FIMPAS project – Pre-assessment of the impact of fisheries on the conservation objectives of Dutch marine protected areas

C. Deerenberg, L.R. Teal, D. Beare, J.T. van der Wal.

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IMARES Wageningen UR

(IMARES - institute for Marine Resources & Ecosystem Studies)

Clients:	International Council for the Exploration of the Sea (ICES) H. C. Andersens Boulevard 44-46, DK-1553 Copenhagen V Denmark Ministerie van LNV Directie Visserij Postbus 20401
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Content

1 Introduction and background

1.1 FIMPAS project

The project *Fisheries Measures in Protected Areas* (FIMPAS) aims to introduce by the end of 2011 fisheries measures in the marine Natura 2000 sites within the Exclusive Economic Zone of the Dutch part of the North Sea. The FIMPAS project will deal with three such areas, the Dogger Bank and the Cleaver Bank (both to be designated for protection under the Habitats Directive) and the Frisian Front (to be designated for protection under the Birds Directive). These sites are located within the Exclusive Economic Zone of the Netherlands beyond the Dutch 12 nm coastal zone. Several EU Member States fish within these areas. Therefore fisheries measures must be implemented through the Common Fisheries Policy. These marine protected areas, as well as the potential fisheries measures, are a consequence of the implementation of the European Birds and Habitats Directives and will be proposed to the European Commission by the Dutch government. The Dutch Ministry for Agriculture, Nature and Food Quality (LNV), together with Dutch environmental NGOs and the Dutch fishing industry, are cooperating within the FIMPAS project to develop the necessary fisheries measures to achieve the conservation objectives for the Dutch Natura 2000 sites of the North Sea. LNV has asked the International Council for the Exploration of the Sea (ICES) to organize the necessary scientific processes and give advice on the desired fisheries measures involving the relevant stakeholders in this process.

The FIMPAS project comprises an international process involving all relevant stakeholders (fishing industry, environmental organisations, scientists and policymakers, including site managers). The aim of this process is

i) to gather the maximum possible amount of relevant information necessary to assess the level and severity of interaction between different types of fishing activities and conservation objectives of Marine Protected Areas (MPAs)

ii) to determine what fisheries measures are possible in order to achieve the conservation objectives.

The FIMPAS project consists of three phases, each culminating into a (stakeholder) workshop:

Workshop 1 aims to establish the data basis on which the following two workshops will be based.

Workshop 2 aims to assess the impact of fisheries on the conservation objectives of the designated sites.

Workshop 3 aims to generate management actions to meet the defined conservation objectives.

For the preparation of the second workshop ICES has requested IMARES (Institute for Marine Resources and Ecosystem Studies, part of Wageningen University Research, Wageningen UR) to draft a report that

1) shows the spatial and temporal distribution of the fisheries in and around the designated sites, i.e. the Dutch EEZ or the southern North Sea
2) summarises the main impacts of the various gears on the habitats and species
3) identifies – based on ii. – the expected conflicts between fisheries and the conservation aims of the designated sites.

This report constitutes the basis for further discussions on conflicts and their relevance in view of the conservation aims of the designated sites during the workshop.

1.2 Assignment

IMARES proposed to apply an approach similar to the one developed for the Effect Analyses of fisheries in the Dutch coastal Natura 2000 areas of the Wadden Sea and North Sea coastal zone. This approach is essentially stepwise in selecting relevant potential conflicts: firstly considering the trends in the fisheries and the conservation objectives for the Natura 2000 areas, secondly looking for overlap in time and space between fisheries and conservation objectives, and lastly describing and discussing the effects of remaining relevant potential conflicts.

After long debate, and pressed by time, ICES and LNV gave priority to seasonal distribution maps of the fisheries and of the conservation objectives to feed the discussions in FIMPAS workshop 2. In addition, they asked for a brief (1 page) description of the effects of each type of fishery on each conservation objective, based on “one or two literature reviews”. The latter appeared impossible, as only effects of beam trawl fisheries and – to a lesser extent – otter board trawl fisheries have been extensively studied (and reviewed). To fill that gap in the assignment, we have done ad hoc literature searches and drawn judgement from experts working at IMARES.

2 Areas and conservation objectives

2.1 Overview

The three marine Natura 2000 sites (Dogger Bank, Cleaver Bank and Frisian Front) and the general and area-specific conservation objectives for each of these areas have been described by Jak et al. (2009) and have been reiterated in Chapter 5 of Van Hal et al. (2010). We here start again with an overview of the site-specific conservation objectives (listed in Table 1). Maps delineating the distribution of these conservation objectives (habitats and/or species) in the Dutch EEZ of the southern North Sea based on available (sometimes very limited) knowledge are provided in the Annexes (1-9).

Table 1 Overview of the various site-specific conservation aims

Natura 2000		**Conservation objective**		
Objective	**Area**	**Surface area**	**Quality**	**Average numbers (period)**
H1170 Open-sea reefs	Cleaver Bank	Maintain	Improve	
H1110_C Inundated sandbanks	Dogger Bank	Maintain	Improve	
Harbour porpoise	Cleaver Bank, Dogger Bank	Maintain	Maintain	
Grey seal	Cleaver Bank, Dogger Bank	Maintain	Maintain	
Harbour seal[4]	Cleaver Bank, Dogger Bank	Maintain	Maintain	
Great skua	Frisian Front	Maintain	Maintain	180 birds (Aug-Sep)
Great black-backed gull	Frisian Front	Maintain	Maintain	80 birds (Oct-Nov)
Common guillemot	Frisian Front	Maintain	Maintain	20,000 birds (Jul-Aug)
Lesser black-backed gull	Frisian Front	Maintain	Maintain	

2.2 Dogger Bank

The Dogger Bank qualifies for habitat type H1110_C (Sandbanks which are slightly covered by sea water all the time) and is also an area where harbour porpoises and grey and harbour seals are found, three species that are to be protected under the Habitats Directive (Table 1). The notified site ‘Dogger Bank’ is part of a continuously covered sandbank that stretches across the UK, Dutch, German and Danish sectors of the North Sea. Habitat H1110_C is defined only for the Dutch part of the Dogger Bank, which constitutes roughly 20 % of the total area of designated or proposed Natura 2000 sites on the Dogger Bank (i.e., British, German and Dutch parts combined).

The Dogger Bank is a special ecological region that supports a relatively diverse benthic macrofaunal community compared to other areas in the EEZ (Daan & Mulder, 2006). The eastern part of the Dogger Bank contains three faunal communities, referred to as the typical ‘sandbank’ community, the ‘northern’ community, and the ‘Amphiura’ community typical of the south. These three distinct communities are separated mainly by depth and sediment type (Wieking & Kröncke, 2003). The sandeel (*Ammodytes* spp.) is an important fish species on the Dogger Bank, and is an important food source for many species, including seabirds (Parsons et al., 2008), sea mammals (MacLeod et al., 2007) and predatory fish species.

2.3 Cleaver Bank

The Cleaver Bank comes under habitat type H1170 (Open-sea reefs) and is also an area where harbour porpoises and grey and harbour seals are found, three species that are to be protected under the Habitats Directive (Table 1). Areas where large cobbles or coarse gravel occur are a characteristic feature. An additional characteristic is the presence of a mosaic of places with gravel (maximum 80%) and boulders that alternate with coarse sand and places with old shell material (Laban, 2004). In some areas boulder clay rises to the surface. The area containing habitat type H1170 is cut in two by the deep and silt-rich Botney Cut, which has a high biodiversity (Lindeboom et al. 2005) but does not contain habitat type H1170. The Cleaver Bank is one of the clearest areas in the southern North Sea, allowing light to penetrate to deeper water and resulting in growth of red seaweeds at 34-39m (van Moorsel, 2003). The mosaic pattern and the low mobility of a large part of the sediment in combination with the clarity of the water make the Cleaver Bank unique in the Dutch EEZ, although this combination of features is less rare in other parts of the North Sea. The area of H1170 on the Cleaver Bank constitutes less than 0.5 % of the total area of habitat H1170 in the EU part of the North Sea. For the Netherlands habitat H1170 is unique with a very specific biodiversity (references in Jak et al. 2009).

The Cleaver Bank hosts a great diversity of species. Of all the macrobenthic species present in the Dutch EEZ, 44% occur exclusively on the Cleaver Bank (van Moorsel, 2003) and the diversity of the macrobenthos on the Cleaver Bank is among the highest in the EEZ (see Lindeboom et al., 2008). Characteristic sessile organisms are the dead men’s fingers (*Alcyonium digitatum*), encrusting coralline red algae (*Lithothamnion sonderi* and *Phymatolithon* sp.) and several species that function as eco-engineers, by cementing the substrate and giving its structure and texture an extra dimension, stimulating the attachments of other species. The site also hosts species that occur specifically in coarse sediment, because they have a thick shell, which makes them well suited to the incidental movements of the gravel, e.g. *Dosinea exoletea*. The site has the potential to host various long-lived shellfish species. Furthermore, a variety of species are found that are otherwise only common in the deeper, more northern North Sea and a number of other species that are new for the Netherlands. The fish species Norway bullhead (*Taurulus liljeborgi*) and the two-spotted clingfish (*Diplecogaster bimaculata*) prefer to live on and between cobbles and are therefore considered characteristic of the area.

Several species of marine mammals have been sighted within the Cleaver bank area. During summer, the harbour porpoise (*Phocoena phocoena*, Arts & Berrevoets 2005; Van der Meij & Camphuysen 2006) can be found, particularly around the Botney Cut. Seals can be tracked with the help of satellite transmitters, which has shown that both the harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) can occur in the area (Lindeboom et al. 2008).

2.4 Marine mammals

2.4.1 Harbour porpoise

In 1994 abundance for harbour porpoises was estimated at 262,540 individuals including the whole North Sea and the Channel (Hammond et al. 2002). The Kattegat and part of the Skagerrak had an additional estimate of 36,046 harbour porpoises. During the SCANS II survey in 2005 the abundance estimate was 38,000 animals in the Northern North Sea, 59,000 animals in the Central North Sea and 134,400 animals for the Southern North Sea and the Channel. An additional 23,200 animals were estimated for the Inner Danish waters, Kattegat and Skagerrak and 128,600 animals for the western shelf waters (ICES 2008). The status of the population is unknown.

Both the SCANS I and the SCANS II survey results have been used to spatially model the distribution of porpoises observed in one summer (see Van Hal et al. 2010). The distribution in the Dutch EEZ of the North Sea has been modelled using aerial and ship-board based observations over several years (Annex 3). The SCANS results show that the distribution of porpoises in the North Sea has changed over the last decade from north to south. Other data sources such as the strandings and sighting data from the Dutch coast confirm that over the last decade porpoise occurrence has increased (data Camphuysen in Brasseur et al. 2008).

2.4.2 Harbour seal

In the North Sea the harbour seals consist of several populations, which are more or less closed. In 2007 ICES reported a number of over 45,000 animals in the North Sea area. In 2007, for the population in the Wadden Sea, ranging from Texel in the Netherlands to the Danish Esbjerg, a maximum of 17,605 seals were counted during the moulting season. These represented an estimated population size of almost 26,000 seals. The Harbour seal population in the North Sea was reduced by almost 50% in both1988 and 2002 due to a virus epizootic, but recovered relatively well afterwards (Brasseur et al. 2008). The status of the Harbour seal population is perceived as resilient or even increasing (Annex 4).

Within the southern North Sea area, the harbour seal (ssp. *vitulina*) occurs in four more or less distinct areas. Though some exchange is recorded, these groups have been considered to form four different populations. These are: the Wadden Sea population ranging from Esbjerg in Denmark to Den Helder in the Netherlands, the southern Dutch and Belgian population, the Wash population in Great Britain and the population in the Baie de Somme, France (De Jong et al. 1997b). However, there are several indications that there is a regular exchange between the different colonies (e.g. Brasseur & Reijnders 2001).

Seals typically divide their time over a terrestrial phase and an aquatic phase. During the terrestrial phase animals lay on the haulout sites. Population estimates are based on counts made when seals are hauled out. Typically, the harbour seal does not show marked differences between seasons in its spatial distribution and seem to show fidelity to haul out areas (Härkönen 1987). For approximately 80% of their time, the seals spend time at sea where they forage, mate, travel and even sleep occasionally.

2.4.3 Grey seal

Grey seals range over the North Atlantic coast. Roughly three stocks can be identified: one in the West Atlantic, one in the Baltic and one in the East Atlantic, they are not considered different subspecies (Bonner 1989, Anderson 1990, De Jong et al. 1997a). The number of grey seals in the Eastern Atlantic stock is dominated by the numbers that occur in the UK area. In 2006 the total population of grey seals was estimated to be 133,000 seals (Duck & Thompson 2007). New colonies of grey seals at the southern North Sea and Channel Coasts, growing since the 1990’s, were most probably fed by grey seals from Britain (Annex 5).

Being a relatively recent inhabitant along the Dutch coasts, little is known about the distribution and variation of grey seals in the (coastal) area. Most extensive knowledge is based on the yearly census. As described in Reijnders et al. (1995), regular counts of the seal colony which had settled on “de Richel” between the Dutch islands of Vlieland and Terschelling were made by boat until the end of last century. Despite the regular morphological changes the colony grew steadily to over 500 animals during the moult in March-April. From 2000 onwards also the pupping and moulting colony spread out over several sites to the west around the island of Texel. The Dutch population is growing and now estimated at approx. 2100 (Brasseur pers.com.), while the total population is likely to be resilient.

2.5 Frisian Front

The Frisian Front is a relevant area for several bird species under the Birds Directive (BD). The site is characterized by the occurrence of specific bird species in relatively high numbers. The site's boundary was set by drawing straight lines around the sampling stations with a higher biodiversity of benthos, locations at which the Ocean Quahog is present and with high bird values (Lindeboom et al. 2005). The Frisian Front is the southern part of the long physical front in the central part of the North Sea that is stratified in summer. Various physical factors combine to produce a zone with a relatively high primary production, a high biomass and a high diversity of zoobenthos. Relatively high concentrations of fish and birds have been observed in this area as well.

2.5.1 Great skua

The Great skua (*Stercorarius* (= *Catharacta*) *skua*) qualifies under the Birds Directive for the Frisian Front on the grounds of the Ramsar criteria for concentration areas. In the late summer and autumn the species satisfies the standard that >1% of the total European population of this bird species occurs at the Frisian Front. The Great skua is a bird of the open sea, where it forages for mainly fish that it robs from gulls, terns and northern gannets. It also catches fish by itself. Its breeding grounds are in northern Europe.

2.5.2 Great black-backed gull

The great black-backed gull has been selected following the principles for non-qualifying drawn by the Ministry of Agriculture, Nature and Food Quality. The rule is that at least 0.1% of the biogeographical population must be present regularly on the site. Based on aerial counting (RWS), ship-board surveys (ESAS database) and a directed survey of the area (Leopold & Camphuysen 2006) the species was selected (Jak et al. 2009)

2.5.3 Guillemot

The guillemot qualifies under the Birds Directive for the Frisian Front on the grounds of the Ramsar criteria for concentration areas. The common guillemot (*Uria aalge*) satisfies the criterion that more than 20,000 individuals regularly reside at the site.

2.5.4 Lesser black-backed gull

The lesser black-backed gull has been selected following the principles for non-qualifying drawn by the Ministry of Agriculture, Nature and Food Quality. The rule is that at least 0.1% of the biogeographical population must be present regularly on the site. Based on aerial counting (RWS), ship-board surveys (ESAS database) and a directed survey of the area (Leopold & Camphuysen 2006) the species was selected (Jak et al. 2009).

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3 Disturbance factors of fisheries

3.1 Disturbance factors to habitats and species

In this paragraph we give an overview the various factors of a fishery event that potentially disturb the habitats and species of the designated marine Natura 2000 areas (see Par 1.2). A fishery may exert one or several direct impacts (disturbances). These disturbances may ultimately change the abundance of the species living in the area that is fished, and, if species disappear from the area or new species can settle in the area, alter the diversity of species present in the area or lead to a change in the community. Whether these indirect population and community effects actually come about and can be observed depends on the severity and frequency of the direct impact and the vulnerability and resilience of the species involved. The mechanisms indicate the ways how these indirect effects may come about (Figure 1). Below, we briefly describe each identified direct impact and its potential ensuing effects, including as much as possible the various modes of propagation of these effects ('mechanisms').

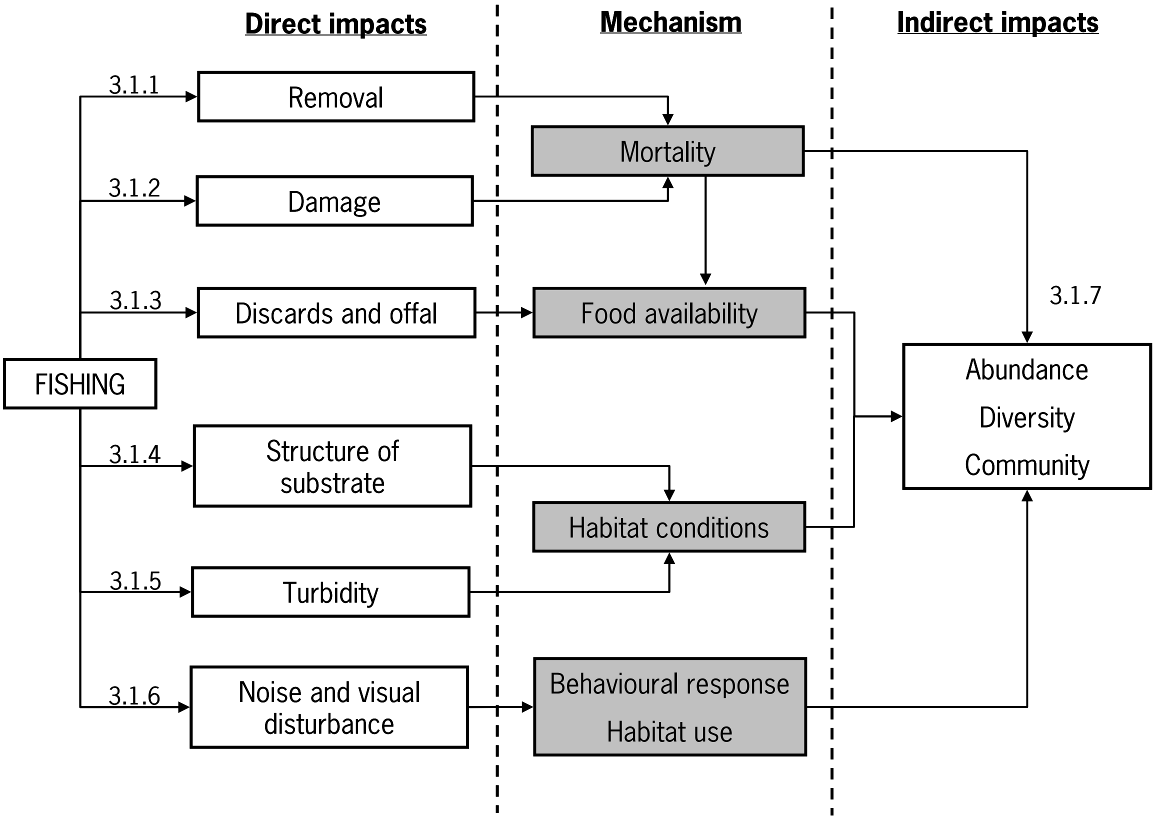

Figure 1 Overview of potential direct impacts of fisheries on habitats and species and the main mechanisms through which they may effect populations and communities.

3.1.1 Removal

Catch (Target species)

Fish species targeted directly by fisheries (those caught are removed from the system) will experience a decline in abundances. Not all species are equally vulnerable to fishing, however. An individuals vulnerability is largely dependant on behaviour, which determine susceptibility to fishing gears (how effectively it is caught), and life history, which determines a populations response to a given level of fishing mortality. Behaviour, ecology and life-histories affect the population response to fishing mortality.

Shoaling, swimming, feeding and migratory behaviour all affect a species susceptibility to being caught. Fisheries can take advantage of shoaling behaviour (e.g., sandeel) using acoustic techniques to detect large aggregations of fish or schools in the water column. Such aggregations of fish can be surrounded by seine nets or trawled for, using the acoustic data as a guide. Fishing on aggregations/schools in hot spots thus remains profitable even at low population sizes. Swimming speeds and escape responses affect the ability of a species to avoid nets. As swimming speeds are a function of body length, smaller fish are generally less able to swim ahead (escape) of an oncoming trawl (Videler 1993). Escape responses to an oncoming net differ between species, with some swimming upwards as they drop back into the net (e.g. haddock) and others staying low (e.g. cod; Main and Sangster 1982). Knowledge of escape behaviour can be used to divert targeted species into the codend of a trawl whist allowing incidental catch to escape. Equally, knowledge of feeding behaviour can help fishermen design gear using baited hooks and traps (type of food, its presentation, depth of fishing, time of fishing), increasing the catchability of certain species. Migration bottlenecks are easy targets for fisherman.

Species habitat preferences will further affect their vulnerability. Flatfish live in smooth sandy sediments, which are readily accessible to fishing gears, whilst other species, such as Norway lobster (*Nephrops norvegicus*), lying in hide in burrows in muddy sediment, are not.

Long-lived, slow-growing, late maturing species with low fecundity are more vulnerable to an increase in mortality by fishing than short-lived, fast-growing species with high fecundity, as these attributes are associated with lower intrinsic rates of population increase (e.g., Trippel 1995, Pope et al. 2000). Some populations are therefore able to sustain higher fishing mortality rates, whilst others collapse. Depending on the scale and intensity, fisheries cause a shift in species composition and age structure of populations.

Unintentional catch (by-catch)

Most (if not all) fisheries catch at least some non-target species (fish and benthos, seabirds and sea mammals) which are subsequently discarded. Due to the damage caused by the fishing process, discarded by-catch suffer high mortality rates. Many measures are taken to reduce the amount of by-catch (increased mesh size, modification to gear), which is dependant both on the fishing gear used (selectivity, mesh size) and the area fished (bottom versus mid-water trawls, coastal versus offshore areas).

Fish: The quantity of fish by-catch varies considerably between mid-water (pelagic) and bottom-trawling. Midwater hauls are generally more targeted to shoals of a particular species, whereas bottom trawling catches any species within the path of the net. Fish are considered by-catch if they are not commercially valuable and are subsequently discarded (see section 3.1.3). This includes fish that are below the minimum landing size (MSL) or that are discarded due to their low value (high-grading). Discarded fish suffer high mortality rates, either directly from the damage caused to the individual or due to subsequent predation by seabirds and benthic scavengers.

Benthos: Fishing gear targeting bottom-dwelling species remains in close contact with or, dependant on the type of fishery, penetrates the seabed and inevitably catches a large proportion of non-targeted benthic by-catch species, having a direct affect on benthic communities (for indirect effects through seabed disturbance see section 3.1.4).

Seabirds: Seabirds may be captured and drowned by certain types of fishing gear, with set net, drift net and long-line fisheries the most likely to take seabirds. The number of seabirds killed varies considerably between the different types of fishery and gill nets and trammel nets are perceived the “worst” in this respect. As by-catch of seabirds occurs mostly from birds diving for prey getting entangled in invisible meshes, diving birds are much more likely to suffer as by-catch than surface feeding birds. By-catch of seabirds becomes a problem when mortality rates from by-catch constitute a significant proportion of the local populations.

Cetaceans: Where fisherman are pursuing large amounts of fish that are at the same time a preferred prey item of cetaceans, incidental catches may occur (Fertl & Leatherwood 1997). The probability of incidentally capturing cetaceans depends on the type of gear used, the habitat and the targeted species. Currently, estimates of the extent of cetacean by-catches are limited, mainly based on the type of injuries of dead animals washed ashore, or from direct observation during fishing trips (Couperus 2009). By-catch of cetaceans becomes a problem when mortality rates from by-catch constitute a significant proportion (>1%) of the local populations.

3.1.2 Damage

Whilst removal of catch from the system will affect the population, mortality can also occur through damage to individuals during the process of fishing. These organisms are not brought on board but remain damaged on the sea floor. Damaged organisms are not observed by fishermen and rarely by researchers (only those that sample in the tracks or observe the benthic community directly). Injuries may originate during movement through the mesh of the net. Damage also occurs to organisms outside of the net through direct contact with fishing gear (otter doors, tickler chains, nets etc). Benthic communities are also directly affected by the trawl gear passing over the seabed causing mortality and damage to organisms within the path of the gear. On average it has been found that the immediate impact of bottom gears on benthic communities is the removal or killing of half the individuals, although the magnitude of impact is highly dependant upon the gear used, the habitat and taxa. Changes in the structure of megafaunal communities are often visible in stable habitats for example, but less detectable in habitats with a high physical impact (Kaiser et al. 1998). Sessile benthic species generally show a decrease in abundance following trawling, whilst due to immigration mobile scavengers can increase in abundance in trawled areas, where they feed off the damaged fauna or discarded organisms (Ramsay et al. 1996). Bivalves and organisms with an exoskeleton are particularly vulnerable to damage and mortality caused by trawl gear.

3.1.3 Discards and offal

A proportion of the by-catch from fisheries will be discarded dead or dying because it is illegal to land or because there is little or no economic gain associated with it. An estimated 475’000 t of fish, offal and benthic invertebrates are discarded into the North Sea annually (Camphuysen et al. 1993), with demersal trawling being the major source. Due to the quantity of discards, consequent effects are expected for the marine ecosystem resulting from changes in food availability. Discards are preyed upon by a range of scavengers (birds, epifauna) whose ecology was extensively reviewed by Britton and Morton (1994). In the North Sea it has been estimated that seabirds consume 90% of discarded offal, 80% of roundfish, 20% of flatfish and 10% of discarded invertebrates, in other words enough food to maintain approximately 2.2 million seabirds (more than the total estimated population of scavenging seabirds in the North Sea). Such a change in food availability will be reflected in population changes, including numbers of breeding birds (Lloyd et al. 1991, Furness 1996). However, it is important to realise that not all bird species will feed on discards and that intra- and inter-specific competition for discards also occurs, thus discards will have a variable affect on individuals and species. Discards that sink are also scavenged by epifaunal species that have been shown to move into areas recently trawled. This increase in food availability to epifaunal scavengers will also be reflected in their population sizes and community composition.

3.1.4 Structure of the substrate

Changes to the substratum (direct effect)

Physical disturbance of the seabed through fishing activities results through direct contact with fishing gear, e.g. otter boards (doors), tickler chains, the bottom of the net, etc., as well as the turbulent resuspension of surface sediments (Jennings and Kaiser 1998). The following effects on the substrate can be identified:

Removal of physical features and/or structural biota: Physical structures such as boulders and sand ripples support high levels of biodiversity (Lindeboom et al. 2005). Biogenic structures such as biogenic reefs, sponges and burrows/mounds in the sediment, as well as emergent benthic fauna, all contribute to the topography and microtopography of the sediment. Both physical and biogenic structures will be seriously impacted (physically (re-)moved, damaged or destroyed) by gear which is dragged along the seafloor and directly affect the biota living in and on these structures.

Homogenisation of seabed: Removal of physical and biological structures, as well as the effect of sediment redistribution, leads to a reduction in habitat complexity of the seabed surface (and in soft sediments also the internal structure; Schwinghamer et al. 1996) and thus an increase in homogeneity.

All habitat types are sensitive to changes in substrate, although the magnitude of impact and the associated recovery time are dependant on the habitat type (type of substratum, strength of currents or tides, vulnerability of benthos) and the type of fishing gear used (rigging, speed of towing, physical dimensions and weight of gear, Kaiser et al. 2006). Sandy Habitats which are subject to intense natural perturbations are generally less heavily impacted with shorter recovery periods. Exceptions are shellfish beds (oysters and mussels) or biogenic habitats such as *Sabellaria* reefs.

3.1.5 Increased turbidity of the water mass

Trawling of the seabed causes an increase in sediment resuspension and a subsequent increase in turbidity of the water column. An increase in turbidity causes a decline in the penetration depth of light, as well as an increase in sedimentation rates once the re-suspended particles settle back out of the water column. In addition, deposition in other more vulnerable areas is possible. Increased turbidity of the water column has direct consequences for the biota mainly by affecting the food availability:

Penetration of light: Light will be unable to penetrate to deeper layers in a turbid environment. Primary producers, including crustose red algae typical of the open-sea reefs, rely heavily on light for photosynthesis.

Predation success: An increase in turbidity in the water column affects visual predators as the ability to detect prey decreases.

Sediment resuspension: Contact of fishing gear with seabed combined with the towing motion resuspends surface sediments into the water column. This can remobilise contaminants and radionuclides and expose the anoxic layer of sediment (Auster et al. 1996). These anoxic sediments can release phosphates, but on the other hand resuspended clay minerals are known to scavenge nutrients from the water phase. Whether sediment resuspension leads to release or absorption of certain compounds depends upon the sediment composition, redox status and depth of penetration and may differ locally. Effects in the Natura 2000 areas are largely unknown.

Particle deposition: Benthic suspension feeders, which rely on a feeding apparatus to filter food from the water column, are affected by an increase in suspended sediment particles that can clog the feeding apparatus. This makes it difficult for the organisms to obtain sufficient food. At very high levels and/or prolonged periods of resuspension and subsequent deposition, benthic sessile organisms may become buried by the settling particles.

3.1.6 Sound and visual disturbance

Sound

The presence of several main ports along the North Sea with a very high shipping intensity and offshore activities with related seismic research and drilling activities makes it probably one of the noisiest seas in the world. Ambient noise levels in the past 50 years have increased. Marine mammals live in an acoustic world and depend very much on sound emission and receiving for prey detection, navigation and communication. Low frequency, continuous sound or ambient noise includes natural (biological and physical processes) and anthropogenic sounds. Research has shown increases in ambient noise levels in the past 50 years mostly due to shipping activity. This increase might result in the masking of biological relevant signals (e.g. communication calls in marine mammals and fish) (Tasker et al. 2010). Richardson et al. (1995) reviewed documented observations of reactions of marine mammals to boats, aircrafts and other (noisy) human presence. The reviewed data seem to show a lot of contradictions. Dolphins and seals are often observed in areas with a lot of human noise, but in some occasions they seem to avoid small vessels at distances of several miles. These data are mostly anecdotal and consider all short-term reactions. At present, existing data are insufficient to predict any but the grossest noise impact on marine mammals (references U.S. Marine Mammal Commission 2007, Southall et al. 2007 in Ainslie et al. (TNO) 2009).

High amplitude, low and mid-frequency impulsive anthropogenic sounds include those from pile driving, seismic surveys and some sonar systems. Laboratory studies have found both physiological and behavioural effects in a variety of marine organisms, while field studies have shown behavioural disturbance and in some cases death (Tasker et al. 2010). High frequency impulsive sounds (sonar) are typically used on small vessels and sonar usage, particularly on leisure boats, is increasing and is unregulated. There is an overlap with the frequency that marine mammals use for communication. However, the sounds are similar to those used in acoustic alarms (pingers) that are designed to scare away small cetaceans from gill and tangle nets, and can therefore be expected to cause adverse effects. The scientific evidence for adverse effects is limited (Tasker et al. 2010).

Visual disturbance

The effects of visual disturbance on marine mammals have not been studied. In contrast, seabirds, especially divers and sea ducks are easily disturbed by ship movements, including the presence and actions of fishing vessels. Krijgsveld et al. (2008) give an extensive overview of the studies done to assess vulnerability of all kind of species (groups) to disturbance by presence of people or boats etc. Most studies are done on land or inland or coastal waters. The average observed distances causing alertness or taking wing for groups of foraging birds is low for gulls (125m and 75m respectively) and high for seaducks and eiders (3.5km and 1.5km respectively). In contrast, susceptibility to disturbance based on a set of general parameters results in similar values for seaducks and gulls (Krijgsveld et al. 2008). We assume that skuas behave like gulls. Own at-sea observations on guillemots show that flight/dive distances to approaching vessels are low, generally less than 100m (although birds might stop feeding and become alert at slightly larger distances) (M. Leopold pers. comm.).During the moult or when the fledglings are still not capable to fly these birds may be extra sensitive to disturbance by passing fishing vessels.

3.1.7 Effects on abundance, diversity and community structure

Catch and by-catch becomes a problem for a population when removal and mortality rates from (by-)catch and damage constitute a significant proportion of the local populations that cannot be compensated by productivity. Populations of slow-growing species with low fecundity are more likely to suffer these effects (e.g. ocean quahog, elasmobranchs, cetaceans, seabirds). Vulnerable species are replaced by less vulnerable species or scavengers that are able to thrive due to higher resilience to the disturbance, reduced competition, or on the increase in food availability.

Whilst abundances are most likely to change in response to fishing mortality, the structure of an exploited community can also change in a number of ways due to the selective removal of target species and larger size-classes of the respective species. The number of species (diversity) and their relative abundance within the community may vary. Although the local diversity of a benthic community within an intensely fished region may decrease, some studies have shown that species richness can remain stable, whilst the species composition of a community instead shifts between two states. Exploited species may be replaced by ecologically similar species that are less sensitive to fishing disturbance (Pimm & Hyman 1987), causing systems to switch between alternate stable states (e.g. Beddington 1984). The size composition of individuals may also change (e.g. Pope et al. 1988), which may subsequently lead to changes in the trophic structure of the system (Greenstreet & Hall 1996). Whilst differential effects of fishing on species with contrasting life histories can lead to gross changes in community structure (Jennings et al. 1999, Greenstreet & Rogers 2006), environmental forces may contribute to these changes (O'Brien et al. 2000) further influencing the fish community and also mediating its response to fishing pressure. In light of recent changes in climate, it is important to consider the interactions of both anthropogenic and environmental drivers on the fish community.

Changes to the substratum by removal or damage to physical and biogenic structures and a decrease in habitat complexity have indirect effects on the benthic communities by decreasing the availability of suitable habitat for benthic communities. Consequently a decrease in abundance and diversity of benthic species that are supported by these structures can be expected. In addition, resuspended sediment can cause smothering of fauna and clogg feeding apparatus of suspension feeders. Changes to the structure of the seabed and the associated benthic communities inhabiting it (see also section 3.1.1) can also negatively impact the functioning of the seabed in terms of its capacity for biogeochemical cycling (carbon and nutrient remineralisation (Duplisea et al. 2001, Duineveld et al. 2007)

When changes in the turbidity of the water column affecting the food availability (light or prey detection) are sufficiently severe and prolonged, this may have indirect effects on the benthic communities by reducing primary production when light is limiting and thus on the production of the whole community depending on it. Furthermore, reduced ability to locate or catch food reduces survival of the visual predators. Increased mortality may also occur in organisms that become buried by the settling particles. The magnitude of the impact will depend on the type of habitat, the agility and behaviour of the biota and the natural conditions of the site.

The North Sea is a heavily exploited system, with the quantity of fish taken from the North Sea estimated to be around 1 million tonnes around 1900, growing to 3.5 million tonnes during the 1970s, and currently estimated around 2.5 million tonnes (Daan et al. 1990, ICES 1995). As the total biomass of the North Sea has been estimated at approximately 10 million tonnes (Sparholt 1990), these large catches cause concern over the wider impacts on the North Sea fish community and ecosystem (ICES 1995, Greenstreet & Hall 1996). It is thus important to consider that the North Sea has been exploited for over a century and that many changes to the community have already occurred. Pauly (1995) pointed at shifting baselines when considering the natural occurrence of species. Another phenomenon are regime shifts that may lead to sudden large changes in the ecosystem with other species becoming dominant (Holbrook et al. 1997). And changes will continue to occur, especially when climate change also affects the marine ecosystem.

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4 Description of conflicts

Based on the types of fisheries occurring in the Dutch EEZ and the disturbance factors distinguished and described in chapter 3, we here present gear-impact matrices for each of the relevant (groups of) conservation objectives habitats, marine mammals and sea birds. Given the application of the disturbance factors of a type of fishery on a conservation objective, we will rate the impacts of the fishery. An overview of all rated impacts will be presented in the gear-impact matrix (Ch 5).

4.1 H1110_C Submerged sandbanks

4.1.1 Vulnerability and resilience

The vulnerability of H1110_C on the Dogger Bank is related to its physical features (e.g., softness of the sediment, great clarity of the water column) and the characteristics (e.g., trophic position) and life histories of the typical species (e.g., longevity). The initial experimental effect of a beam trawl disturbance is larger in a sand habitat than in a muddy sand habitat: on average 67% and 38% reduction in abundance of taxa, respectively (Kaiser et al. 2006). The initial experimental effect of an otter board trawl disturbance was not evident in a sand habitat, but present in a muddy sand habitat, the reduction in abundance of taxa larger for crustaceans (on average 81%) than for worms and molluscs (26%, Kaiser et al. 2006). The resilience of sandy habitats is assumed to be relatively high, with apparent rapid recovery of 2-50 days after the initial disturbance (but based on few data points after the initial impact, Kaiser et al. 2006). In muddy sand habitats that are mediated by a combination of physical, chemical and biological processes, habitat restoration is much longer (months or >1 yr, Dernie et al. 2003). In the former case, recolonisation is probably dominated by active and passive migration of adults into the disturbed areas (e.g. McLusky et al. 1983), whereas in the latter case recolonisation is likely to require (in part) recruitment of larvae, and is therefore a much longer process.

4.1.2 Effects of beam trawl fishing

Removal and damage – The beam trawl fishery is directed at flat fish species (with plaice as typical species of H1110_C) and characterised by high percentages of by-catch of undersized or non-target fish, epifauna and infauna (71-95%, Lindeboom & De Groot 1998) and high annual mortality of benthic species in the tracks (5-39% annual mortality of megafauna, Bergman & van Santbrink, 2000). Beam trawl fishery directed at plaice uses a lower number of chains and the mesh size of the net is larger than fishery directed at sole. The severity of the effects on the bottom, benthos and fish is related to the intensity of fishing and the specifics of the gear type: the number of tickler chains (more for sole) or the use of a chain mat (smaller beams) or the mesh size. The high ensuing mortality rates mainly affect long-lived species (four of the typical species of H1110_C), especially e.g. rays, whelks and urchins (Philippart 1998).

Discards – The beam trawl fishery is characterised by a high percentage of discards (40-60% STECF, Dutch fleet in 2008: 35%, Van Helmond & Van Overzee 2010). A regular availability of discards favourises scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – The classic beam trawl with 10-12 tickler chain penetrates a sand substrate about 3-8 cm (Lindeboom & De Groot 1998). Structure is a less important feature of the purely sandy, shallow parts of the Dogger Bank, whereas it is for the slopes into deeper areas with more muddy habitat (Jak et al. 2009).

Turbidity – There is no specific knowledge on the effects of beam trawling in (muddy) sand habitats on turbidity of the water column. On the shallower sandy parts of the Dogger bank, due to the high energetic nature, the water is permanently mixed with a low content of suspended material. Owing to the low silt sediment, the effect of natural or human-induced resuspension is brief. The adjacent transitions to deeper areas have silt-rich fine sands, with a relatively nutrient-rich bottom layer, and are often stratified (warm top-cold bottom) in summer. Clarity is important for the sessile diatoms (three of the typical species of H1110_C).

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

Taken together, beam trawling causes changes (mainly reduction) in abundance of typical species of H1110_C), and changes in the community resulting from more sustained effects on suspension feeders compared to deposit feeders (Kaiser et al. 2006). Although recovery is fairly rapid in sand habitats, with a distinct difference between the shallow areas and the slopes, the high fishing effort resulting in on average low inter-fishing intervals have caused a permanent state of disturbance of the habitat, which may have been the case for more than a century (Frid et al. 2000).

Effect of beam trawling on H1110_C: HIGH

4.1.3 Effects of otter board trawl fishing

Removal and damage – The otter board trawl fishery is directed at roundfish (large mesh sizes, group II) and *Nephrops* (smaller mesh sizes, group I) and is used to target sandeel. Various types of otter board fishing have different effects on the rate of by-catch (see below). The fishery on (muddy) sand habitats is characterised by high percentages of by-catch of mainly epifauna (67-86%, Lindeboom & De Groot 1998), but low annual mortality of benthic species in the tracks (<0.5-3% annual mortality of megafauna, Bergman & van Santbrink 2000). The fishing mortality rates mainly affect long-lived species (four of the typical species of H1110_C), especially rays (Philippart 1998).

Discards – The otter board trawl fishery is characterised by a modest percentage of discards (up to 28%, Kelleher 2005). However, the fishery directed at sandeel (and Norway pout) has a discard rate of <1% (Kelleher 2005). The fishery directed at flatfish has a higher discard rate (51%, Kelleher 2005). The otter boards trawl fishery directed at *Nephrops* (by the Dutch fishery, concentrating in the Botney Cut of the Cleaver Bank) has a discard rate of 60% (Van Helmond & Van Overzee 2009). A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – The boards at the side of the net cut fairly deep into the sediment about 20 cm (O'Neill et al. 2009, Van Marlen et al. 2010) to resuspend the sediment and chase the target fish species, whereas the ground-ropes glide over the seabed. The structure is a less important feature of the purely sandy, shallow parts of the Dogger Bank, whereas it is for the transitions to deeper areas with muddy sand habitat.

Turbidity – There is no specific knowledge on the effects of otter board trawling in (muddy) sand habitats on turbidity of the water column. See 4.1.2.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

To summarise, otter board trawling causes changes (mainly reduction) in abundance of typical species of H1110_C), and changes in the community resulting from negative initial effects on suspension feeders whereas deposit feeders seem unaffected (Kaiser et al. 2006). Although recovery is fairly rapid in sand habitats, the high fishing effort resulting in on average low inter-fishing intervals causes a permanent state of disturbance of the habitat, which may have been the case for more than a century (Frid et al. 2000).

Effect of otter board trawling on H1110_C: MEDIUM

4.1.4 Effects of seine fishing

Removal and damage – The demersal purse seine is a preferred technique for capturing all kinds of fish species which live close to the sediment surface, such as cod, plaice, haddock, red mullet. Seines are used when there are flat but rough sea beds, which are not trawlable. Only plaice is among the typical species of habitat H1110_C. Removal and damage of non-taget species is likely but unknown.

Discards – The seine fishery has low discards rates of less than 5% (Kelleher 2005). Given the high catches, this still amounts to large volumes of discarded fish and benthos. A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002). In the northeast Atlantic (south of Portugal) discards consist mainly of pelagic species and juveniles of the target species (Gonçalves et al. 2008).

Structure of substrate – The Scottish Seine or flyshooting fishery uses long lengths of seine rope to herd fish into the path of the net as the gear is hauled. Danish seining or ‘snørrevåd’ is a semi-static fishing method based on the herding effect of cables running over the sea bed. Floats keep the net open vertically and this is attached to the footrope that is generally rigged much lighter than that of a trawl, but is sufficiently weighted to keep the lower edge of the net mouth in contact with the sea bed. Seines can not work on such rough grounds as otter trawls. There are no studies on the effects of seine fishery on benthic habitats. We surmise that disturbance of the structure of H1110_C is relatively low or hardly relevant because of the energetic nature of the habitat and relatively light contact of the footrope with the sea bottom. However, if benthic structures are present the rope might cause some damage.

Turbidity – No information. We surmise that induced turbidity is low due to the relatively light contact of the footrope with the sea bottom.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

The main effect of seine fishery may be catch of the commercial exploited species plaice, which is also a typical species of H1110_C, potential by-catch of other typical species such as rays, and potential high amounts of discards.

Effect of seine fishery on H1110_C: LOW

4.1.5 Effects of gill net fishing

Removal and damage – Gill nets set at the sea bottom are used to catch e.g., cod, turbot, plaice. Trammel nets target mainly sole. The mesh size is dependant on the target species. By-catch rates are usually low (<10%, Kelleher 2005). The distribution and intensity of gill net fishery is poorly known, because type of net used and length of stay are not reported and if operated from small vessels (<15m of length) they do not appear in VMS registrations. In recent years, the use of gill nets in the North Sea has increased, in particular around wrecks. Quite a number of nets get lost (no data) but continue to catch fish (“ghost fishing”). While loss rates are generally below one per cent, the length of netting lost each year in those fisheries that have been studied is over 209 km (Brown & Macfadyen 2007)

Discards – The gill net fishery has low discard rates of less than 10% (Kelleher 2005). Discards are not perceived as a problem of this fishery.

Structure of substrate – No information. Expected to be low.

Turbidity – No information. Expected to be low.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

There is no knowledge available on the effects of setting and hauling or fishing by gill nets on habitat H1110_C. Effect of seine fishery on H1110_C: UNKNOWN – expected LOW

4.1.6 Effects of mid-water trawl fishing

Removal and damage – Midwater trawls target pelagic species such as herring and mackerel.

Discards – The midwater trawl fishery has low discard rates of less than 5% (Kelleher 2005). The Dutch pelagic freezer trawls has discard rates of about 10% (Van Helmond & Overzee 2009). Given the high catches, this still amounts to large volumes of discarded fish. A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – No information. Not relevant due to lack of contact between gear and sea bottom.

Turbidity – No information. Not relevant due to lack of contact between gear and sea bottom.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

There is no knowledge available on the effects of mid water trawls on habitat H1110_C, and if the trawl does not hit the bottom no effects are expected.

Effect of mid water trawling on H1110_C: NOT RELEVANT

4.2 H1170 Open-sea reefs

4.2.1 Vulnerability and resilience

The vulnerability of H1170 on the Cleaver Bank is related to its physical features (e.g., cobbles, coarse gravel and sand in a mosaic pattern, great clarity of the water column) and the characteristics (e.g., sessile epifauna, trophic position) and the life histories of the typical species (e.g., longevity). The initial experimental effect of a beam trawl disturbance in a gravel habitat is on average a 42% reduction in abundance of taxa (Kaiser et al. 2006). Based on the study reviewed by Kaiser et al. (2006) there is no initial effect of an experimental otter board trawl disturbance on a gravel habitat and recovery after initial effects have not been studied. In contrast, the initial effect after an experimental otter board trawl disturbance in biogenic habitats was strong with 62-91% reduction in abundance of taxa (Kaiser et al. 2006). The resilience of open-sea reef habitats is assumed to be low. Collie et al. (2000) report a recovery time of 180 days for gravel habitats (based on Kaiser & Spencer 1996 and Kaiser et al. 1998), and Collie et al. (2000) and Kaiser et al. (2006, referring to six comparative studies) conclude that biogenic structures have prolonged recovery times of 1-3 years.

4.2.2 Effects of beam trawl fishing

Removal and damage – The beam trawl fishery is directed at flat fish species and characterised by high percentages of by-catch (71-95%, Lindeboom & De Groot 1998). Specific mortality caused by beam trawling in open-see reef habitat or similar habitats has not been assessed. Kaiser et al. 2006 report 42% initial reduction in abundance of benthic taxa after experimental trawling. There are no studies carried out in biogenic habitats. High mortality rates mainly affect long-lived species (four of the typical species of H1170).

Discards – The beam trawl fishery is characterised by a high percentage of discards (40-60% STECF, Dutch fleet in 2008: 35%, Van Helmond & Van Overzee 2010). A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – The classic beam trawl with 10-12 tickler chain penetrates a gravel substrate about 1-8 cm (Paschen et al., 2000), removing the large physical features and reducing the structuring biota (e.g. ICES 2007a, b). The structure of features that arise from the bottom, the mosaic pattern of variation in sediment and the seabed stability are key features of the open-sea reef habitat of the Cleaver Bank (Jak et al. 2009).

Turbidity – We are not aware of any studies describing the extent and duration of turbulent resuspension of the finer sediment due to beam trawl activity in (sandy) gravel habitats. The concentrations of suspended material on the Cleaver Bank are low, enabling light to penetrate to the bottom and the growth of e.g., calcareous red algae (and seven other typical species of H1170). H1170 is of low energetic nature, suggesting that resuspended material may take some time to settle.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

All taken together, beam trawling removes, homogenizes and flattens the substrate of H1170, and causes changes (mainly reduction) in abundance of its typical species. Initial impact appears severe and recovery is unknown, but expected to be slow owing to their stable nature characterised by diverse communities. Any beam trawl activity on habitat type H1170 on the Cleaver Bank causes a long-term state of disturbance of the habitat.

Effect of beam trawling on H1170: HIGH

4.2.3 Effects of otter board trawl fishing

Removal and damage – The otter board trawl fishery is directed at roundfish species and *Nephrops* and characterised by high percentages of by-catch (67-86%, Lindeboom & De Groot 1998). Specific mortality caused by otter board trawling in open-see reef habitat or similar habitats has not been assessed. High mortality rates mainly affect long-lived species (four of the typical species of H1170).

Discards – The otter board trawl fishery is characterised by a modest percentage of discards (up to 28%, Kelleher 2005). However, the fishery directed at sandeel (and Norway pout) has a discard rate of <1% (Kelleher 2005). The fishery directed at flatfish has a higher discard rate (51%, Kelleher 2005). The otter boards trawl fishery directed at *Nephrops* (by the Dutch fishery, concentrating in the Botney Cut of the Cleaver Bank) has a discard rate of 60% (Van Helmond & Van Overzee 2009). A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – The otter boards penetrate a gravel substrate about 1-25 cm to resuspend the sediment and chase the target fish species, whereas the ground-ropes glide or hop over the seabed and penetrate 0.5-6.5 cm depending its construction (van Marlen et al., 2010). The structure of features that arise from the bottom, the mosaic pattern of variation in sediment and the seabed stability are key features of the open-sea reef habitat of the Cleaver Bank (Jak et al. 2009). We surmise that disturbance of the structure of H1170 is potentially high, owing to typical and vulnerable biogenic structure elements of habitat H1170.

Turbidity – We are not aware of any studies describing the extent and duration of turbulent resuspension of the finer sediment due to otter board trawl activity in (sandy) gravel or biogenic habitats. The concentrations of suspended material on the Cleaver Bank are low, enabling light to penetrate to the bottom and the growth of e.g., calcareous red algae (and seven other typical species of H1170). We surmise that any turbidity resulting from trawling would settle relatively quickly owing to the low energetic nature of habitat type H1170.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

Otter board trawling in sum mainly causes reduction in abundance of its typical species, of which several contribute to a complex biogenic structure. Initial impact appears severe and recovery is unknown, but expected to be slow owing to the stable nature characterised by diverse communities. Any otter board trawl activity causes a long-term state of disturbance of the habitat.

Effect of otter board trawling on H1170: HIGH

4.2.4 Effects of seine fishing

Removal and damage – The demersal purse seine is a preferred technique for capturing all kinds of fish species which live close to the sediment surface, such as cod, plaice, haddock, red mullet. Seines are used when there are flat but rough sea beds, which are not trawlable. Removal and damage of non-target species is likely but unknown. There is potential for by-catch of Norway bullhead and Two-spotted clingfish, the two typical fish species for H1170.

Discards – The seine fishery has low discards rates of less than 5% (Kelleher 2005). Given the high catches, this still amounts to large volumes of discarded fish and benthos. A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002). In the northeast Atlantic (south of Portugal) discards consist mainly of pelagic species and juveniles of the target species (Gonçalves et al. 2008).

Structure of substrate – The Scottish Seine or flyshooting fishery uses long lengths of seine rope to herd fish into the path of the net as the gear is hauled. Danish seining or ‘snørrevåd’ is a semi-static fishing method based on the herding effect of cables running over the sea bed. Floats keep the net open vertically and this is attached to the footrope that is generally rigged much lighter than that of a trawl, but is sufficiently weighted to keep the lower edge of the net mouth in contact with the sea bed. Seines can not work on such rough grounds as otter trawls. There are no studies on the effects of seine fishery on benthic habitats.

Turbidity – No information. We surmise that induced turbidity is low due to the relatively light contact of the footrope with the sea bottom.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

There is little or no information about potential effects of seine fisheries on benthic habitats. Key issue in that respect is the nature of the contact between fishing gear and sea bottom, which is surmised to be light, although a moving footrope can be expected to affect the epifauna. By-catch has not been assessed, discards appear to be low.

Effect of seine fishery on H1170: UNKNOWN – expected LOW – MEDIUM

4.2.5 Effects of gill net fishing

Removal and damage – Gill nets set at the sea bottom are used to catch e.g., cod, turbot, plaice. Trammel nets target mainly sole. The mesh size is dependant on the target species. By-catch rates are usually low (<10%, Kelleher 2005). The distribution and intensity of gill net fishery is poorly known, because type of net used and length of stay are not reported and if operated from small vessels (<15m of length) they do not appear in VMS registrations. In recent years, the use of gill net fisheries in the North Sea have increased, in particular around wrecks. Quite a number of nets get lost (no data) but continue to catch fish (“ghost fishing”). While loss rates are generally below one per cent, the length of netting lost each year in those fisheries that have been studied is over 209 km (Brown & Macfadyen 2007)

Discards – The gill net fishery has low discard rates of less than 10% (Kelleher 2005). Discards are not perceived as a problem of this fishery.

Structure of substrate – No information. Expected to be low.

Turbidity – No information. Expected to be low.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

There is no knowledge available on the effects of setting and hauling or fishing by gill nets on habitat H1170. Effect of seine fishery on H1170: UNKNOWN - expected LOW

4.2.6 Effects of mid-water trawl fishing

Discards – The mid-water trawl fishery has low discard rates of less than 5% (Kelleher 2005). The Dutch pelagic freezer trawls has discard rates of about 10% (Van Helmond & Overzee 2009). Given the high catches, this still amounts to large volumes of discarded fish. A regular availability of discards favours scavengers that dominate heavily fished areas (e.g. Kaiser et al. 2002).

Structure of substrate – No information. Not relevant due to lack of contact between gear and sea bottom.

Turbidity – No information. Not relevant due to lack of contact between gear and sea bottom.

Noise and visual disturbance is not relevant for this benthic habitat.

Rating of effects

There is no knowledge available on the effects of mid water trawls on habitat H1170, and if the trawl does not hit the sea floor no effects are expected.

Effect of mid water trawling on H1170: NOT RELEVANT

4.3 Marine mammals – on Dogger Bank and Cleaver Bank

4.3.1 Vulnerability and resilience

Marine mammals may be caught by both active and passive fishing gear causing them to drown. This is most likely to happen when a fishery targets the species that are important food species for the mammalian predators or at locations where both fishery and predators occur at the same time (and in sufficient densities). Grey seals have relatively high food intake in summer and autumn, whilst harbour seals can be expected to have a higher food intake in autumn and winter. This is related to the timing of pupping and moult. Grey seals have been observed further offshore, though more often the distribution of both seal species overlap. In the UK sandeel forms a major component of the grey seals' diet (references in Brasseur et al. 2008). Although any incidental catch of marine mammals is unwanted (as is all unintentional by-catch), catches or entanglements and ensuing drowning of marine mammals are relevant for the conservation objectives of sites only when the additional by-catch mortality potentially causes decline of the population. The Harbour seal population in the southern North Sea is perceived as resilient or even increasing, though locally, e.g., in the Dutch Delta area, this might be contested (Brasseur et al. 2008, Brasseur pers. comm.). For the Grey seals, the population may also be resilient, although influx from the British Islands could affect the perceived numbers. The status of the Harbour porpoise in the southern North Sea is not known. An observed increase in numbers of the last decades is most likely due to a change in spatial distribution (SCANS II). The areas of the Dogger Bank and the Cleaver bank constitute a minor part of the total distribution area of the Harbour Porpoise, Grey Seal and Harbour Seal. There are no indications that the areas are of specific importance to these species.

4.3.2 Effects of fishing

Removal and damage – The issue of by-catch of marine mammals in the North Sea mainly focuses on harbour porpoises caught in gill nets. Fixed and drift gillnets cause the greatest by-catch of small marine mammals, although small cetaceans and seals also can be caught in purse seines, mid-water trawl nets (Lewinson et al. 2004), and also bottom trawl nets (experts at FIMPAS workshop 1). Vinther (1999) concluded from observations on set-net fisheries in Danish waters that by-catch rates differed between the métiers identified by target species. By-catch rates were lower in fisheries for plaice and turbot (none observed in sole fisheries) compared to roundfish fisheries, with highest rates in cod fishery over wrecks. Vinther (1999) reported highest by-catch rates in the 1st and 3rd quarter of the year, whereas stranding on Dutch coastal sites are highest in the 1st (and 4th) quarter (Brasseur et al. 2008). The by-catch of marine mammals in seine nets south of Portugal appeared extremely rare, mainly because the fishing grounds are close to shore, at depths less than 25 to 30 m (Gonçalves et al. 2008). In addition, in the western Mediterranean neither the consumption of fished production nor the mixed trophic impact analysis suggests significant competition between vulnerable species (cetaceans, seabirds) and fishing activity (Coll et al. 2006). Incidental catches of marine mammals in the Dutch pelagic trawl fishery are largely restricted to late winter / early-spring, in an area along the continental slope southwest of Ireland. These incidents show a distinct peak during the period when mackerel move into the area (Feb-Apr) and are caught by the fishery (Couperus 1997). The information on the by-catch of marine mammals by beam trawls is based on observations made during many years of surveys (e.g. De Boois & Bol 2009). Additional information is available from the observer programme on discards from commercial ships using both beam trawls and otter board trawl (e.g. Van Helmond & Van Overzee 2010). During both types of surveys, over the years only one or two catches marine mammals have been recorded. The participating experts and fishermen of FIMPAS workshop 1 concluded that by-catch of marine mammals by all discussed types of fisheries can not be excluded. Specific information on by-catch of marine mammals in the Dogger Bank and Cleaver Bank areas is unknown. The probability of bycatch is expected to be higher in gillnetting as compared to the other types of fishing in the areas. The bottom trawl fisheries (beam trawl and otter board trawl) negatively affects the valuable zoobenthos and demersal fish populations (see Ch. 3) in the areas. As most fish species are very mobile, it is not certain whether this will cause any local effects on the food availability of the residing or passing marine mammals.

Discards – Whether marine mammals eat discards is unlikely but unknown. The relative importance of the Dogger Bank and Cleaver Bank as feeding areas for marine mammals is also unknown (Brasseur et al. 2008). Harbour porpoises are observed on the Dogger Bank, and both Harbour seals and Grey seals are expected to occur in both areas, the latter in higher densities if concentrating on seals from Dutch waters (Brasseur et al. 2008). NOTE: There is a general agreement to reduce discards and the potential effects of an ensuing reduced food availability will not be considered as a relevant issue for the impact of fishery on marine mammals.

Structure of substrate – Effects of fisheries (mainly bottom trawling) trawling on the substrate (see 3.1.1, 3.1.2 and 3.1.4) are only relevant to the extent that it may affect food availability of marine mammals. However, the relative importance of benthic species of the Dogger Bank and Cleaver Bank as food for marine mammals is not known (see above).

Turbidity –Effects of fisheries (mainly bottom trawling) on the turbidity of the water and subsequent potential feeding efficiency of marine mammals is most likely irrelevant unless indirectly, when prey is affected by turbidity. Marine mammals can also find their prey in rather turbid coastal waters whereby porpoises use echo sounding and seals use feeling with their very sensitive whiskers.

Sound and visual disturbance –The effect of sounds produced by fishing vessels on marine mammals has not been studied. Even if it does have an effect, e.g. through avoidance of fishing vessels, the effects of this reaction on the population dynamics of marine mammals will be close to impossible to assess, given the limited knowledge on marine mammal behaviour and demographic impacts. In view of the current knowledge on marine mammals it is unlikely that one could define the effect of disturbance specifically by fisheries on the species or populations, although fisheries may play a role when effects are accumulated.

Rating of effects

The effect of interaction between fisheries and marine mammals which has had most public attention in the Netherlands is the by-catch of porpoises in the gill net fishery. However, as indicated above, the by-catch differs with the type of gill net that is used. Still, the distribution and intensity of the various types of gill net fishery is poorly known, because type of net used and length of stay are not reported. In addition, gill net fishery operated from small vessels (<15m of length) are not subjected to the obligatory VMS registrations. In recent years, the use of gill net fisheries in the North Sea have increased, in particular around wrecks. Quite a number of nets get lost (no data) but continue to catch fish (“ghost fishing”).

Effect of beam trawling and otter board trawling on Harbour porpoise, Harbour seal and Grey seal : LOW

Effect of seine fishing on Harbour porpoise, Harbour seal and Grey seal : LOW - MEDIUM

Effect of gill net fishing on Harbour porpoise : MEDIUM

Effect of gill net fishing on Harbour seal and Grey seal : LOW

Effect of mid-water trawling on Harbour porpoise, Harbour seal and Grey seal : LOW - MEDIUM

4.4 Seabirds – on the Frisian Front

4.4.1 Vulnerability and resilience

The moulting period of the adult Guillemots that coincides with the period that their fledglings are still incapable of flight (July-August) is a very sensitive period.

4.4.2 Effects of fishing

Removal and damage (direct effects) – Seabird mortality in fishing gear is a globally recognised conservation issue. Virtually all types of gear used in zones in which seabirds feed may catch birds. Seabirds get hooked on longlines, become entangled in gillnets, collide with trawler cables, and become trapped in trawl nets and fish traps (Tasker et al., 2000). Fixed and drift gillnets cause the greatest by-catch of seabirds, although they also can be caught in purse seines, mid-water trawl nets, and bottom trawl nets (experts at FIMPAS workshop 1). Fishing gear in EU waters is estimated to have killed two million seabirds in the past ten years (www.birdlife.org/seabirds/seabird-news.html). Bycatch events can be highly episodic (e.g., Piatt & Nettleship 1984, Vader et al. 1990), likely due to the overlap of aggregations of these species and fishing effort at certain times of the year in specific areas. Žydelis (2009) reviewed studies reporting bird by-catch in coastal gillnet fisheries in the Baltic Sea and the North Sea region. All species of diving birds that occur in the study region have been reported as dying in fishing nets. By-catch rates varied depending on species' foraging technique and were influenced by net parameters and fishing depth, and were especially high for Guillemots. The same applied to studies around Britain (Tasker et al. 2000). Despite the presumably high mortality, the breeding populations of Guillemot do not seem affected (Tasker et al 2000, Žydelis et al. 2009). Guillemots have also been recorded in sandeel (*Ammodytes* spp.) trawls in the North Sea used in the feeding area of a colony (M. L. Tasker, pers. obs. in Tasker et al. 2000). Mortalities of seabirds in midwater (pelagic) trawl fisheries in other areas of the world are receiving increasing attention recently (references in Žydelis et al. (2009). The information on the by-catch of sea birds by beam trawls is based on observations made during many years of surveys (e.g. De Boois & Bol 2009). Additional information is available from the observer programme on discards from commercial ships using both beam trawls and otter board trawl (e.g. Van Helmond & Van Overzee 2010). During both types of surveys, over the years there is one documented case of a puffin *Fratercula arctica* caught (alive!) in a beam trawl (54°13'N, 01°35'E, 29 November 2005). After publication of this case, two guillemots (dead) were brought in by beam-trawling fishermen for stomach analyses (Dutch Seabird Group, unpubl.). We surmise that by-catch of seabirds by trawl and seine fishery, particularly of diving species such as the guillemot, does happen occasionally, but that most cases will go unrecorded.

Removal and damage (indirect effects through food availability) – There are indications that, at a large scale, some fisheries and some birds are exploiting the same species in the same place, but at different times of the year. It appears difficult to demonstrate the competitive impact of fisheries on seabirds. However, fishery impacts at high harvest levels, such as those for sandeel, could be cumulative, and potential effects on seabird populations might be lagged in time (Tasker et al. 2000). The bottom trawl fishery negatively affects the valuable zoobenthos and demersal fish populations (see Ch. 3) in the area. As most fish species are very mobile, it is not certain whether this will cause any local effects on the residing bird species. In addition, the specific diet of the seabirds at the Frisian Front is only poorly known (only in general terms, an internal report on stomach content of Guillemots, and observations on Lesser black-backed that forage above flocks of foraging Guillemots).

Discards – Great skuas and great black-backed gulls profit most from discards (Camphuysen et al. 1995). They are socially dominant species and out-compete other seabirds when the trawl comes to the surface. These two species obtain substantial amounts of prey by robbing other scavengers (Tasker et al. 2000). The relative importance of the Frisian Front as feeding areas for seabirds is unknown, and based solely on observed numbers (Jak et al. 2009). NOTE: There is a general agreement to reduce discards and the potential effects of an ensuing reduced food availability will not be considered as a relevant issue for the impact of fishery on seabirds.

Structure of substrate –Effects of beam trawling on the substrate (see 5.1.1 and 5.1.2) are only relevant to the extent that it may affect food availability of seabirds, but bottom fishes do not seem a major part of the diet of the four conservation species.

Turbidity – There is no specific knowledge on the effects of beam trawling on turbidity of the water column. Effects of beam trawling on the turbidity of the water and potential feeding efficiency of sea birds is only relevant when the turbid state affects the whole water column and remains for some time (see 5.1.1 and 5.1.2).

Sound and visual disturbance – Guillemots generally avoid vessels to some extent, by swimming out of the ship's path. Direct effects do not seem to be large (displacement over tens of meters only). However, fishing attracts large numbers of large gulls and skua's to the area (see above): exactly those birds that guillemots try to avoid while swimming with small chicks at sea (Van Katwijk & Camphuysen 1993). It cannot be excluded that the present fishing intensity is sufficient to cause relevant displacements in season when these birds are the most vulnerable, i.e. when chicks are still small and vulnerable to gull/skua predation (July-August). In contrast, in summer there are large numbers of Lesser black-backed gulls on the Frisian Front and only relatively few Great skuas and Great black-backed gulls.

Rating of effects

Fixed and drift gillnets cause the greatest by-catch of seabirds, and of the conservation objective species of the Frisian Front especially Guillemots, although they also can be caught in purse seines, mid-water trawl nets, and bottom trawl nets (experts at FIMPAS workshop 1).

Effect of fisheries on Great skua, Great black-backed gull, Lesser black-backed gull : UNKNOWN, expected LOW

Effect of trawl fisheries on Guillemot : MEDIUM (due to visual disturbance and attraction of gulls and skuas)

Effect of gill net on Guillemot : MEDIUM - HIGH (due to by-catch)

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5 Gear – impact matrix

5.1 Gear-impact matrix

Table 2 Gear – impact matrix of potential effects

CONSERVATION OBJECTIVES	Beam trawl	Otter trawl	Seine nets	Gill nets	Midwater trawl
Habitats					
H1110_C Inundated sandbanks	high	medium	low	[low]	not relevant
H1170 Open-sea reefs	high	high	[medium]	[low]	not relevant
Marine mammals					
Harbour porpoise	low	low	[low]	medium	[low]
Harbour seal	low	low	[low]	low	[low]
Grey seal	low	low	[low]	low	[low]
Seabirds					
Great skua	low	low	[low]	low	[low]
Great black-backed gull	low	low	[low]	low	[low]
Guillemot	[medium]	[medium]	[medium]	high	[low]
Lesser black-backed gull	low	low	[low]	low	[low]

Note: if insufficient information, impact rating [between brackets] based on reasoning and/or expert judgement.

5.2 Conclusions

Based on Ch. 4 and summarized in the gear – impact matrix above (Table 2), the main body of knowledge is about about effects of various types of bottom trawls (beam trawl and otter board trawl) on bottom habitats and bottom fauna. This (large) body of knowledge is insufficient to specify effects according to gear variation such as tickler chain, chain mats of beam trawl, type of ground rope of otter board trawl, mesh size of the net and codend, or the use of new gear developments such as pulstrawl or sumwing, etc.

Another body of knowledge is about bycatch of marine mammals (mainly harbour porpoise or other cetaceans) and seabirds by gill nets. The facts of occurrence of bycatches and relative susceptibilty of various groups of species is fairly well documented. To interpret this knowledge in view of effects on species, reported numbers caught need to be raised to mortality rates to assess the impact on the total population in relation to the level of gill netting effort, i.e. length of nets and duration of stay. The information on intensity and distribution of gill net effort and on mortality rates and reproduction are currently unavailable or insufficient. Thus, the current knowledge is insufficent to generate knowledge-based conclusions on (strengths of) possible effects.

The effects of gear other than gill nets on marine mammals and seabirds are largely or completely unknown. The same applies to the effects on see floor habitats of gear other than bottom trawls. These data gaps necessarily have to be filled out using expert judgement.

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Justification

Rapport C071/10

Project Number: 4302501002

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Gerjan Piet

Scientist

Signature:

Date: October 2010

Approved: Han J. Lindeboom

Director of Science

Signature:

Date: October 2010

Approved: Jakob Asjes

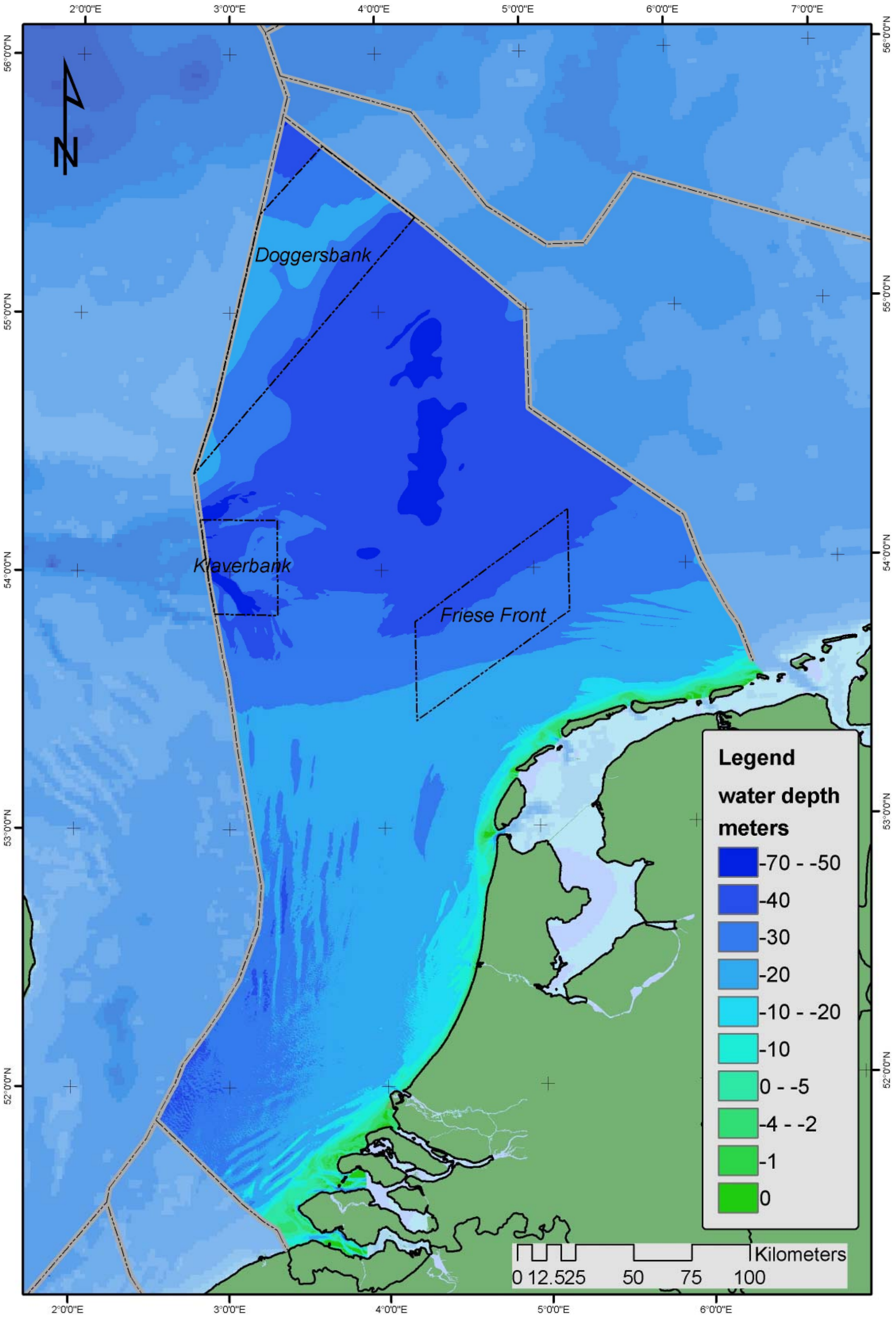
Head of Department Fish

Signature:

Date: October 2010

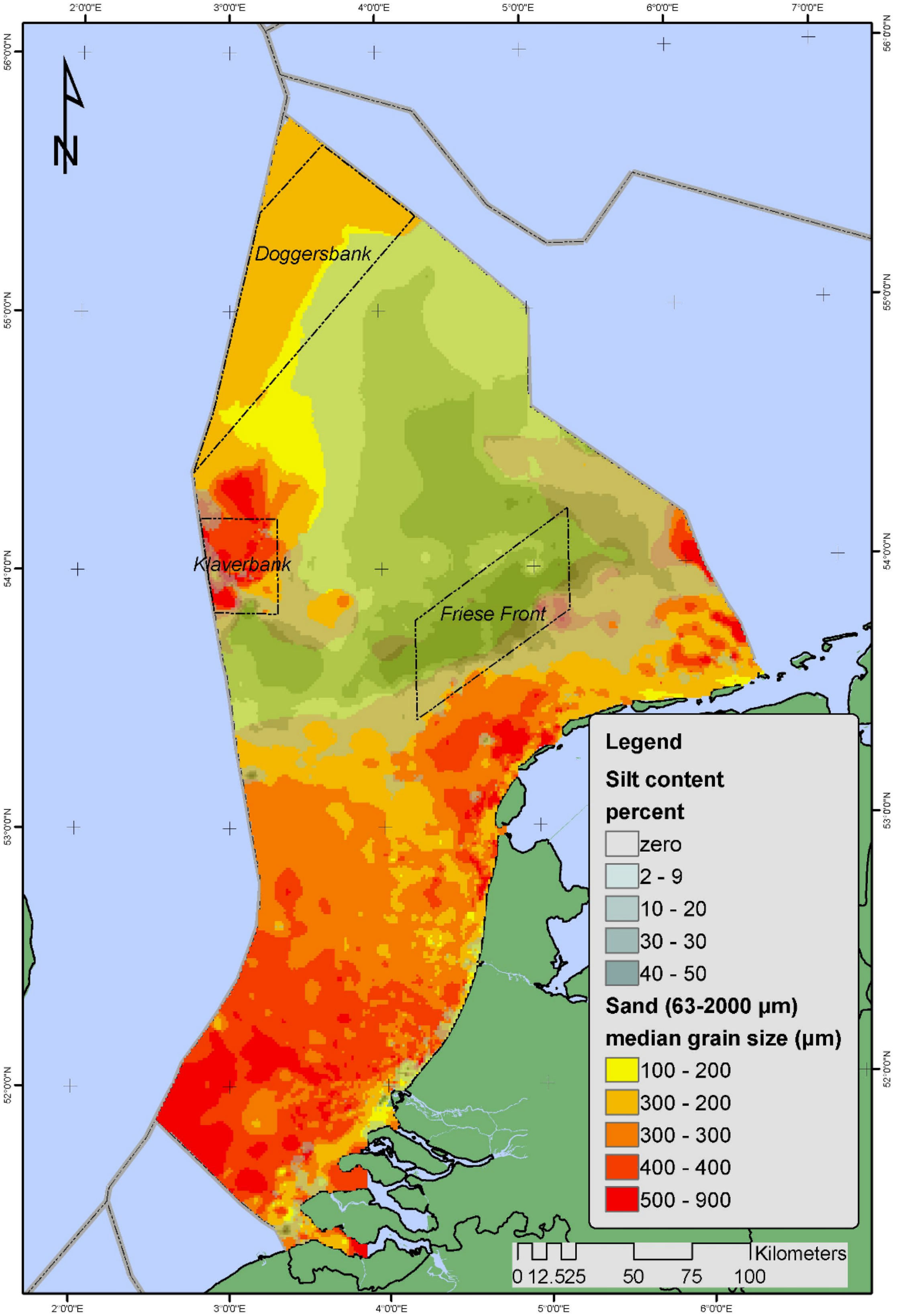
6 Annexes

01 Habitats Depth



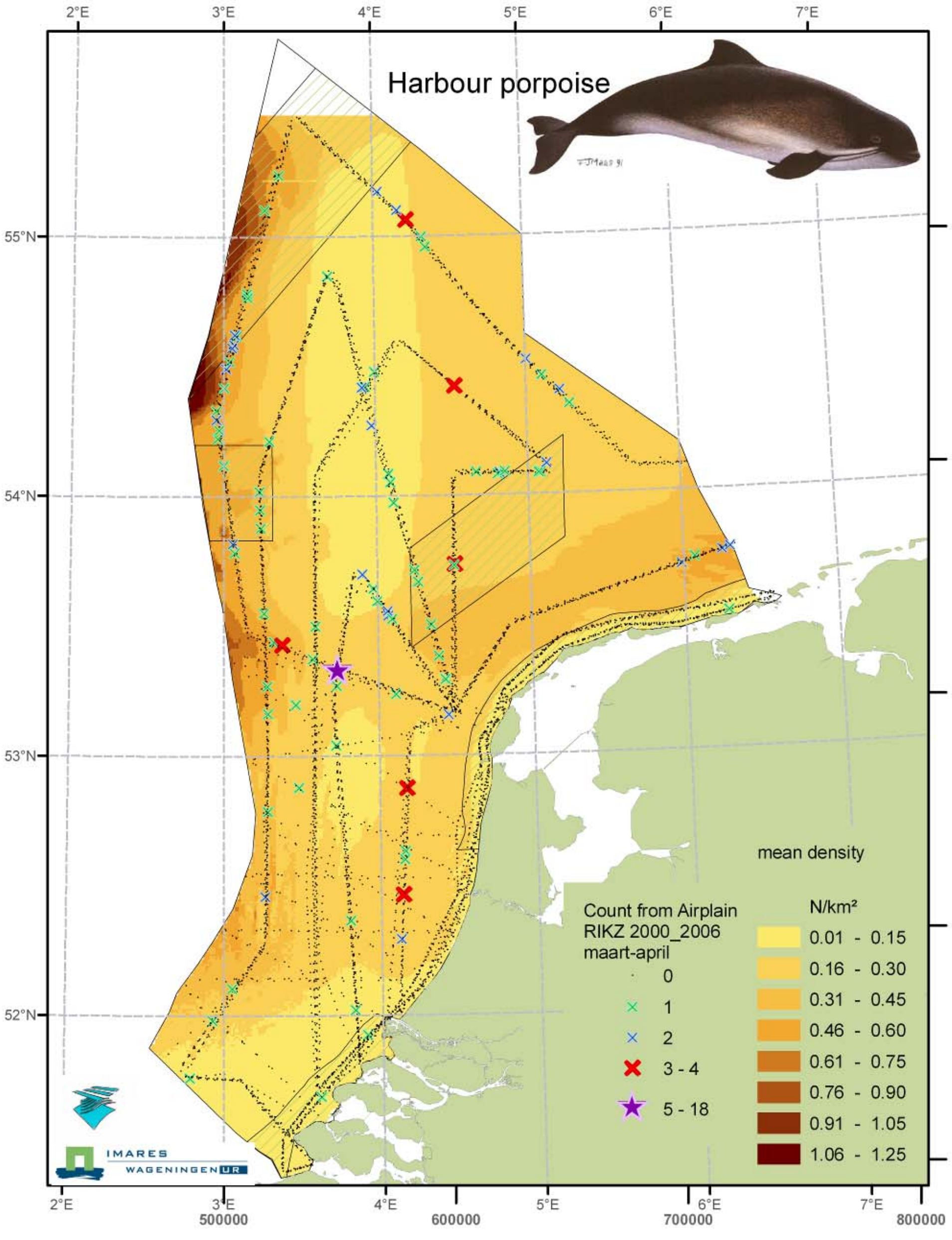
01 InternationalVMS_v2_Habitat=depth.jpg

02 Habitats Sediment



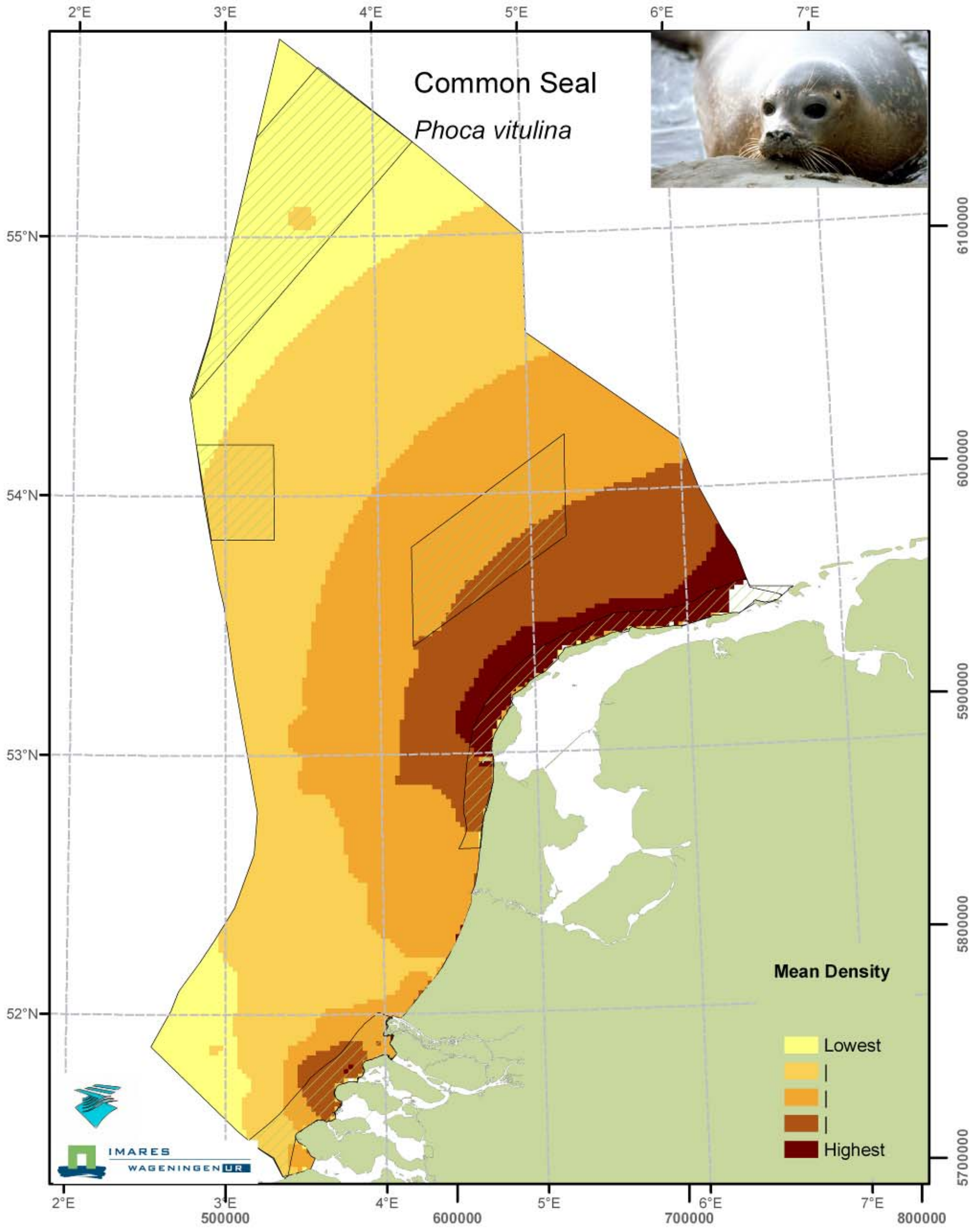
02 InternationalVMS_v2_Sediment_new_classified.jpg

03 Mammals Harbour porpoise March - April



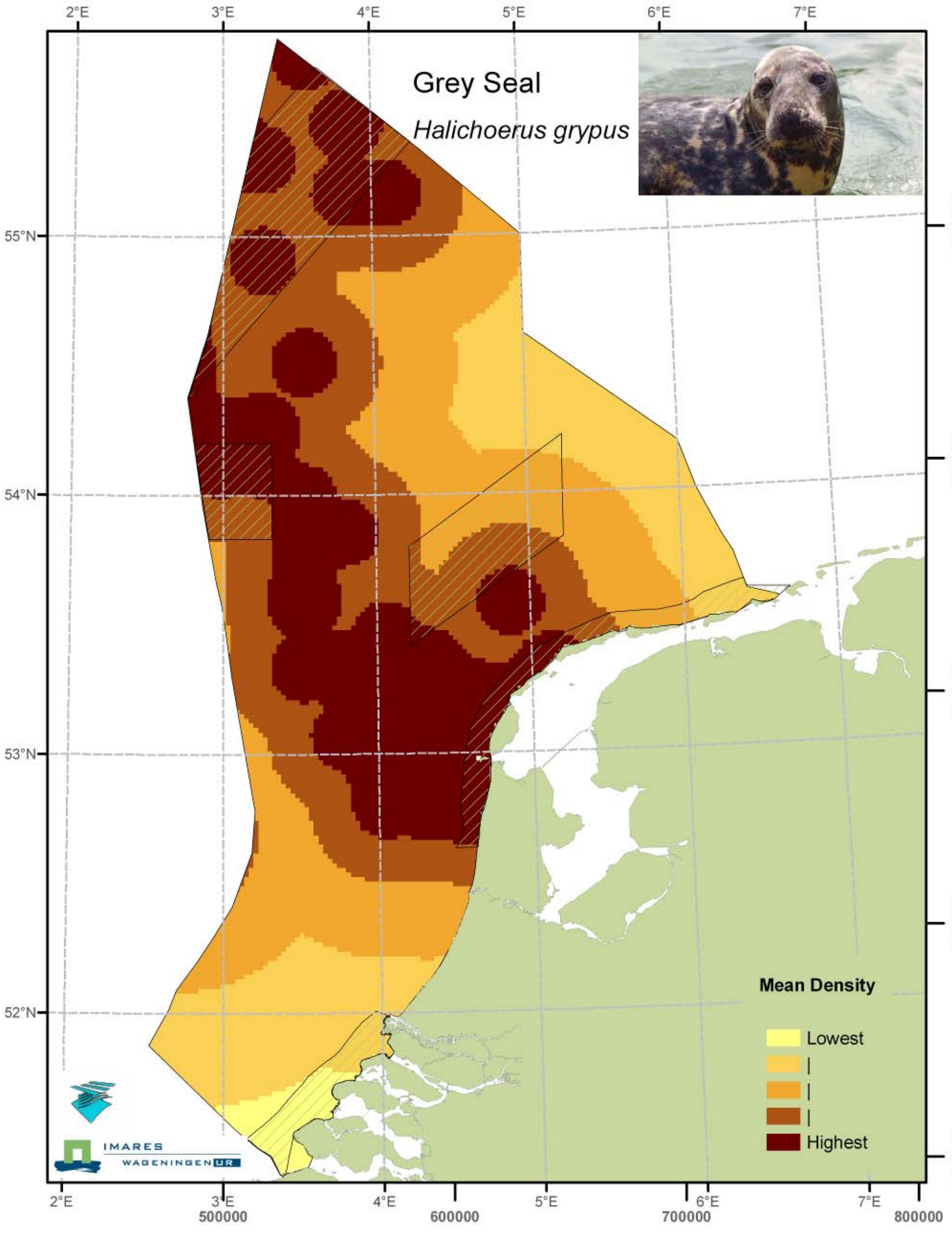
03 HarbourPorpoise_mrz_apr.emf

04 Mammals Common Seal

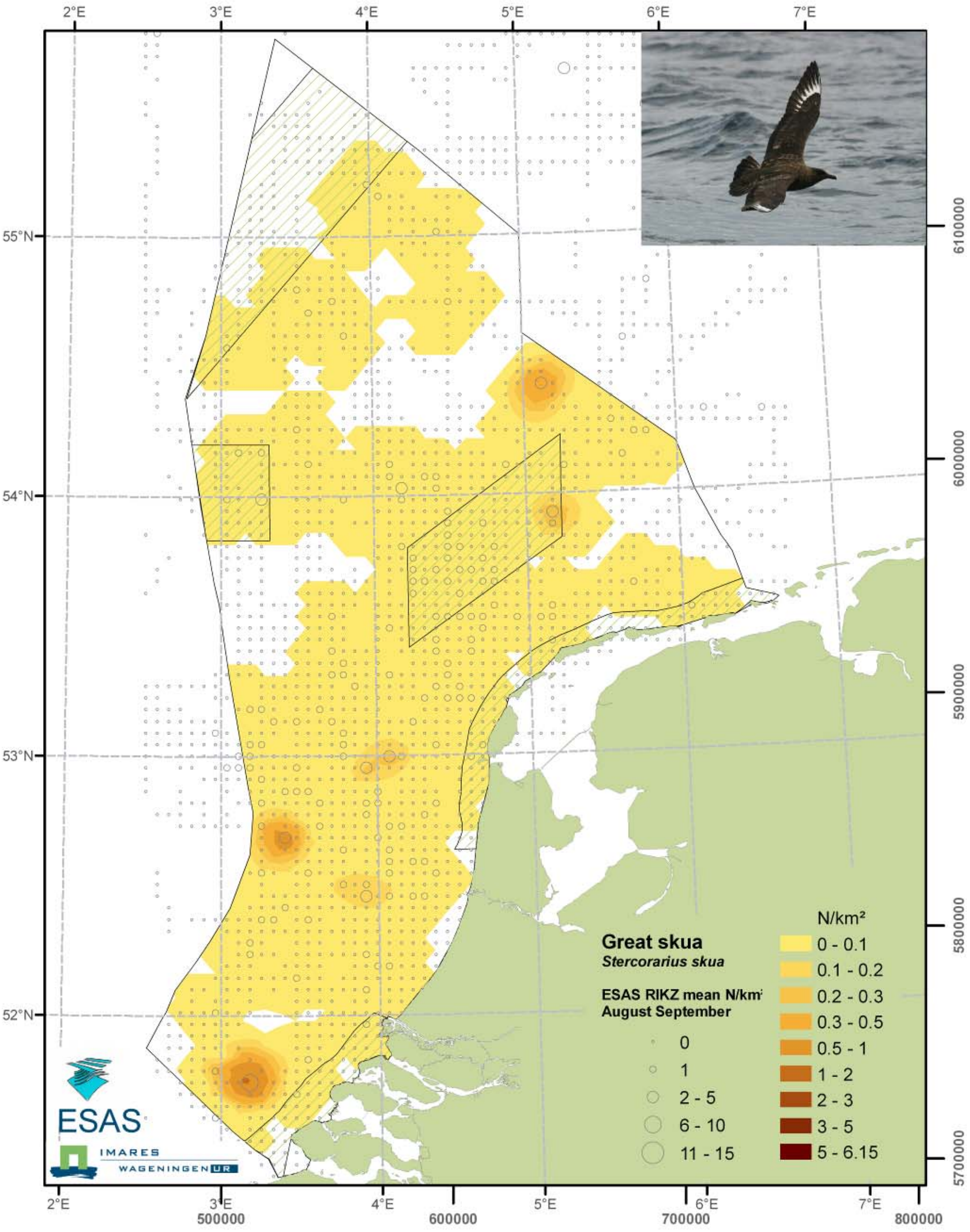


04 CommonSeal.emf

05 Mammals Grey Seal

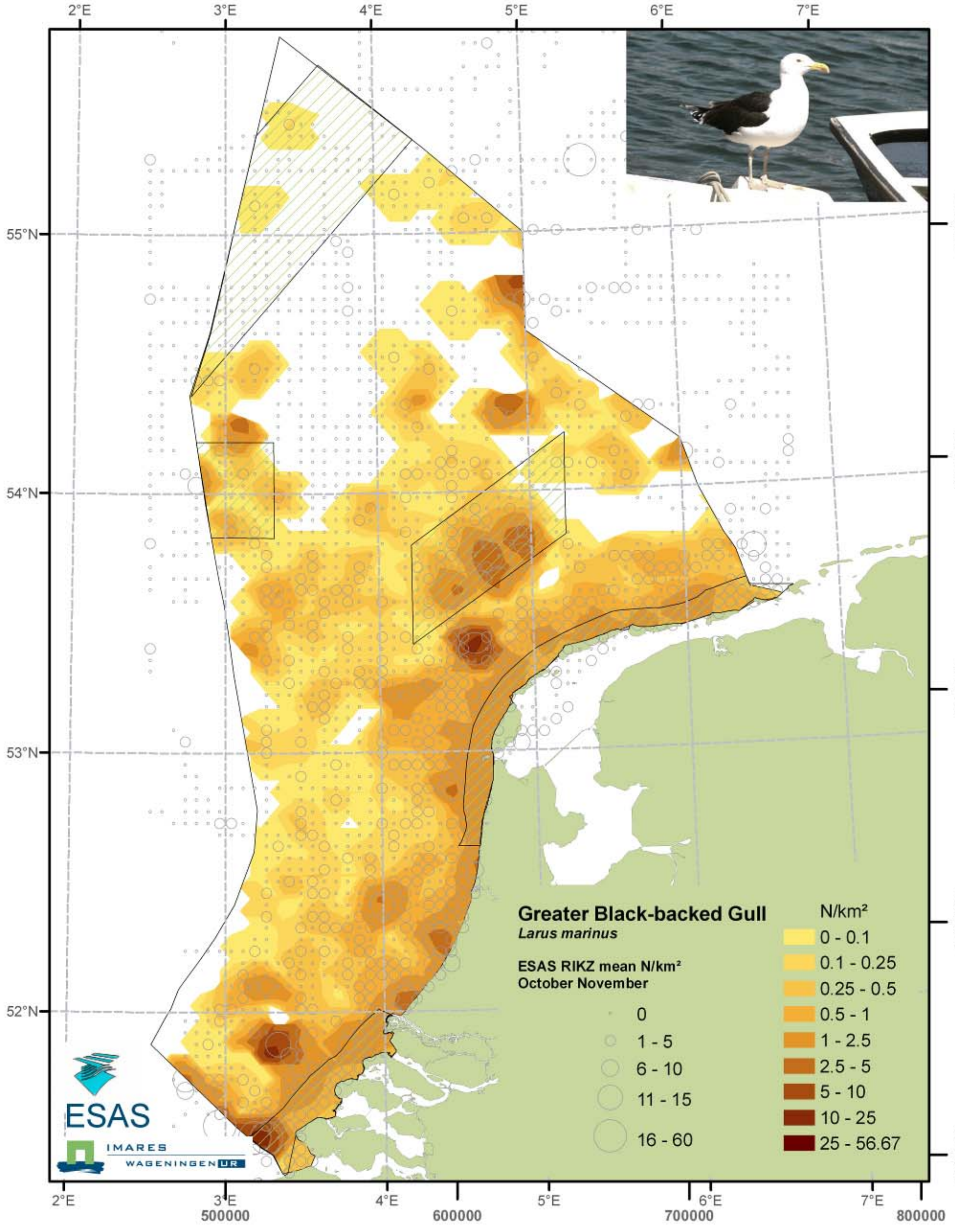


05 Grey_Seal.emf



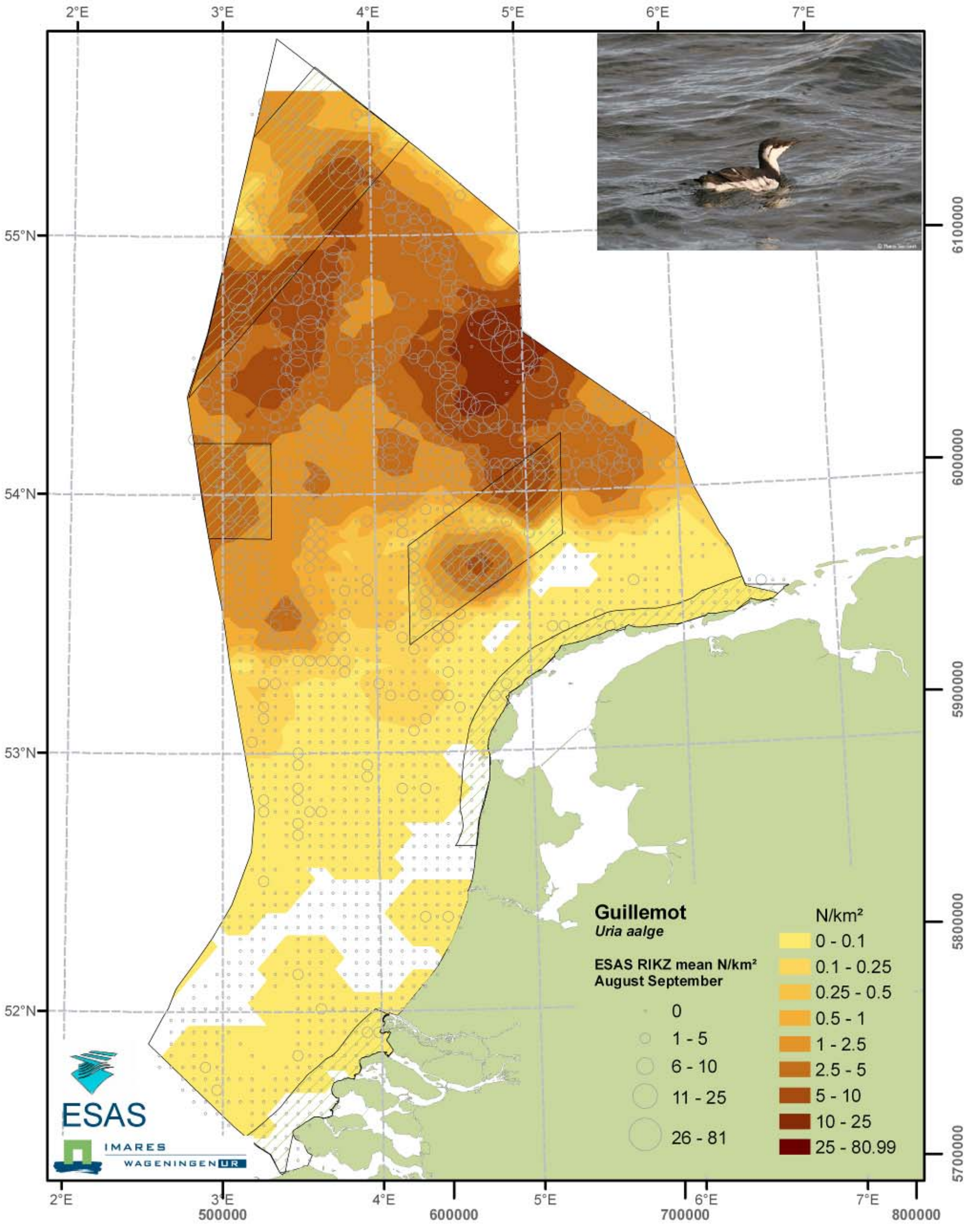
06 Birds_Great_Skua_1.emf

07 Birds Greater Black-backed Gull October - November

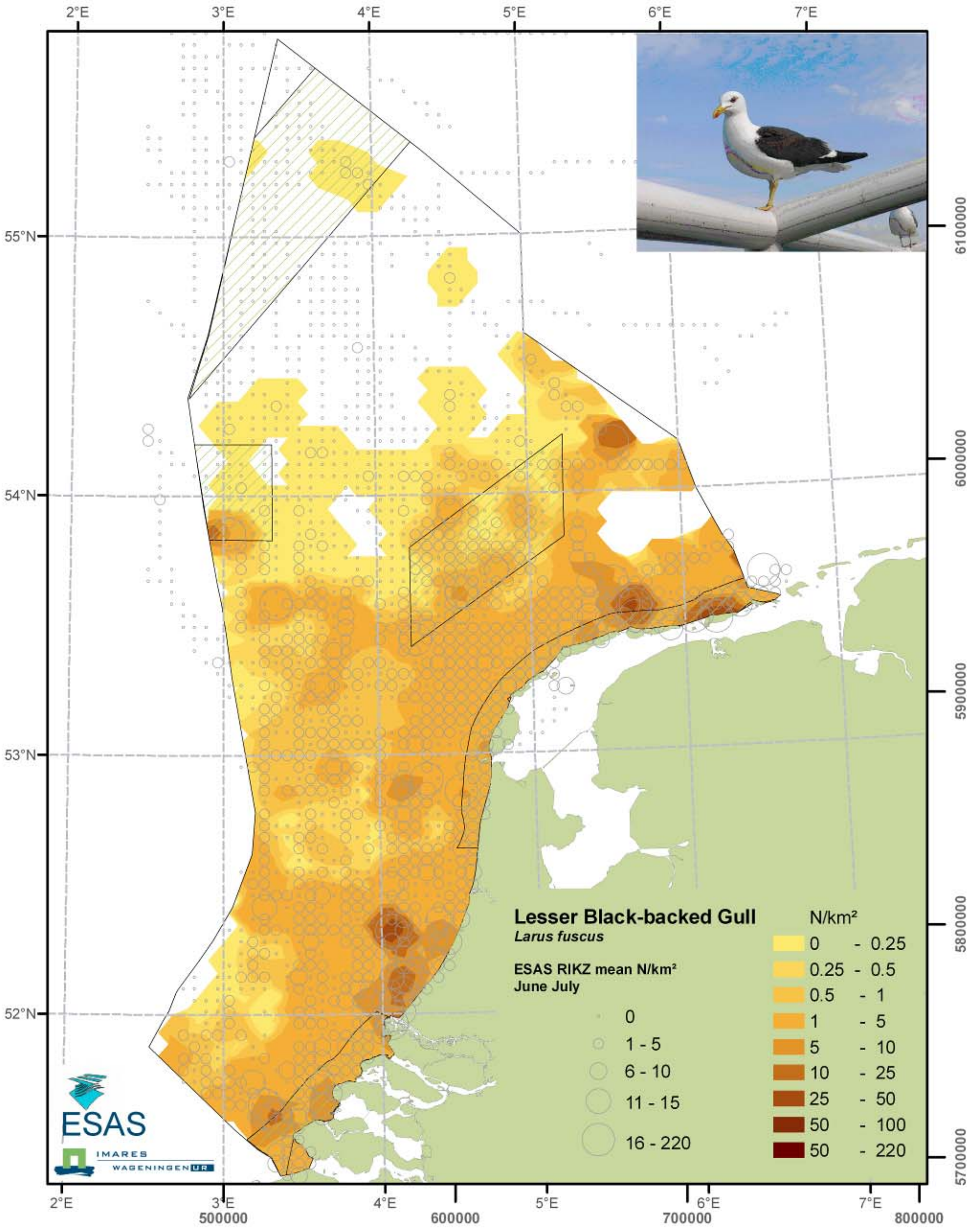


07 Birds_Greater_Black-backed_gull_Oct_Nov.emf

8a Birds Guillemot August - September

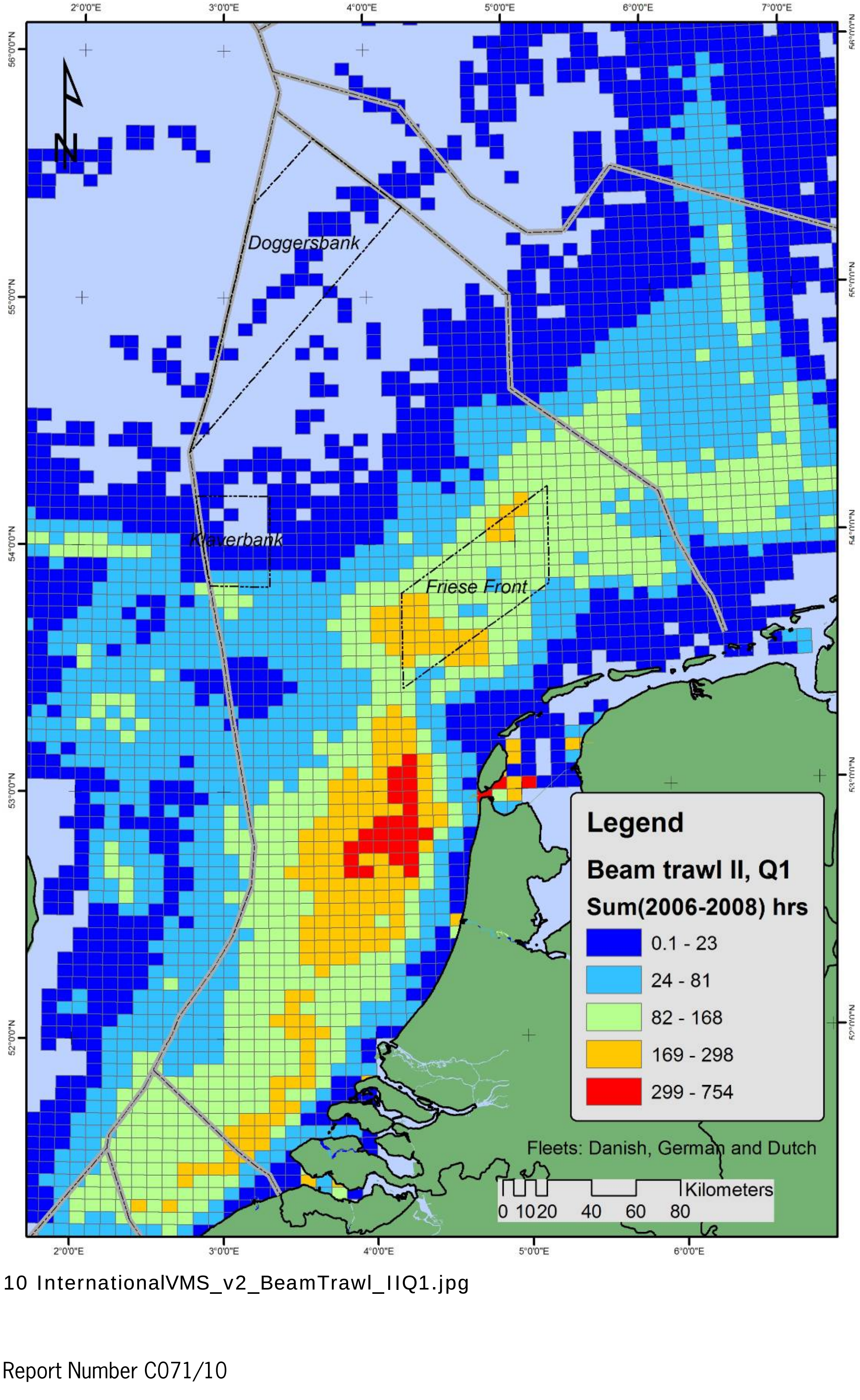


08 Birds_Guillemot_Aug_Sep.emf



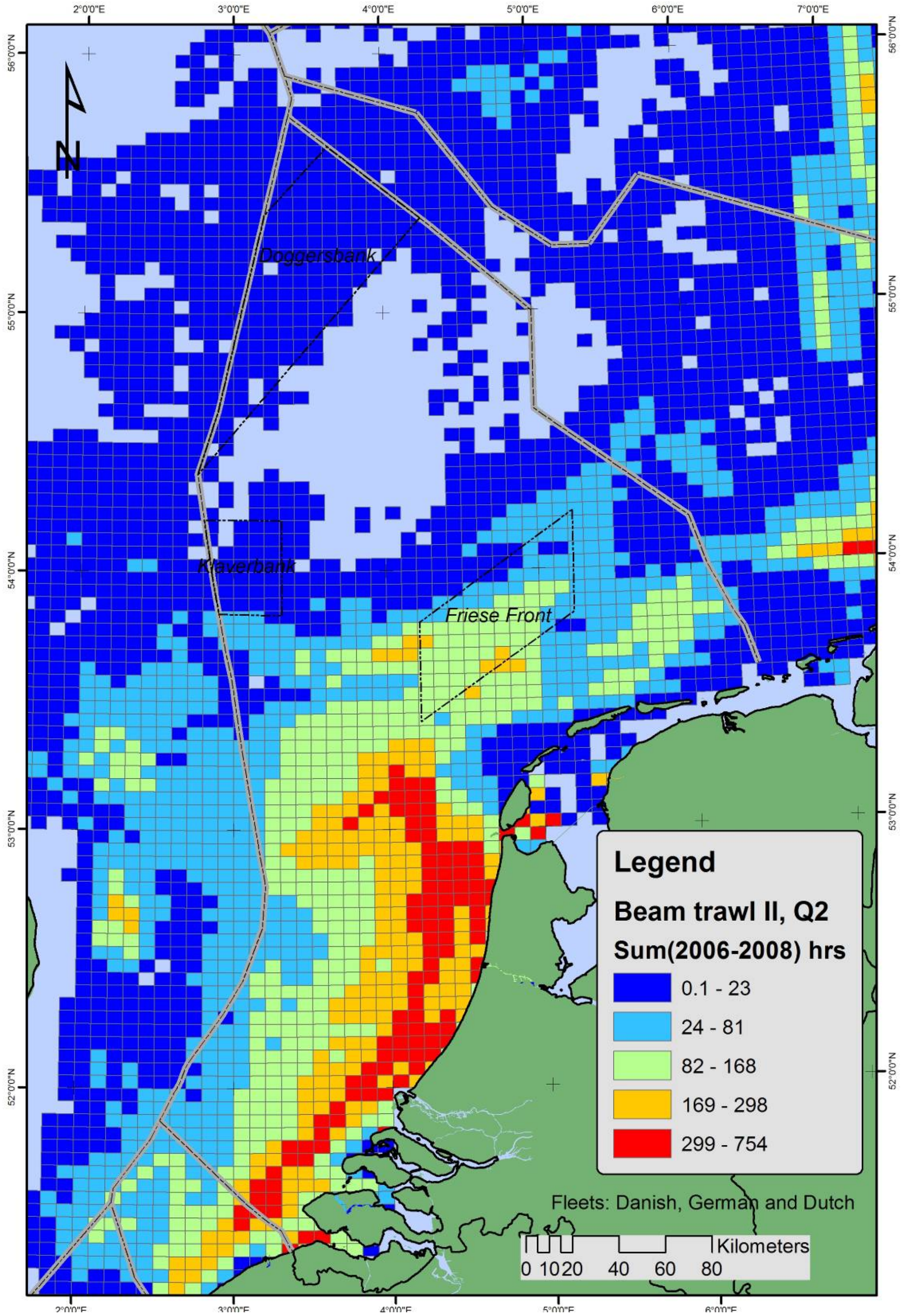
09 Birds_Lesser_Black-backed_gull_Jun_Jul.emf

10 Beam Trawl Q1 II = mesh size > 80mm



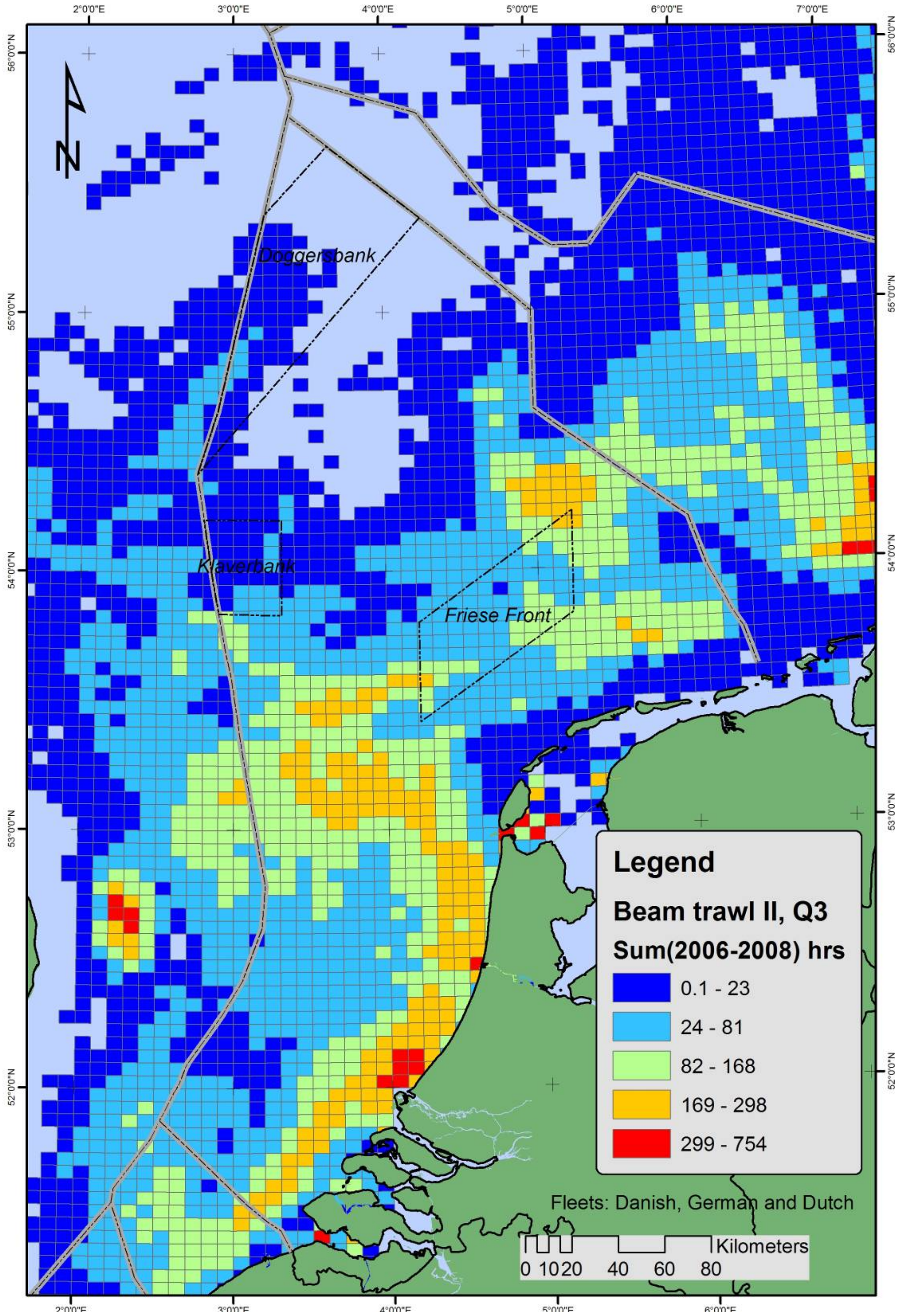
10 InternationalVMS_v2_BeamTrawl_IIQ1.jpg

11 Beam Trawl Q2 II = mesh size > 80mm



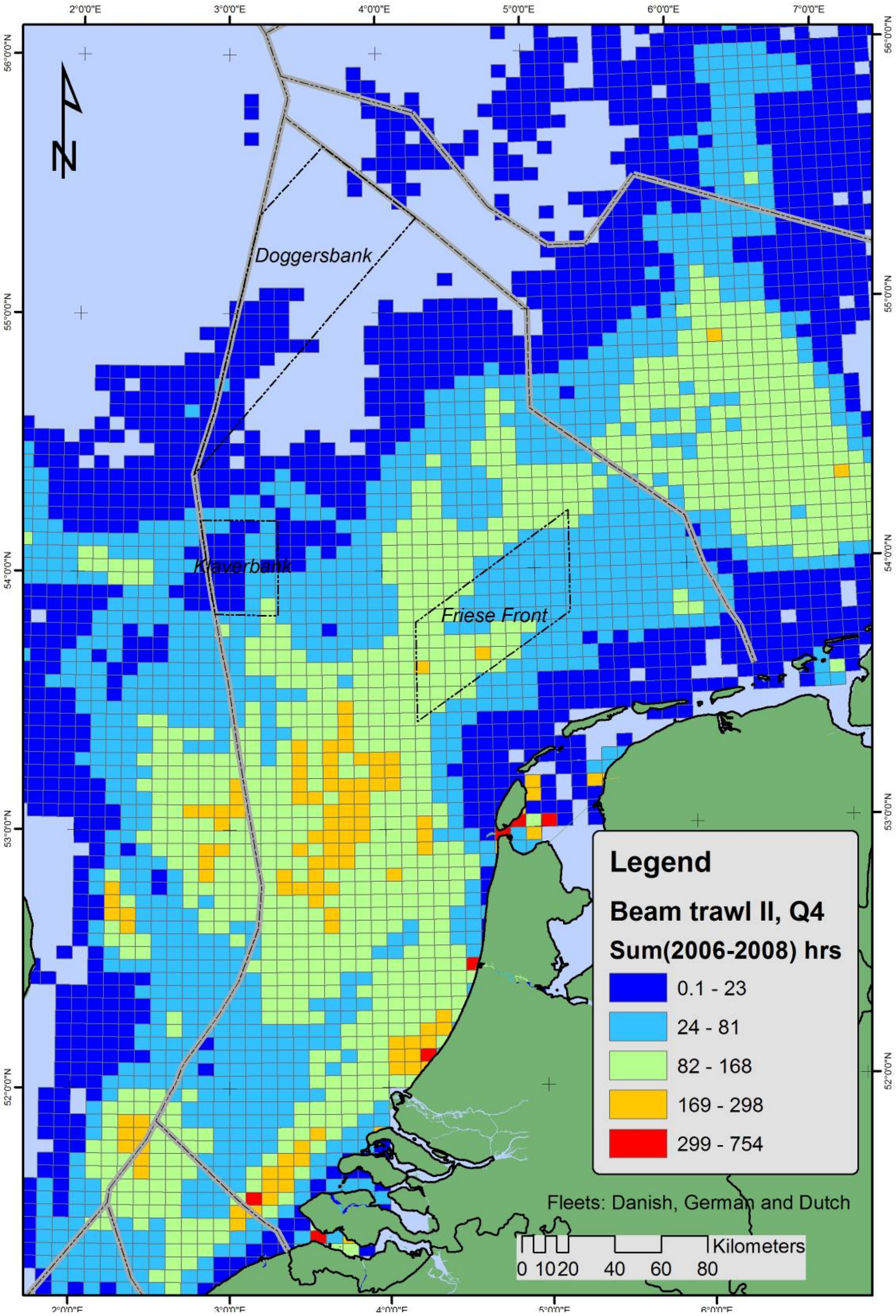
11 InternationalVMS_v2_BeamTrawl_IIQ2.jpg

12 Beam Trawl Q3 II = mesh size > 80mm



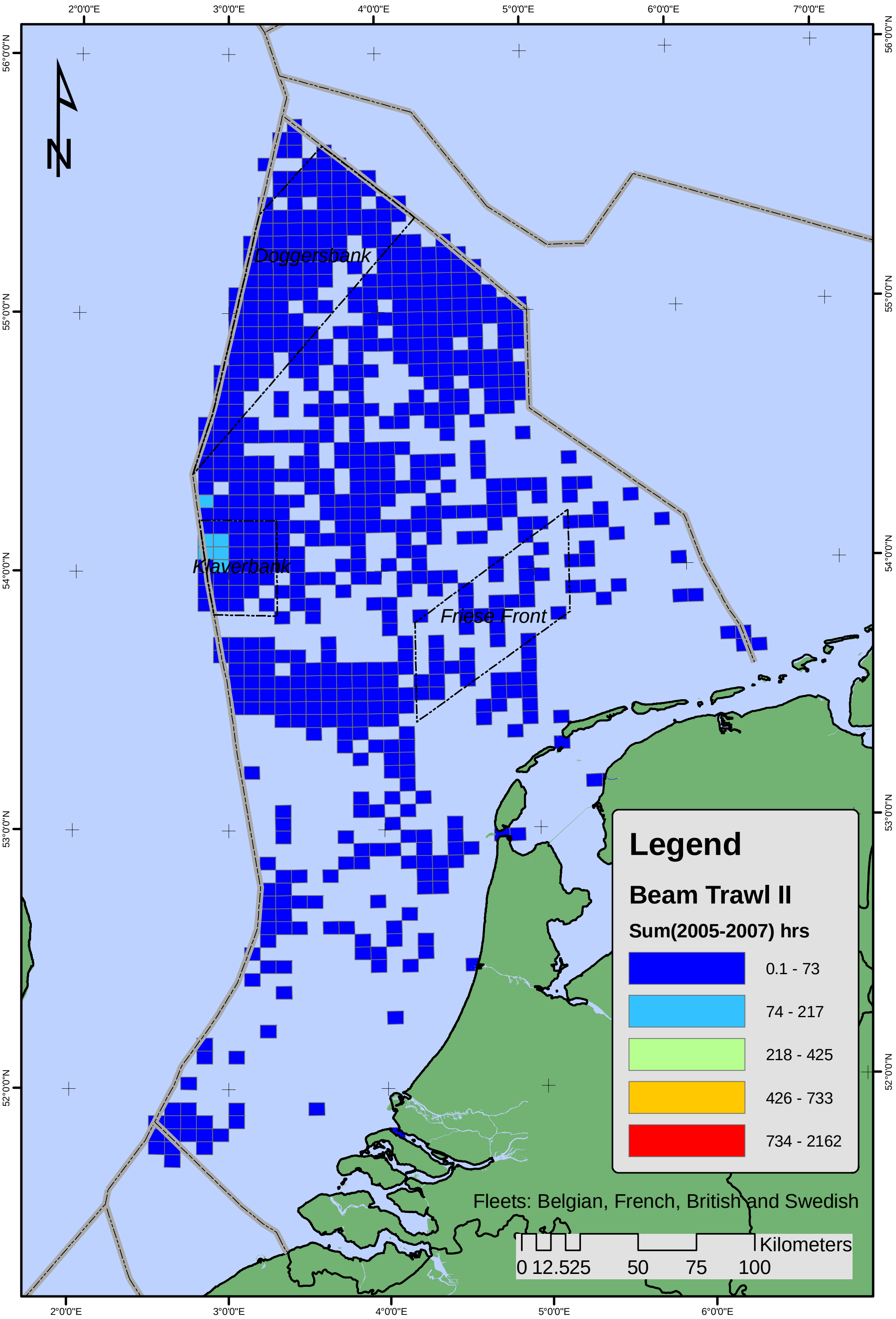
12 InternationalVMS_v2_BeamTrawl_IIQ3.jpg

13 Beam Trawl Q4 II = mesh size > 80mm



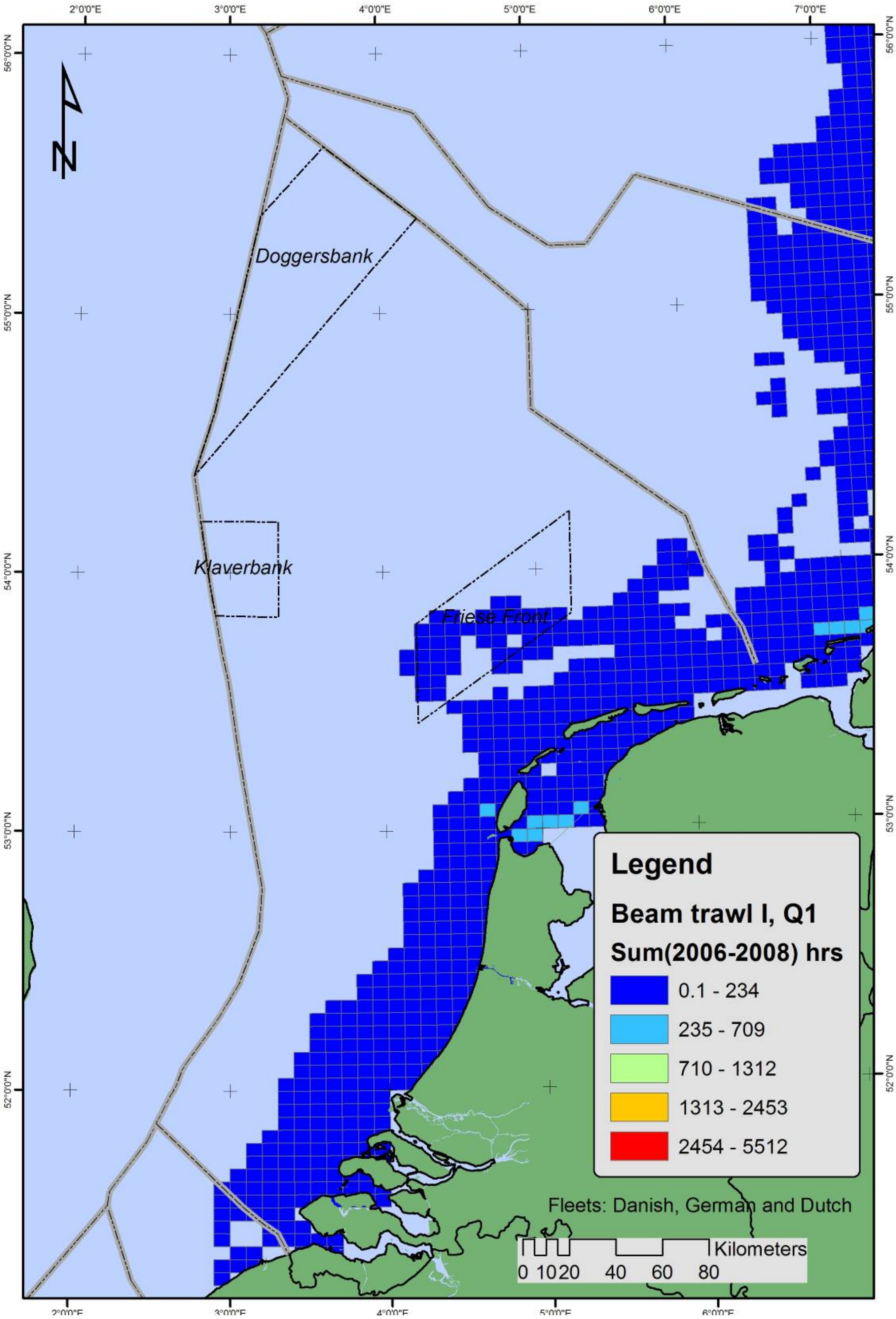
13 InternationalVMS_v2_BeamTrawl_IIQ4.jpg

14 Beam Trawl II = >221 kW



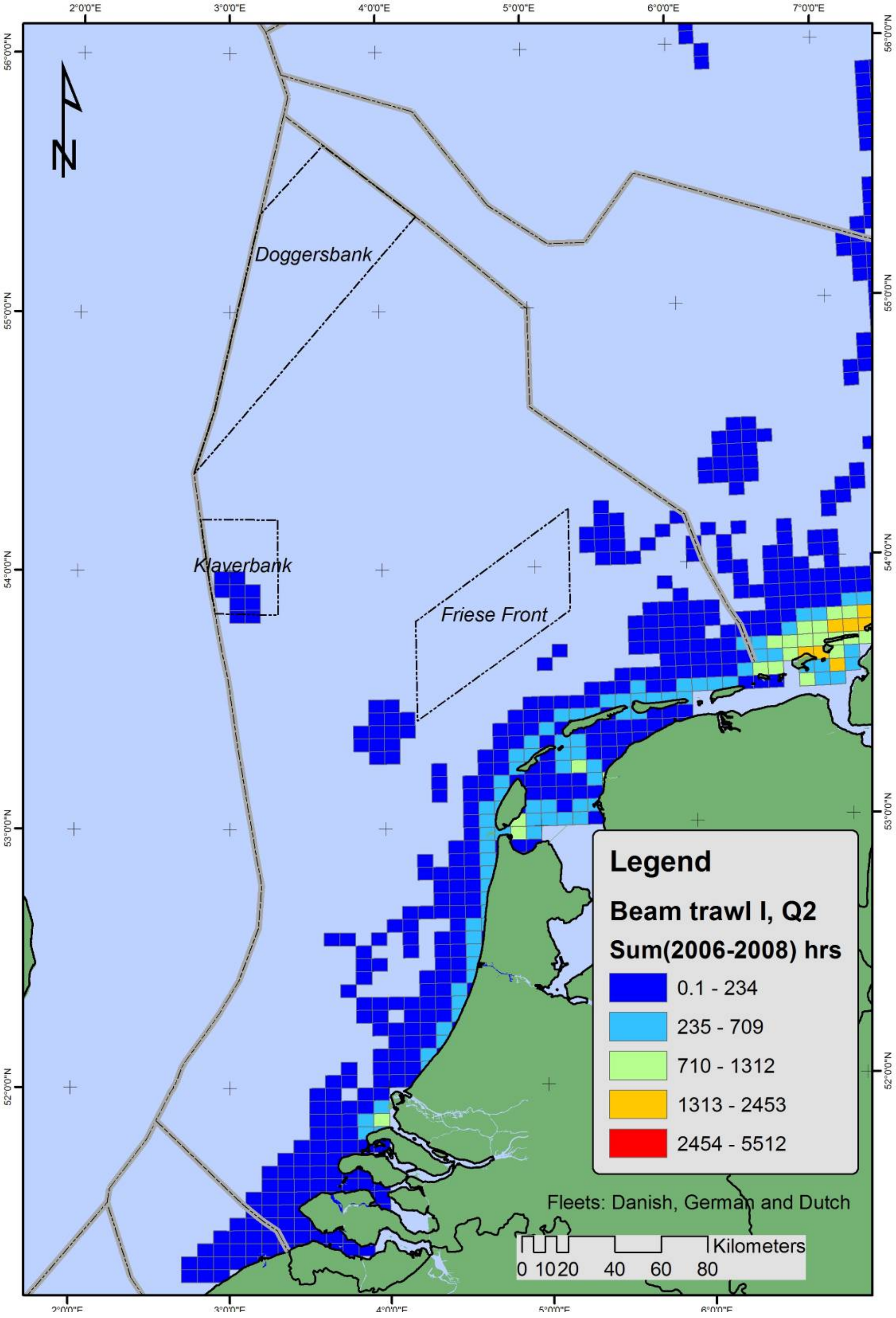
14 InternationalVMS_v2_foreign0507_final_BeamII.emf

15 Beam Trawl Q1 I = mesh size 16 -31 mm



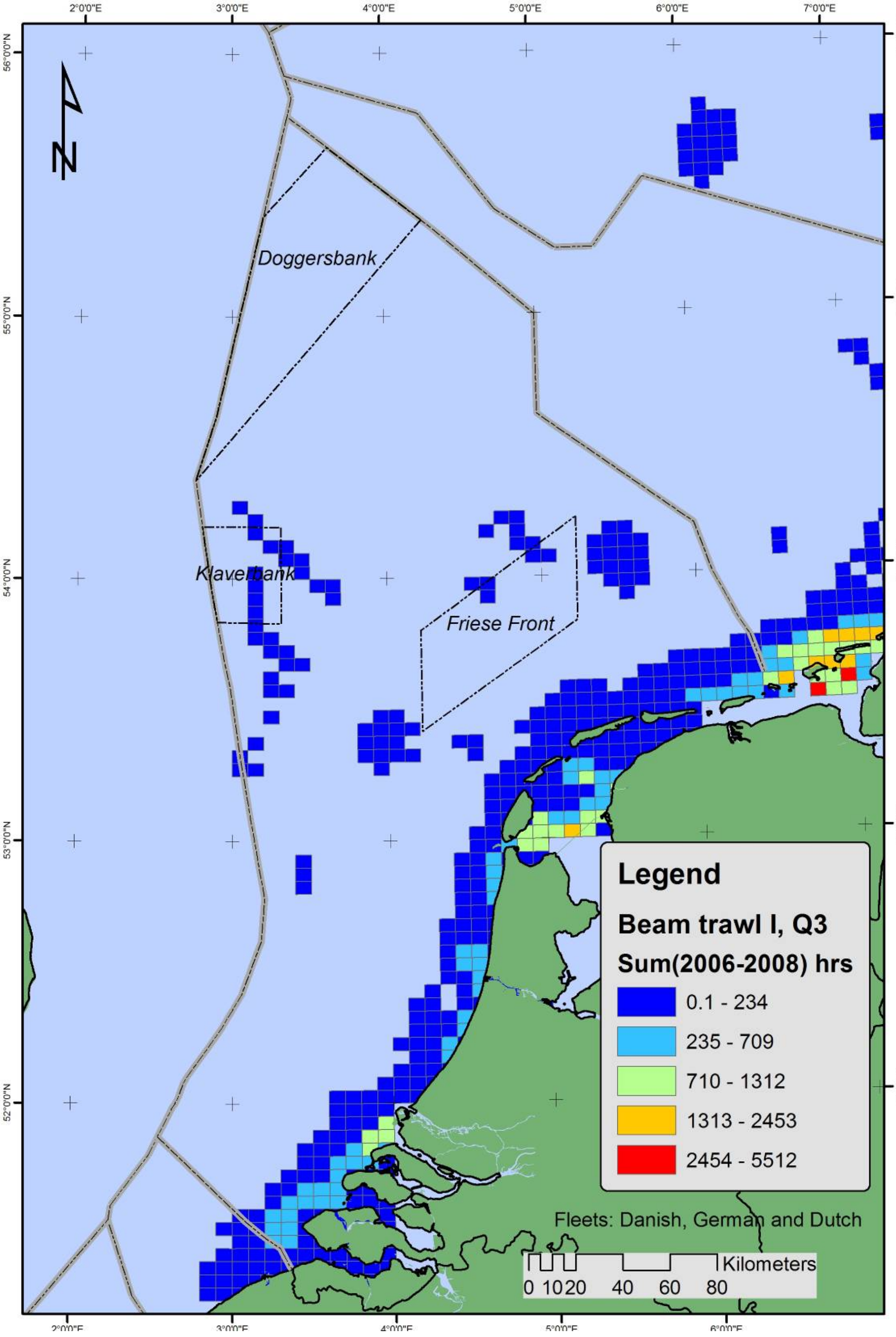
15 InternationalVMS_v2_BeamTrawl_IQ1.jpg

16 Beam Trawl Q2 I = mesh size 16 -31 mm



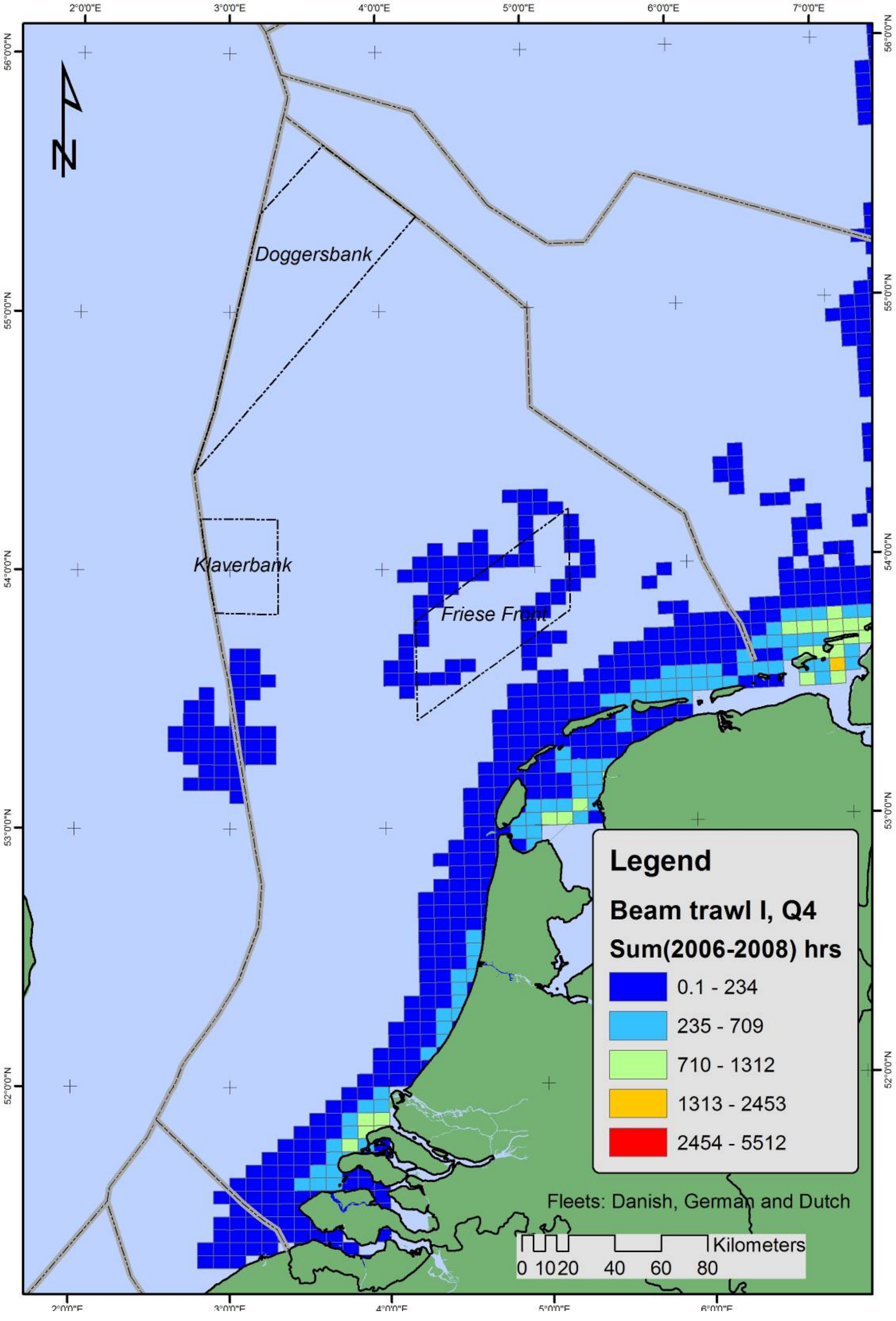
16 InternationalVMS_v2_BeamTrawl_IQ2.jpg

17 Beam Trawl Q3 I = mesh size 16 -31 mm



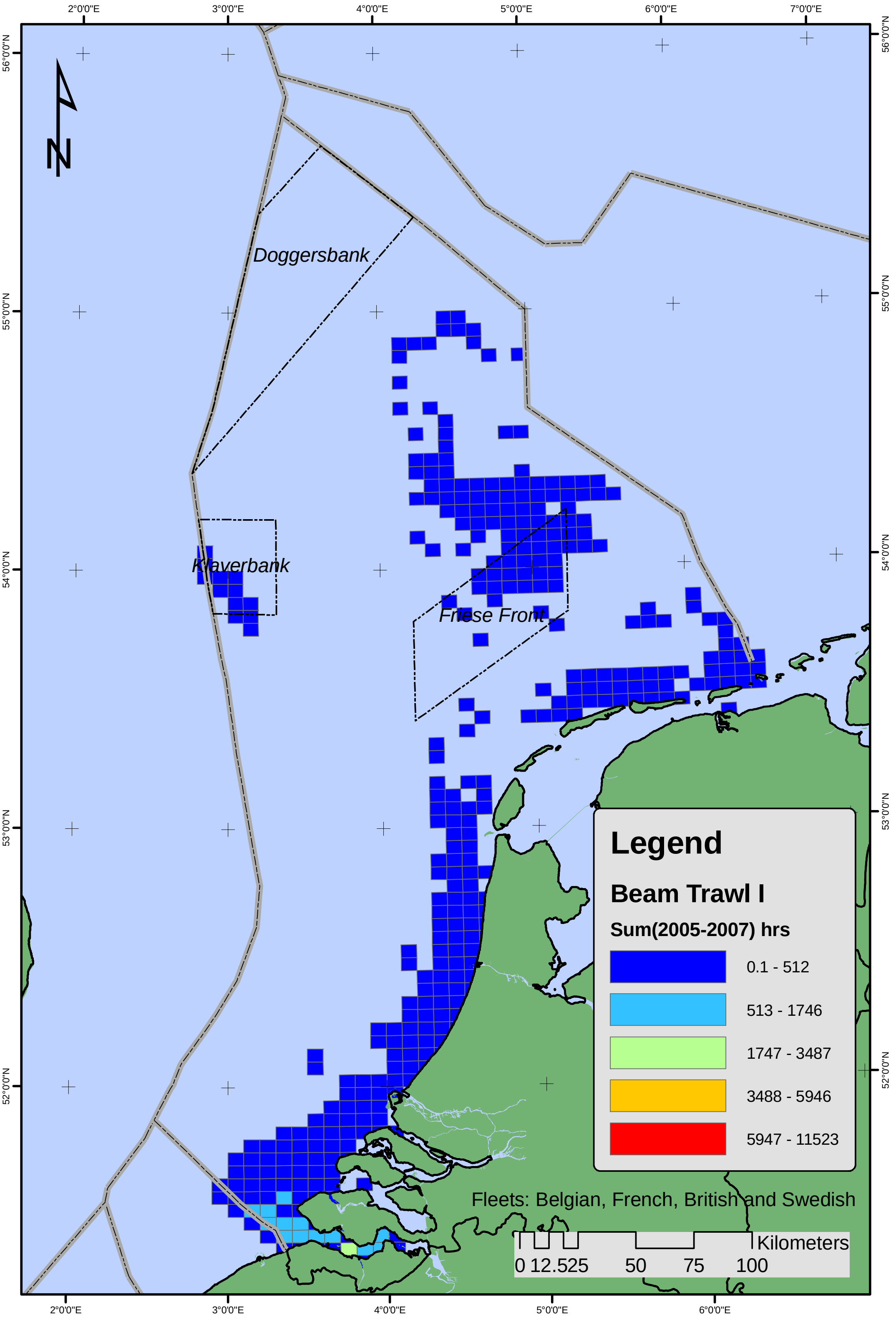
17 InternationalVMS_v2_BeamTrawl_IQ3.jpg

18 Beam Trawl Q4 I = mesh size 16 -31 mm



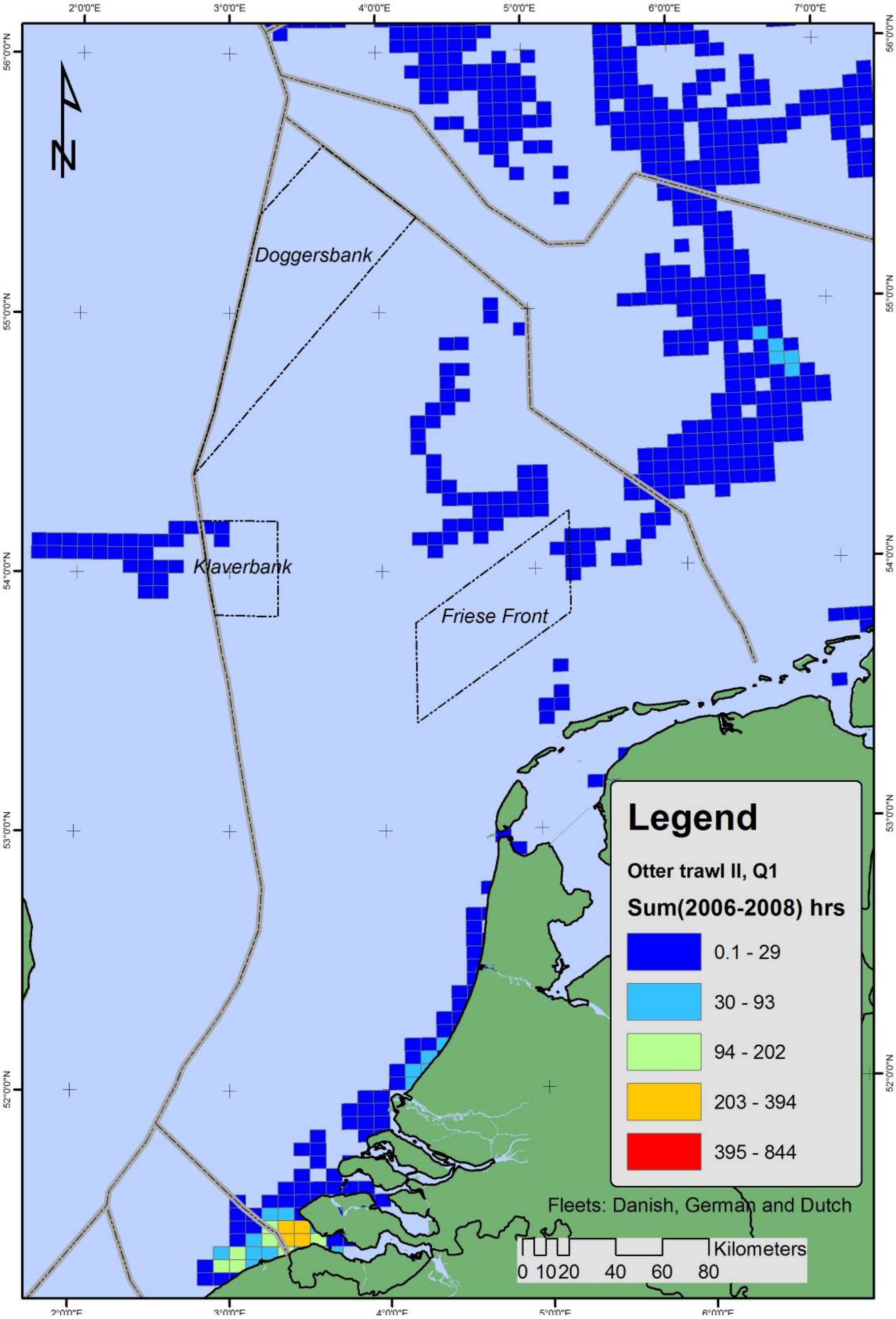
18 InternationalVMS_v2_BeamTrawl_IQ4.jpg

19 Beam Trawl I <=221 kW



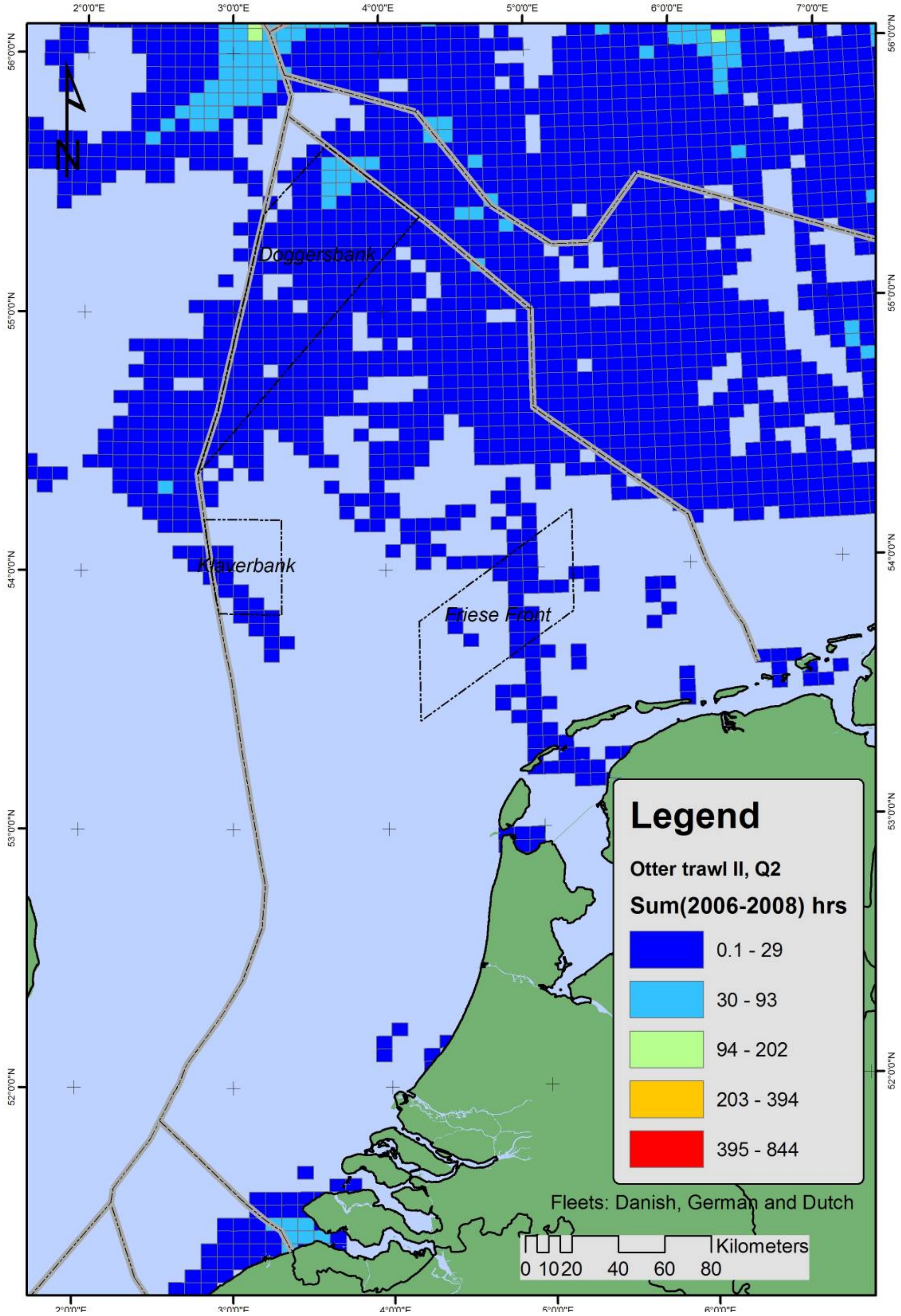
19 InternationalVMS_v2_foreign0507_final_BeamI.emf

20 Otter Trawl Q1 II = mesh size >100 mm



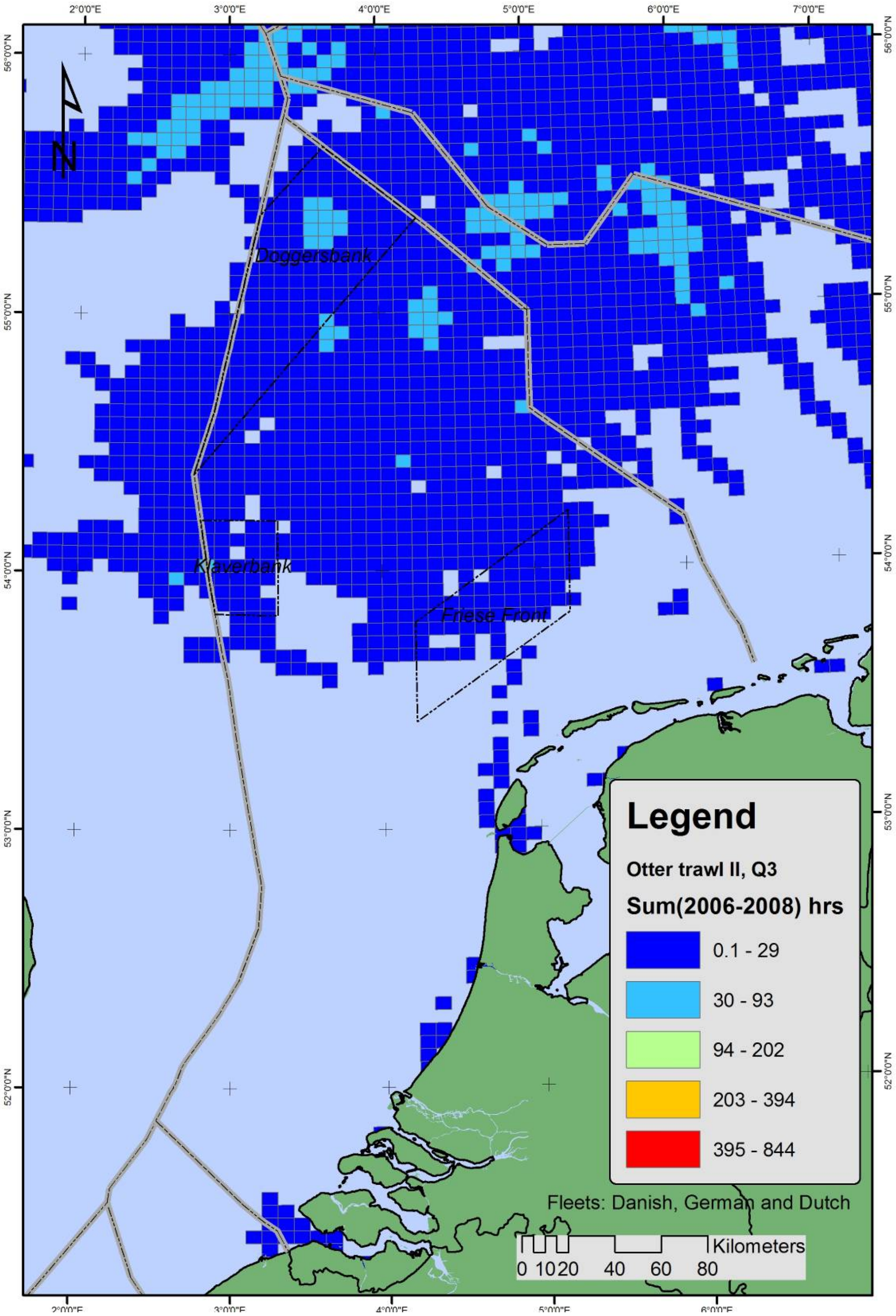
20 InternationalVMS_v2_OtterTrawl_IIQ1.jpg

21 Otter Trawl Q2 II = mesh size >100 mm



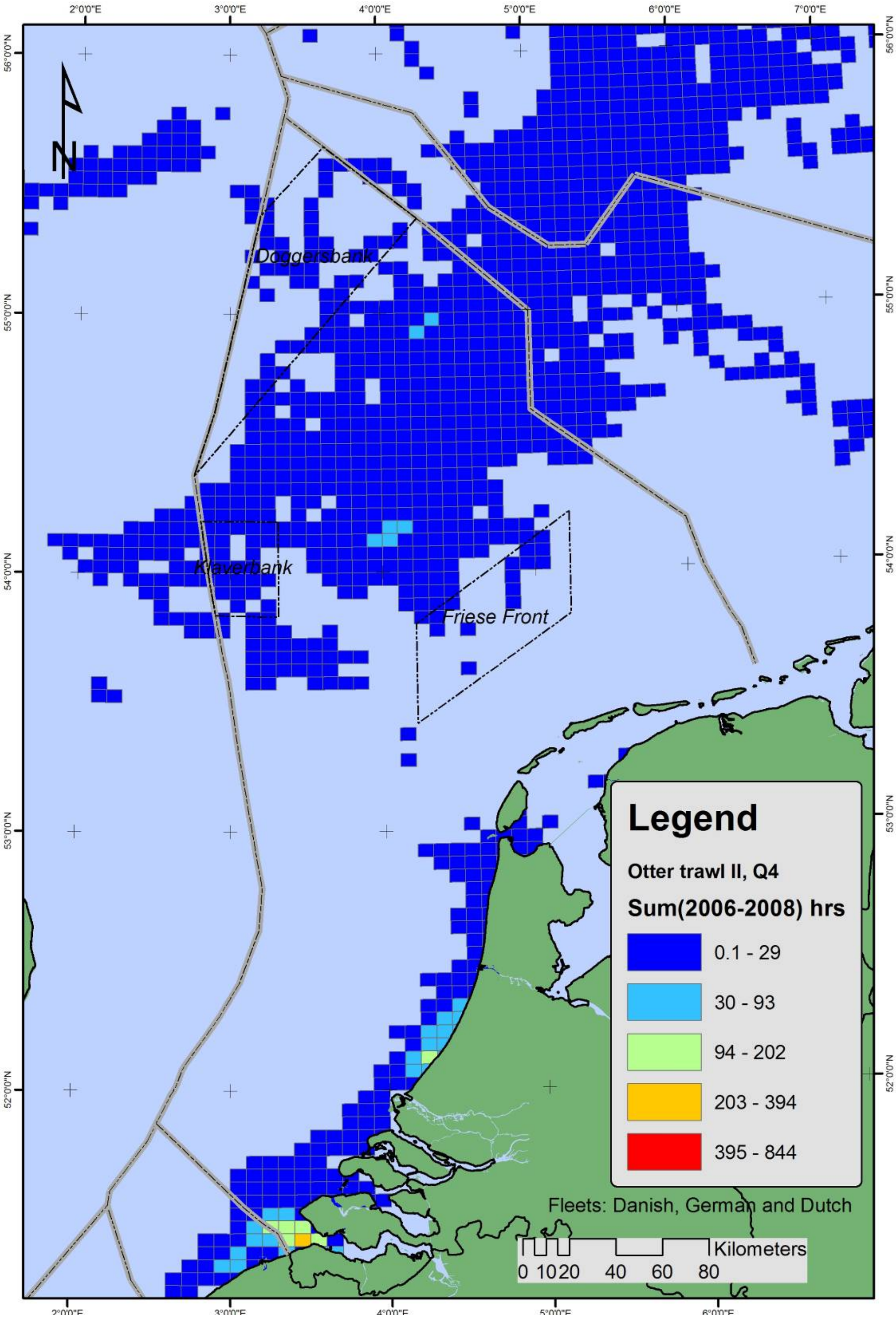
21 InternationalVMS_v2_OtterTrawl_IIQ2.jpg

22 Otter Trawl Q3 II = mesh size >100 mm



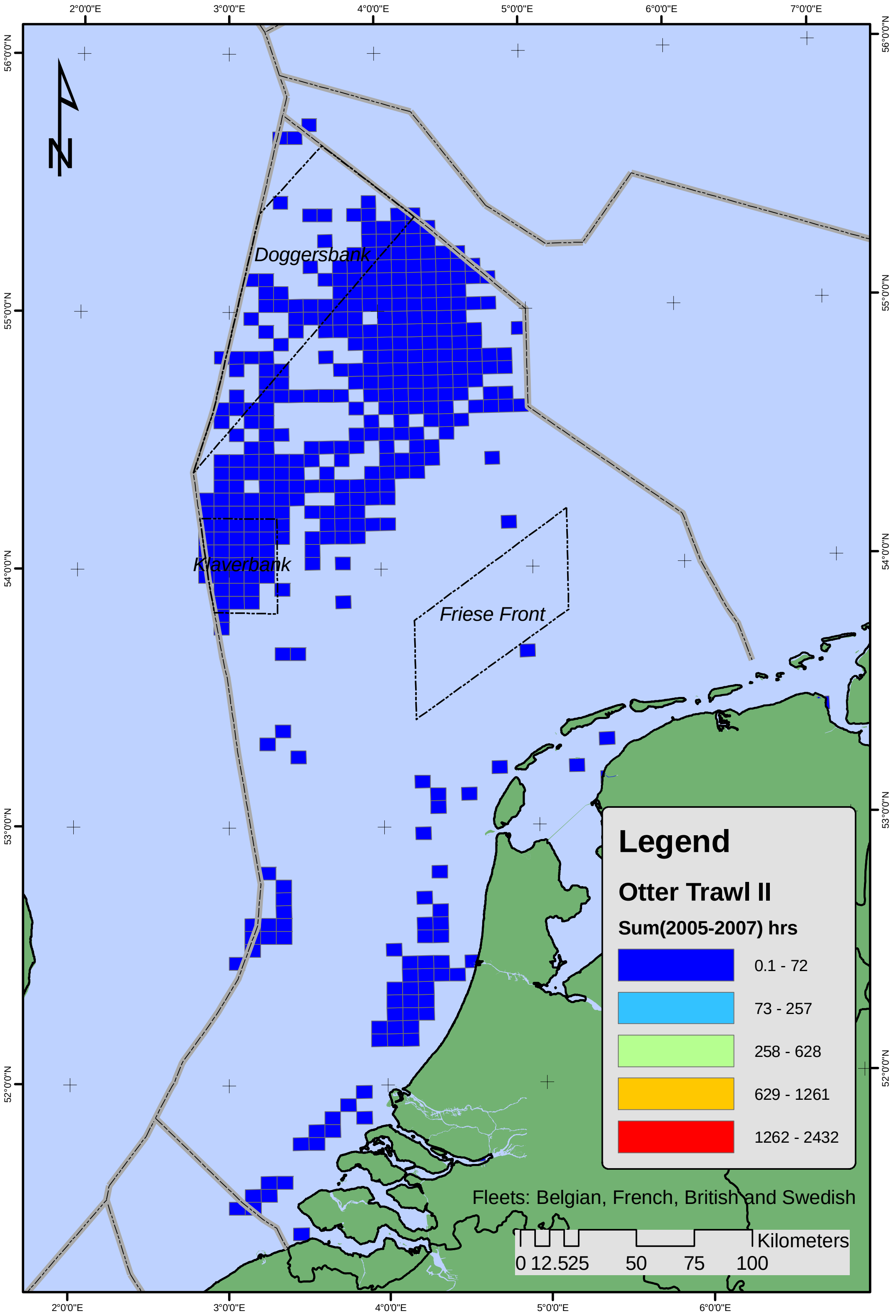
22 InternationalVMS_v2_OtterTrawl_IIQ3.jpg

23 Otter Trawl Q4 II = mesh size >100 mm



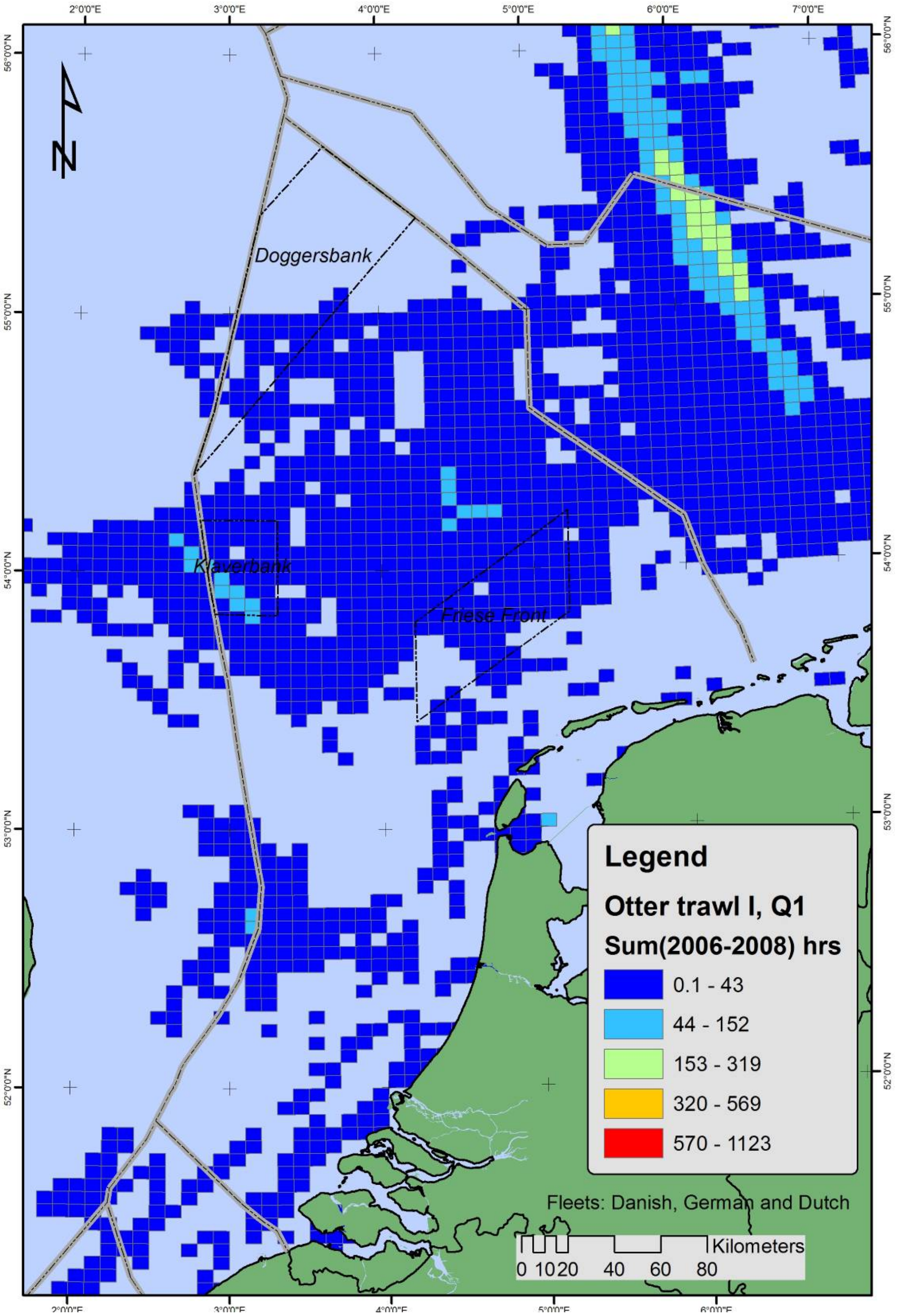
23 InternationalVMS_v2_OtterTrawl_IIQ4.jpg

24 Otter Trawl II = >221 kW



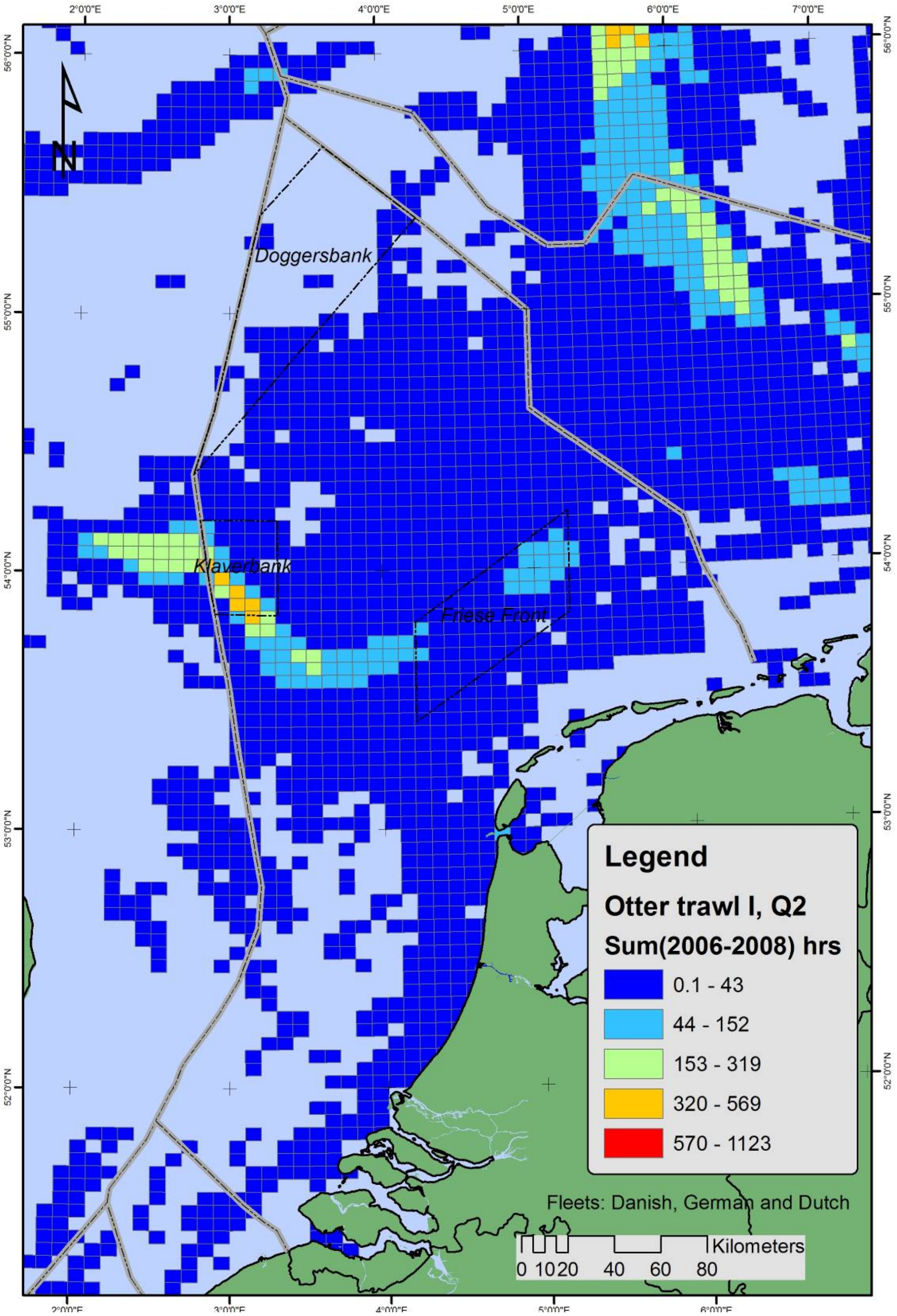
24 InternationalVMS_v2_foreign0507_final_OtterII.emf

22 Otter Trawl Q1 I = mesh size 80 - 99 mm



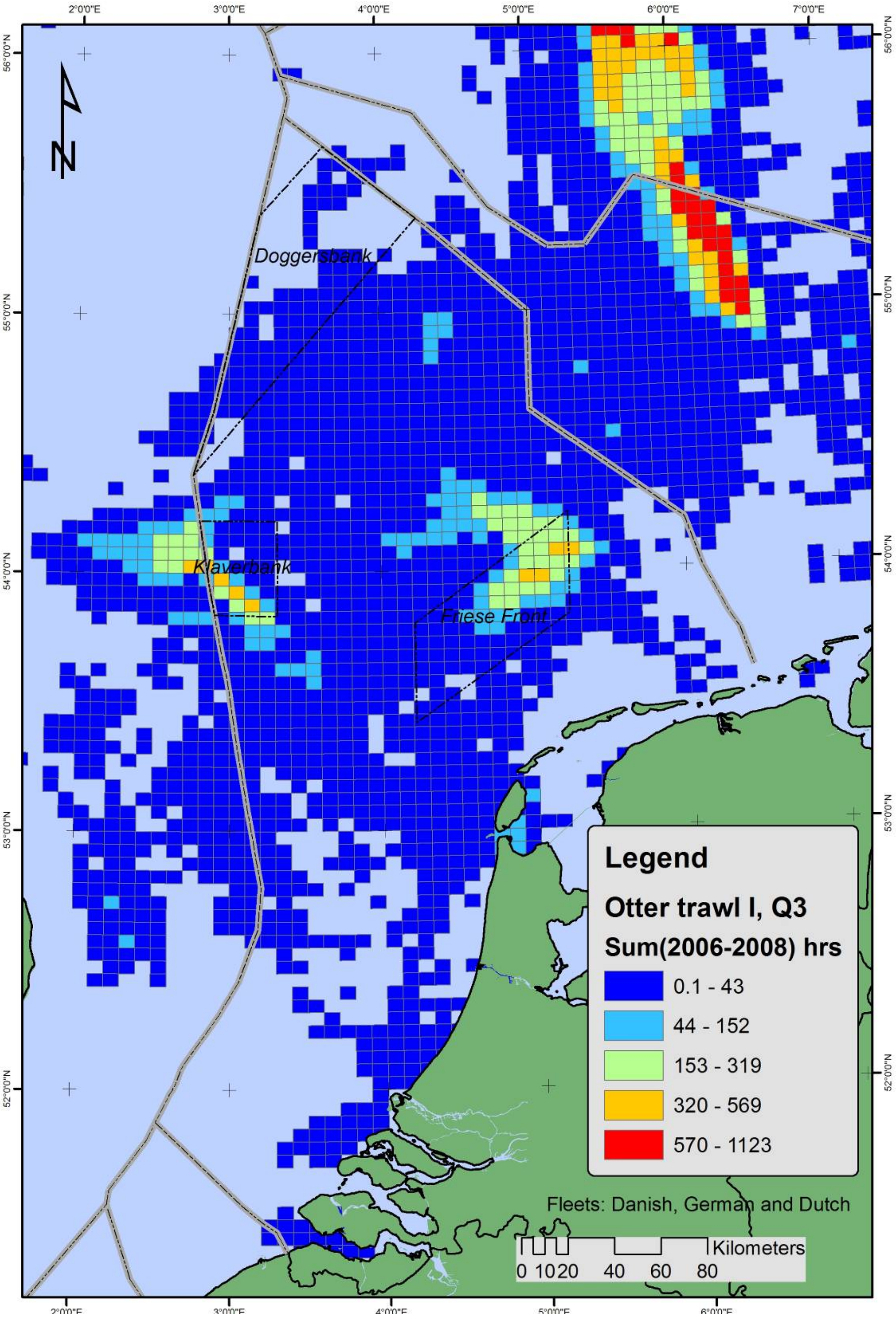
22 InternationalVMS_v2_OtterTrawl_IQ1.jpg

25 Otter Trawl Q2 I = mesh size 80 - 99 mm



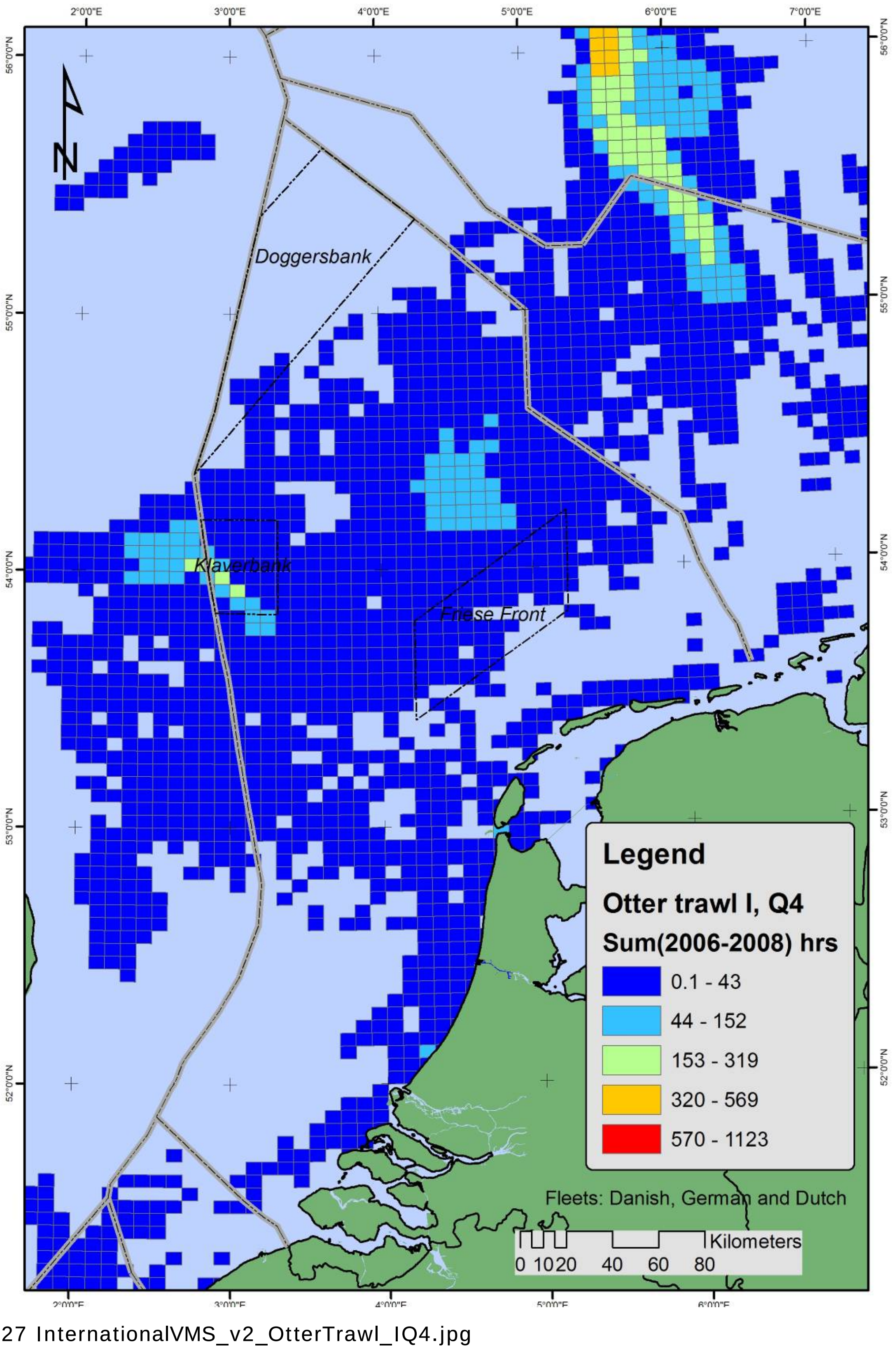
25 InternationalVMS_v2_OtterTrawl_IQ2.jpg

26 Otter Trawl Q3 I = mesh size 80 - 99 mm



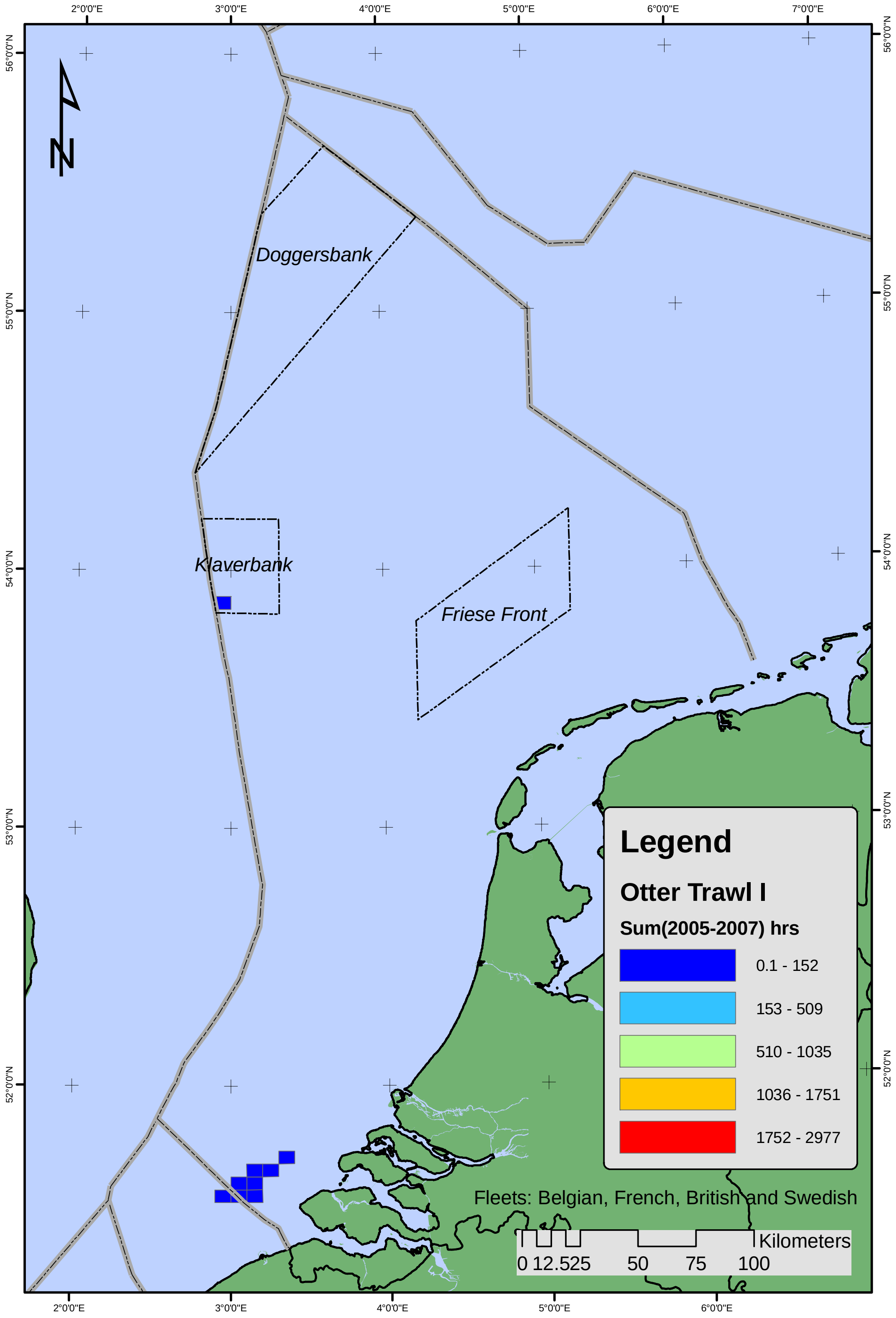
26 InternationalVMS_v2_OtterTrawl_IQ3.jpg

27 Otter Trawl Q4 I = mesh size 80 - 99 mm



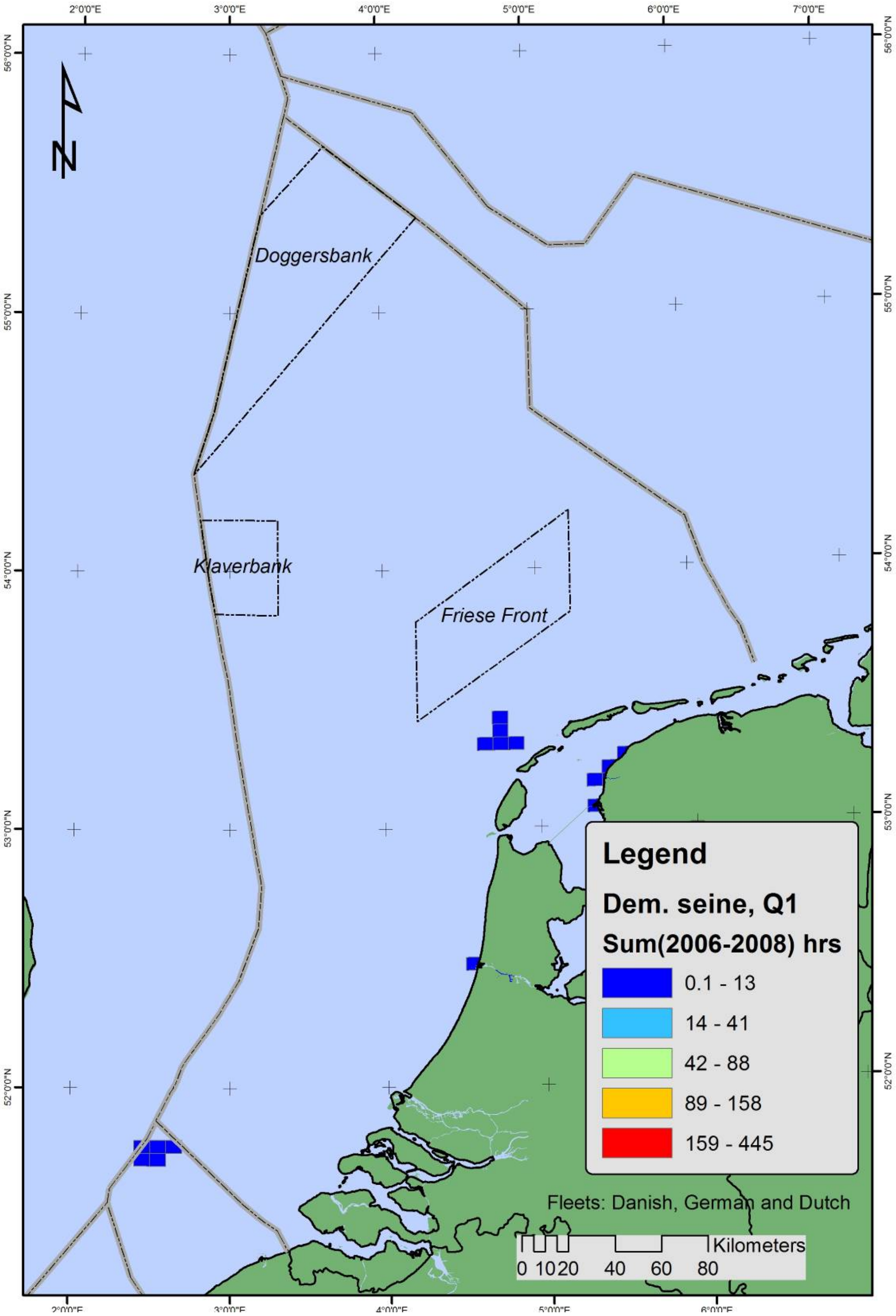
27 InternationalVMS_v2_OtterTrawl_IQ4.jpg

28 Otter Trawl I <=221kW



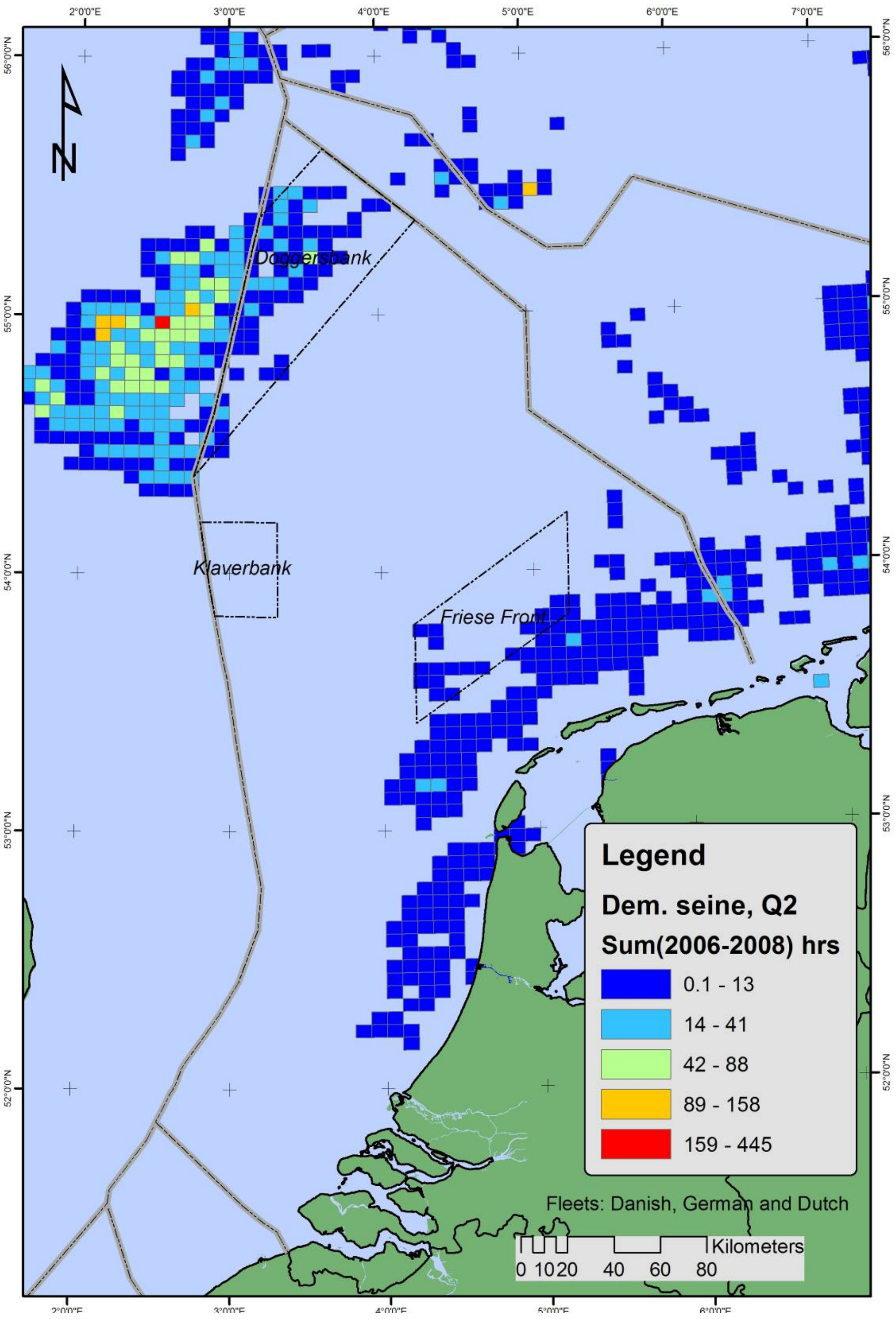
28 InternationalVMS_v2_foreign0507_final_OtterI.emf

29 Seine Q1



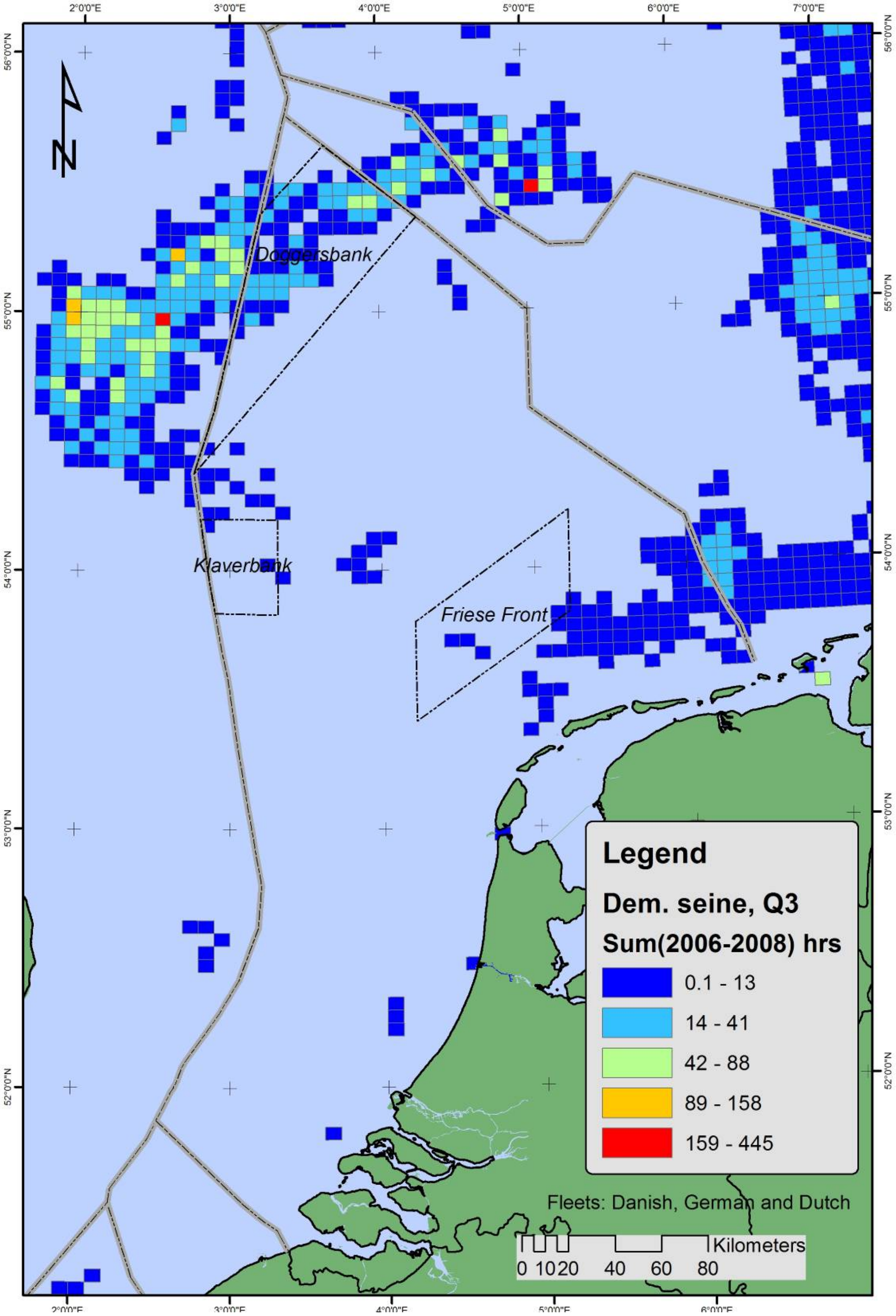
29 InternationalVMS_v2_DemSeineQ1.jpg

30 Seine Q2



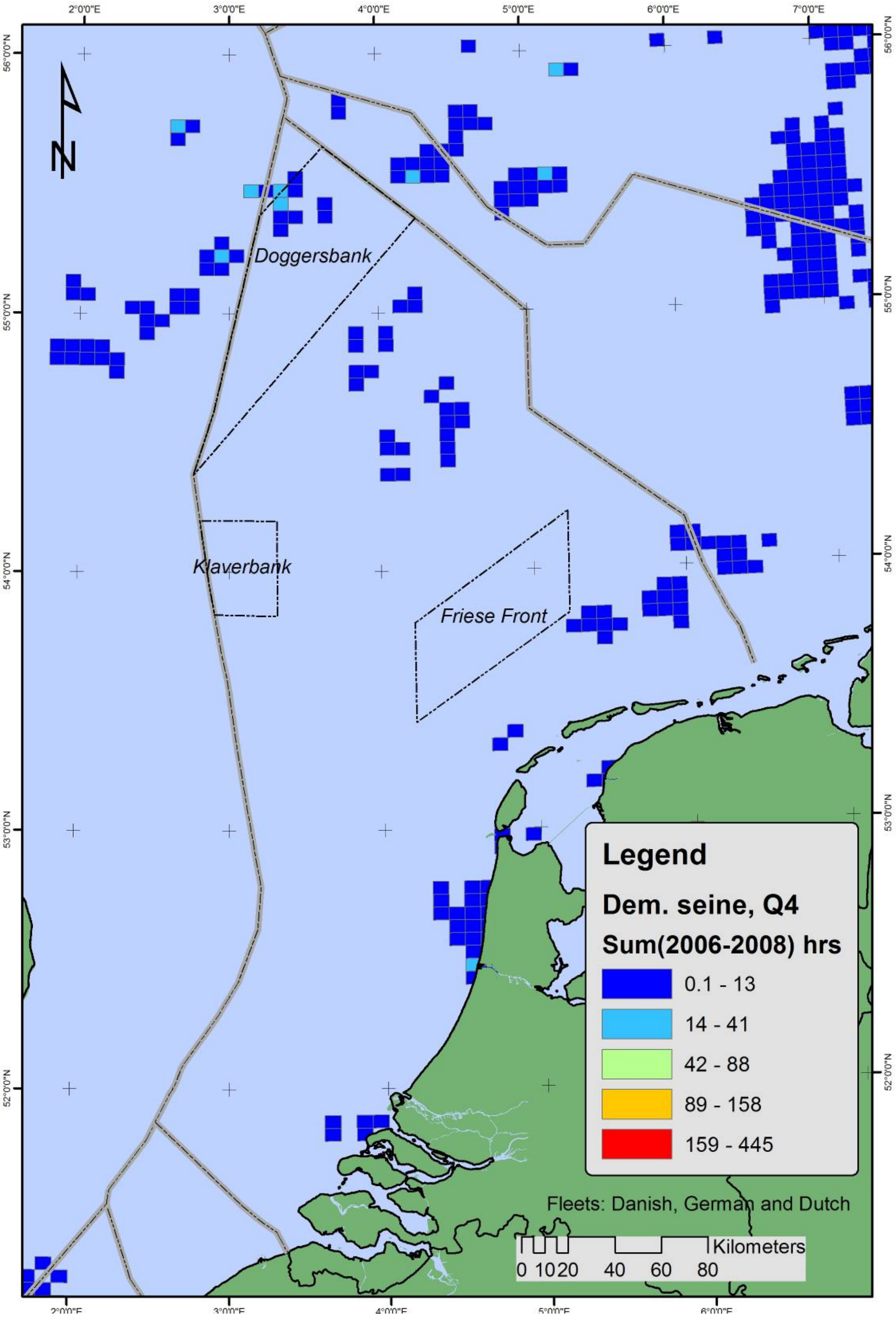
30 InternationalVMS_v2_DemSeineQ2.jpg

31 Seine Q3



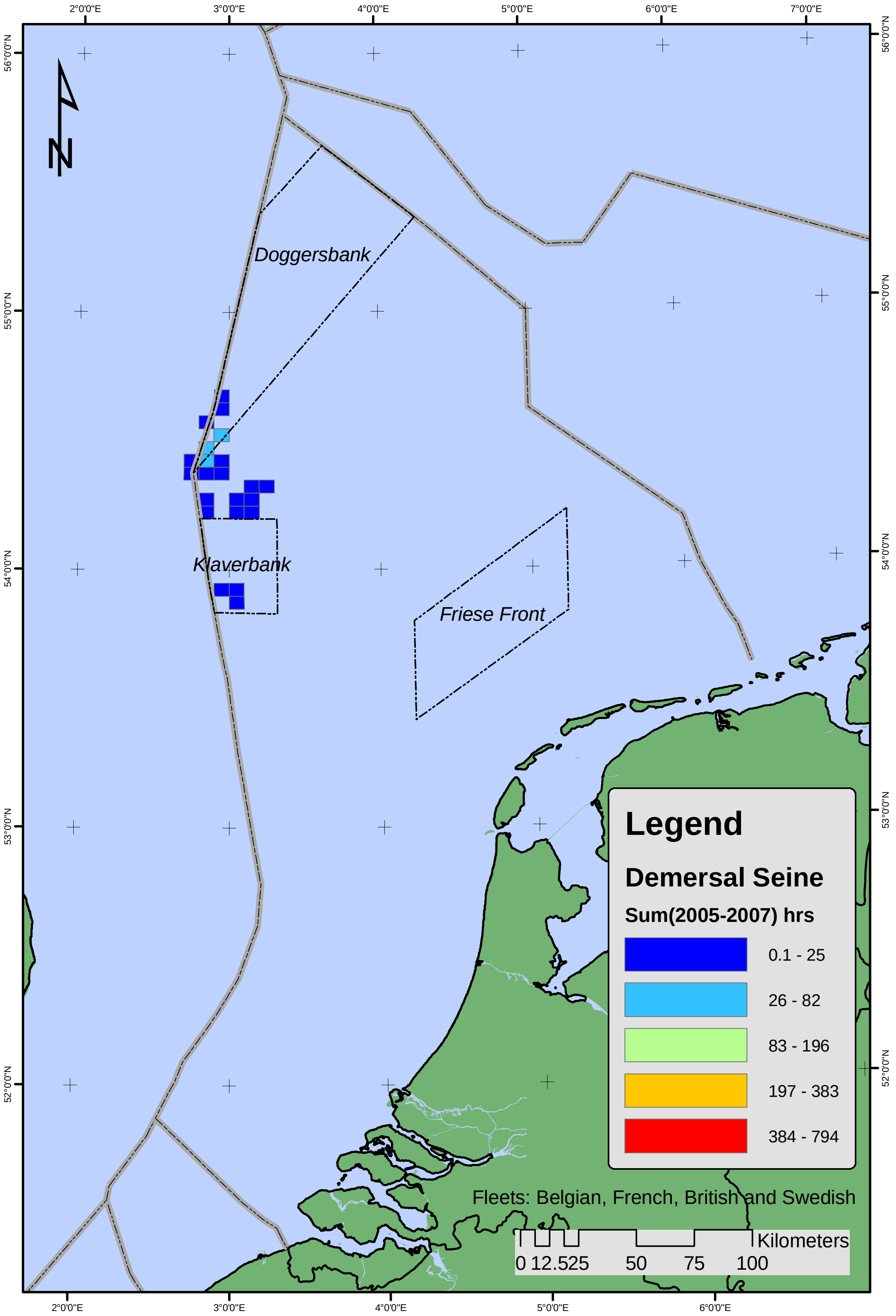
31 InternationalVMS_v2_DemSeineQ3.jpg

32 Seine Q4



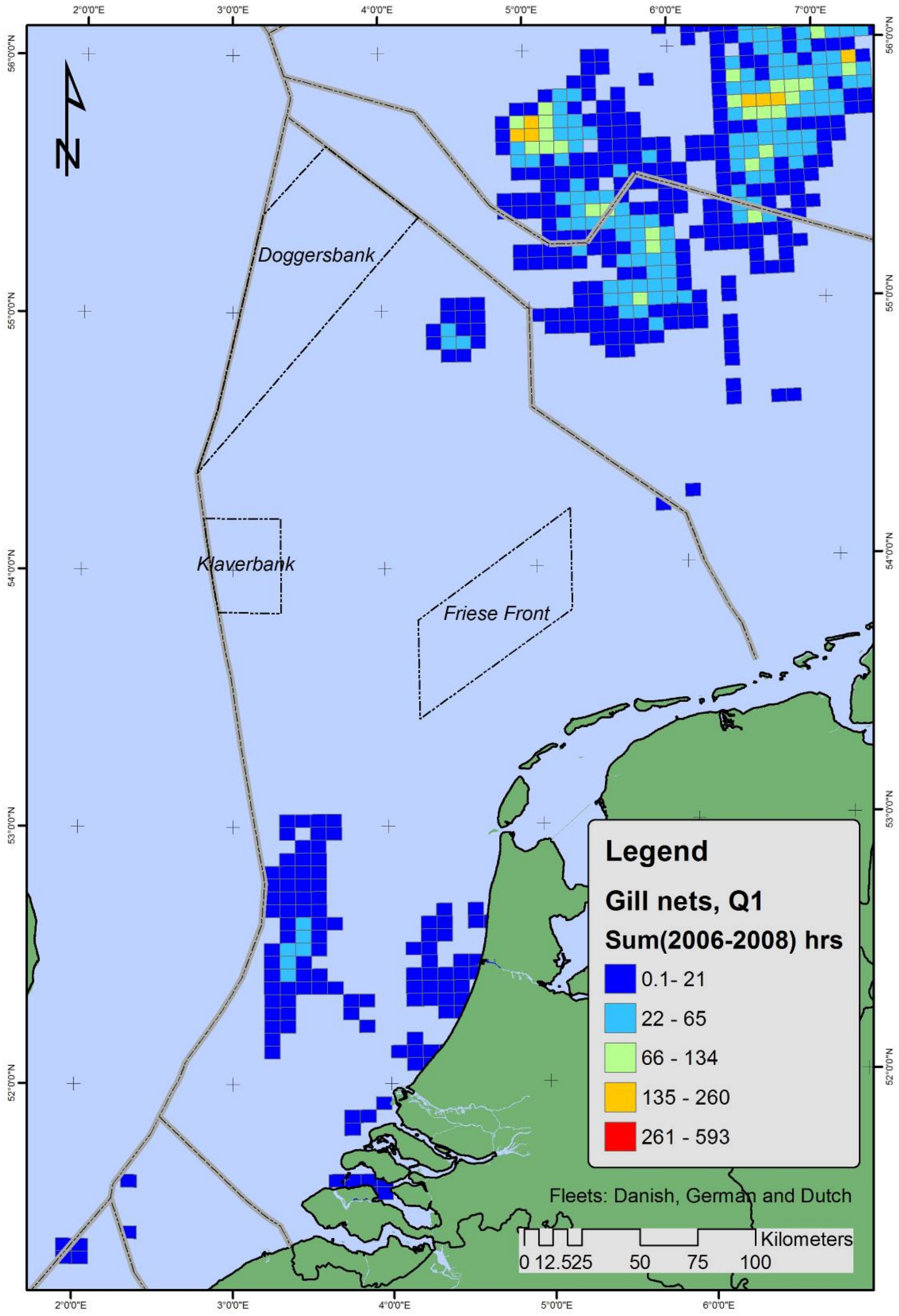
32 InternationalVMS_v2_DemSeineQ4.jpg

33 Seine



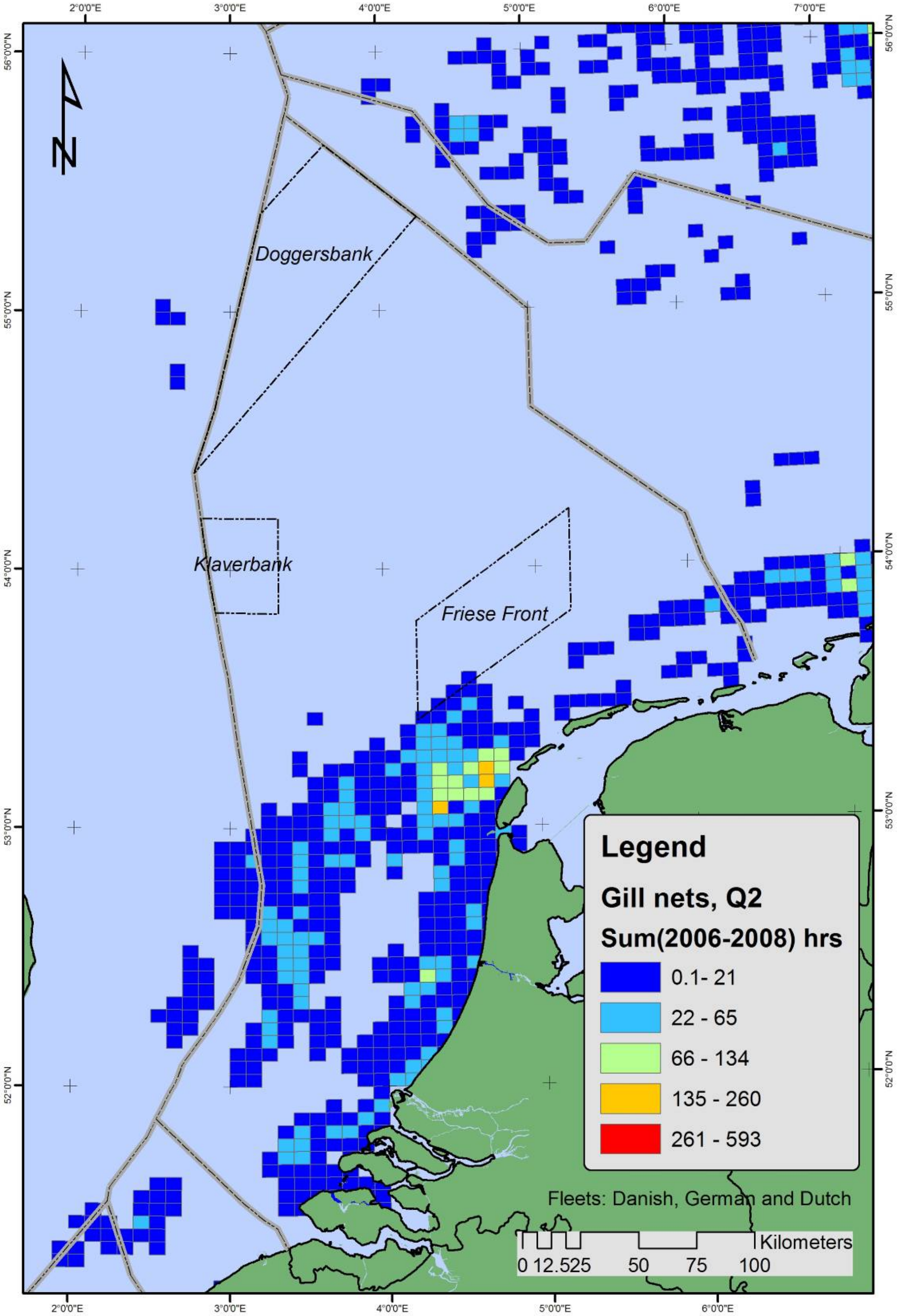
33 InternationalVMS_v2_foreign0507_final_DemSeine.emf

34 Gill nets Q1



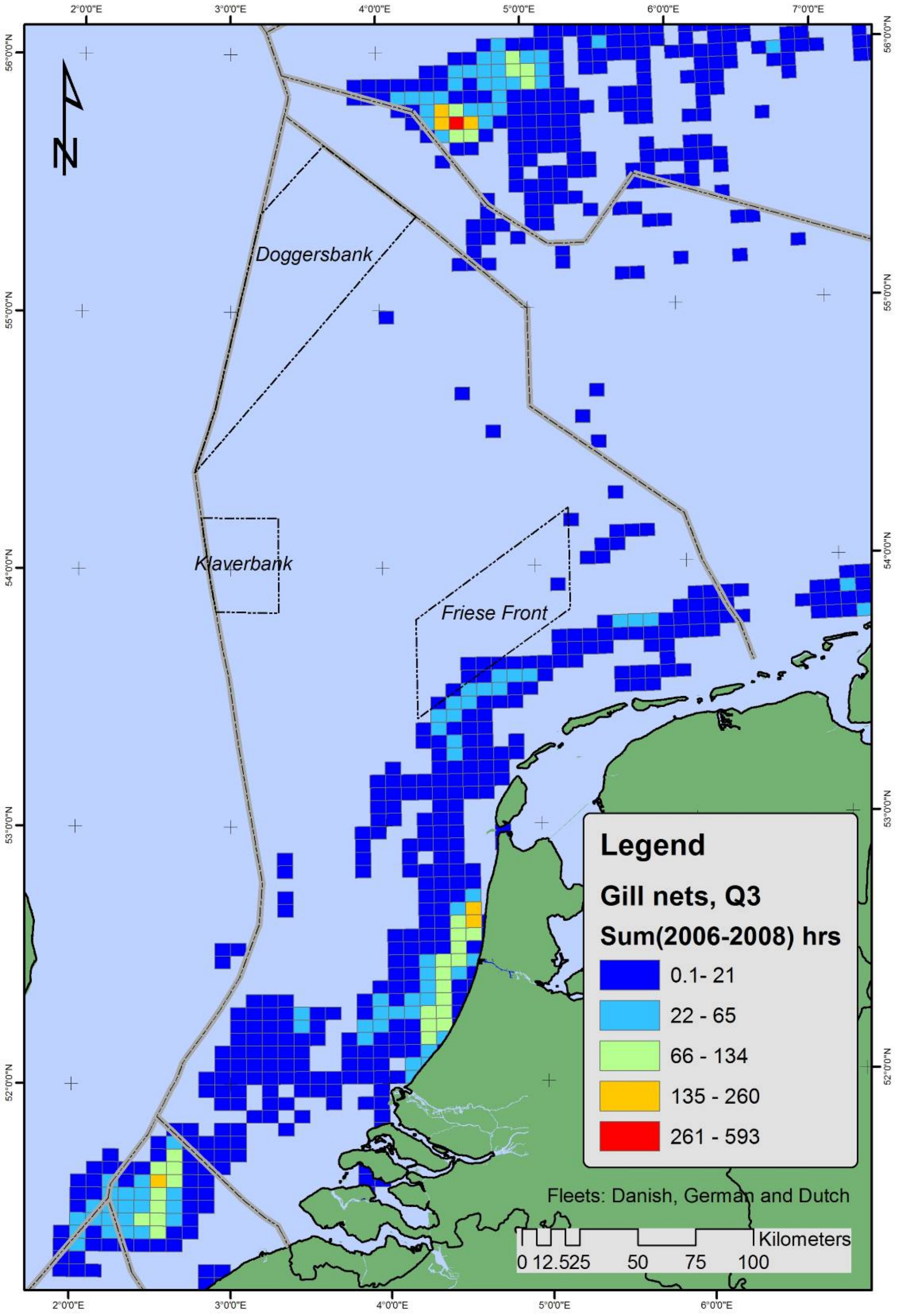
34 InternationalVMS_v2_GillNetsQ1.jpg

35 Gill Nets Q2



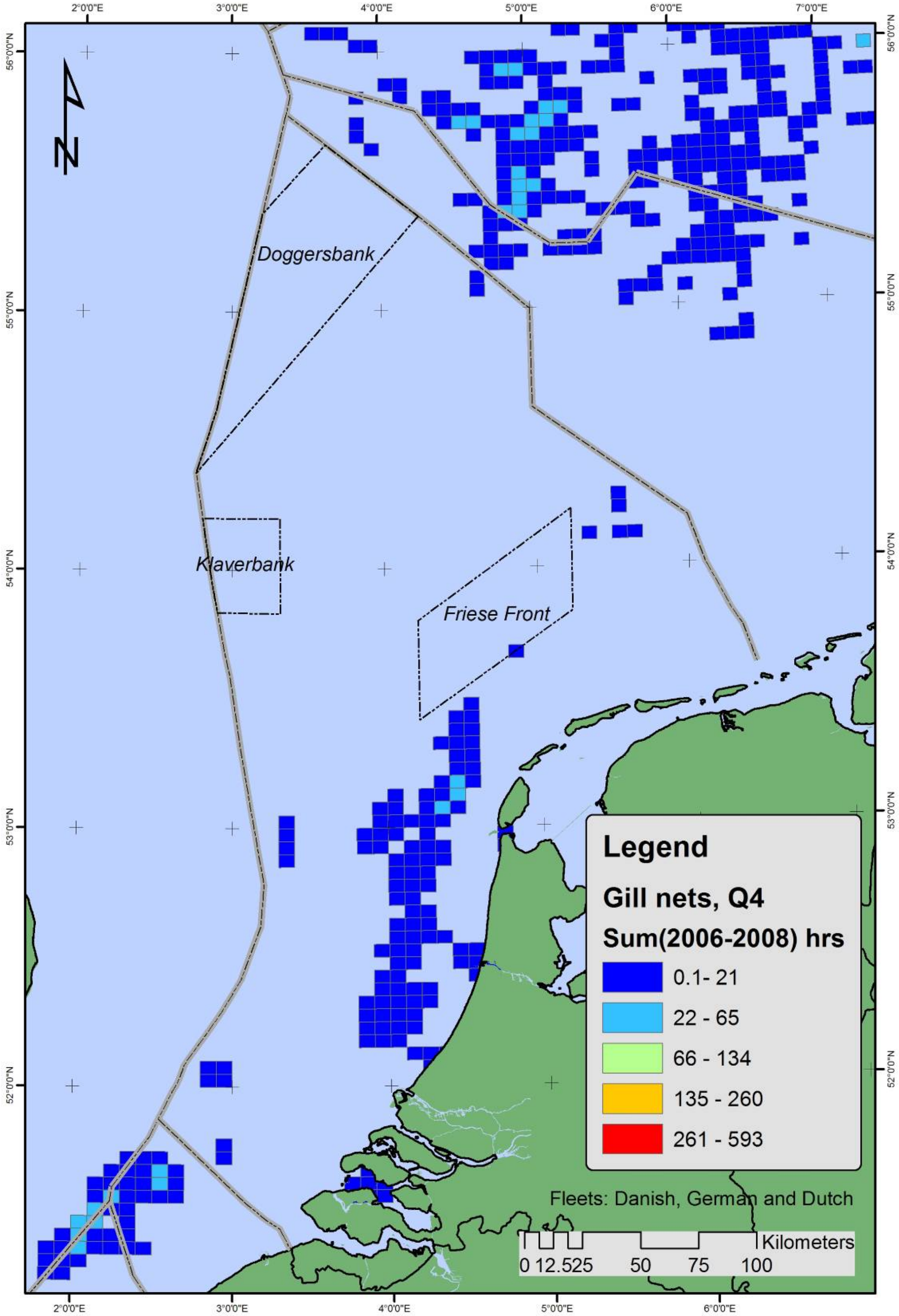
35 InternationalVMS_v2_GillNetsQ2.jpg

36 Gill Nets Q3



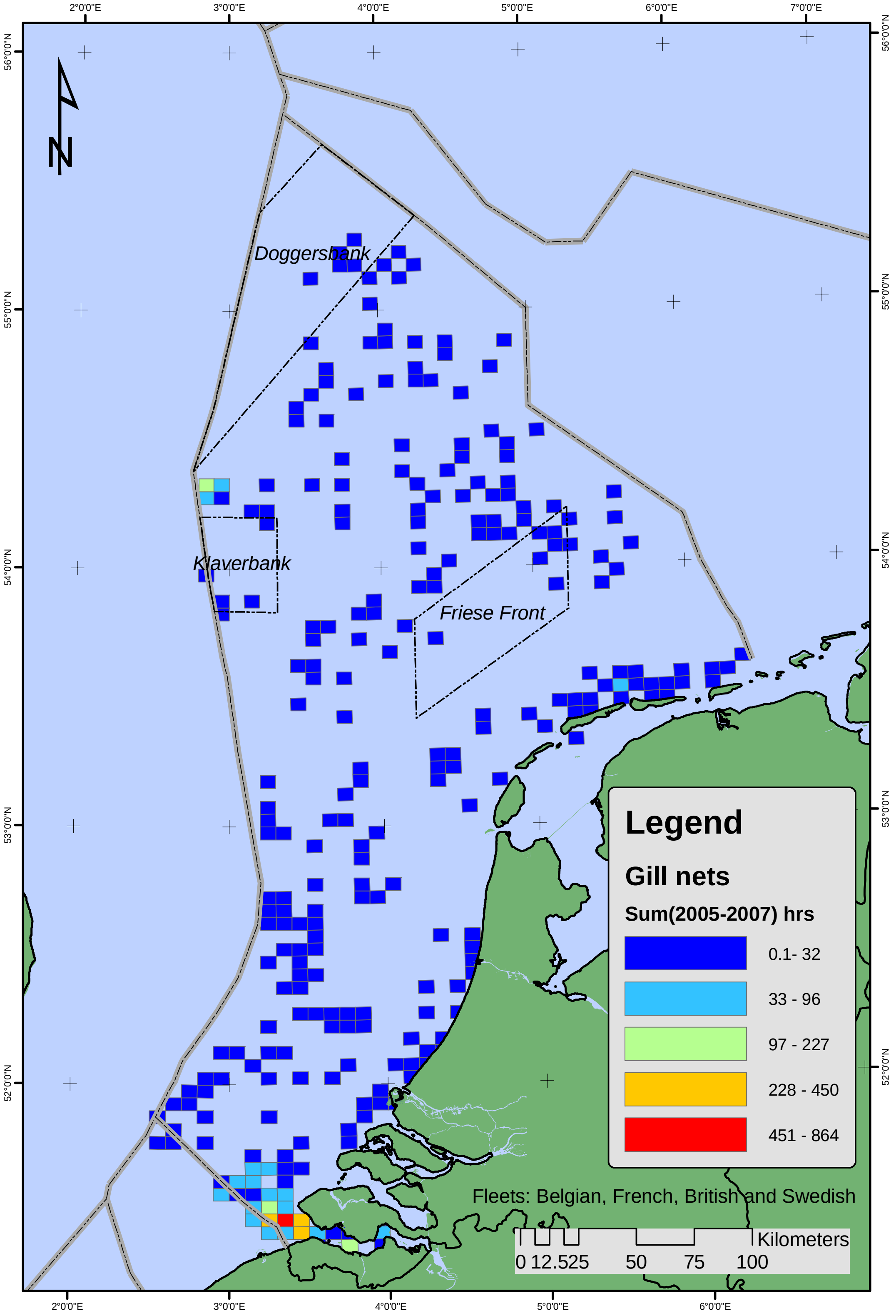
36 InternationalVMS_v2_GillNetsQ3.jpg

37 Gill Nets Q4



37 InternationalVMS_v2_GillNetsQ4.jpg

38 Gill Nets



38 InternationalVMS_v2_foreign0507_final_Gillnets.emf