REPORT

Equinor ASA – Heimdal - Consequences for fisheries related to jacket removal

Revision and approval form

REPORT		
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0 Summary - Sammendrag

0.1 Summary

Equinor is planning to remove the platforms on the Heimdal field in the Norwegian part of the North Sea, located within production license (PL) 036BC in block 25/4. Equinor's final disposal plan for Heimdal includes Heimdal Main Platform (HMP) and Heimdal Riser Platform (HRP). A condensate pipeline from Heimdal HMP to Brae in the UK sector is also part of the decommissioning project. The pipeline is buried and is not a part of this assessment.

For the HMP two alternatives for removal of the steel jacket is assessed;

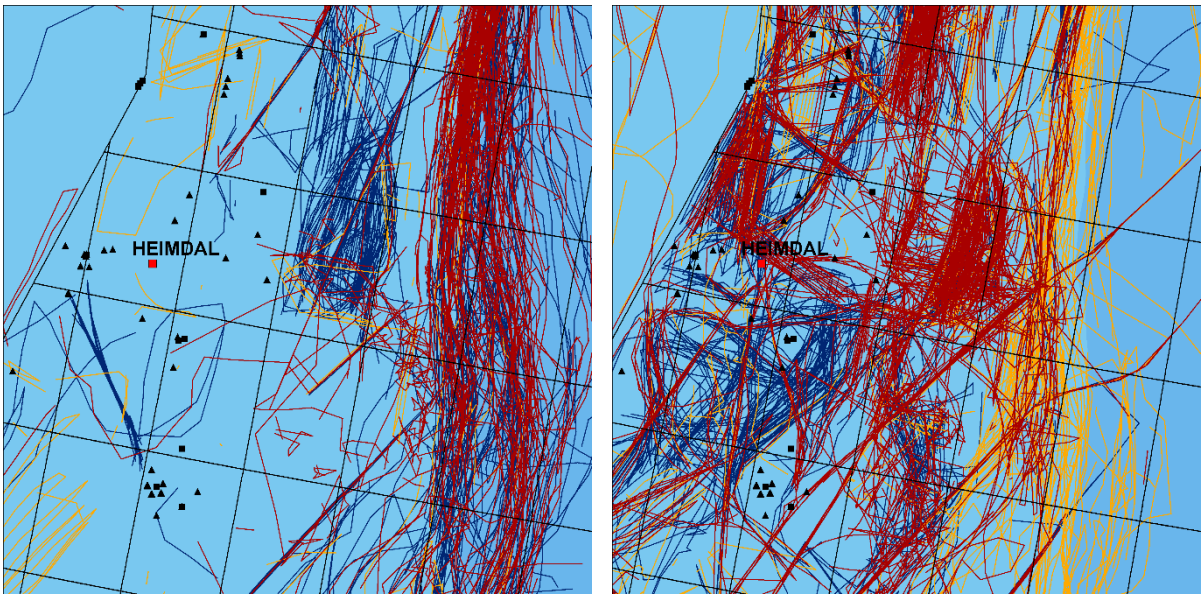
- Complete removal, cutting of the piles 1-2 meters below the seabed, i.e. complete removal, leaving a smooth seabed.
- Removal of the upper part of the jacket with cutting above the piles, leaving the lower part of the jacket and piles on the seabed. The bottom section remaining on the seabed will be approx. 32 m high and occupy an area on the seabed of approx. 75 m by 90 m.

The HRP removal is conducted by cutting of the piles 1-2 meters below the seabed, i.e. complete removal, leaving a smooth seabed.

The pipelines will be cleaned and cut below seabed level. The pipeline ends will be secured by over-trawlable rock dumping.

Fisheries in the Heimdal area

The Norwegian fishing activity close to Heimdal is rather limited compared to the total fishing activity in Norwegian sector in the North Sea. Most of the fisheries in the area are conducted by foreign vessels (Figure 1). A typical activity in this area is Scottish trawlers trawling along pipelines in the area. Trawling by other vessels is conducted without any specific direction. Some purse seiners and pelagic trawlers operate in the area as well. The activity in areas to the north and south of Heimdal are higher than in the vicinity of the Heimdal installations.



Blue = 2016 **Orange** = 2017 **Red** = 2018

Figure 1 An example on the difference of the difference between (left) Norwegian bottom trawling and (right) foreign (right) fishing, mainly bottom trawl, in the Heimdal area. The figure presents results from satellite tracking in Q3 in the period 2016 – 2018. Data from the Directorate of Fisheries.

Throughout the period 2010 - 2018, pelagic catches (herring and mackerel) have been the most important in the Norwegian fisheries in the Heimdal area, an area corresponding to 24 blocks, in eight out of nine years measured by weight. The catches of demersal species were

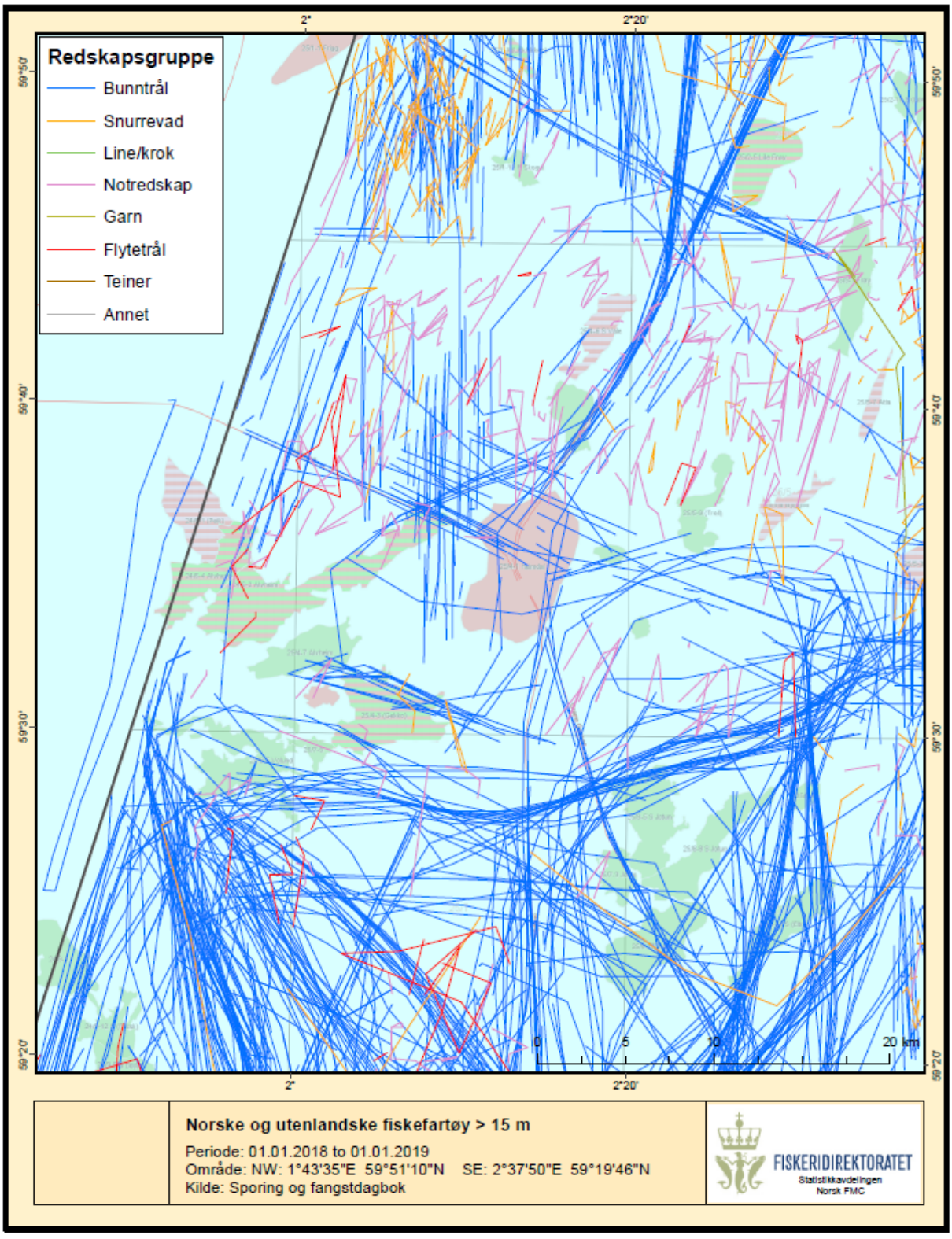


Figure 2 All fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2018. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.

the most important in 2018. However, we are talking about moderate catches. At maximum the Norwegian catches of pelagic species represented 7% of the total Norwegian catches in the North Sea (2015), and 3% of the demersal catches in the North Sea (2016).

Foreign catches of demersal species in the Norwegian sector in the North Sea are much higher than the Norwegian catches. The main species in these fisheries are cod, saith and hake ("lysing"). In the years 2015 – 2017 there are high catches of pelagic species, mainly herring, as well. The major part of the foreign catches in NEZ in the North Sea is fished by Danish and British/Scotch vessels. Some catches are reported from German, Swedish and French vessels as well.

All fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2018 is presented in Figure 2.

Effects of complete removal

The disposal alternative with complete removal of the structures implies a smooth seabed when all operations are finished. The area occupies by the Heimdal installations and their safety zones will be open to all fisheries, with no loss of fishing area or operational inconveniences.

Effects of partly removal

When the work is finished, and the safety zone abandoned, the loss of fishing area for vessels conducting bottom trawling is reduced. Trawlers may exploit the area within the present safety zone. Trawling close to the remaining parts of the structures, or moments with some lack of attention, represent a risk for hooking of the wires, trawl door or the trawl net in the obstruction. A technical note "Heimdal jacket removal - Trawl impact risk assessment" has been prepared by Acona AS (Acona 2019).

For the purse seine fisheries, the remaining parts of the structures will still be an obstacle to the catch operations. Partial removal is not expected to represent any noticeable changes regarding operational inconveniences compared to the present situation.

The Heimdal platforms have already existed as an artificial reef for the fish stocks for more than 30 years. Based on the observed fishing pattern and catch statistics for the area during the last decade, any noticeable effect as artificial reef has so far not been observed. It seems unlikely that this picture will change after the field is shut down with. However, the trawlers will be able to exploit areas within the present safety zone.

Table 1 The effects on fisheries from the different disposal alternatives compared with the present situation.

	Bottom trawl	Purse seine / Pelagic trawl	Other gear [1)]
Full removal of HMP	No limitations	No limitations	No limitations
Partial removal of HMP. Cut to at least 55 m below sea surface	Recovered fishing area, with some operational disadvantages. Risk for hooking of equipment.	Some increased operational area. Will still represent an obstacle during catch operations	No significant limitations

1) Minor parts of the high sea fisheries in the North Sea

Conclusion

Full removal will imply increased fishing area for all types of gear and reduce the operational disadvantages during fishing in the area. Especially foreign trawlers will benefit from this disposal alternative.

With partial removal the remaining structures will still represent an obstacle during bottom trawl fisheries, and sporadic for the purse seine fisheries. The Norwegian bottom trawl fisheries in the Heimdal area are sporadic, and partial removal is expected to have limited effects on the total Norwegian fisheries. Foreign fisheries with bottom trawl dominate in the Heimdal area. Based on the scale presented in Table 4-1, the Heimdal area represent medium consequences for these fisheries in the present situation. With partial removal, the vessels operating in the area will still experience some operational disadvantages combined with reduced loss of fishing area. Partial removal is expected to represent small consequences for the foreign fishing fleet operating in the Heimdal area.

0.2 Sammendrag på norsk

Equinor planlegger å fjerne innretningene på Heimdalfeltet i Nordsjøen, i utvinningstillatelse (PL) 036BC i blokk 25/4. Equinors avslutningsplan inkluderer Heimdalplattformen (HMP) og stigerørsplattformen (HRP) som er installert ved siden av denne. En kondensatrørledning fra Heimdal HMP til Brae i britisk sektor er også en del av avviklingsprosjektet. Rørledningen er nedgravd, og er ikke en del av denne utredningen.

For HMP vurderes to alternativer for fjerning:

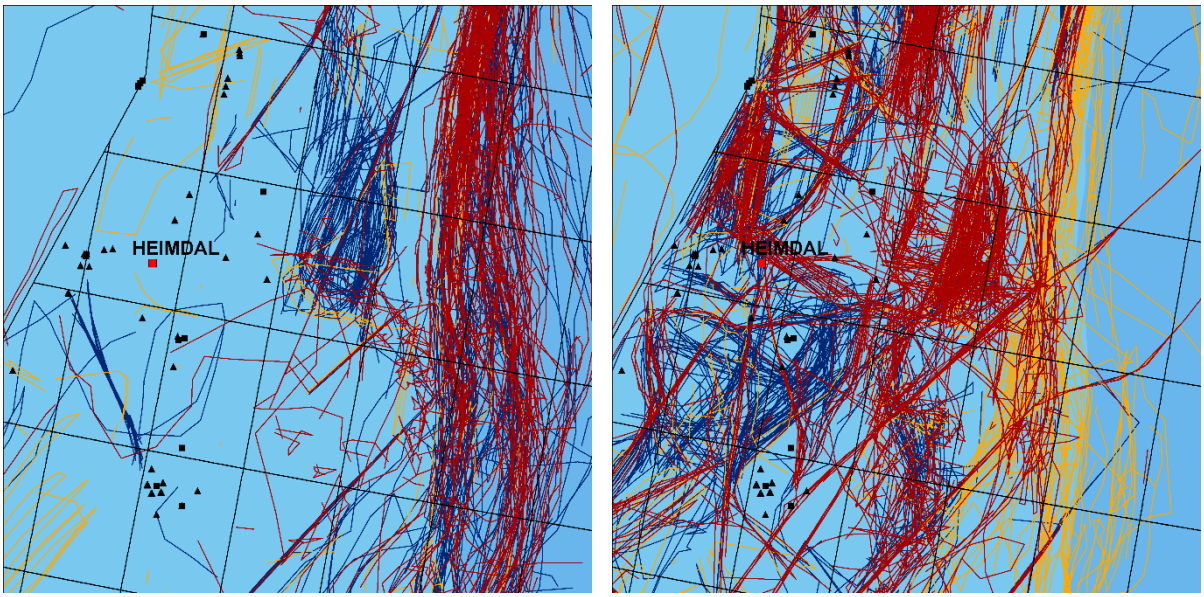
- Fullstendig fjerning, kutting av plattformbeina 1-2 meter under havbunnen, og etterlate en jevn havbunn.
- Fjerning av den øvre delen av stålunderstellet, etterlater nederste del av understellet og kakshauger på havbunnen. Bunnseksjonen som etterlates ved denne løsningen vil være ca 32 m høy og oppta et areal på havbunnen på ca 75 m x 90 m.

HRP fjernes ved å kutte plattformbeina 1-2 meter under havbunnen og det etterlates en jevn havbunn.

Rørledningene blir rengjort og kuttet under havbunnsnivå. Rørledningsendene vil bli sikret ved steindumping og være overtrålbare.

Fisket i Heimdal-området

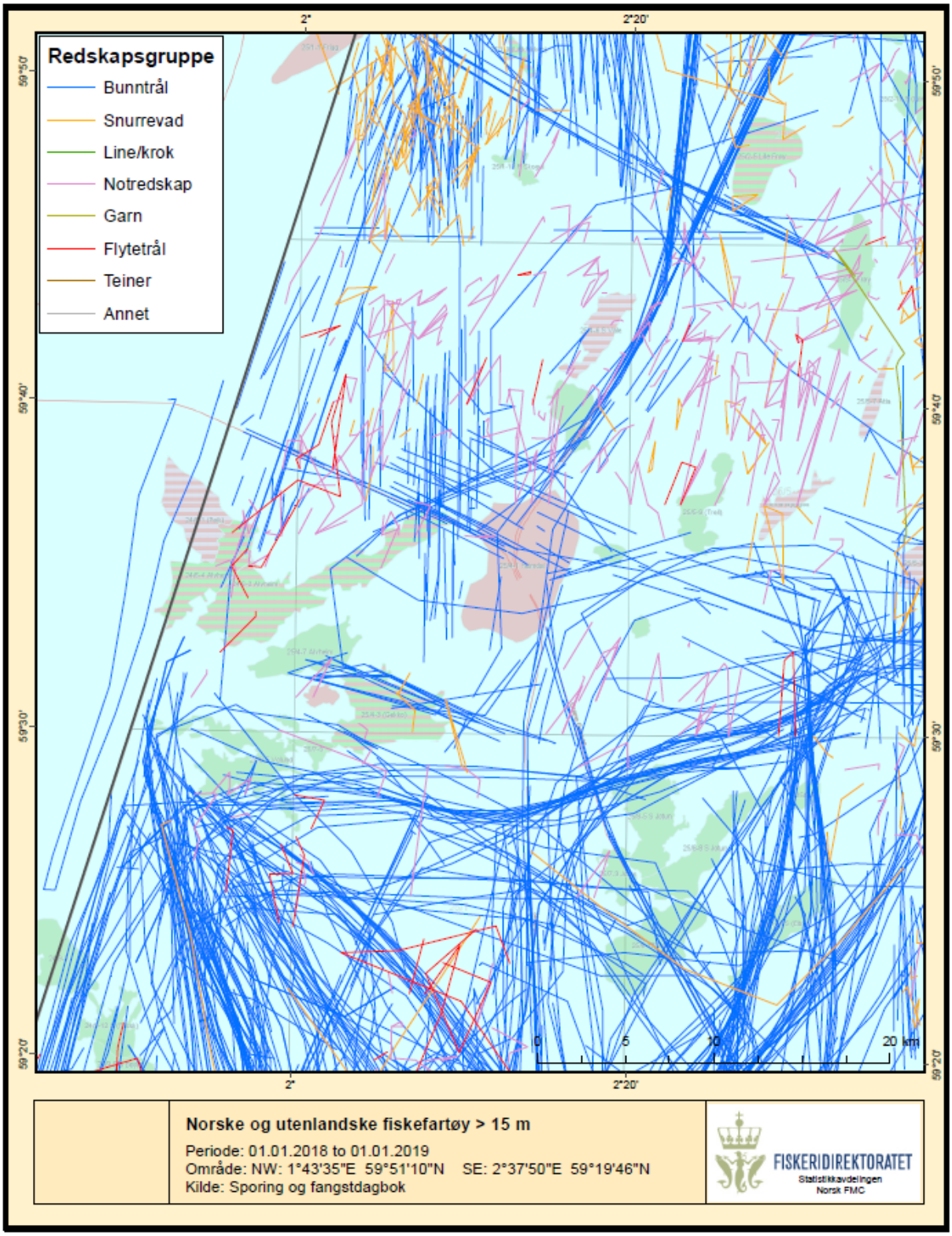
Den norske fiskeaktiviteten nær Heimdal er ganske begrenset sammenlignet med samlet aktivitet i den norske Nordsjøsonen. Det meste av fisket i området drives av utenlandske fartøy. Et eksempel på dette er vist i **Error! Reference source not found.**. En typisk aktivitet i dette området er skotske trålere og partrålere som tråler langs rørledninger i området. Annen tråling drives uten noen bestemt trålretning. Noen ringnotfartøyer og pelagiske trålere opererer også i området. Aktiviteten i områder h h v nord og sør for Heimdal er høyere enn i nærheten av Heimdal-installasjonene.



Blå = 2016 **Orange** = 2017 **Rød** = 2018

Figur 1 Et eksempel på forskjellen mellom norsk bunntråling (venstre) og utenlandsk fiskeriaktivitet (høyre), hovedsakelig bunntråling, i området omkring Heimdal. Figuren viser satellittsporingsresultater for tredje kvartal I årene 2016 – 2018. Figuren er basert på data fra Fiskeridirektoratet.

Gjennom perioden 2010-2018 har det pelagiske fisket (sild og makrell) vært det viktigste norske fisket i Heimdal-området, et område tilsvarende 24 oljeblokker, i åtte av ni år regnet etter vekt. Fangstene av bunnfiskarter var viktigst i 2018. Det er imidlertid tale om moderate fangster. På det meste utgjorde norsk fangst av pelagiske arter 7% av de totale norske fangstene i Nordsjøen (2015), tilsvarende tall for bunnfiskarter var 3% (2016).



Figur 2 Registrert aktivitet fra alle norske og utenlandske fiskefartøyer over 15 meter i Heimdal-området i 2018. Heimdal er det rosa området midt i kartet. Figuren er basert på resultater fra elektronisk fangstrapportering, og er utarbeidet av Fiskeridirektoratet.

Utenlandske fangster av bunnfiskarter i norsk sone i Nordsjøen er mye høyere enn norske fangster. Hovedartene i disse fiskeriene er torsk, sei og lysing. I årene 2015 - 2017 er det også

tatt betydelige store fangster av pelagiske arter, hovedsakelig sild. Hovedparten av de utenlandske fangstene i norsk sone i Nordsjøen er tatt av danske og britiske / skotske fartøy. Noen få fangster er også rapportert fra tyske, svenske og franske fartøyer.

Samlet fiskeriaktivitet med norske og utenlandske fartøyer over 15 meter i Heimdal-området i 2018 er vist i **Error! Reference source not found.**

Effekt ved full fjerning

Alternativet med full fjerning av innretningene innebærer en jevn havbunn når alle operasjoner er ferdige. Området som i dag beslaglegges av Heimdal-innretningene og sikkerhetssonen omkring disse vil være tilgjengelige for alle fiskerier. Det vil ikke lenger være noe arealtap og driftsmessige ulemper for fisket i området.

Effekt ved delvis fjerning

For alternativet med delvis fjerning av Heimdal-plattformen vil arealtapet for trålerflåten bli redusert når arbeidet er avsluttet og sikkerhetssonen opphører. Trålerne kan da utnytte arealer innenfor eksisterende sikkerhetssone. Tråling nær inntil de etterlatte delene av plattformen, eller ikke tilstrekkelig oppmerksomhet ved passering, kan utgjøre en risiko for å hekte trålvaiere, tråldørene eller selve trålposen. Et teknisk notat om risiko for fasthekting, "Heimdal jacket removal - Trawl impact risk assessment", er utarbeidet av Acona AS (Acona 2019).

For ringnotfisket vil de resterende delene av strukturen fortsatt være et hinder for å ta fangst om bord i dette området. Delvis fjerning forventes ikke å utgjøre noen merkbare endringer i operative ulemper i forhold til nåværende situasjon.

Heimdal-plattformene har allerede eksistert som et kunstig rev for fiskebestandene i mer enn 30 år. Basert på det observerte fiskemønsteret og fangststatistikken for området i løpet av det siste tiåret, har det ikke blitt observert noen merkbar effekt av dette. Det virker lite sannsynlig at dette bildet vil endres etter at feltet avvikles. Trålerne vil imidlertid kunne utnytte områder innenfor dagens sikkerhetssone.

Tabell 1 Effektene på fiskeri fra de ulike avviklingsalternativene i forhold til dagens situasjon.

	Bunntrål	Ringnot / pelagisk trål	Andre redskaper [1)]
Full fjerning av HMP	Ingen hindring	Ingen hindring	Ingen hindring
Delvis fjerning av HMP. Kuttet 55 meter under havflaten	Liten økning i tilgjengelig areal., med noen opera-sjonelle ulemper. Risiko for hekting av trålutstyr.	Liten økning i tilgjengelig areal. Vil fortsatt utgjøre en hindring for fangst-operasjoner.	Ingen vesentlige hindringer

1) Utgjør bare en liten del av fisket til havs i Nordsjøen.

Konklusjon

Full fjerning vil innebære økt fiskeområde for alle typer utstyr og ingen operasjonelle ulemper under fiske i området. Spesielt utenlandske trålere vil dra nytte av dette alternativet.

Ved delvis fjerning vil de gjenværende strukturene fortsatt utgjøre et hinder under bunntrål-fiske og sporadisk for ringnotfiske. Det norske bunntrålfisket i Heimdal-området er sporadisk, og delvis fjerning forventes å ha begrenset virkning på norsk fiske i Nordsjøen. Det utenlandsk fisket med bunntrål dominerer i Heimdal-området. Basert på skalaen som er presentert i Tabell 4 1, representerer Heimdal-innretningene middels konsekvenser for disse fiskeriene i dag. Ved delvis fjerning vil fartøyene som opererer i området fortsatt oppleve noen operative ulemper kombinert med redusert tap av fiskeområde. Når fjerningsarbeidet er fullført, ventes delvis fjerning å medføre små konsekvenser for det utenlandske fisket i Heimdal-området.

1 Introduction

Equinor is planning to remove the platforms on the Heimdal field in the Norwegian part of the North Sea. The platforms are located within production license (PL) 036BC in block 25/4. Equinor's final disposal plan for the Heimdal field includes Heimdal Main Platform (HMP) and Heimdal Riser Platform (HRP) and the condensate pipeline from Heimdal to Brae in the UK sector.

For the HMP two alternatives for removal of the steel jacket is to be assessed:

Heimdal Main Platform removal - Alternative 1:

Cutting of the piles 1-2 meters below the seabed, i.e. complete removal, leaving a smooth seabed.

Heimdal Main Platform removal - Alternative 2:

Removal of the upper part of the jacket with cutting above the piles, leaving the lower part of the jacket and piles on the seabed.

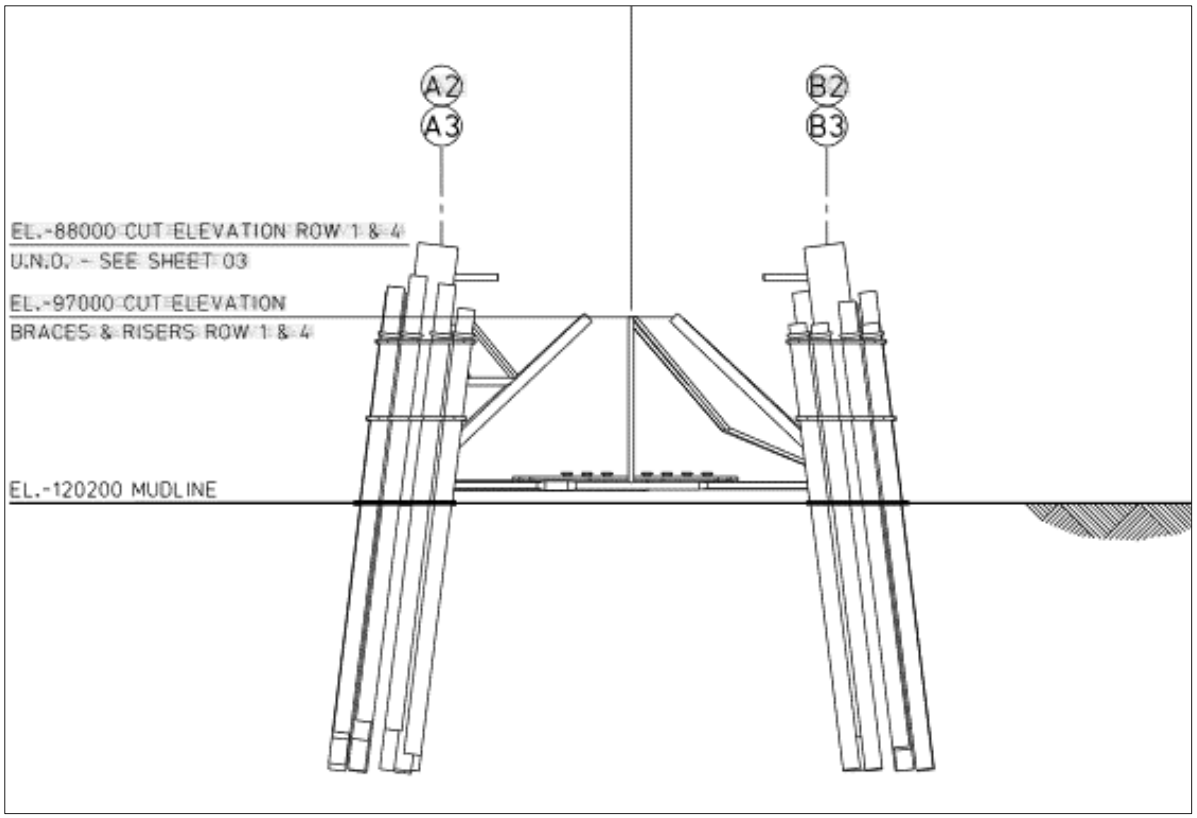


Figure 1-1 The Heimdal bottom section remaining on the seabed (Figure from Equinor)

The Heimdal bottom section remaining on the seabed in a derogation case will be approximately 32 m high and occupy an area on the seabed of approximately 75 m by 90 m from the corners of the mud mats. The jacket bracings and legs will be cut in such a way that there will be free bracing and leg ends extending above the piles and bottom jacket section. This is within the IMO requirement of 55 meters free sailing depth. The obstruction will be marked on navigational charts.

Heimdal Riser Platform removal

For the Heimdal Riser Platform (HRP) the removal is conducted by cutting of the piles 1-2 meters below the seabed, i.e. complete removal, leaving a smooth seabed.

Pipelines

Pipelines will be cleaned and cut below seabed level. The pipeline ends will be secured by over-trawlable rock dumping.

Scope of work

The scope of work for the study requested is to present:

- Fishing activities in the relevant area for the years 2010-2018, including quarterly reports for each year with type of fishing gear
  - Identifying nationality of fishing vessels
  - Quantify amount of catch for relevant species

- Evaluation of consequences for the removal options on the future fishing activity in the area:
  - Evaluation of consequences on the future fisheries in the area from full removal (Alternative 1)
  - Evaluation of reduced fishing area due to obstruction. Assume that the jacket footings (Alternative 2) will remain an obstruction on the seabed for at least 200 years
  - Evaluation of impacts on fishing activity for relevant fish species and catch methods from the jacket footings (Alternative 2), acting as 'artificial reef', include brief evaluation of any identified wrecks in the area

Evaluation of the risk for hooking of fishing gear including possible accidents involving the fishing vessel resulting from hooking will be presented in a separate document.

2 Main picture of the fisheries in the North Sea and the larger Heimdal area

The North Sea is a very important fishing area for both Norwegian and foreign vessels (Figure 2-1). There is a constant development of new equipment and technology, increasing the catch efficiency of the fishing fleet. The fisheries depend on the different fish species' migrations, accessibility, operating conditions, regulations, market development etc., meaning that the intensity and location of fishing activity varies from season to season and between years. Changes in physical conditions may lead to changes in the distribution and accessibility of the commercially important species. However, some fisheries are typical in the North Sea, such as:

- Mackerel fishery in the period August – October.
- Herring fishery (North Sea herring) with purse seine mainly in the period May – July, and by pelagic trawl late autumn.
- Fishing for reduction purposes to fish meal and oil (Industrial fisheries) for Norway pout, sandeel and blue whiting. The sandeel fishery has been restricted to Q2.
- Saithe fishery with trawl throughout the year.
- Gillnet fishery for cod and haddock throughout the year.
- Trawl fishery for shrimp and Norway lobster (nephrops) in the Norwegian Trench and coastal areas throughout the whole year.

In this chapter the most important areas for fishing in the North Sea are described with emphasis on areas where bottom trawling is conducted. In fisheries with purse seine or mid-water (pelagic) trawl for herring and mackerel the fishing areas will depend on both the stocks migration and regulations, both varying from year to year. As a result, these fisheries are not as dependent on specific fishing areas as the bottom trawl fisheries.

2.1 Whitefish trawling / fishing for human consumption

Most of the Norwegian whitefish trawling is conducted from about 160-170 meters depth along the edge of the Norwegian Trench and further west. Saithe is currently the most important species in this fishery. In the Heimdal area trawling is conducted westwards to the UK-Norwegian border, and the fishery is conducted without any specific trawling direction.

Historically an important part of the whitefish fisheries was conducted by the trawlers mainly fishing species for reduction purposes ("industrial trawlers"), but through the latest decades they have withdrawn from this fishery. The fishery is today conducted by the much bigger fresh fish trawlers and factory trawlers. A typical weight of trawl doors used in Norwegian fishery in this area is 4.5 tonnes. Sporadically, when the catch rates are low, these vessels use twin trawls equipped with centre weight. The centre weight is dragged along the bottom and has a weight of up to 80% more than a trawl door. A typical size of centre weights used in this area today is approximately 6.5 tonnes. The pull/traction power of the vessels winches is up to 45-60 tonnes each. Foreign vessels fishing within the Norwegian Economic Zone (NEZ) are smaller than the Norwegian. Most of them use trawl doors with a weight of less than 2 tonnes. Many of them conduct pair trawling, i.e. two vessels towing the trawl(s), without the use of trawl doors (Pers. message. Dagfinn Lilleng, Directorate of Fisheries, 07.06.2019).

2.2 Trawl fishery for reduction purposes / Industrial trawling

The most important species in the trawl fisheries for reduction purposes are Norway pout, blue whiting, horse mackerel and sandeel. The important trawling areas for Norway pout are along the edge of the Norwegian Trench. Most catches are taken in waters deeper than 160-170 meters. The Heimdal area with its water depth of some 120 meters is thus too shallow for this fishery. The area is not regarded as any important area for the trawl fishery for reduction purposes, but occasionally some blue whiting catches are reported. No important areas for the sandeel fishery is located near Heimdal.

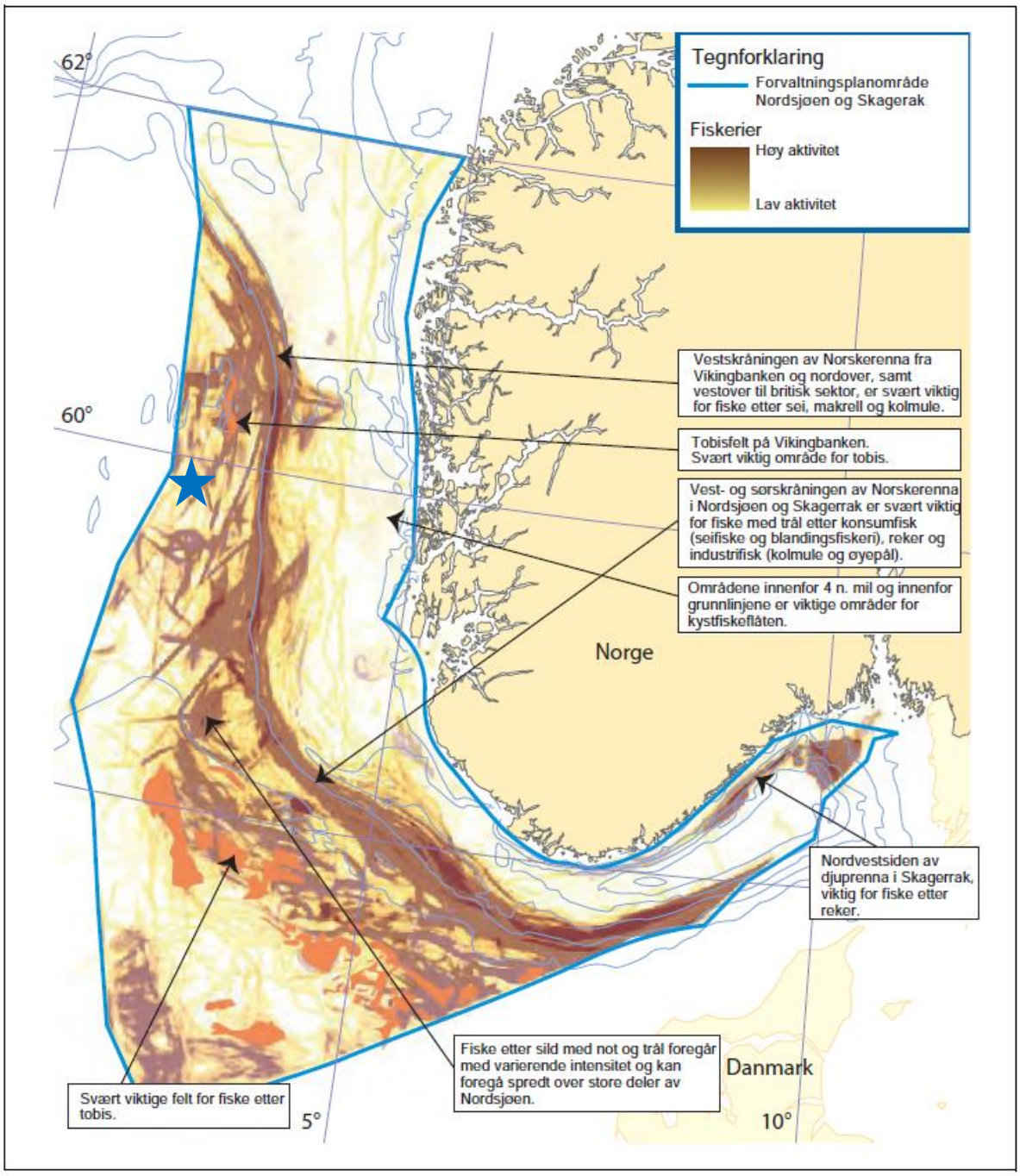


Figure 2-1 Important fishing areas in the North Sea and Skagerrak. Darker colours indicate increased density of reported fishing activity. Figure from Meld. St. 37 (2012-2013). Heimdal marked with a blue star.

2.3 Purse seine fishery

The purse seine fishery for herring and mackerel is not as dependent on specific fishing areas as the trawl fisheries. These fisheries are highly dependent on the different fish species' migrations, varying from one year to another. Generally, the North Sea is of more importance for the pelagic fisheries than for the bottom trawl fisheries. Second and fourth quarter are the most important catch periods. Herring is the most important species in second quarter. The autumn fishery is for both mackerel and herring.

2.4 Other fisheries

A few of the recorded demersal landings from the Heimdal area are stated as coming from gillnets and longlines, indicating that these types of fishing gear sporadically may be applied. This is considered sporadic and mostly carried out along the edge of the Norwegian Trench.

3 Fisheries in the area around Heimdal

The Norwegian Directorate of Fisheries (NDF) has provided statistics of landings from the area around Heimdal, and the North Sea as a whole. Furthermore, the Directorate has provided results from the satellite tracking of fishing vessels on a quarterly basis for the period 2010-2018. The satellite tracking system includes all fishing vessels larger than 15 meters overall length. The fishery statistics and results from the satellite tracking are used to present the fishing activity in the Heimdal area.

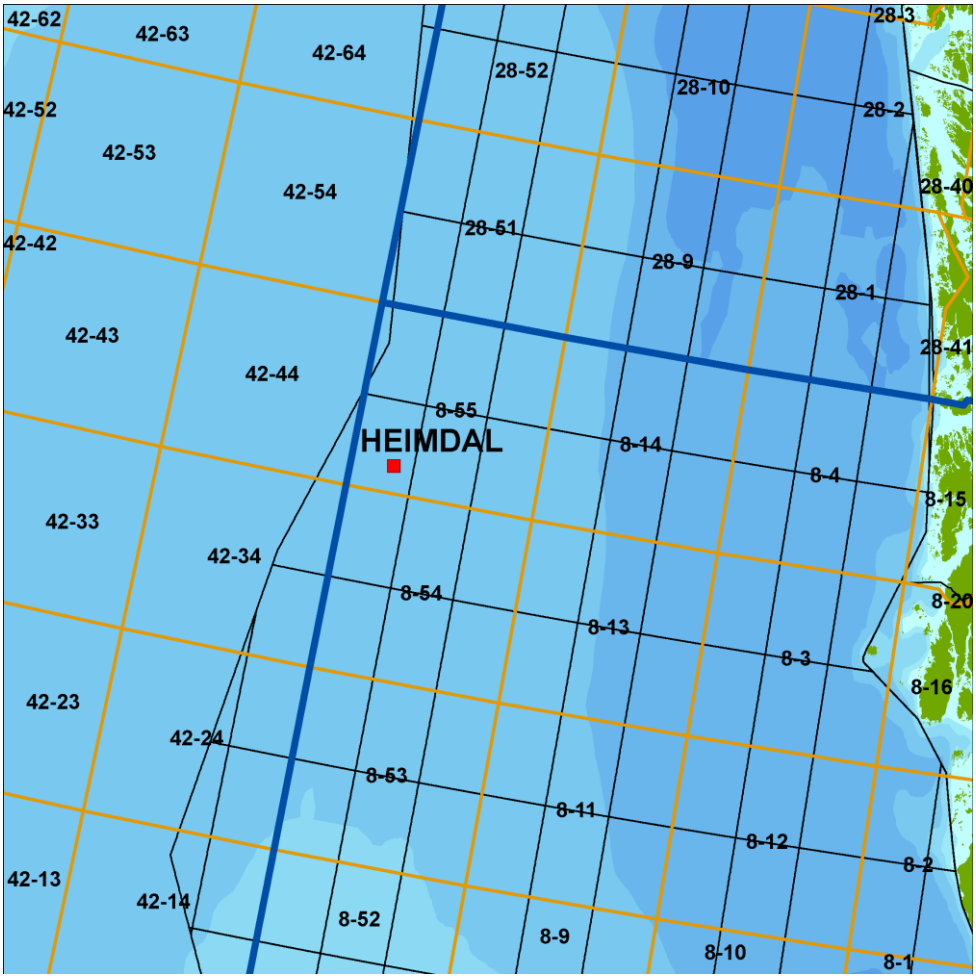


Figure 3-1 Main areas and locations in the fishery statistics. Heimdal is located in fisheries statistics location 08-55. Recorded landings from this location and the neighbouring locations 08-54, 42-34 and 42-44 are presented to illustrate the importance of the area to fisheries.

3.1 Landings from the Heimdal area

Fisheries landings is recorded in statistical areas of varying size and shape for the entire North Atlantic. Each area is further subdivided into several statistical locations. The Norwegian sector of the North Sea (South of 62°N) covers all of statistics area 28 and 08, and parts of area 41 and 42. These four areas cover the entire North Sea.

In the North Sea, a statistical location corresponds to six oil-exploration blocks. The fisheries statistics provide data on which fisheries are carried out in an area and provide basis for comparison of importance among areas (locations). Fishing with trawl and purse seine dominates in the open parts of the North Sea.

In this study we present landing data from location 08-55 housing Heimdal, and the neighbouring locations 08-54, 42-34 and 42-44 immediately adjacent to Heimdal (Figure 3-1). These four locations are collectively referred to as the Heimdal area in this chapter.

3.1.1 Norwegian landings in the Heimdal area

Annual landings by Norwegian vessels from the Heimdal area and the entire North Sea during the period 2010 – 2018 are presented in Table 3-1and Table 3-2.

The statistics for 2018 are preliminary. The landings are reported and presented in three groups:

- Demersal species (cod, haddock, saithe, flatfish and shrimp)
- Pelagic species (herring and mackerel)
- Species for production of fishmeal and oil, "industry species" (Norway pout, blue whiting and sandeel)

Throughout the period presented here, pelagic catches (herring and mackerel) have been the most important, measured by weight, in the Heimdal area for eight out of nine years. The catches of demersal species were the most important in 2018. The catch statistics indicate that the areas from Heimdal towards the UK sector are more important for the pelagic fisheries than the area close to Heimdal. Statistics from location 0855, corresponding to blocks 24/1-6, show that this location differs from the rest, and fishing for demersal species dominated throughout the period.

3.1.2 Foreign landings from the Heimdal area

Foreign vessels fishing within the Norwegian Economic Zone (NEZ) report their catches to their flagstate's authorities. After the introduction of electronic catch reporting during 2010, data for foreign fishing in NEZ are later submitted to the Directorate of Fisheries. Quarterly data for foreign fishing in NEZ in the years 2011 – 2018 are presented in Table 3-3 and Table 3-4. Complete data for foreign fishing in NEZ in 2010 is not available.

In most of the years in the period presented here, demersal species are the most important in foreign fishing in NEZ. Foreign catches of these species are much higher than the Norwegian catches. The main species in these fisheries are cod, saith and hake ("lysing"). In the years 2015 – 2017 there are high catches of pelagic species, mainly herring, as well. One should note that foreign activity in NEZ is dependent on the annual quota agreement between Norway and the EU. This agreement defines both the total quota of each species for both parties, and the quantity that can be fished in the other party's zone. Foreign catches of species for reduction purposes are not reported from the Heimdal area.

The major part of the foreign catches in NEZ in the North Sea is fished by Danish and British/Scotch vessels. Some catches are reported from German, Swedish and French vessels as well.

In the tables on the next pages the following colour code is used to simplify the reading of the catch levels:

Less than 1000 tons		*1000 – 5000 tons*		*5000 – 10000 tons*		*More than 10000 tons*	

Table 3-1 Norwegian catches in the Heimdal area -1000 tons live weight (Directorate of Fisheries)

Location			2010	2011	2012	2013	2014	2015	2016	2017	2018
0854	Q1	Demersal species etc.	0,0	-	-	-	0,0	-	0,0	0,0	-
		Pelagic species	0,0	-	-	-	-	-	-	-	-
Blocks 24/7-12		Species for reduction	0,0	-	-	-	-	-	-	-	-
		Total	0,0	-	-	-	0,0	-	0,0	0,0	-
	Q2	Demersal species etc.	0,8	0,0	0,0	0,2	0,0	0,1	0,1	2,7	0,0
		Pelagic species	-	0,0	0,0	0,0	0,0	0,1	0,7	0,3	0,0
		Species for reduction	-	-	-	-	-	-	-	0,0	0,0
		Total	0,8	0,0	0,0	0,2	0,0	0,2	0,8	3,0	0,0
	Q3	Demersal species et.c	0,2	0,0	-	0,0	-	1,0	0,0	0,1	0,0
		Pelagic species	-	0,0	-	0,0	0,0	0,3	-	0,0	-
		Species for reduction	-	-	-	0,0	0,0	-	-	-	-
		Total	0,2	0,0	-	0,0	0,0	1,6	0,0	0,1	0,0
	Q4	Demersal species etc.	-	-	-	0,0	-	1,4	1,4	0,1	1,9
		Pelagic species	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0
		Species for reduction.	-	-	-	0,0	0,0	-	-	-	0,0
		Total	0,0	0,0	0,0	0,0	0,0	1,5	1,4	0,1	1,9
	Year	Demersal species etc.	1,0	0,0	0,0	0,2	0,1	2,7	1,5	2,8	1,9
		Pelagic species	0,0	0,0	0,0	0,0	0,0	0,5	0,7	0,3	0,0
		Species for reduction	-	-	-	0,0	0,0	0,0	-	0,0	0,0
		Total	1,0	0,0	0,0	0,2	0,1	3,2	2,3	3,1	1,9
0855	Q1	Demersal species etc.	-	-	-	0,0	-	0,0	2,8	0,0	0,2
		Pelagic species	-	-	-	0,0	0,0	0,4	0,0	0,0	0,0
Blocks 24/1 - 6		Species for reduction	-	-	-	-	-	0,0	-	-	0,0
		Total	-	-	-	0,0	0,0	0,4	2,8	0,0	0,2
	Q2	Demersal species etc.	0,0	0,0	-	-	0,2	0,9	0,3	0,1	1,1
		Pelagic species	0,0	0,1	-	0,0	0,0	0,0	0,0	0,0	0,0
		Species for reduction	0,1	-	-	-	0,0	-	0,1	-	0,0
		Total	0,1	0,2	-	0,0	0,2	0,9	0,4	0,1	1,1
	Q3	Demersal species etc.	0,0	-	-	0,4	0,0	0,1	0,1	0,7	0,1
		Pelagic species	0,0	0,0	-	0,0	-	0,0	0,0	-	-
		Species for reduction	-	-	-	4,7	-	-	0,0	-	-
		Total	0,0	0,0	-	5,1	0,0	0,1	0,1	0,7	0,1
	Q4	Demersal species etc.	-	-	0,1	-	0,2	-	0,0	0,0	0,6
		Pelagic species	0,1	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0
		Species for reduction	-	-	-	-	-	-	-	-	-
		Total	0,1	0,0	0,2	0,0	0,2	0,1	0,0	0,0	0,6
	Year	Demersal species etc.	0,0	0,2	0,1	0,4	0,4	1,0	3,2	0,8	1,9
		Pelagic species	0,1	0,2	0,0	0,0	0,1	0,6	0,1	0,0	0,0
		Species for reduction	0,1	-	-	4,7	0,0	0,0	0,1	-	0,0
		Total	0,2	0,4	0,2	5,1	0,5	1,5	3,3	0,8	2,0
Heimdal area 0854, 0855, 4234, 4244		Demersal species etc.	1,0	0,2	0,1	0,8	0,6	4,3	4,8	3,9	4,1
		Pelagic species	2,4	0,3	1,6	9,1	6,1	12,7	5,2	10,0	2,8
		Species for reduction	0,1	-	-	4,7	-	-	0,1	-	-
		Total	3,5	0,5	1,7	14,6	6,7	17,0	10,1	13,9	6,9

Table 3-2 Norwegian catches in the Heimdal area -1000 tons live weight (Directorate of Fisheries)

Location			2010	2011	2012	2013	2014	2015	2016	2017	2018
4234 Blocks 24/9,12 and areas in UK sector	Q1	Demersal species etc.	-	-	-	-	-	-	0,0	-	-
		Pelagic species	-	0,1	-	-	-	-	-	-	-
		Species for reduction	-	-	-	-	-	-	-	-	-
		Total	-	0,1	-	-	-	-	0,0	-	-
	Q2	Demersal species etc.	-	-	-	0,0	-	0,0	0,0	0,2	0,1
		Pelagic species	1,4	-	0,1	7,4	2,5	3,7	0,6	8,4	0,8
		Species for reduction	0,0	-	-	0,0	-	-	-	-	-
		Total	1,4	-	0,1	7,4	2,5	3,7	0,6	8,6	0,9
	Q3	Demersal species etc.	-	-	-	0,1	-	0,0	0,0	-	0,0
		Pelagic species	-	-	-	-	-	-	-	-	1,8
		Species for reduction	-	-	-	-	-	-	-	-	-
		Total	-	-	-	0,1	-	0,0	0,0	-	1,8
	Q4	Demersal species etc.	-	-	0,0	-	-	0,1	0,0	0,0	-
		Pelagic species	0,6	-	1,4	1,1	1,3	6,3	2,1	0,1	0,1
		Species for reduction	-	-	-	-	-	0,0	0,0	-	-
		Total	0,6	-	1,4	1,1	1,3	6,4	2,1	0,1	0,1
	Year	Demersal species etc.	0,0	-	0,0	0,1	-	0,1	0,1	0,2	0,1
		Pelagic species	2,0	0,1	1,5	8,5	3,7	10,0	2,7	8,5	2,7
		Species for reduction	0,0	-	-	0,0	-	0,0	0,0	-	-
		Total	2,0	0,1	1,5	8,6	3,7	10,1	2,8	8,7	2,8
4244 Blocks 24/3,6 and areas in UK sector	Q1	Demersal species etc.	-	0,0	-	-	-	-	-	0,0	-
		Pelagic species	-	2,3	-	-	-	-	-	-	-
		Species for reduction	-	0,0	-	--	--	-	-	-	-
		Total	-	2,3	-	-	-	-	-	0,0	-
	Q2	Demersal species etc.	0,0	-	0,0	0,1	-	0,0	0,0	0,1	0,0
		Pelagic species	1,3	0,4	2,8	0,5	0,7	2,6	1,4	2,6	0,7
		Species for reduction	-	-	0,0	-	-	-	-	-	-
		Total	1,3	0,4	2,8	0,6	0,7	2,6	1,4	2,7	0,0
	Q3	Demersal species etc.	-	-	-	0,0	-	0,1	-	-	-
		Pelagic species	-	-	-	2,5	-	-	-	-	-
		Species for reduction	-	-	-	0,0	-	-	-	-	-
		Total	-	-	-	2,5	--	0,1	-	-	-
	Q4	Demersal species etc.	0,0	-	0,0	-	0,1	0,4	0,0	0,0	0,2
		Pelagic species	0,3	0,2	0,1	0,6	2,3	2,1	1,8	1,2	0,1
		Species for reduction	-	-	-	-	0,0	0,0	0,0	-	0,2
		Total	0,3	0,2	0,1	0,6	2,4	2,5	1,8	1,2	0,5
	Year	Demersal species etc.	0,0	0,0	0,0	0,1	0,1	0,5	0,0	0,1	0,2
		Pelagic species	1,6	2,9	2,9	3,6	3,2	4,8	3,2	3,8	0,8
		Species for reduction	0,0	-	-	0,0	-	0,0	0,0	-	-
		Total	1,6	2,9	2,9	3,7	3,2	5,3	3,2	3,9	1,2
Norwegian catches in the North Sea		Demersal species etc.	171,9	224,0	139,1	123,0	193,4	190,6	171,0	250,3	183,2
		Pelagic species	231,5	235,1	192,9	276,8	229,6	172,4	206,5	186,0	298,5
		Species for reduction	156,1	118,9	51,5	85,7	121,9	176,2	102,7	165,7	117,8
		Total	481,5	469,0	341,0	455,0	462,4	438,8	438,4	481,8	530,0

Table 3-3 Foreign catches within NEZ in the Heimdal area in 1000 tons live weight (Directorate of Fisheries)

Location			2011	2012	2013	2014	2015	2016	2017	2018
0854	Q1	Demersal species etc.	0,1	0,4	0,1	0,1	0,1	0,4	0,5	0,6
		Pelagic species	-	-	-	-	0,0	-	0,0	-
Blocks 24/7-12		Total	0,1	0,4	0,1	0,1	0,1	0,4	0,5	0,6
	Q2	Demersal species etc.	0,3	0,3	0,5	0,5	0,7	0,7	0,5	1,0
		Pelagic species	-	0,0	-	0,0	0,2	0,9	0,3	-
		Total	0,3	0,3	0,5	0,5	0,9	1,6	0,8	1,0
	Q3	Demersal species etc.	0,2	0,2	0,2	0,3	0,4	0,7	0,3	0,5
		Pelagic species	-	-	-	-	0,2	-	-	-
		Total	0,2	0,2	0,2	0,3	0,6	0,7	0,3	0,5
	Q4	Demersal species etc.	0,7	0,1	0,4	0,1	0,5	0,4	0,4	0,4
		Pelagic species	-	-	-	-	-	0,0	-	-
		Total	0,7	0,1	0,4	0,1	0,5	0,4	0,4	0,4
	Year	Demersal species etc.	1,4	0,9	1,3	1,1	1,7	2,2	1,7	2,5
		Pelagic species	-	0,0	-	0,0	0,4	0,9	0,3	-
		Total	1,4	0,9	1,3	1,1	2,1	3,1	2,0	2,5
0855	Q1	Demersal species etc.	0,1	0,2	0,2	0,1	0,1	0,2	0,2	0,1
		Pelagic species	-	-	-	-	1,8	-	1,5	0,1
Blocks 24/1 - 6		Total	0,1	0,2	0,2	0,1	1,9	0,2	1,7	0,2
	Q2	Demersal species etc.	0,3	0,4	0,4	0,5	1,6	0,7	0,9	1,5
		Pelagic species	-	0,0	0,0	-	-	1,4	0,1	-
		Total	0,3	0,4	0,4	0,5	1,6	2,1	1,0	1,5
	Q3	Demersal species etc.	0,3	0,3	0,3	0,6	0,4	0,5	0,4	1,3
		Pelagic species	-	-	-	-	-	0,0	-	-
		Total	0,3	0,3	0,3	0,6	0,4	0,5	0,4	1,3
	Q4	Demersal species etc.	0,1	0,2	0,4	0,1	0,1	0,2	0,1	0,2
		Pelagic species	-	-	-	-	-	-	-	-
		Total	0,1	0,2	0,4	0,1	0,1	0,2	0,1	0,2
	Year	Demersal species etc.	0,8	1,0	1,2	1,2	2,3	1,7	1,5	3,1
		Pelagic species	-	0,0	0,0	-	1,8	1,4	1,6	0,1
		Total	0,8	1,0	1,2	1,2	4,1	3,1	3,1	3,2

Table 3-4 Foreign catches within NEZ in the Heimdal area in 1000 tons live weight (Directorate of Fisheries)

Location			2011	2012	2013	2014	2015	2016	2017	2018
4234, only areas in NEZ (blocks 24/9,12)	Q1	Demersal species etc.	0,0	0,0	0,0	-	0,0	0,0	0,1	0,0
		Pelagic species	-	-	-	-	-	-	-	-
		Total	0,0	0,0	0,0	-	0,0	0,0	0,1	0,0
	Q2	Demersal species etc.	0,0	0,1	0,1	0,0	0,2	0,1	0,2	0,2
		Pelagic species	-	-	-	-	-	-	1,2	-
		Total	0,0	0,1	0,1	0,0	0,2	0,1	1,4	0,2
	Q3	Demersal species etc.	0,0	0,1	0,1	0,1	0,1	0,3	0,1	0,1
		Pelagic species	-	-	-	-	-	0,7	-	-
		Total	0,0	0,1	0,1	0,1	0,1	1,0	0,1	0,1
	Q4	Demersal species etc.	0,1	0,0	0,2	0,0	0,3	0,2	0,3	0,3
		Pelagic species	-	-	-	-	-	-	-	-
		Total	0,1	0,0	0,2	0,0	0,3	0,2	0,3	0,3
	Year	Demersal species etc.	0,2	0,1	0,3	0,1	0,6	0,6	0,6	0,5
		Pelagic species	-	-	-	-	-	0,7	1,2	-
		Total	0,2	0,1	0,3	0,1	0,6	1,3	1,8	0,5
4244. only areas in NEZ (blocks 24/3,6)	Q1	Demersal species etc.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		Pelagic species	-	-	-	-	-	-	-	-
		Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Q2	Demersal species etc.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		Pelagic species	-	-	-	-	-	-	-	-
		Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Q3	Demersal species etc.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		Pelagic species	-	-	-	-	-	0,0	-	-
		Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Q4	Demersal species etc.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		Pelagic species	-	-	-	-	-	-	-	0,0
		Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Year	Demersal species etc.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		Pelagic species	-	-	-	-	-	0,0	-	0,0
		Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Heimdal area 0854, 0855, 4234, 4244		Demersal species etc.	2,3	2,0	2,8	2,5	4,6	3,3	3,8	6,1
		Pelagic species	-	-	-	-	2,2	4,2	3,2	0,1
		Total	2,3	2,0	2,8	2,5	6,8	7,5	7,0	6,2
Nationality		Denmark	0,5	0,4	1,1	0,7	3,9	4,5	2,9	2,4
		France	0,4	0,0	0,0	0,0	0,0	-	0,0	-
		Germany	0,2	0,4	0,3	0,3	0,5	0,5	0,7	1,2
		Great Britain	1,3	1,0	1,5	1,5	2,4	2,5	2,6	2,4
		Sweden	-	0,2	0,0	-	-	0,0	0,9	0,2

3.2 Results from electronic catch reporting and satellite tracking

Results from the electronic reporting of catches to the Directorate of Fisheries are presented in Figure 3-2 to Figure 3-9, giving the most detailed picture possible of the fisheries. This reporting system was introduced in the autumn 2010 and may for this reason only be presented for the period 2011 - 2018. Data from the electronic catch reporting are not open to distribution, hence the maps have been prepared by the Directorate of Fisheries. These maps show that bottom trawl is by far the most important fishing gear used in the Heimdal area.

The satellite tracking results can be split into the following groups:

- bottom trawler (vessel> 21 m),
- vessels (> 21m) fishing with conventional gear such as gillnet and long-line
- purse seine / pelagic trawl (> 21m)
- coastal fishing vessels - all gear (> 18 m)
- coastal fishing vessels (15-18 m), and
- foreign vessels.

A further breakdown of the data provided by the Directorate of Fisheries is not possible. Nor is it possible to distribute foreign vessels by type of fishing gear or nationality.

The quarterly distribution of the fisheries in the Heimdal area results from satellite tracking of fishing vessels over 15 meters overall length are presented in the subsequent figures (Figure 3-14 to Figure 3-19). The main Norwegian fisheries in the Heimdal area are conducted with bottom trawl and purse seine. Bottom trawl is the most important gear for foreign fishing in the area. As a main rule a purse seine will be operated in the water column and will not be in contact with the sea bottom. The catch area will wary from one year to another, depending on the relevant species migration pattern. In practice the difference between the two disposal alternatives for Heimdal will be of importance for the bottom trawl fisheries (see Chapter 4).

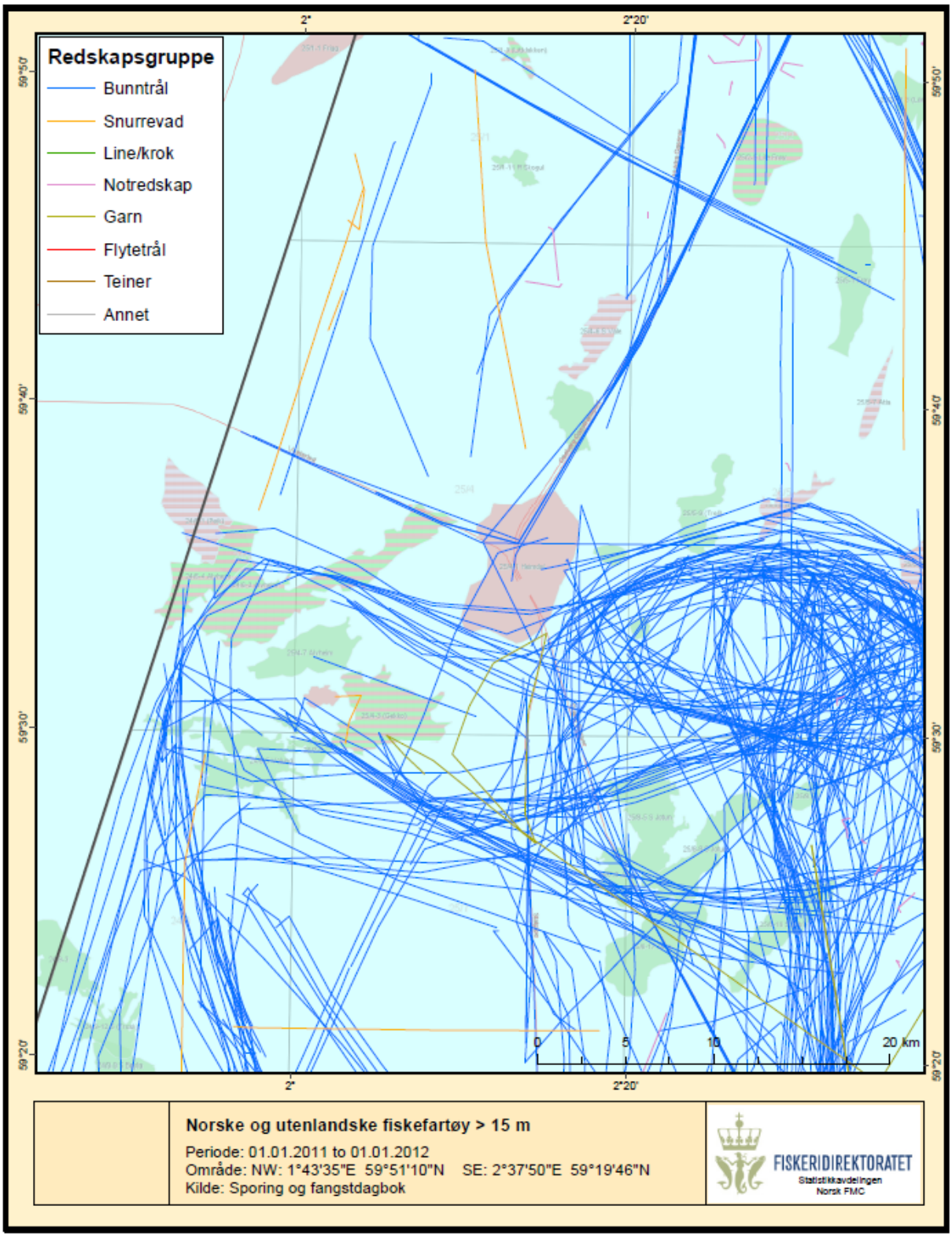
3.2.1 Results for the Norwegian fisheries in the area

The Norwegian fishing activity close to Heimdal is rather limited, as reflected in the catch statistics. The results from the satellite tracking of Norwegian trawlers show high activity along the western slope of the Norwegian trench and bank areas immediately to the west from the slope. The results indicate very low activity in the Heimdal area throughout the years 2010 – 2018. The Norwegian trawling activity in the period presented should be characterized as sporadic. In some periods, like Q2 - Q3 in both 2012 and 2013, clusters of trawler movements are registered in areas close to Heimdal. However, these clusters do not represent trawling. Such clusters are a typical pattern for trawlers engaged in the petroleum industry for periods, often as stand-by vessels.

3.2.2 Results for foreign fisheries in the area

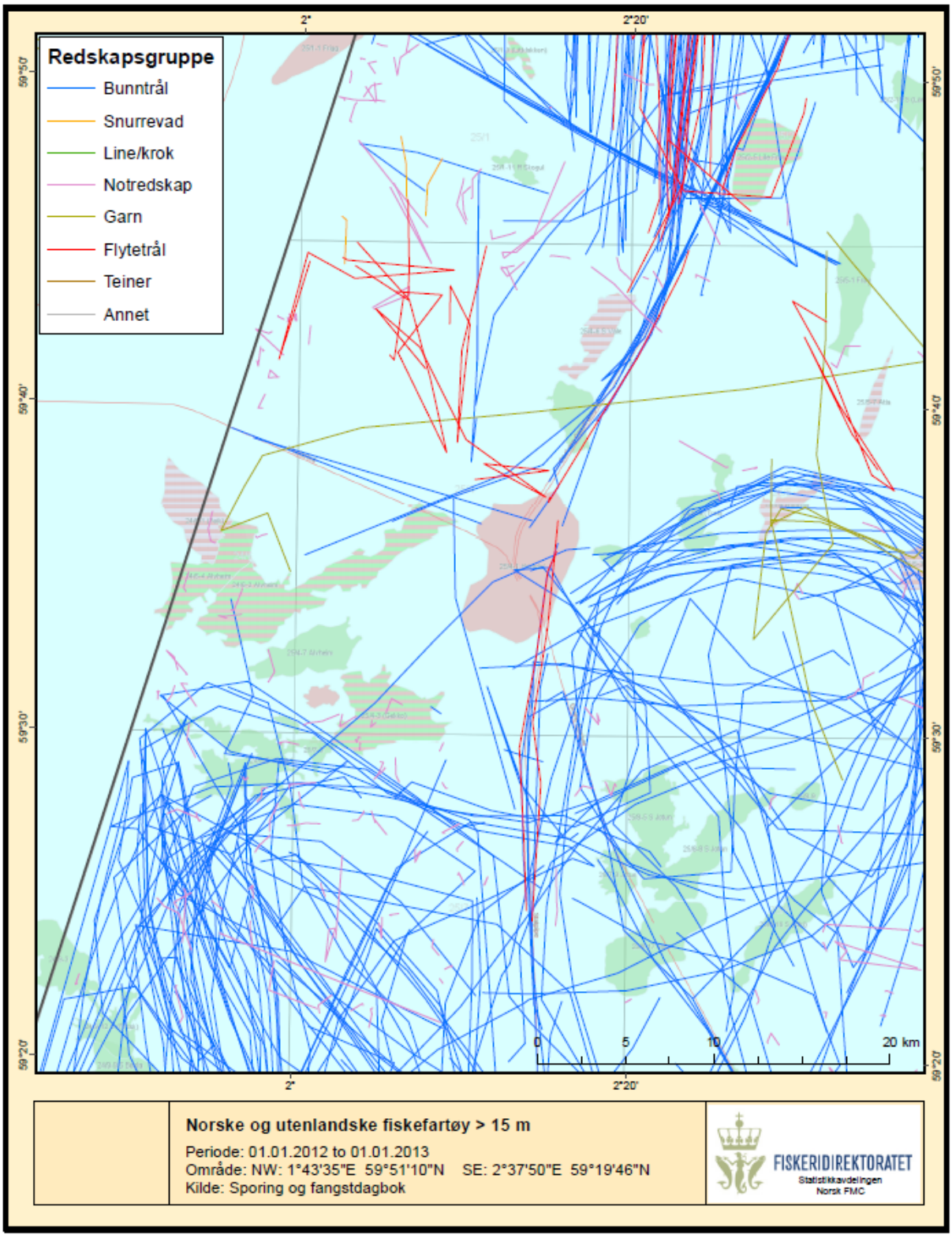
Most of the fisheries in the Heimdal area is conducted by foreign vessels. The foreign trawler activity in the Heimdal area is much higher than the Norwegian. A typical pattern is Scottish trawlers, including pair-trawlers (two vessels operating the same bottom trawl without any trawl doors) trawling along pipelines in the area. Except this activity, trawling is conducted without any specific direction in the area. Some purse seiners and pelagic trawlers operate in the area as well.

The activity in areas north and south of Heimdal are higher than in the vicinity of the Heimdal installations. The activity is at its highest in the summer period, Q2 and Q3. In areas south of Heimdal the activity is still at a rather high level in Q4.



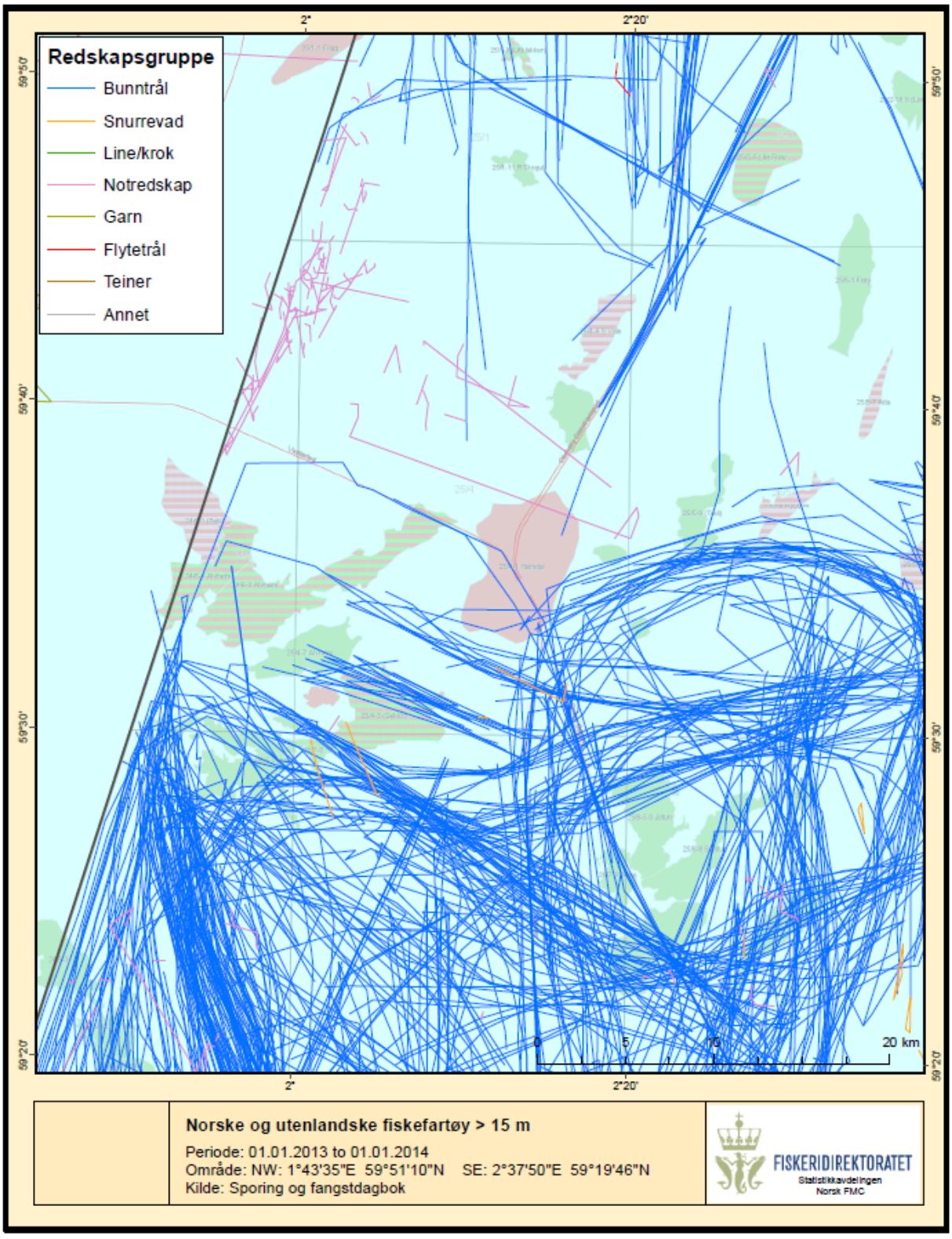
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-2 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2011. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



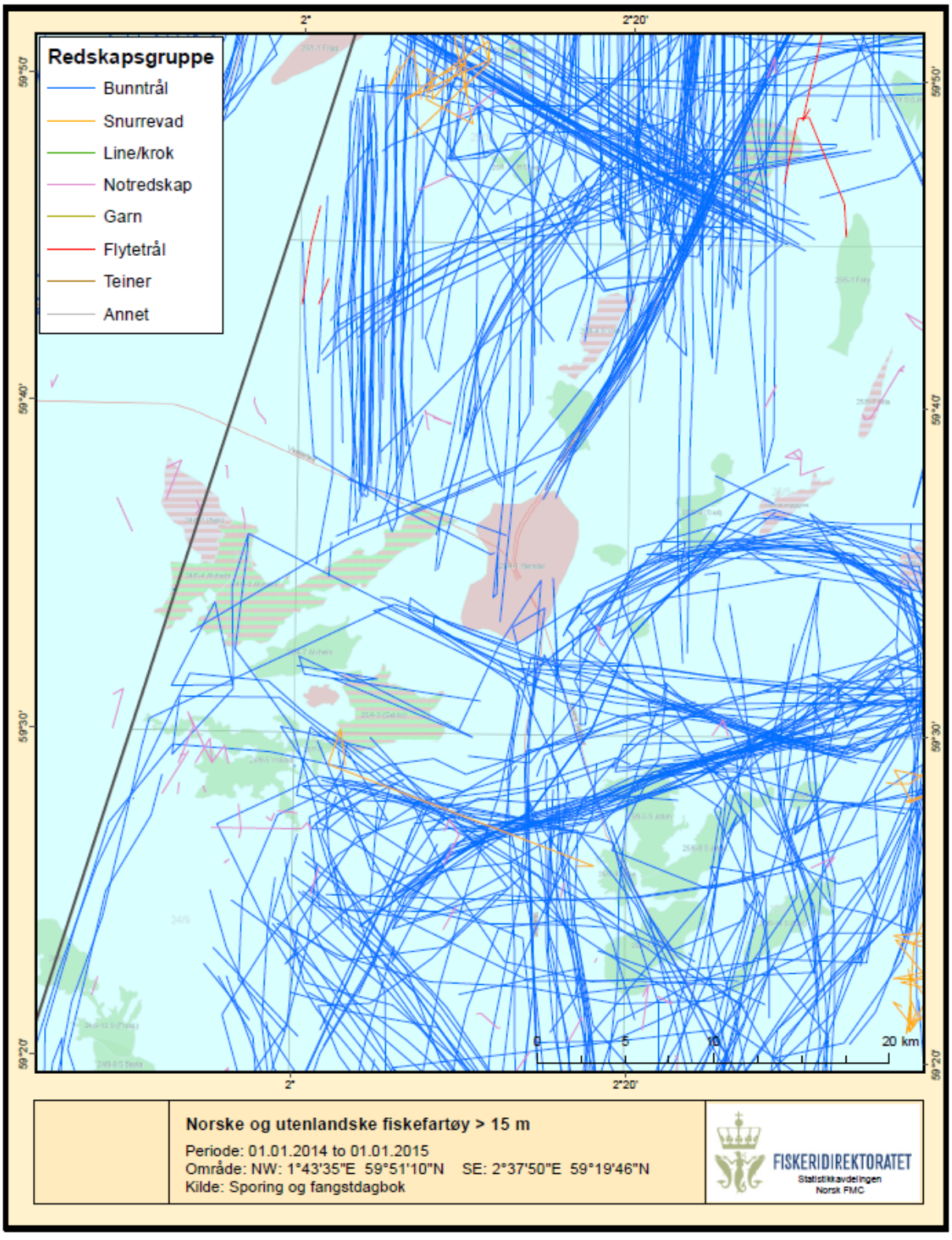
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-3 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2012. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



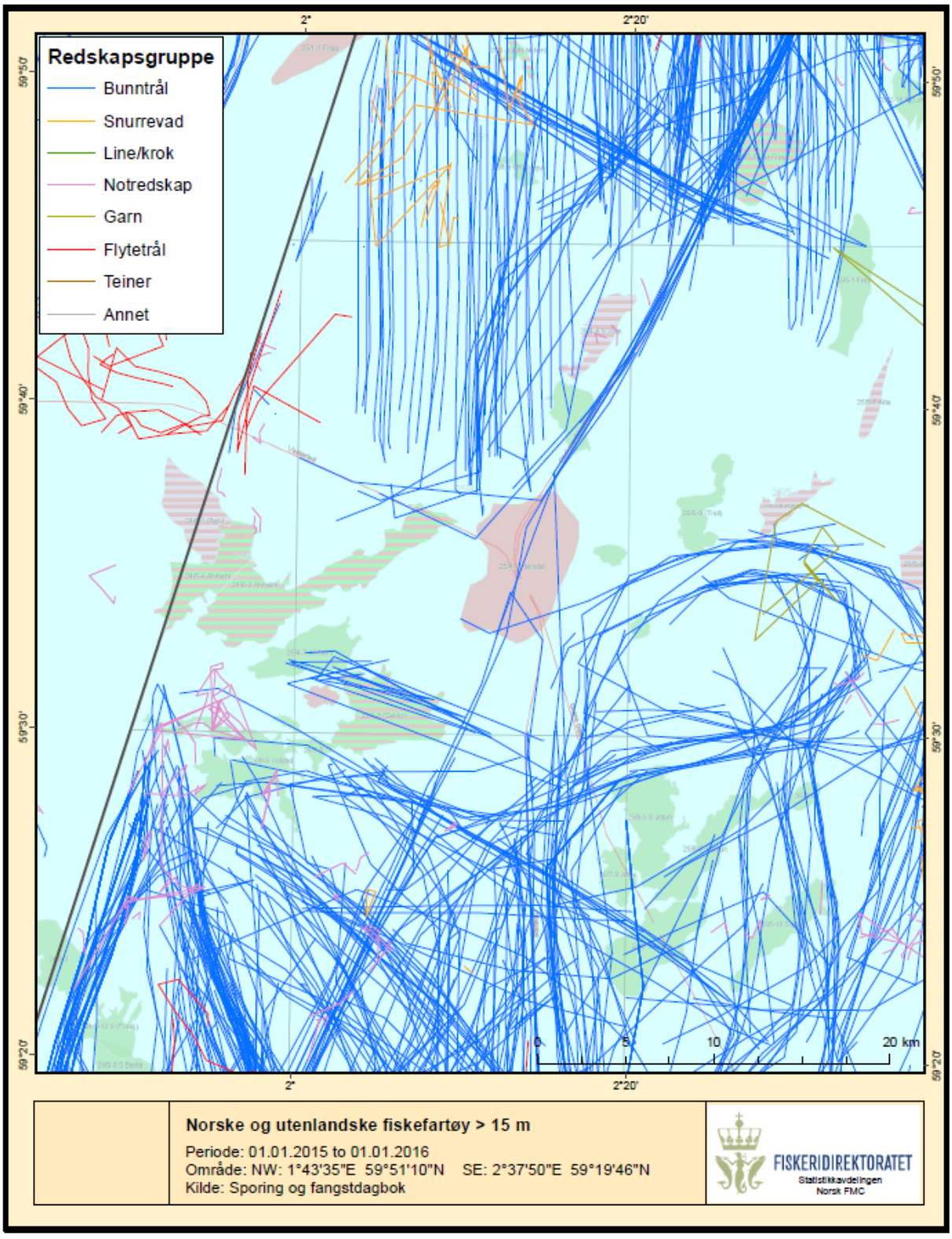
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-4 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2013. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



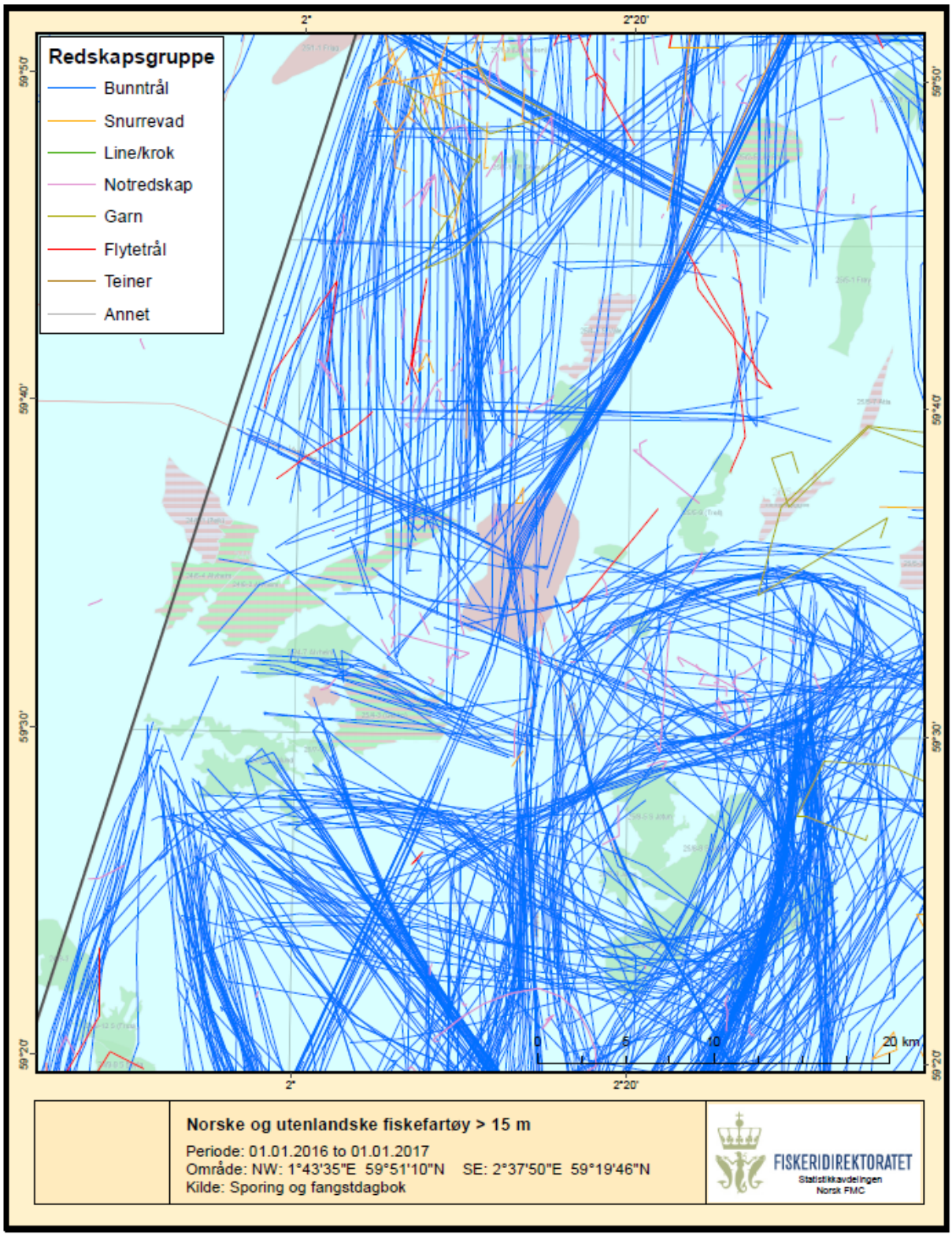
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-5 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2014. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



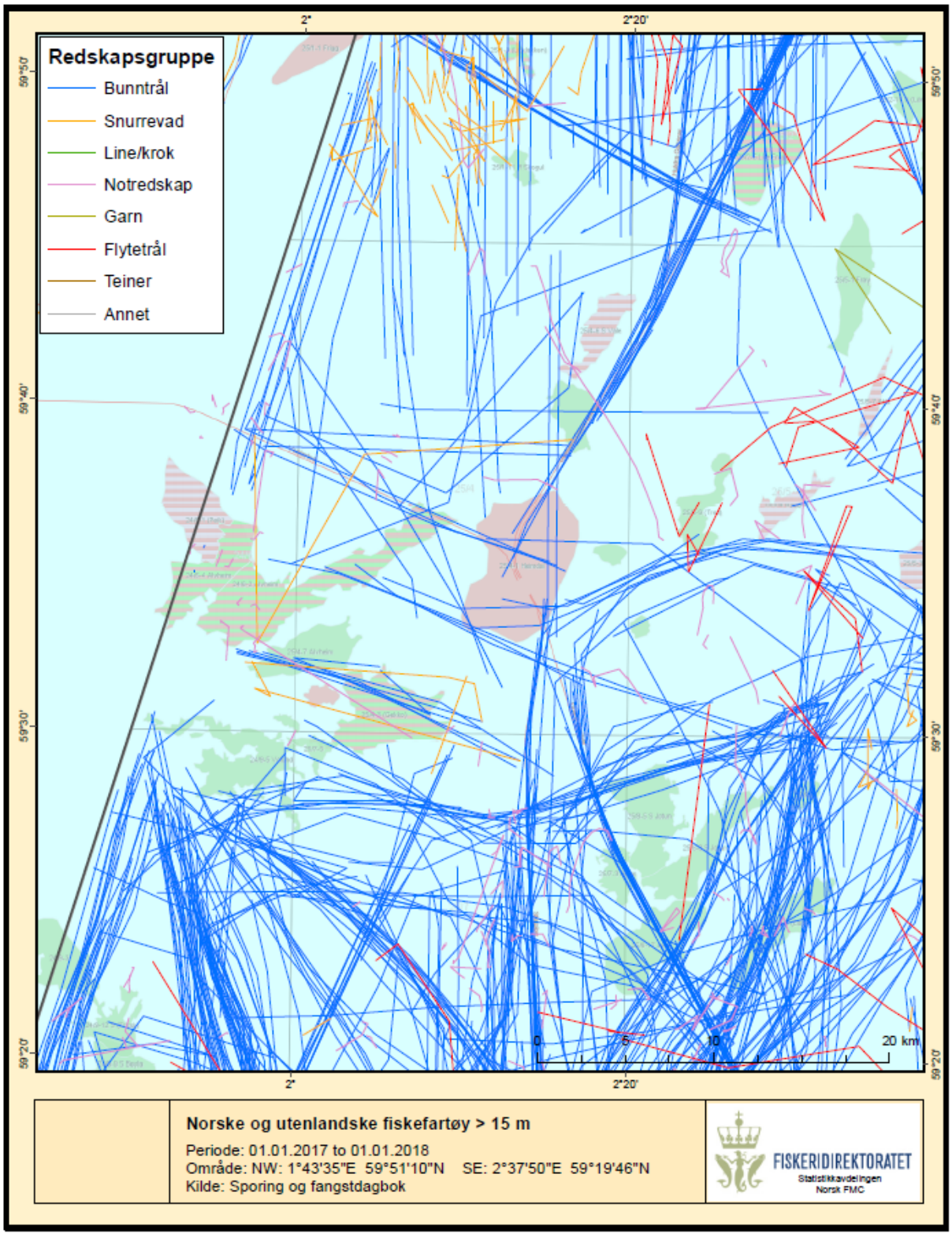
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-6 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2015. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



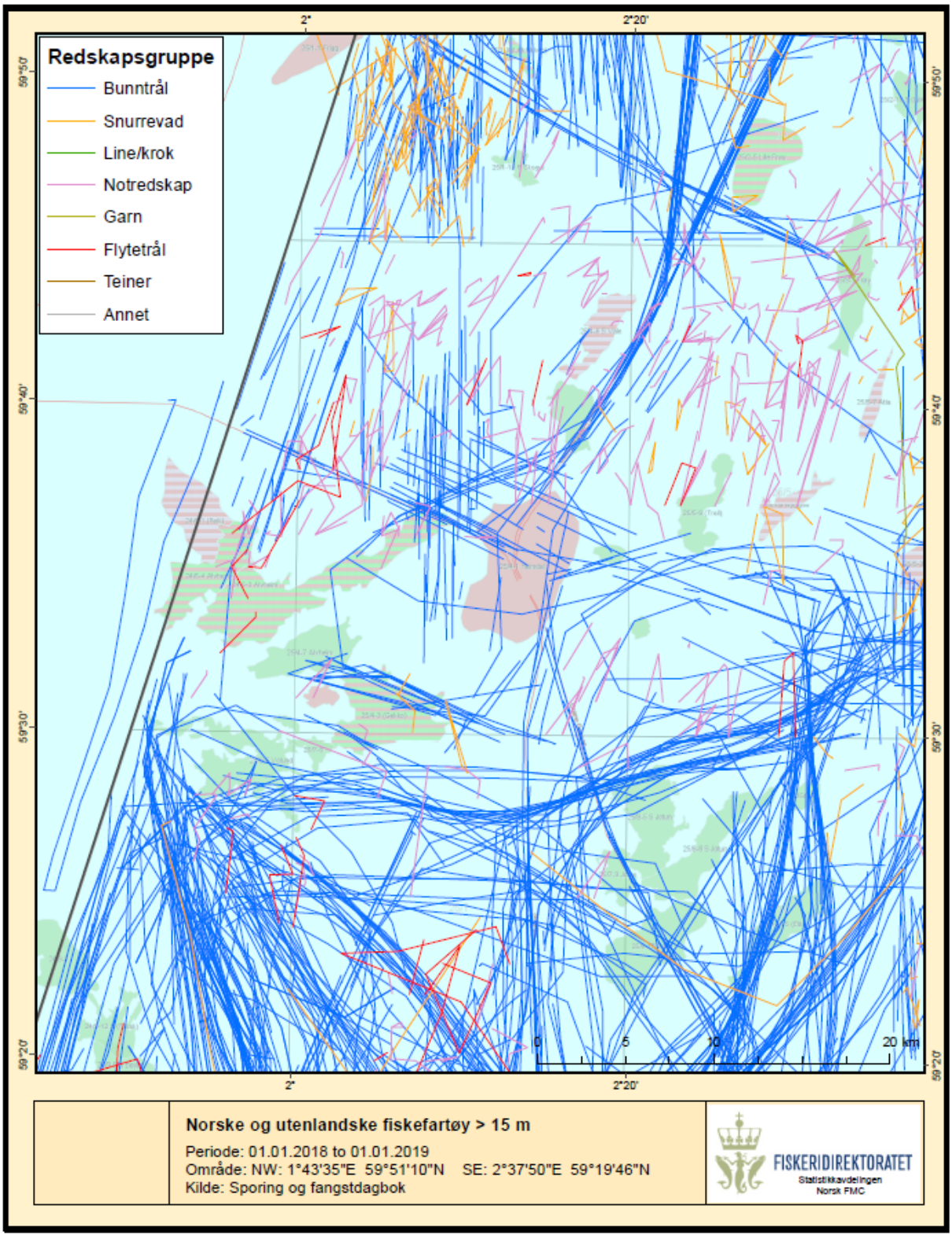
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-7 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2016. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



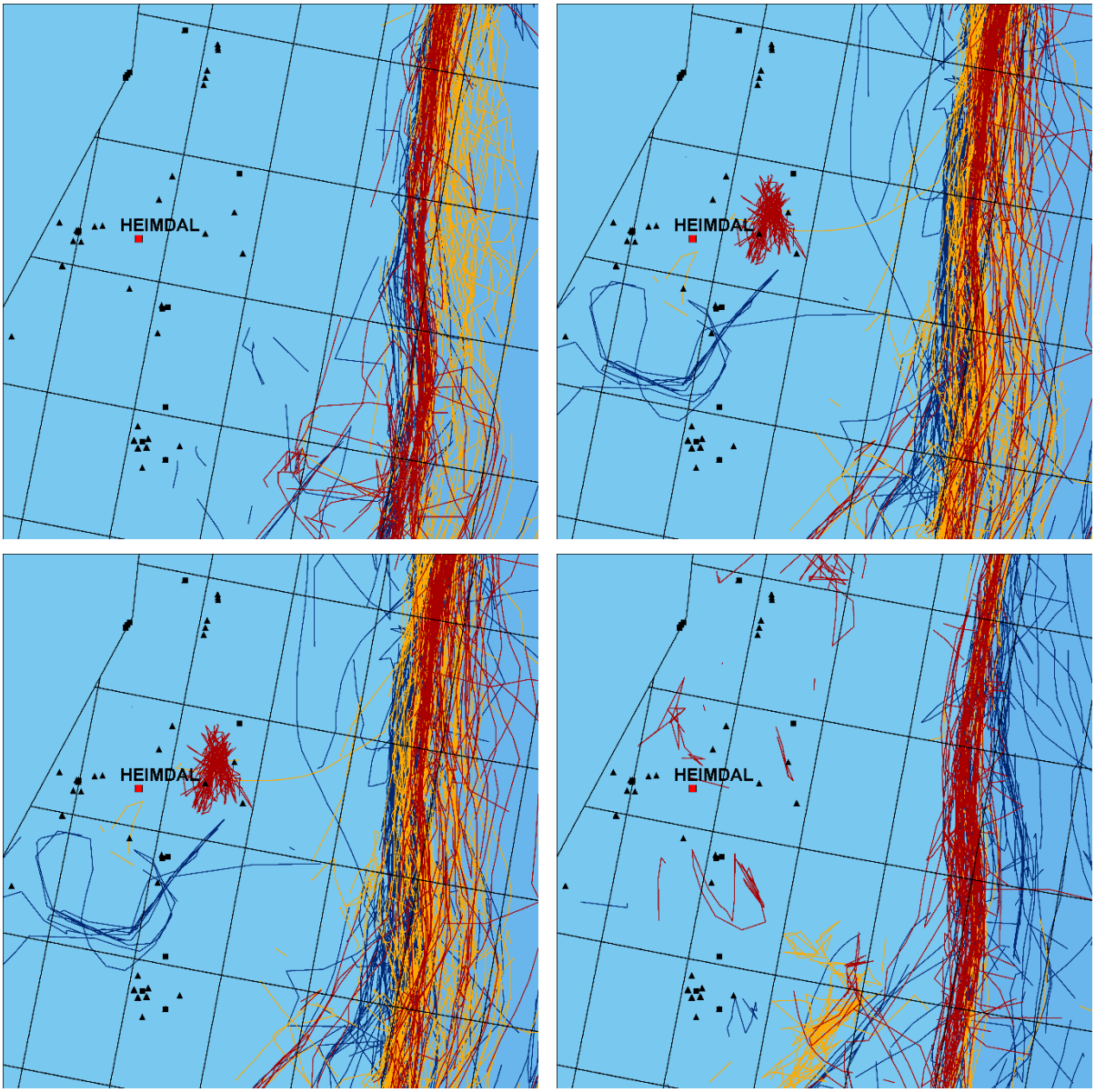
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-8 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2017. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



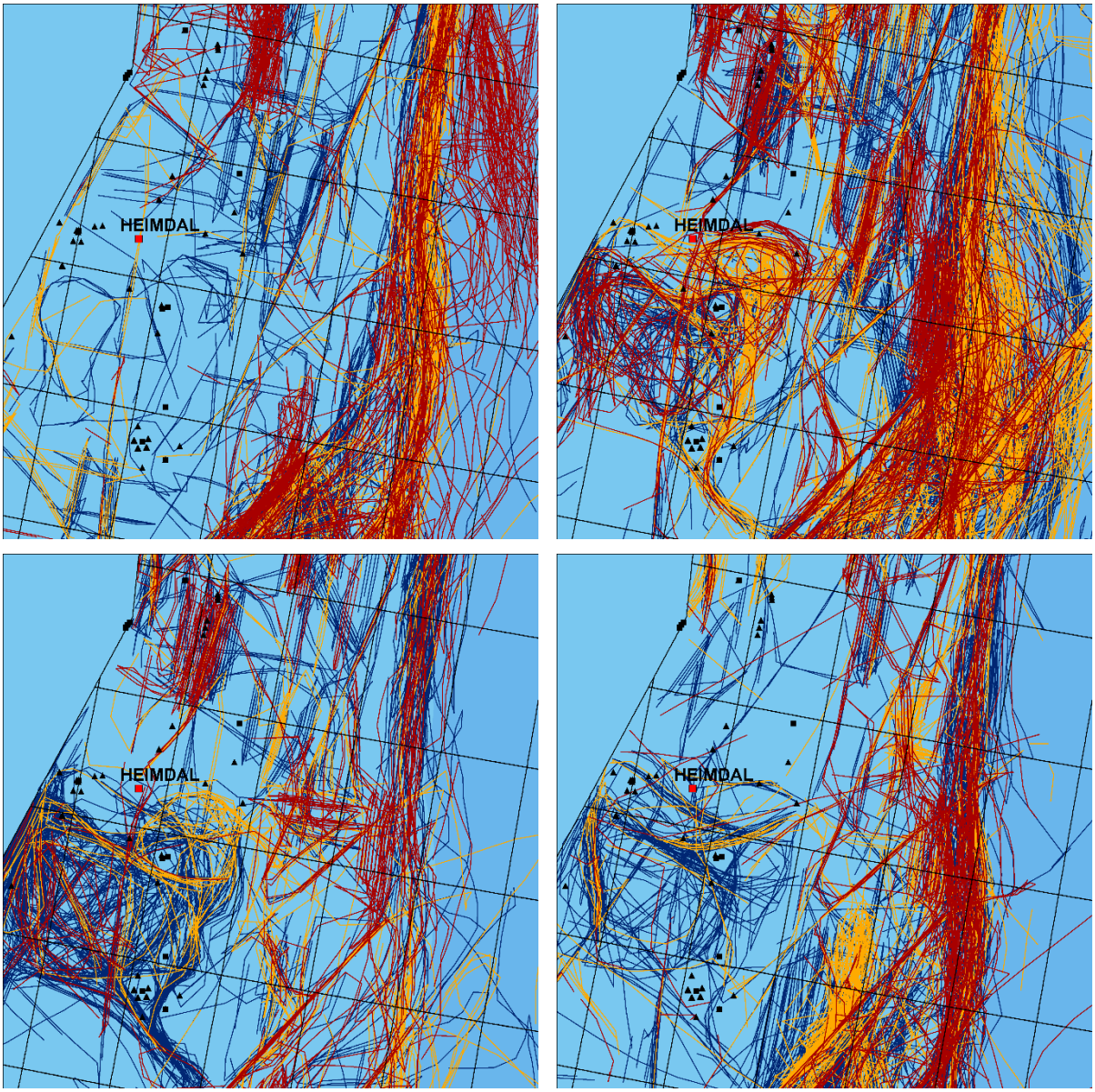
Bunntrål – Bottom/otter trawl; Snurrevad – Danish seine; Line/krok – Long-line/hook; Notredskap – Seine; Garn – Gillnet; Flytetrål – Pelagic trawl; Teiner – Traps; Annet – Other gear

Figure 3-9 Fishing activity with Norwegian and foreign vessels over 15 meters in the Heimdal area in 2018. The Heimdal field is the pink area in the middle of the map. The figure is prepared by the Directorate of Fisheries.



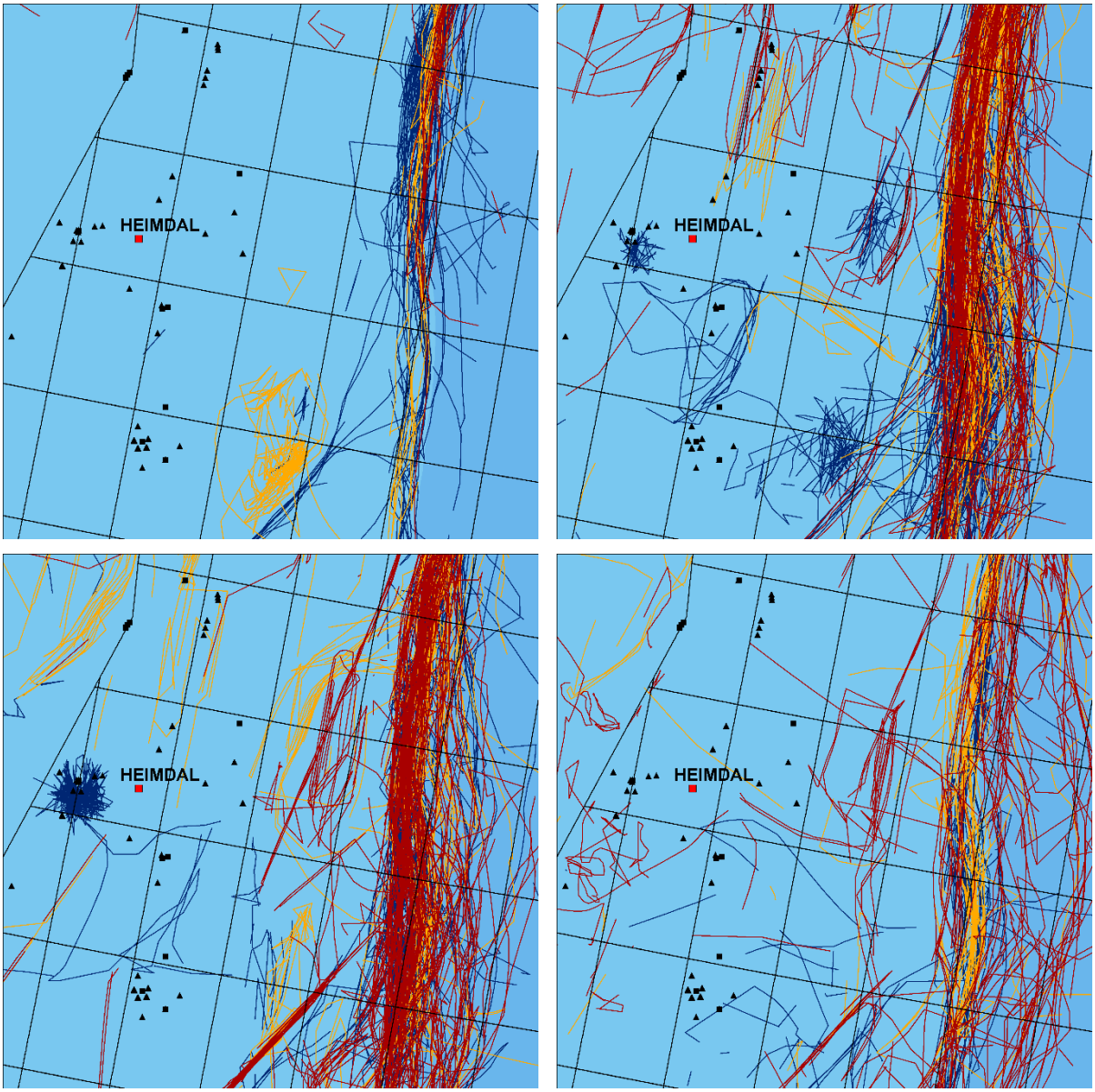
Blue = 2010 **Orange** = 2011 **Red** = 2012

Figure 3-10 Quarterly distribution of Norwegian bottom trawl fishery in the Heimdal area in the period 2010 – 2012. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.



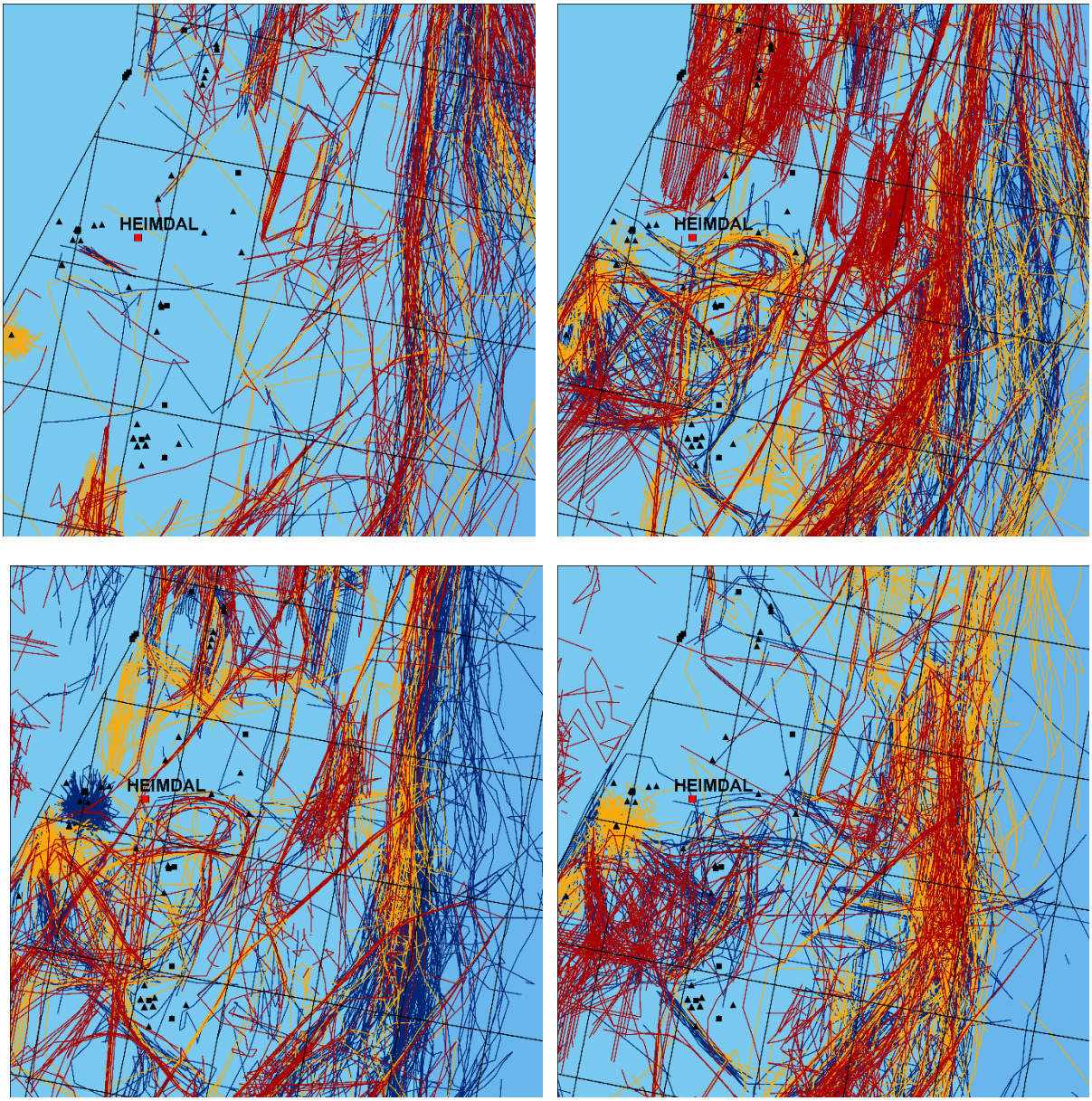
Blue = 2010 **Orange** = 2011 **Red** = 2012

Figure 3-11 Quarterly distribution of foreign fishing (mainly bottom trawl) in the Heimdal area in the period 2010 – 2012. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.



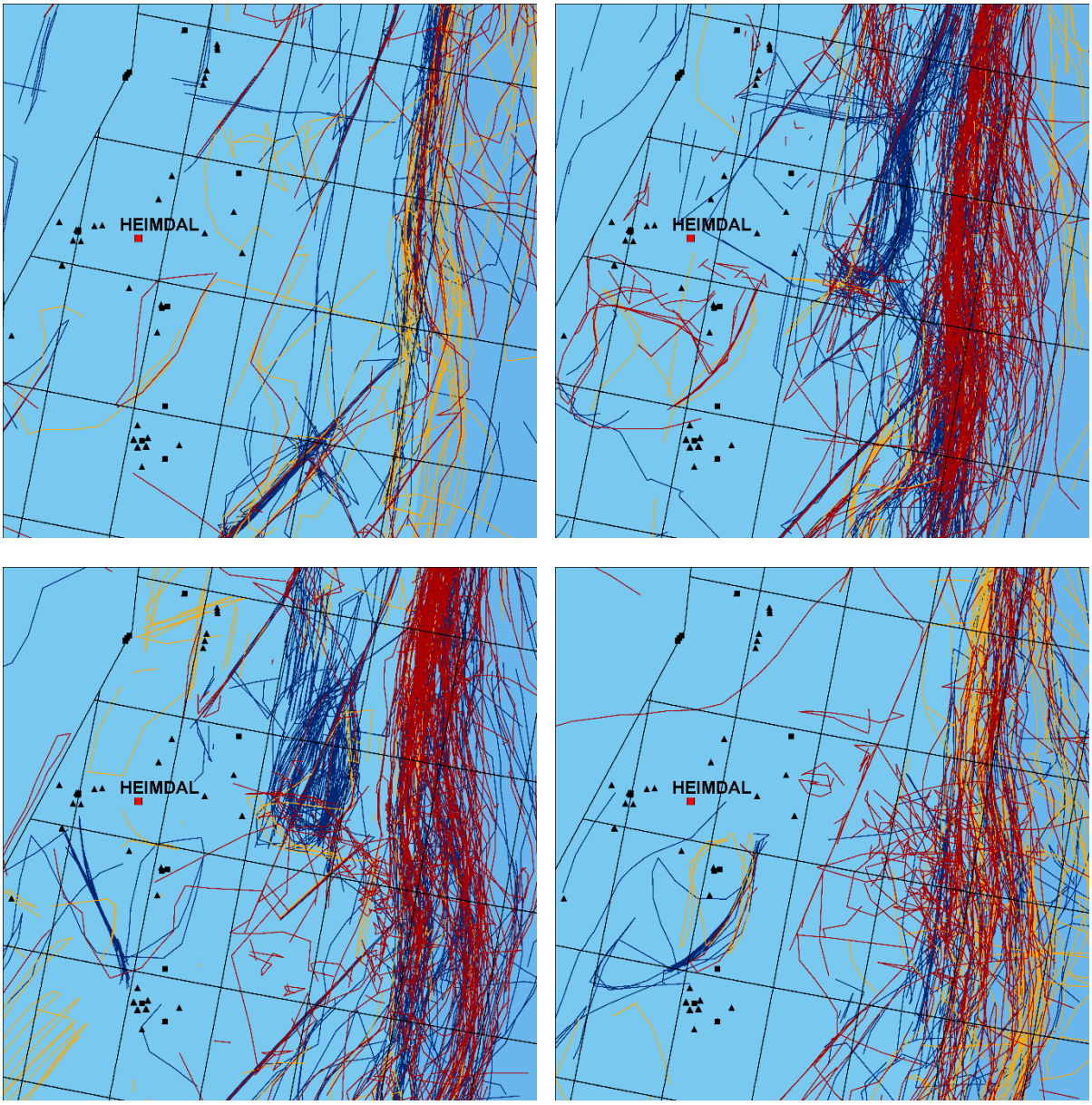
Blue = 2013 **Orange** = 2014 **Red** = 2015

Figure 3-12 Quarterly distribution of Norwegian bottom trawl fishery in the Heimdal area in the period 2013 – 2015. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.



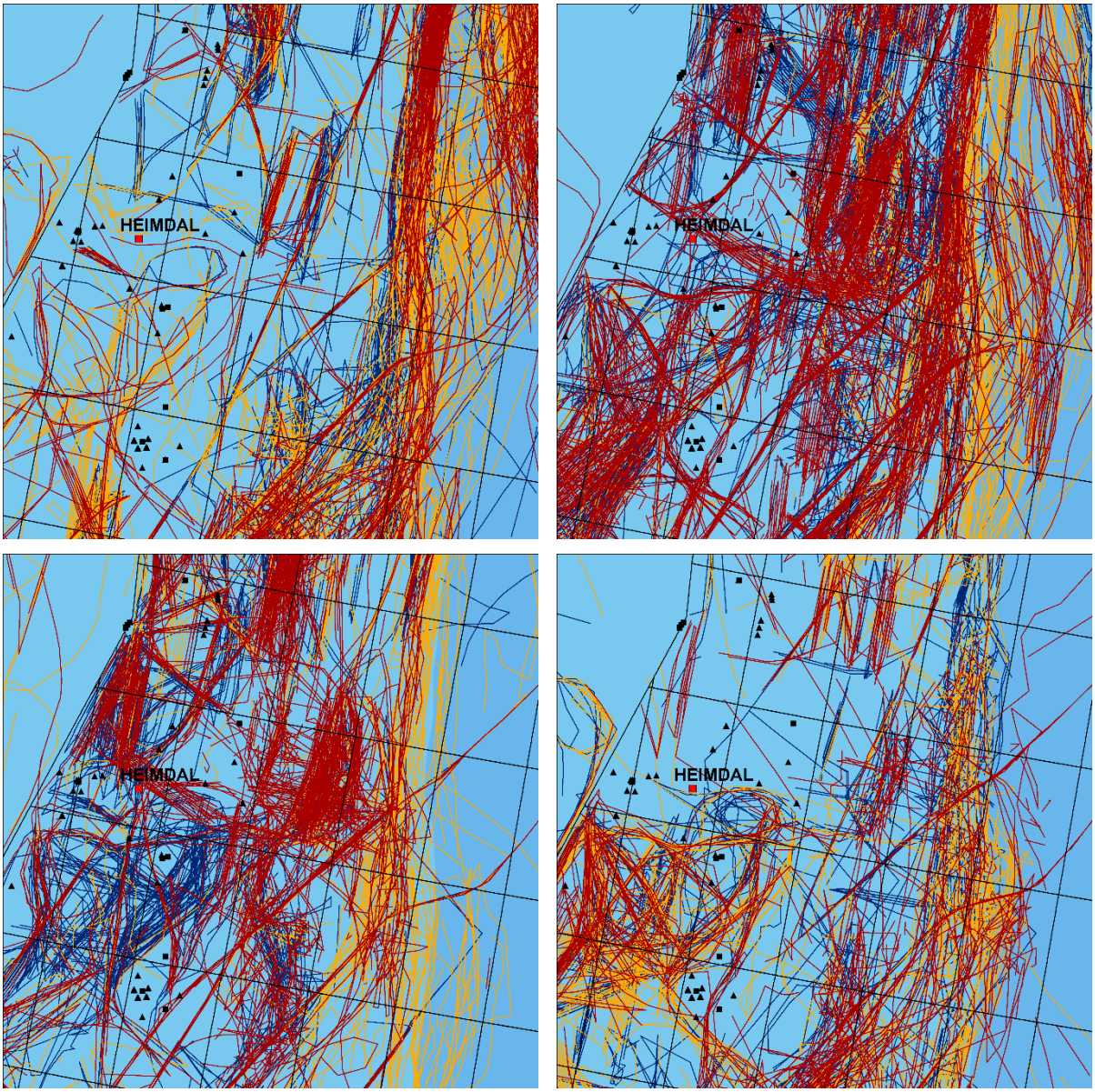
Blue = 2013 **Orange** = 2014 **Red** = 2015

Figure 3-13 Quarterly distribution of foreign fishing (mainly bottom trawl) in the Heimdal area in the period 2013 – 2015. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.



Blue = 2016 **Orange** = 2017 **Red** = 2018

Figure 3-14 Quarterly distribution of Norwegian bottom trawl fishery in the Heimdal area in the period 2016 – 2018. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.



Blue = 2016 **Orange** = 2017 **Red** = 2018

Figure 3-15 Quarterly distribution of foreign fishing (mainly bottom trawl) in the Heimdal area in the period 2016 – 2018. Upper left: Q1. Upper right: Q2. Bottom left: Q3. Bottom right: Q4. Data from the Directorate of Fisheries.

3.3 Jacket footings as artificial reef

3.3.1 General research of jacket footings

Fish aggregations have been reported around abandoned oil facilities because the facility has served as a kind of artificial reef for the fish. This can also be important locally for other organisms that grow on or live on animals and plants on the facility. Positive effects of artificial reef are primarily documented from the Gulf of Mexico, not the North Sea.

However, despite a large research effort in several countries there is no international consensus on whether artificial reefs have a significant fish stock enhancement effect or only positive stock concentration effects (Soldal et al., 1999).

It is a conventional wisdom among fishermen that the areas around shipwrecks are often good fishing grounds (Valdemarsen, 1978). Based on visual observations from petroleum installations, trawlers tend to fish in a circle as close to the safety zone of the platforms as possible. For instance, around the Ekofisk field Scottish purse seiners are involved in an intensive haddock fishery in periods (Soldal et al., 1999).

There are several issues to be considered in an analysis of effects on fisheries from abandoned installations (Osmundsen and Tveterås 2003).

- *Stock pollution*: Are there any toxic emissions from abandoned installations that can lead to increased mortality and/or reduction in the market value of the fish?
- *Stock enhancement effect*: Does the physical presence of oil installations increase the reproductive ability of fish stocks (fishing reefs), thus leading to an increase in fish biomass and harvesting potential?
- *Stock concentration effect*: Will the fish stocks gravitate towards the feedstock that tends to gather around offshore installations?
- *Fishing access*: To what extent does the physical presence of obsolete installations and pipelines limit the accessibility of different types of fishing vessels and different gear types

In Norwegian coastal areas artificial reef structures as habitats have given an increase in fauna density. Small reef units both in Risør in southern and Lofoten in northern Norway have shown promising results attracting fish and high density of fouling organisms. The structures seem to increase both biomass and diversity in the coastal areas (IMR 2005).

Reef effects likely depend on the characteristics of the marine environment in the particular area, such as fish species composition, nutrient conditions and topographical conditions, making generalization difficult The introduction of a reef gives three possible scenarios for the total fish biomass and its distribution at a fishing ground: (1) introduction of reefs leads only to a stock concentration around the reefs, (2) reefs cause both stock enhancement and stock concentration, and (3) the reef causes only a stock enhancement effect, because the increased stock of fish migrates from the reefs to the surrounding areas, leading to a fairly even distribution of the biomass in a larger area. Hence, the question is not only what effects artificial reefs have on the total biomass, but also what effects they have on the spatial distribution of the biomass in the areas around the reef (Osmundsen and Tveterås 2003).

Petroleum installations may function as artificial reefs providing positive fish stock concentration and enhancement effects, generating gains to specialized artificial reef fisheries but losses to demersal trawlers that will not be able to access the area.

At the end of the 1990s, the Institute of Marine Research examined whether such effects could be of interest also in our waters, with surveys and assessments related to the possibility of increased biological production, accumulation / protection effect (Soldal et al., 1999). An attraction was shown with increased catches towards facilities in the Ekofisk area, but the catch rates were nevertheless low and would not provide the basis for commercial fishing. Some fishing technologies may be physically prevented from operating in the vicinity of oil installations. Evidence from other countries suggests that efficient exploitation close to reefs requires specialised reef fisheries utilising a suitable gear (Osmundsen and Tveterås 2003).

The alternative with artificial reefs was not found attractive to Ekofisk I and was also later considered and dismissed for Frigg (NPD 2019).

3.3.2 Specific evaluation of Heimdal Jacket acting as artificial reef

Heimdal is located within the widespread spawning areas for saithe, cod, haddock and Norway pout. No commercial important species har concentrated spawning areas close to Heimdal. In the area surrounding the Heimdal field the catch rates in the Norwegian fisheries for demersal species are low. Although the foreign activity is much higher than the Norwegian in the area, there is no sign of intensive trawling in the vicinity of the Heimdal installations, or trawlers circling around the installations to catch possible concentrations of fish. For pelagic species, with changes in the migration route from one year to another, artificial reefs may not have any effect.

The production at Heimdal commenced in 1985, thus the platform has already existed as an artificial reef for the fish stocks for more than 30 years.

Based on the observed fishing pattern and catch statistics for the area during the last decade, no noticeable effect as artificial reef has been observed. It seems unlikely that this picture will change after the field is shut down, with the case of leaving the platform's jacket footings cut approximately 30 meters above the seabed (Alternative 2).

3.4 Wrecks in the Heimdal area

In connection with the preparation of a regional environmental impact assessment for petroleum activities in the North Sea in 2006, the Norwegian Maritime Museum, formerly known as Norsk Sjøfartsmuseum, presented a report on cultural heritage in the North Sea (NSM 2006). This report included a map on known positions for wrecks in the North Sea, see ***Figure 3-16***. According to this map there are a few known wrecks in the vicinity of Heimdal. The map has not been updated since 2006.

To gain more detailed information on possible wrecks in the Heimdal area, supplementary information has been collected from the Norwegian Mapping Authority (Kartverket sjødivisjonen). The information is based on this authority's register on wrecks and other possible obstacles on the seabed ("Vrak- og hefteregisteret"). The results for the Heimdal area are presented in Figure 3-17, showing three known non-dangerous wrecks located in the area north-east of Heimdal. The distance from these wrecks to Heimdal is approximately 8,5 km, 6 km and 17,5 km respectively.

A non-dangerous wreck is a wreck which is not considered to be dangerous to surface navigation, an area over which it is safe to navigate but which should be avoided for anchoring, taking the ground or ground fishing.

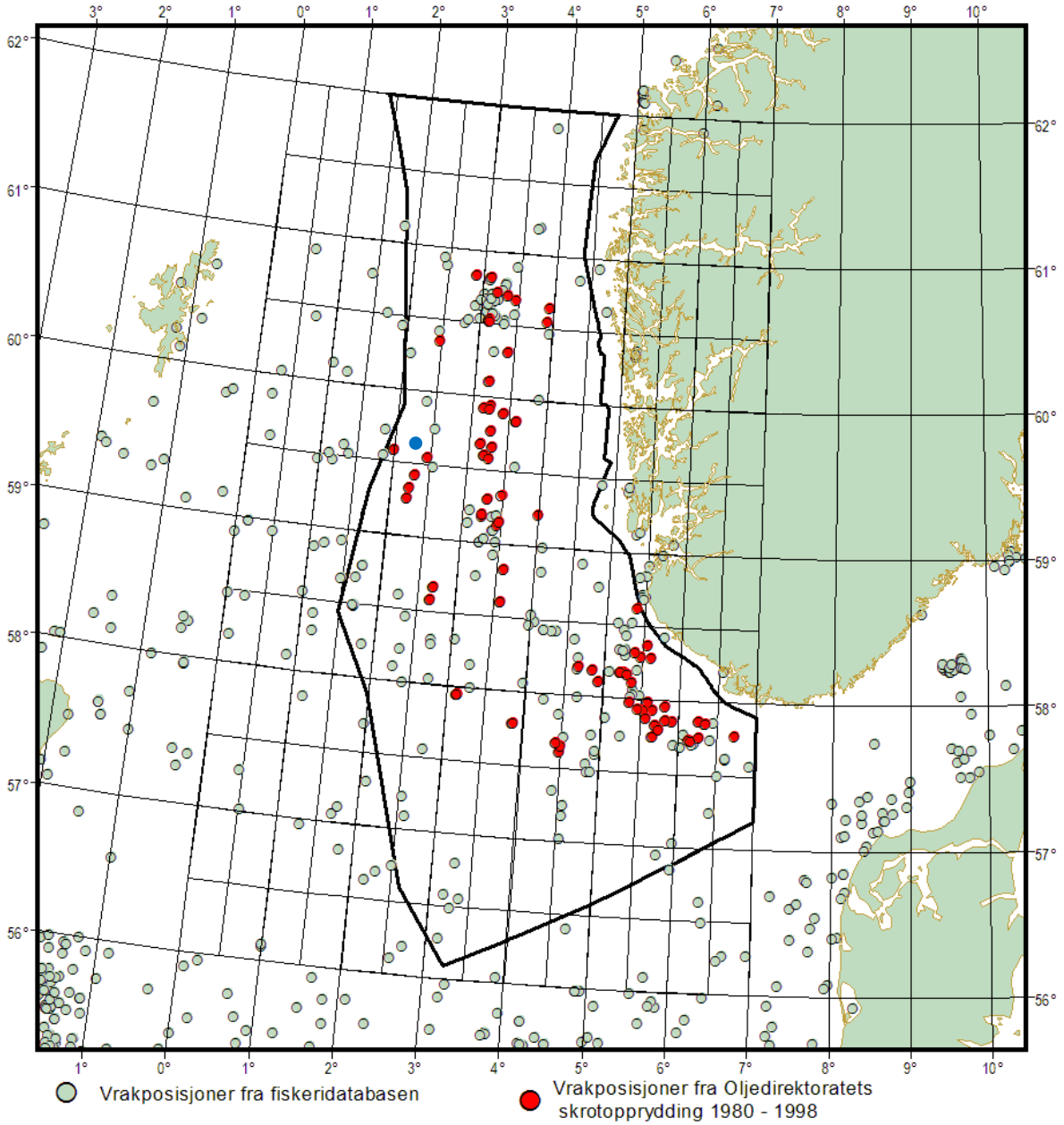
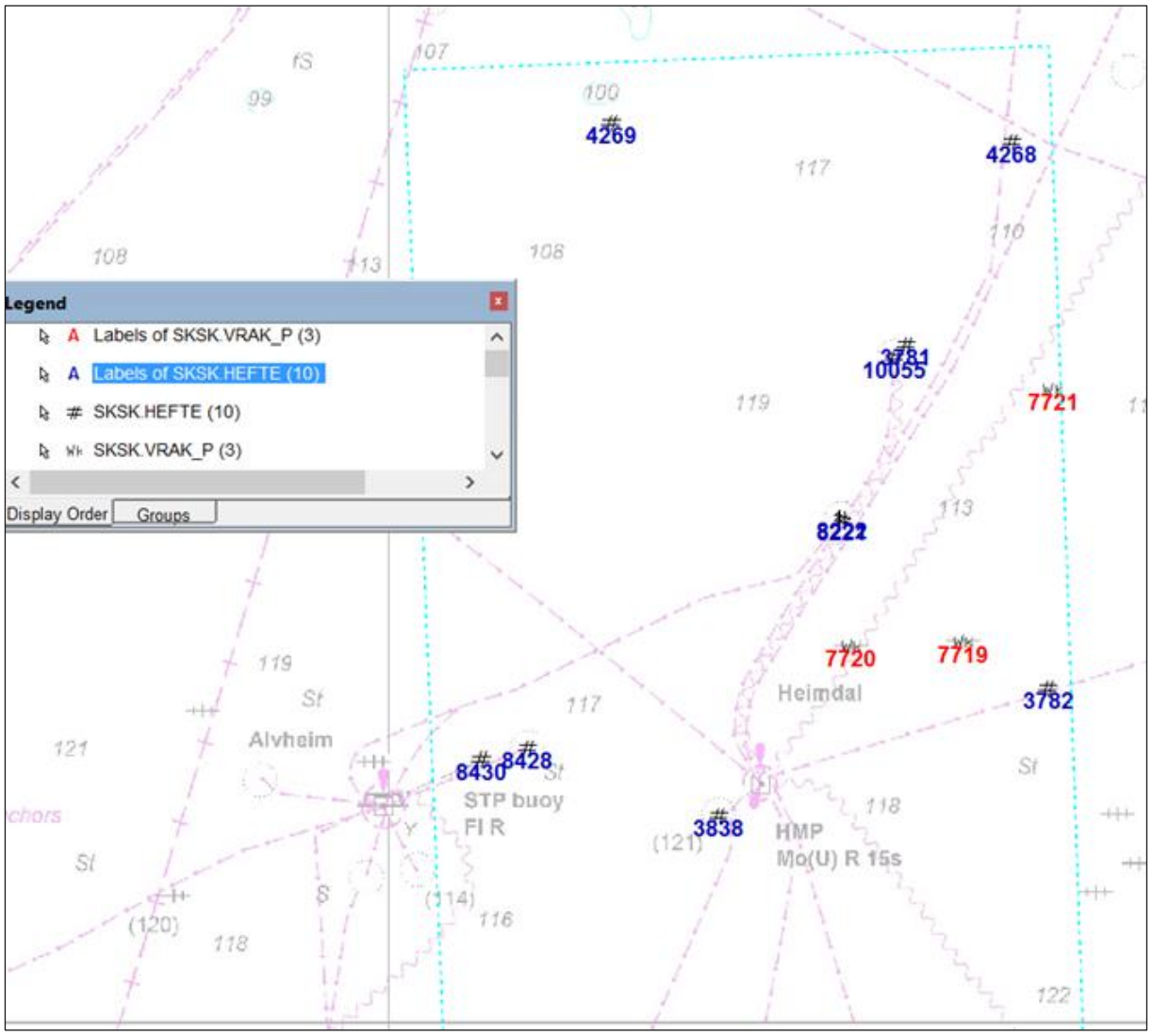


Figure 3-16 Known positions for wrecks in the North Sea (NSM 2006). Heimdal is marked by a blue dot in the figure.



SKSK.VRAK_P

OID	DYBDEKVALITET	HEFTEINFO	TIDEVANNSEFFEKT	VRAKTYPE	SKSKSOURCEID
7720	2 depth unknown	Fra kart 307_0911	3 always under water/submerged. (>0.5m)	1 non-dangerous wreck	59639
7719	2 depth unknown	Fra kart 307_0911	3 always under water/submerged. (>0.5m)	1 non-dangerous wreck	59639
7721	2 depth unknown	Fra kart 307_0911	3 always under water/submerged. (>0.5m)	1 non-dangerous wreck	59639

Figure 3-17 Wrecks and other obstacles on the seabed in the Heimdal area. The blue numbers represent well-heads. The red numbers represent non-dangerous wrecks. (Source: Kartverket sjødivisjonen). The distance to Heimdal is approx. 8,5 km (7719), 6 km (7720) and 18,5 km (7721).

3.5 Future fisheries in the area

Pelagic fisheries that dominate fishing in the North Sea today, with mackerel as the main species. The catch area for the pelagic species varies from year to year, depending on the fish migration pattern. In recent years mackerel catches have been taken further north than previously, which is often explained as a result of increased water temperatures. In the North Sea as a whole, and in the Heimdal area, the pelagic fisheries are expected to dominate in the foreseeable future.

Most of the bottom trawl fisheries for human consumption have traditionally been conducted from approx. 160-170 meters deep along the western slope of the Norwegian Trench and further west. At Heimdal bottom trawling is conducted across the entire area, and it is trawled without any specific direction. Saithe is currently the most important species in this fishery.

The area along the western slope of the Norwegian trench has traditionally been important for the bottom trawl fishery for Norway pout for reduction purposes. The characteristic of the Norway pout fishery along the western slope is that the fish often stands at a certain depth, and that trawling is thus done along the depth contour. The most important fishery has been conducted from 300 meters deep and further west towards shallower waters. In recent years, only a limited Norway pout fishery har been conducted at less than 170-180 meters depth. Development of such fishery in the Heimdal area is not expected.

The general development is that the trawl equipment is becoming increasingly heavier, and according to the fishermen, there was about 50% weight gain per decade on trawl equipment up to the turn of the millennium (Agenda 2002a and b). There is no reason to believe that the trend towards heavier equipment has stopped. One of the largest Norwegian trawlers conducting bottom trawling for human consumption species in the northern part of the North Sea, recently received a middle weight of 8 tonnes for use in fishing with double trawls (Pers. message. Dagfinn Lilleng, Directorate of Fisheries, 03.05.2017).

Regarding the further development of bottom trawl, research teams are working on finding methods for using the bottom trawl with reduced contact with the sea bottom and thus reduce the fuel consumption. With today's selection technology, it may also be relevant to test mid-water trawl / semi-pelagic trawl in fishing for bottom fish species (Fisheries Directorate 2010). The development on new technologies or further development of the existing technologies will be an ongoing process in the fisheries.

In the foreseeable future big changes in the fisheries or equipment used in the Heimdal area are not expected. Further predictions of development in the lifespan of a possible abandoned structure are not possible.

4 Impact of the alternative disposal alternatives

The impacts on the fisheries from the two alternative disposal options for the Heimdal Main Platform (HMP), is presented in this chapter, taking into account other installations in the area. The impacts use the same scale as developed in connection with the Ministry of Petroleum and Energy's acquisition of knowledge for the North-East Norwegian Sea and in the impact assessments for the Barents Sea south-east and the areas at Jan Mayen (***Table 4-1***).

Table 4-1 The scale used for assessing the impacts on fisheries from petroleum activities (Acona Wellpro og Akvaplan-niva 2010; Akvaplan-niva og Proactima, 2012)

Insignificant	Small	Medium	Large
Areas of minor importance to fisheries are affected. Does not involve catch loss, operational disadvantages or increased operating costs of any importance.	The affected area is used by few vessels in current period. May cause limited catch loss / limited operational disadvantages and limited increase in operating costs.	The affected area is important to both local and visiting fishing vessels during the relevant time period. Scheduled activity may result in some catch loss/ operational disadvantage and some increasing operating costs.	The affected area is of great importance to several groups of vessels in the relevant time period. Cause significant catch loss / operational disadvantages and significantly increased operating costs.
Catch loss: Reduced operating base due to reduced catch, fishing in less attractive areas / periods, or species with lower value. *Operational disadvantages:* Increased need for vigilance, adjustment of courses etc. during fishing due to the presence of vessels / installations or other activities related to the petroleum industry. *Operating costs*: Costs related to increased walking distance to available fishing grounds, or temporary transfer to another base port.			

4.1 Impacts from complete removal

In case of full removal of the structure the piles will be cut 1 – 2 meters below seabed and the seabed will be backfilled leaving a smooth seabed. The fisheries will gain full and unlimited access to the area.

4.2 Impacts of partial removal

This disposal alternative with partial removal implies removal of the upper part of the HMP jacket with cutting above the piles, leaving the lower part of the jacket and piles on the seabed resulting in obstructions raising approximately 30 - 35 meters up from the seabed. This is within the IMO requirement of 55 meters free sailing depth. The obstruction will be marked on navigational charts. No safety zone will be established around the structure.

4.2.1 Fishing with bottom trawl

When the work is finished, and the safety zone abandoned, the loss of fishing area for vessels conducting bottom trawling is reduced. The trawlers may exploit areas, and possible congregations of fish, close to the parts of the installation left in place. In practice the construction will represent a minor loss of area and some operational inconveniences for the bottom trawlers.

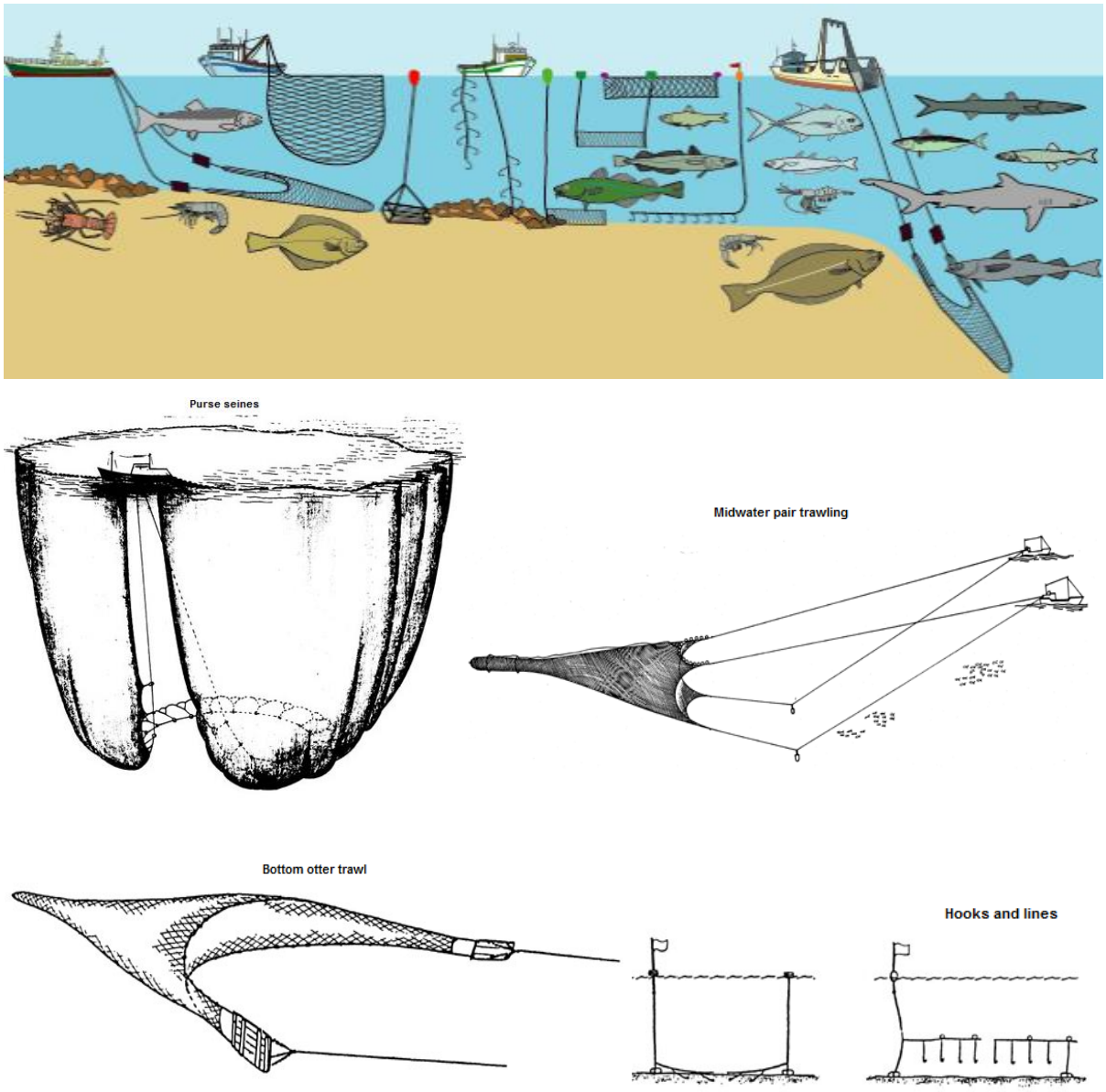


Figure 4-1 Continental shelf fishing methods: Above: Purse seine and mid-water(pelagic) trawl used in fishing for pelagic, schooling fish like herring and Norway pout. Below: Otter trawl (bottom trawl) and longlines used for demersal species (FAO. © 2001-2012).

It should be expected that trawlers will exploit the area within the present safety zone, however the risk of snagging will prevent full use of the area.

With modern equipment for naval navigation and control of the equipment in the sea, it is possible to trawl close to an obstruction. Trawling close to an obstruction, or moments with some lack of attention, represent a risk for hooking of the wires, trawl door or the trawl net in the obstruction. The outcome of such incident may vary from loss of trawling time and some economic loss to more serious technical and safety problems. Historically events of snagging leading to serious accidents have been reported. This is described in the risk assessment.

4.2.2 Purse seine fisheries

Information on the North Sea purse seine fisheries has been collected from the Directorate of Fisheries. During the search for catchable concentrations of fish the vessels have no gear in the sea. In this phase the abandonment of the safety zone may represent minor operational advantages. During the catch operation a purse seine vessel lay almost still in the sea. Prone

to wind and currents, it may drift during this phase. Modern purse seine vessels use fishing nets with a maximum depth of 150 – 200 m in the North Sea.

If the construction is cut to at least 55 m below sea level it may still be an obstacle to the catch operations. There will be no safety zone, but due to the remaining parts of the construction, this alternative is expected to still represent the same operational inconveniences as the present situation.

4.2.3 Fishing with long-line or gillnet

For fishing with long-line or gillnet reduced or abolished safety zone would reduce the loss of fishing areas. However, long-line and gillnet are far less important gears in the North Sea than in areas further north. This disposal alternative is expected to represent a marginal change compared to the present situation.

4.3 Comparison of the disposal alternatives

A comparison of the disposal alternatives compared with the present situation is presented in Table 4-2 The main conclusions are:

Full removal of the platforms

The disposal alternative with complete removal of the structures implies a smooth seabed when all operations are finished. The area occupies by the Heimdal installations and their safety zones will be open to all fisheries. Loss of area and operational inconveniences for the bottom trawl fisheries, mainly conducted with foreign vessels in this area, is removed.

Partial removal of HMP

When the work is finished, and the safety zone abandoned, the loss of fishing area for vessels conducting bottom trawling is reduced. Trawlers may exploit the area within the present safety zone. Trawling close to the remaining parts of the structures, or moments with some lack of attention, represent a risk for hooking of the wires, trawl door or the trawl net in the obstruction.

For the purse seine fisheries, the remaining parts of the structures will still be an obstacle to the catch operations.

Table 4-2 The effects on fisheries from the different disposal alternatives compared with the present situation.

	Bottom trawl	Purse seine / Pelagic trawl	Other gear [1)]
Full removal of HMP	No limitation	No limitations	No limitation
Partial removal of HMP. Cut to at least 55 m below sea surface	Increased fishing area, with some operational disadvantages. Risk for hooking of equipment.	Will still represent an obstacle during catch operations	Increased fishing areas

1) Minor parts of the high sea fisheries in the North Sea

The Heimdal platforms have already existed as an artificial reef for the fish stocks for more than 30 years. Based on the observed fishing pattern and catch statistics for the area during the last decade, any noticeable effect as artificial reef has so far not been observed. It seems unlikely that this picture will change after the field is shut down with.

Conclusion

Full removal will result in an increased fishing area for all types of gear and remove the operational disadvantages during fishing in the area. Especially foreign trawlers will benefit from this disposal alternative.

With partial removal the remaining structures will still represent an obstacle during bottom trawl fisheries, and sporadic for the purse seine fisheries. The Norwegian bottom trawl

fisheries in the Heimdal area are sporadic, and partial removal is expected to have insignificant effects on the total Norwegian fisheries. Foreign fisheries with bottom trawl dominate in the Heimdal area. Based on the scale presented in Table 4-1, the Heimdal area represent medium consequences for these fisheries in the present situation. With partial removal the vessels operating in the area will still experience some operational disadvantages combined with reduced loss of fishing area. Partial removal is expected to represent small consequences for the foreign fishing fleet operating in the Heimdal area.

5 Risk of snagging of fishing gear with partial removal of jacket

A technical note "*Heimdal jacket removal - Trawl impact risk assessment*" has been prepared by Acona AS. The technical note addresses the risk potential of trawl impact on the Heimdal jacket remains, after the installation has been removed. The concern is that the top of the jacket structure is cut loose and lifted away whereas the last 30 – 35 m of the structure with the piles will be left in place such that nets and trawl gear easily could snag on it if it were unintentionally trawled over.

5.1 Possible events

The main concern would be the trawl being stuck in the structure. The damage potential of such an event would be:

- The trawl can be freed by carefully manoeuvring the vessel and operating the winches
- The trawl remains stuck and has to be left on the structure by cutting the wires, or the wires break
- The trawl wires break and cause damage to the trawler and potentially injure personnel on board.
- The trawl is stuck, the vessel does not react adequately and gets a list due to sideways wire pull, takes in water and sinks.

The outcome from such events varies from short stop in the fishery during the operation to loosen the wire or the door, with low risk involved, to more severe incidents. Going fast with a trawl wire or door in a free span or structures on the seabed entails a serious safety risk. On the Norwegian shelf no dramatic incident of going fast in a free span is known. But on the British shelf the trawler Westhaven capsized and sank in March 1997 after having lodged a trawldoor inside a free span on a 30" pipeline. The report after the accident indicates wrong use of the winches as the main cause for the accident. The vessels probably pulled the trawl wires over the side of the vessel and overturned in a few minutes. The crew did not have enough time to get into the lifeboat (Scanews1998).

In preparation of this report both the Norwegian Directorate of Fisheries and the Norwegian Petroleum Directorate was contacted to collect information on events with hooking of trawl equipment in petroleum structures, and the outcome of such events. It was confirmed by both directorates that that there is no systematic compilation of such events (Pers. message. Dagfinn Lilleng, Norwegian Directorate of Fisheries, 05.05.2019; e-mail from Heidi Hagland. Norwegian Petroleum Directorate, 09.05.2019).

5.2 Assessment principles

There is a certain similarity between the risk of a trawlnet getting caught in a seabed structure, and the risk of a vessel collision with an offshore installation. In both cases, the position of the structure is known, marked on maps and shown on navigation systems; the main difference being that one is visible by eye and by radar whereas the other is not. The visibility is a factor that increases the probability of "detecting" the structure, thereby reducing the probability of impact.

The collision model considers two aspects:

- The number of vessels that has a course towards the installation/seabed obstruction
- The probability of these vessels having the trawlnet impacting on the seabed obstruction.

The number of vessels on course towards the seabed obstruction is normally estimated from historic vessel traffic data.

The approach for assessing the probability of the trawl to impact the seabed obstruction is to distinguish four factors:

1. Navigation equipment error: the obstruction is not shown on the navigation screens
2. Planning error: the course of the vessel is not planned such to avoid impact.

3. Watch keeping error: the vessel is potentially aware of the obstruction, but does not react timely to avoid impact
4. Alarm error: the navigation system does not activate an alarm prior to impact.

For a fishing vessel, there may not be a great distinction between the planning and watch keeping errors. However, watch keeping refers more to the short term there and then planning, whereas planning in this context applies to planning of actions further away in time.

5.3 Probability of snagging trawl

The trawling density has been calculated for block 25/4 where Heimdal is located, based on data from the satellite tracking of fishing vessels (data from the Norwegian Directorate of Fisheries). The results from electronic catch reporting and the satellite tracking system show considerable variation in vessel density in the Heimdal area. The Heimdal location almost seems a deserted spot compared to areas further afield. It cannot be ruled out that these patterns change after the installation has been removed.

Based on the density of trawling operations in the area as documented by the Norwegian Directorate of Fisheries and assessment of the probability of avoidance (of contact with the structure) by comparison with ship collision models, the probability of a trawl snagging on the Heimdal jacket remains is estimated to be in the order of $1.3.10^{-3}$ per year.

The uncertainties with this number are caused by the uncertainty in the trawler density for the site and the uncertainty regarding the probability of avoidance. Both could be an order of magnitude. The upper uncertainty bound for the probability of a trawl snagging on the jacket remains would then be in the order of 5.10^{-2} per year.

The consequences of a trawl getting caught on the structure, may range from loss of the trawl-gear, to sinking of the trawler.

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