each of the gear types being used. If the ratios for each gear are the same, then the bycatch of salmon can be estimated simply by raising the catch of smolts per unit of target species using the total catches for a given area.

The principal problem is to avoid population dependant differences, which would necessitate using different haul techniques, where one vessel is used and conducts a number of hauls with each net. These hauls can be done in series, alternately or with a structured sample design. It is important to consider natural variations that may influence the design of the protocol such as species-specific diurnal effects *etc.* It would also be preferable to conduct parallel hauls with the research vessel used for the salmon and pelagic fish survey and a vessel typical of the commercial fleet.

While this will increase the costs, it will provide more robust and accurate data. Research vessels normally have a lower catching efficiency in comparison to commercial vessels. This may result in a biased estimate of target to non-target species when using a commercial trawl from a survey vessel. Clearly, such work must be conducted at a time when the fishery spatially overlaps with the post-smolt feeding area in ICES IIa.

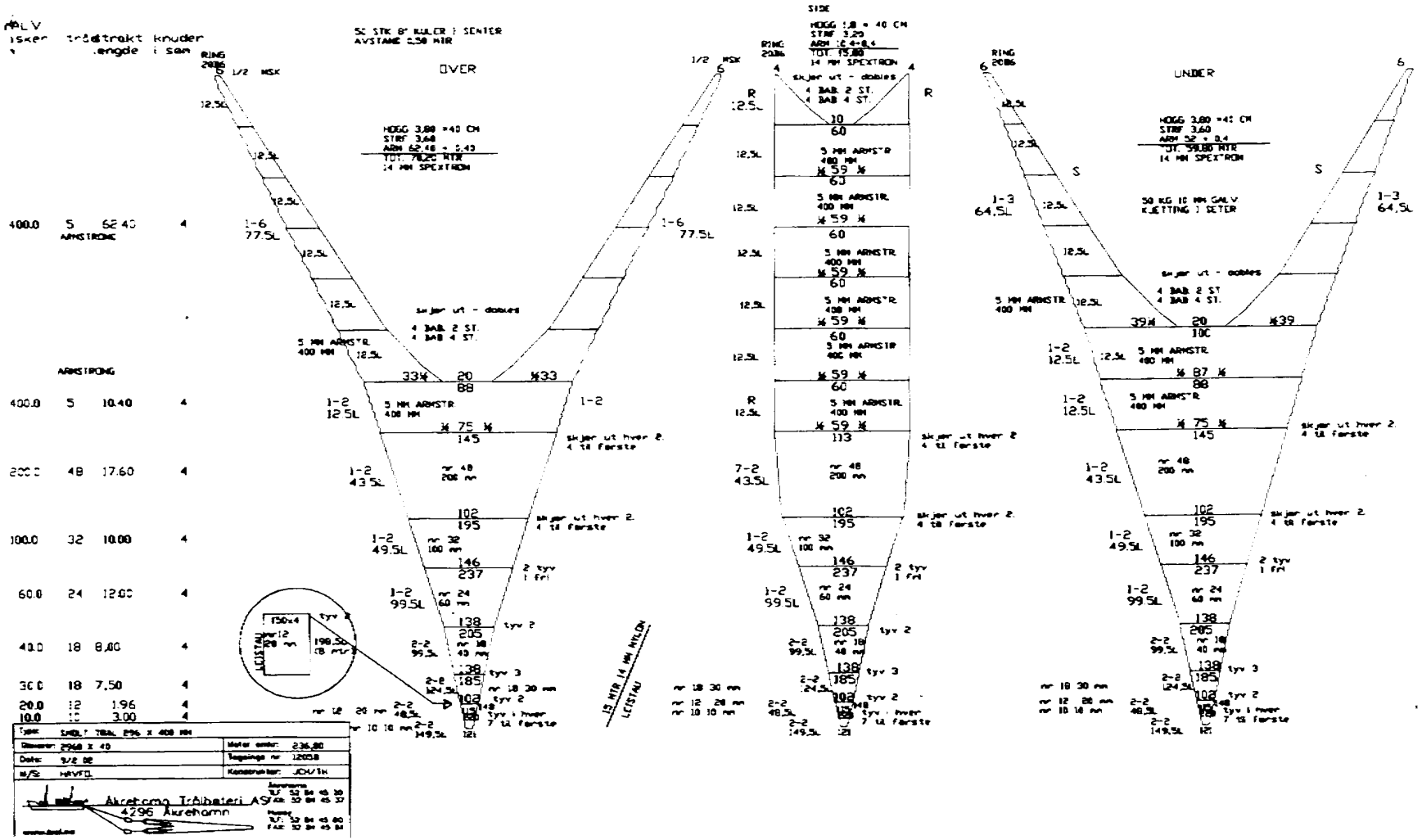

Figure 3.2.1. Net plan of salmon survey trawl used by IMR.

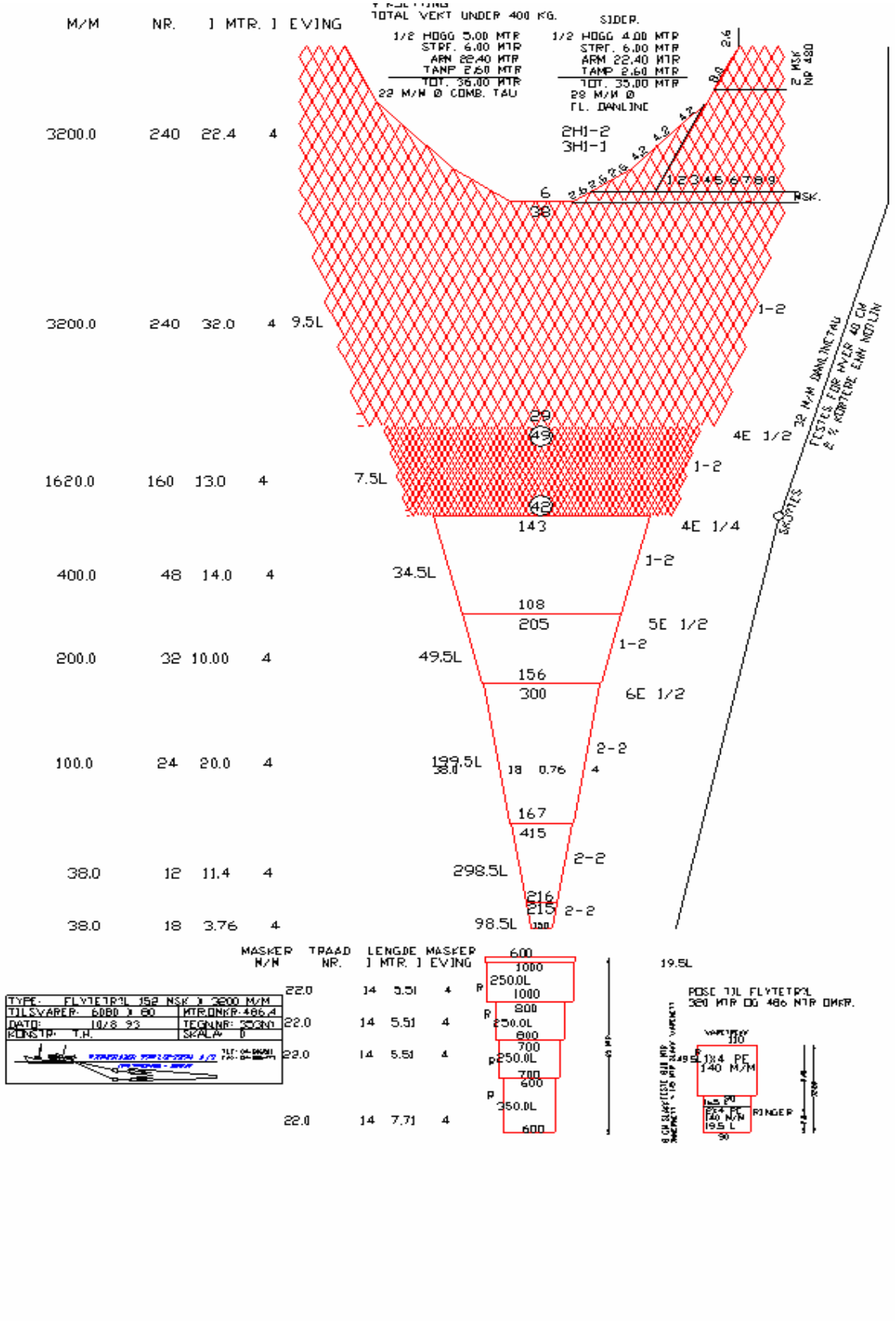

Figure 3.2.2. Pelagic species survey trawl used by IMR.

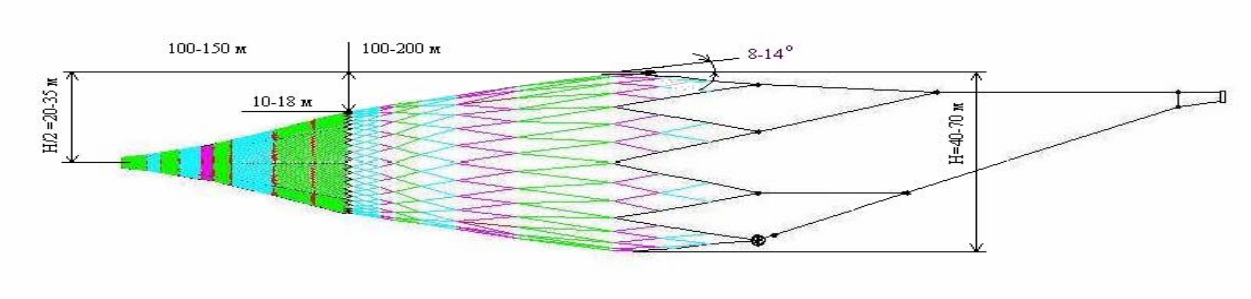

Figure 3.2.3. Schematic diagram of commercial pelagic trawl used by the Russian fleet.

4 METHODS FOR SCREENING FOR NON-TARGET FISH IN CATCHES AND NEW REPORTS OF OBSERVED BYCATCHES OF SALMON.

4.1 Observing salmon in pelagic catches

As described in the 2004 SGBYSAL report, adult salmon should be relatively easy to distinguish from other fish even in large catches, while the postsmolts pose a much greater problem to the observer. The integument of postsmolts is very loose and without their scales, the colour becomes bluish green on the dorsal side (Holm, pers. obs.) and much more like that of herring, sprat and mackerel. Apart from handling the fish individually, it would thus be very difficult to distinguish the postsmolts from the other species. If the salmon are substantially smaller than the target species they risk being covered by a larger fish, and if similar in size they will resemble many of the pelagic species due to the change in coloration. The general size range of postsmolts to be expected by area and time is available from the Norwegian research cruises (Table 4.1.1)

AREA	WEEKS 16 - 20	WEEKS 21- 26	WEEKS 27 - 31	WEEKS 32 - 36
Western UK & Faroes -Shetland Trench areas	No data	15 – 21 cm	--	--
Fjords and coast of Norway	Mean ~ 11.5 cm (West and Mid-Norway)	--	~ 12.5 – 13 cm (Northern Norway)	--
Norwegian Sea south	--	17 – 23 cm	21 – 28 cm	--
Norwegian Sea North	--	20 – 25 cm	22 – 29 cm	25 – 32 cm

Table 4.1.1 Approximate post-smolt sizes (fork-length, cm) as observed in Norwegian research cruises

4.2 Screening of catches and reports of bycatches of salmon in research and commercial fisheries

In 2004 Faroes, Germany, Iceland, Ireland, Netherlands, Norway, UK and the Russian Federation provided information on catch screening methods applied and bycatches of salmon to SGBYSAL. They are accounted for in the SGBYSAL report (ICES, 2004c). Some of the countries had observers on board (Russia, UK, Germany) or screened their total scientific catch (Germany, Norway, Russia, Scotland, Netherlands) or had land based screening programmes (Faroes, Iceland and Netherlands), but bycatches of salmon from the commercial fisheries were only reported by Iceland, Netherlands and the Russian Federation. Only Norway and Russia reported bycatches from scientific surveys.

Apart from Iceland and Russia, which are reported below, there was no new information in 2005.

4.3 Description of methods of screening used by Russian Federation and and results from 2002–2004

4.3.1 Russian pelagic fish surveys

Since 2001 one of the objectives of the pelagic fish surveys conducted by Russian research vessels in the Norwegian and Barents Seas has been to collect data on Atlantic salmon postsmolts and map their distribution. This survey is a part of an international research programme to study commercial species in the Norwegian and Barents Seas and is conducted on a yearly

basis in June-July. Its target species are herring, blue whiting and mackerel. Trawling was done using a pelagic trawl with a 50-meter vertical and horizontal opening. The trawl was not rigged with additional floats. This pelagic trawl was used in the commercial fishery with the only difference being the inclusion of a 16 mm mesh blinder. Hauls were taken with a head-line at different depths with majority of hauls taken with the headline at 0–5 m depth. Towing speed was from 3.0–5.0 kt, with a standard duration of hauls of 30–60 min. The whole catch was screened and each fish was handled and identified to species onboard.

The data collected in 2002–2003 in the Russian pelagic fish surveys are summarized in Table 4.3.1.1

In 2002, 65 of 82 hauls taken in the Norwegian Sea were surface hauls with the headline moved at depths from 0–5 m. The total catch of mackerel was 5450 kg. No bycatch of post-smolts was recorded in June although one adult salmon was caught in the international waters. In July another two adult salmon were found. When the research was conducted north of 66°N in July, this seemed to increase the post-smolt bycatch. On the 8th, 9th and 15th of July 32 post-smolts were taken in four hauls.

In 2003 the area was surveyed from 64°45N to 68°30N between 03°E and 06°W. From the 8th to the 17th of July 31 hauls were taken of which 22 were with a headline at 0–5 m depth. During the survey mackerel were reported in the entire research area and the species occurred in the trawl any time when towing was conducted in the upper layer. Mackerel catches varied from 5 up to 5395 kg, the average being 429 kg. The total catch of mackerel was 13 293 kg. When towing was done with a headline at 30–340 m depth the catch consisted of blue whiting. Other species found were lumpsuckers, herring, saithe and anglerfish. No adult Atlantic salmon or postsmolts were caught.

YEAR	NO OF HAULS TAKEN	TOTAL CATCH, T	MACKEREL CATCH, T	NO OF SALMON CAUGHT		RATIO BETWEEN SALMON AND MACKEREL, FISH PER METRIC TONNE	
				Adults	Post-smolt	Adults	Post-smolt
2002	82	13.7	5.4	3	32	0.56	5.93*
2003	31	15.6	13.3	0	0	0	0

*most of the postsmolts were caught north of 69°N where the mackerel fishery is not significant

Table 4.3.1.1. Data from the pelagic fish surveys conducted in the Norwegian Sea in June–July 2002–2003 by Russian research vessels.

No surveys were conducted in 2004.

4.3.2 Commercial catches screening

Scientific observers and fisheries inspectors work onboard Russian commercial fishing vessels that fish mackerel in the Faeroese fishing zone and international waters of the Norwegian Sea. Usually 2–5 Russian inspectors and 5–7 scientific observers stay permanently onboard the vessels during the season. They check licenses, logbooks, gears, catches and collect biological samples. Their tasks include also screening of the mackerel catch for potential bycatch of postsmolts and adult Atlantic salmon. The vessel's crew assists in this work. The catches are screened immediately after retrieval of the trawl, during discharge of the fish into bins and at the ship factory during grading. All Russian trawlers are equipped with a factory and every single catch is graded onboard.

In 2002 catches from a total of 1070 hauls, or 25% of all hauls taken by the Russian vessels during the fishing season, were screened. Total catch was 10 921 t of which 7760 t was mackerel. Catch from screened hauls varied from a few hundreds of kilos to 87 t. The average catch of mackerel per haul for inspected vessels was 17.5 t and varied from 2 t – 42 t among vessels.

As a result of considerable effort 15 adult salmon (one of them carried a Swedish Carlin tag) and 12 postsmolts were recorded.

In 2003 416 hauls were screened. The total catch of four vessels inspected was 3800 t of mackerel and 3400 t of blue whiting. One post-smolt and 15 adult salmon were recorded in July-August. Two of the adults were caught when target fish was blue whiting. Also one fish caught in late July was described as sea trout.

No adult salmon or postsmolts were recorded in 2004. Detailed data on onboard screening in 2004 are not available yet.

Estimates provided for the research fishery in 2002 suggest a post-smolt/mackerel ratio of 5.93 per tonne and an adult salmon/mackerel ratio of 0.56 per tonne (Table 4.3.1.1), however most of the postsmolts were captured much further north than where the actual mackerel fisheries occur. Calculation of the ratio of total number of postmolts per tonne of mackerel in the international zone gave an estimated 0.0015 postsmolts per metric tonne captured in the commercial fishery in 2002, and 0.0003 in 2003. The ratio of total number of adults per 1 tonne of mackerel in the international zone was 0.0019 in 2002 and 0.0039 in 2003 (Table 4.3.2.1). As in 2002, the results suggest very low numbers of postsmolts and adult salmon caught in the mackerel fishery in July-August in the international waters of the Norwegian Sea.

The catch ratios from the commercial fishery screening are probably more likely due to the methods of catch post-processing employed onboard Russian commercial vessels where catches are handled more or less individually (see section 2.2 *Russian pelagic fishery*).

YEAR	NO OF HAULS SCREENED	TOTAL CATCH, T	MACKEREL CATCH, T	NO OF SALMON FOUND		RATIO BETWEEN SALMON AND MACKEREL, FISH PER METRIC TONNE	
				Adults	Post-smolt	Adults	Postsmolt
2002	1070	10 921	7760	15	12	0.0019	0.0015
2003	416	7200	3800	15	1	0.0039	0.0003

Table 4.3.2.1. Summarized data of the screening of catches from the Russian mackerel fishery in the Norwegian Sea in June-August 2002–2003.

4.3.3 Icelandic Gallup on salmon bycatches

Gallup, Iceland, performed a survey directed at fishermen in 2004. Due to persistent but "anecdotal" information on salmon being taken in various fisheries, the Freshwater Fisheries Research Institute of Iceland (FFRI) commissioned two additional questions aiming at elucidating the occurrence of salmon bycatches to be included in the questionnaire. Nearly 500 fishermen returned the questionnaire (63.3% of the total number addressed). The outcome was that 77 (15.5%) Icelandic fishermen have caught salmon at sea during the last 12 months (2004). The rate of overlap of observations reported by crewmembers from the same ship is not known, and the results need closer scrutiny and will be discussed further by specialists from Gallup, fisheries expertise from the Marine Institute and the Directorate of Fisheries (Fiskistofa) of Iceland.

4.4 Evaluation of bycatch screening methods

ICES (2004c) considered the screening methods reported by various countries and provided an evaluation of the advantages and disadvantages estimating bycatch of salmon.

The study group then concluded that scanning research survey catches for salmon was not viable for the purpose of extrapolation, unless extensive intercalibration of research and commercial gears were carried out. This view is further underlined in Section 3 in the present report. The Study Group strongly recommends screening of commercial catches on board com-

mercial vessels fishing in pelagic fisheries that are of relevance to salmon bycatch, using appropriate protocols.

The additional information provided to the 2005 Study Group on the Russian observer based commercial catch screening programmes in the Norwegian Sea provided further confidence that this represents a viable method of screening for bycatch. Further examination of the gears used by the Russian pelagic research fishery suggested that these pelagic survey catches may also be used in cases where the gear used is similar to the gear used in the commercial fishery and fishing is carried out in a similar fashion.

The information provided by Iceland to the Study group on the Gallup survey of commercial fishers, which included questions on salmon bycatch, may be a viable method of initially establishing whether salmon bycatch in a fishery is an issue, which requires further investigation. However, further information on the design of and results from this survey is required before this can be fully developed. The method could possibly be applied also to fish filleting plants. A full set of recommendations from the Study Group is contained in Section 6.

5 EXPLORATION OF ANALYTICAL METHODS AND POTENTIAL FOR ASSESSING SALMON BYCATCHES IN PELAGIC FISHERIES

5.1 Methods

The Study Group considered that the most reliable method of estimating bycatches of salmon would be derived from direct observation on board commercial pelagic fishing vessels (applying appropriate screening methods). These estimates would be based on consistent gear types and fishing methods and would not require any assumptions about the transferability of research catches (See also Section 4).

5.2 Estimation of salmon bycatch in the mackerel fishery in areas with recorded overlap of salmon in time and space

ICES (2004c) developed a range of estimates of potential post-smolt bycatch in the mackerel fishery in the Norwegian Sea, based on the data available at the meeting (ICES, 2004c, Table 5.1). Estimates were given as illustration of the likely ranges of values obtained by applying different methods and were presented for the purposes of evaluating the performance of these methods. Resultant estimates of potential post-smolt bycatch in this fishery ranged from 26 to >1 million, depending on method of estimation.

The numbers presented in ICES (2004c) indicated that with the input data then available, the research survey method clearly would lead to an overestimate of the bycatches as the estimated numbers arrived at (up to several millions of postsmolts) would represent a major part of the pre fishery abundance of salmon in the whole NEAC area. Hence the Study Group concluded that none of the estimates so far developed could be regarded as reliable in the absence of the appropriate disaggregated catch data, and that the original estimates provided by ICES in 2002 were not viewed by the Group as reliable. On the other hand, the observer based method seemed to be giving equally unreliable results when arriving at less than 100 postsmolts despite several months of intensive commercial fishing in the documented migration path. This may happen because the observer exercises include only part of the documented migration path and spatial-temporal distribution of postsmolts.

Since new disaggregated data sets were made available to the Study Group in 2005 (Section 2), the analyses attempted in 2004 were repeated, but with use of commercial catches from only those ICES statistical rectangles where postsmolts at some time had been registered in surveys.

The input data used were then:

- Russian observer data from commercial catch screening, in the Norwegian Sea in 2002 and 2003 (Total number of postsmolts/total catch of mackerel (t)).
- Data from Russian pelagic fish surveys in the Norwegian Sea, 2002, 2003. (Total number of postsmolts/total catch of mackerel (t)).
- Mackerel catch data (all countries) for each year, disaggregated by, standard week, ICES statistical rectangle for ICES areas IIa and Vb.
- Smolt distribution (from Norwegian research surveys), disaggregated by standard week and statistical rectangle for ICES areas VIa & b–IVa and IIa–Va & b.

Due to time constraints, only three examples were calculated, but the data provided will be used by WGNAS for further analyses. Table 5.2.1 gives an example of the outcome of an estimate for 2001 and 2002 when the observed ratios of postsmolts to total catch of mackerel from the Russian scientific and commercial fishery has been scaled with the tonnage taken in the overlapped rectangle. Only rectangles where salmon have been recorded were used for scaling up, and mackerel catches from rectangles with no salmon were thus excluded. In Method 2 (Table 5.2.1) total commercial and research catches of mackerel have been used and in this example a north- south division has been applied, because the major part of the commercial mackerel catch is taken south of 68°N while the scientific catch rate of postsmolts/ t mackerel is derived from catches occurring north of 68°.

Consequently the estimates of salmon potentially taken, arrived at by these methods are much lower than the previous estimates. Table 5.2.1 shows that when extrapolating from the research catch, the number of postsmolt and salmon potentially taken is consistently higher than using the observer based data. This is undoubtedly the effect of a difference in the northerly extension of the distribution of the two species. The postsmolt seem to have had a more northerly distribution than the mackerel in June, at least in 2002, leading to higher posts-molt catch ratios in relation to that of the mackerel. Another reason might be (cfr Section 3) that the Russian research trawl, although more like a commercial trawl than the Norwegian salmon trawl, is less effective in catching mackerel. Thereby the ratio between the target species and the bycatch becomes higher than in the commercial catch. But it may also reflect that even if very meticulous (cfr Section 4) the observer-based method somehow fails in registering postsmolts in the catch. Even if the spatial and temporal overlap is considerably smaller than originally thought, it still seems unlikely that only a handful of postsmolts should be taken in such large fisheries. It is emphasized that Table 5.2.1 shows the variation of values arrived at by different methods of estimation. The values are not formal estimates for management purposes of bycatch in any particular year or fishery and are not to be used for assessment or management advice.

As a comprehensive examination of the commercial fleet observer data has been carried out and reviewed by ICES and new information brought to the Study Group indicates that that screening method was likely to be the most viable of the methods so far carried out, the estimate(s) from the Russian observer based surveys are to be reported to ICES. The Russian pelagic research survey data may also be carried forward.

It should however be stressed at the same time that the sample is for particular years and locations only and thus it is possible that occasional higher or even much higher bycatches occur on occasion, depending on fishing patterns and smolt migration variations. Hence, further screening of this fishery is recommended. The information from the Russian pelagic research surveys can be cited as evidence of this, as, for the two years of survey reported to ICES, 2003 produced no salmon, while the 2002 survey produced a bycatch ratio of 5.93 salmon/tonnes mackerel north of 68°N.

The Study Group therefore feels that section 5 provides general response to NASCO TOR, but is not a formal assessment for any particular year/cohort.

The study group recommends that future estimates should be refined, if possible with annual estimates, based on observer based screening of catches.

As yet, no other relevant pelagic fisheries have provided salmon catch rate data, but in the light of information presented in sections 2 and 4, the possible interception of salmon by *i.e.* herring or blue whiting fisheries should be further investigated (Sections 2.5 and 4.2).

5.3 Other methods

Although the primary method of assessing potential impact of pelagic fisheries on salmon survival at sea is likely to remain survey and catch based estimates, the Group considers that other approaches should be explored and developed alongside these methods:

1) Following the analyses caried out by the Working group on North Atlantic Salmon in 2004 (ICES, 2004a), further work should be carried out to apply known data on salmon abundance and survival trends in the stocks in question (southern NEAC stock complex mainly) to determine whether the present ranges of estimates of salmon bycatch can account for recent changes in abundance or survival at sea. This would best be carried out using the disaggregated catch data sets established by the present Group.

2) Work should be carried out, under a range of bycatch rate scenarios to determine the scale and nature of any tagging programme that would be required to yield reliable estimates of bycatch.

5.4 Further work

The Study Group discussed further work and concluded that unless new data on a) the temporal and spatial distribution of salmon in the NE Atlantic, b) records of bycatches of salmon in commercial fisheries, c) salmon behaviour in relation to approaching fishing gear or, d) other relevant information needed to improve the bycatch estimates become available, there will be no need to reconvene in 2006.

2001		period		
Method 1	**smolt catch rate/ t mackerel**	**weeks**	**catch (t)**	**by-catch (n)**
Russian research survey	5.93	21-31	26051	**154482**
Russian observer programme	0.002	21-31	26051	**52**
Russian research survey	5.93	26-28	6777	**40188**
Russian observer programme	0.002	26-28	6777	**14**
2002				
		period		
Method 1	**smolt catch rate/ t mackerel**	**weeks**	**catch (t)**	**by-catch (n)**
Russian research survey	5.93	21-31	21265	**126101**
Russian observer programme	0.002	21-31	21265	**43**
Russian research survey	5.93	26-28	7594	**45032**
Russian observer programme	0.002	26-28	7594	**15**
2002				
Method 2	**smolt catch rate/ t mackerel**	**weeks**	**catch (t)**	**by-catch (n)**
>68N (North)	5.93	21-31	48	285
62-68N (Central NS)	0.002	21-31	39083	78
Sum				**363**
>68N (North)	5.93	26-28	25	148
62-68N (Central NS)	0.002	26-28	16089	32
Sum				**180**

1 - The first method uses aggregated catches of mackerel by rectangles in 2001 and 2002 where salmon postsmolts have been observed during the period 1990–2003. Catches of mackerel in rectangles without simultaneous salmon catches are not included.

2 - The second method uses total catches during the same periods in 2002 from two different areas (north and central Norwegian Sea), corresponding to the area where two bycatch ratio estimates have been obtained in 2002.

Table 5.2.1. Examples of two methods to calculate bycatch of postsmolts in the Norwegian Sea.

6 RECOMMENDATIONS

1) Catch ratios should not be extrapolated from Norwegian scientific salmon surveys to the entire fishery due to the absence of efficiency estimates and the considerable differences in design and operation of commercial and survey trawls.

2) Only the catch data from the Russian survey and commercial trawl should be used for extrapolation purposes on the same spatial-temporal fishery.

3) Screening of pelagic survey catches is recommended when both the gear used and the fishery is similar to the commercial fishery (for example, the recent Russian pelagic research surveys in the Norwegian Sea).

4) Research catches should continue to be screened for salmon, as this will add to the knowledge base on temporal and spatial distribution of salmon at sea.

5) Screening of the commercial catches on board commercial fishing vessels in relevant pelagic fisheries is recommended. This is the primary method of producing data for bycatch estimation.

6) A Gallup type survey of the processing plants dealing with mackerel, herring and horse mackerel for human consumption should be considered to establish whether salmon have been observed during processing.

7) Further investigations into salmon marine ecology is required, in particular the distribution in time and space, in order to allow a better assessment of the potential overlap between salmon and pelagic fisheries. This should include research into the migration patterns of post-smolt and salmon from the coastline of the NE-Atlantic countries into the shelf areas and be carried out along with an investigation of migration routes in the North Sea and the northern extension of the summer feeding areas for post-smolt and adult salmon. In particular, surveys in more southerly areas should be undertaken in weeks 20–23 while the northern areas should be covered in weeks 30–34.

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