Ghost nets—A pilot project on derelict fishing gear

DTU Aqua report no. 323-2017

By Josefine Egekvist, Lars O. Mortensen
and Finn Larsen

DTU Aqua
National Institute of Aquatic Resources

Ghost nets—A pilot project on derelict fishing gear

DTU Aqua-rapport nr. 323-2017

Af Josefine Egekvist, Lars O. Mortensen and Finn Larsen

The project was funded by the Ministry of Environment and Food of Denmark, Environmental Protection Agency

DTU Aqua
National Institute of Aquatic Resources

Colophon

Title	Ghost nets—A pilot project on derelict fishing gear
Authors	Josefine Egekvist, Lars O. Mortensen and Finn Larsen
DTU Aqua Report No.	323-2017
Year	November 2017
Reference	Egekvist, J., Mortensen, L.O. & Larsen, F. (2017). Ghost nets—A pilot project on derelict fishing gear. DTU Aqua Report No. 323-2017. National Institute for Aquatic Resources, Technical University of Denmark, 46 pp. + appendicies.
Cover photo	Emil Vesterager
Published by	National Institute for Aquatic Resources, Kemitorvet, DK-2800 Lyngby
Download	aqua.dtu.dk/publikationer
ISSN	1395-8216
ISBN	978-87-7481-243-2

Contents

English summary

Lost or discarded fishing gear that is no longer under a fisherman's control becomes known as derelict fishing gear (DFG) and more popularly as ghost nets. Some DFG can continue to trap and kill crustaceans, fish, seabirds and marine mammals, in a process referred to as ghost fishing. It is known as a major problem in some of our neighbouring countries, but no information is available on the scale of this problem in Danish waters.

The objective of the present pilot project was thus to conduct a basic collection of knowledge on DFG in selected Danish marine areas, which could constitute the basis for a wider effort in Danish waters.

We used VMS and AIS data from Danish fishing vessels to map active and passive fishing activities separately and then overlay these to identify zones of interactions that could be sources of DFG. We also overlaid the maps of fishing activities with maps of wrecks, reefs and marine traffic to identify additional zones of interactions.

Based on these analyses of overlap we identified several areas where interactions appeared to be more pronounced including off the west coast of Jutland, waters around the tip of Jutland, the western Baltic Sea, Langeland Belt, Øresund and waters southwest of Bornholm.

From these areas, we selected three case study areas, i.e. the waters around the tip of Jutland, Langeland Belt and waters southwest of Bornholm, where we interviewed fishermen and conducted questionnaire surveys of sports divers to obtain information on how they saw the problems with DFG. In general, the fishermen did not see DFG as a problem at present because they rarely lose fishing gear, but most of them agreed that dumping old fishing gear was more common earlier. A large majority of the sports divers (94 %) had encountered DFG while diving and particularly on wrecks. They saw DFG as a safety hazard and ghost fishing as a problem that needs to be solved. EU Council Regulation 1224/2009 requires Danish fishermen to report when losing gear, but no reports have been received since 2015.

We recommend conducting the following activities:

- conducting side-scan sonar surveys to verify whether the identified zones of interactions are actual sources of DFG;
- using data from trawl surveys to estimate the relative abundance of DFG in Danish waters;
- investigating whether DFG are a significant source of micro plastic;
- carry out pilot trials of DFG retrieval;
- initiating an information campaign aimed at fishermen to increase awareness of the obligation to report loss of fishing gear;
- assess the usefulness of a number of preventative and mitigative measures.

Danish summary

Mistede eller bortkastede fiskeredskaber, som ikke længere er under fiskerens kontrol, kaldes spøgelsesgarn. En del af disse redskaber kan fortsætte med at fange krebsdyr, fisk, havfugle og havpattedyr i mange år eftersom redskaberne kun nedbrydes meget langsomt. Det vides fra andre lande omkring os at være et stort problem, men omfanget af problemet i danske farvande er ikke kendt.

Formålet med nærværende pilotprojekt er derfor at gennemføre en grundlæggende vidensindsamling om tabte redskabers karakter, omfang og udbredelse i udvalgte, danske havområder, som vil kunne danne grundlag for en videre indsats på området.

Vi benyttede VMS og AIS data fra danske fiskefartøjer til at kortlægge fiskeri med hhv. aktive og passive redskaber og derefter foretage en GIS-analyse af overlappet mellem de to typer fiskeri for at identificere potentielle konflikter, der kunne være kilder til spøgelsesgarn. På samme måde analyserede vi overlappet mellem de to typer fiskeri og skibsvrag, rev og skibstrafik for at identificere andre potentielle konflikter som kilder til spøgelsesgarn.

Baseret på disse analyser identificerede vi en række områder, hvor interaktioner mellem fiskeri og andre aktører så ud til at være mere udprægede. Disse områder var et område udfor Jyllands vestkyst, Jammerbugten, Tannisbugten og området omkring spidsen af Jylland, den vestlige Østersø, Langelandsbæltet, Øresund og området sydvest for Bornholm.

Fra disse områder valgte vi tre fokusområder, Jammerbugten, Tannisbugten og området omkring spidsen af Jylland, Langelandsbæltet og området sydvest for Bornholm, hvor vi interviewede garn- og krogfiskere og gennemførte en online spørgeundersøgelse af sportsdykkere for at undersøge, hvordan de oplever problemet med spøgelsesgarn. Generelt så fiskerne ikke spøgelsesgarn som et problem for hverken fiskeriet eller havmiljøet, idet de meget sjældent har mistet redskaber. De fleste mente, at problemet var meget større tidligere, hvor det var mere almindeligt at smide sine udtjente redskaber i havet. Næsten alle sportsdykkerne (94 %) havde set spøgelsesgarn under dykninger, og det var primært på vrag. De så spøgelsesgarn som en sikkerhedsrisiko og spøgelsesfiskeri som et problem, der bør løses. EU's Rådsforordning 1224/2009 stiller krav om at mistede fiskeredskaber skal indberettes til de danske myndigheder, men ifølge Miljø- og Fødevareministeriet har der ikke været nogen indberetninger siden 2015.

Vi anbefaler at følgende aktiviteter gennemføres:

- sidescan sonar surveys for at verificere om de identificerede konfliktzoner er kilder til spøgelsesgarn;
- analysere data fra trawl surveys for at estimere den relative forekomst af spøgelsesgarn i danske farvande;
- undersøge hvorvidt spøgelsesgarn er en væsentlig kilde til mikroplastik i det marine miljø;
- udføre pilotforsøg med oprensning af spøgelsesgarn;
- gennemføre en informationskampagne rettet mod danske fiskere for at udbrede kendskabet til kravet om indberetning af tabte redskaber;
- vurdere anvendeligheden af en række forebyggende og afhjælpende tiltag.

Introduction

Most fishermen will at some point experience losing their gillnets or trawls at sea during fishing due to e.g. hooking of the gear on wrecks, reefs or other obstacles on the sea floor, or when active gears like trawls, seines etc. collides with passive gear like gillnets or traps. Passive gear can also be lost when marine traffic collides with the gear and drag away the buoys that mark the gear's position or maybe drag the whole gear away. Lost or discarded fishing gear that is no longer under a fisherman's control becomes known as derelict fishing gear (DFG), sometimes also referred to as ALDFG (abandoned, lost or otherwise discarded fishing gear), and more popularly as ghost nets. DFG can continue to trap and kill crustaceans, fish, seabirds and marine mammals, in a process referred to as ghost fishing. The fishermen have an economic incentive to retrieve their lost gear, but that is not always possible.

FAO has established that DFG constitutes close to 10 % of the total amount of plastic debris in the oceans on a global basis. Marine litter is one of the focal areas for the Marine Strategy Directive, which aims to establish good environmental status for the European marine environment by 2020. Most fishing gears are made of various types of plastic, and these will gradually break down to micro plastic, which DTU Aqua has found to be present in the stomachs of a large percentage of the fish species investigated from Danish waters.

Our neighbouring countries Norway and Sweden have a major focus on DFG. Both managers, scientists and NGOs are actively engaged in investigating the problem and finding solutions in the form of both management and mitigation measures. In Norway, fishermen routinely report loss of fishing gear to the Norwegian Fisheries Directorate, which gives the directorate an overview of the scale and distribution of the problem and forms the basis of an annual retrieval survey. Denmark has not had the same focus on DFG and no information is available on the scale of this problem in Danish waters.

The objective of the present pilot project was thus to conduct a basic collection of knowledge on DFG in selected Danish marine areas, which could constitute the basis for a wider effort in Danish waters. The project included five main components:

1. Identification of areas with high risk of overlap between active and passive fisheries.
2. Analysis of the overlap between commercial fisheries and wrecks.
3. Analysis of the overlap between commercial fisheries and stone reefs, biogenic reefs and bubble reefs.
4. Analysis of the overlap between passive gear fisheries and marine traffic activities.
5. Interviews with fishermen and sports divers in three selected case study areas.

Occurrence of derelict fishing gear

The basic premise behind the analyses is that DFG are created in areas where there is overlap between different maritime activities as well as in areas where fishing gear can be hooked on wrecks or reefs. It follows from this, that such areas would have a higher concentration of DFG than areas without such conflicts.

One of the main sources of DFG is the conflict between active and passive fishing, *i.e.* when trawlers, seiners and flyshooters collide with gillnets and drag away the marker buoys or worse, drag away both buoys and gillnets. If the marker buoy is lost, the fisherman will have difficulty finding his gillnets again, which may then end up as DFG. If the gillnet is caught in the trawl, it is up to the trawler to salvage the net and bring it ashore, but this might not always happen, and so the gillnet may end up as DFG.

Another source of DFG is fishing gear getting hooked on the several thousand wrecks found in Danish waters. This can happen with both active gears like trawls and seines and passive gears like gillnets. When it happens with active gears it is often by mistake if the fisherman was not aware of the wreck. Contrary to this, there is a dedicated wreck fishery with gillnets, where the nets are set very close to or sometimes across the wreck. Fishing gear hooked on wrecks can be very difficult to retrieve and may therefore end up as DFG.

Yet another source of DFG is fishing gear getting hooked on natural structures like stone reefs, biogenic reefs and bubble reefs. In these cases, the problem is not just the creation of DFG but also the risk of damaging the reef structures.

DFG can also be created where marine traffic collides with passive gear like gillnets. Such collisions often result in the marker buoys being severed from the anchors or dragged away, which means that the fisherman will have difficulty finding his gillnets again, and they may then end up as DFG.

GIS analyses of overlap

In the GIS analyses, active fishing gears included trawls, Danish seines and flyshooting, while passive gears included gillnets, longlines, pots and fykes.

Fisheries data

Number of fishing vessels

According to the official Fisheries Statistical Yearbook for 2015, a total of 763 vessels were registered in Denmark to fish with passive gears like hook/lines and gillnets and 583 vessels were registered in Denmark to fish with active gears like trawls and seines. It should be noted that the number of fishing days per year varies considerably, and some vessels may not be fishing at all in a given year.

According to the official logbooks for 2015, a total of 308 vessels fished primarily with passive gear and 434 vessels fished primarily with active gear. Logbooks are mandatory only for vessels above 10m (8m in the Baltic), so many smaller vessels are not included in these numbers.

VMS-data

The spatial analyses of overlap were based on data from the Vessel Monitoring System (VMS), which from 2005-2011 was mandatory for fishing vessels above 15m and since 2012 has been mandatory for fishing vessels above 12m. VMS records the position of the vessel on an hourly basis and thus makes it possible to estimate the average vessel speed. The system covered 26 % of the fishing vessels that were active in 2015. The official vessel register provides vessel type and the three most important fishing gears used by each vessel. We have used the first fishing gear given in the vessel register as the basis for determining whether a vessel is primarily fishing with active or passive fishing gear. Using this

criterion, it appears that 75 % of the vessels with an active gear as the primary gear has VMS, while this is the case for only 7.5 % of the vessels with passive gears as their primary. These figures do not consider how many days the vessels are actively fishing. The official sales notes register records all landings from Danish vessels, and according to this, vessels below 12m had on average 36.5 landings in 2015, while vessels above 12m had on average 80.4 landings in 2015. The larger vessels also fish with more nets, so all in all vessels below 12m has a relatively smaller effort than their numbers indicate, which means that the real bias is not as great as the number of vessels suggests.

The fishing activities of each vessel were determined based on the speed of the vessel. For vessels with active gear, we assumed that they were actively fishing when their speed was 2-4 knots. For vessels with passive gear, we assumed that they were actively fishing when their speed was 0-4 knots. To create coherent polygons of activities, we pooled VMS positions that were less than 2 km from each other.

We used VMS data from the period 2007-2015, because this period was characterised by very few changes in the fishing regulations, whereas there were major changes to the catch quota system in the preceding period. We analysed the data as a whole and also split into quarters of the year to determine whether any seasonal changes happened during the year.

AIS data

Because of the low VMS-coverage for vessels using passive fishing gear, and to obtain more precise information on the spatial distribution of these vessels, we wanted to include data from the Automatic Identification System (AIS). AIS is an automatic tracking system used for collision avoidance on ships and by vessel traffic services (VTS). It is mandatory for fishing vessels above 15m, but also found on some fishing vessels below 12m.

It was therefore explored if AIS data could supplement the VMS based information, and data from 2015 was used as a test case. 26 % of the fishing vessels that were active in 2015 were covered by AIS data, and 389 vessels with AIS could be coupled to the vessel register via their call sign. The official vessel register provides information on vessel length, vessel type and the three most important fishing gears used by each vessel. It was tested if the first fishing gear given in the vessel register could be used as the basis for determining whether a vessel is primarily fishing with active or passive fishing gear. However, when comparing the first gear given in the vessel register with the gears given in the logbook[1], it appeared that the first gear given in the vessel register was not very reliable. Therefore, it was decided to use only AIS data for vessels where there was gear information from the logbook register. AIS data to supplement the VMS data is therefore from 32 vessels fishing with active gears and 34 vessels fishing with passive gears in 2015.

As with VMS data, we created coherent polygons of activities by pooling AIS positions that were less than 2 km from each other.

Data from the vessel register

We used data from the official vessel register to produce an overview of the number of fishing vessels in individual, Danish ports. These data are shown in Fig. 1 for vessels fishing with active and passive gears, respectively.

[1] It is mandatory to fill in logbooks for vessels larger than 10m in the North Sea and 8m in the Baltic Sea.

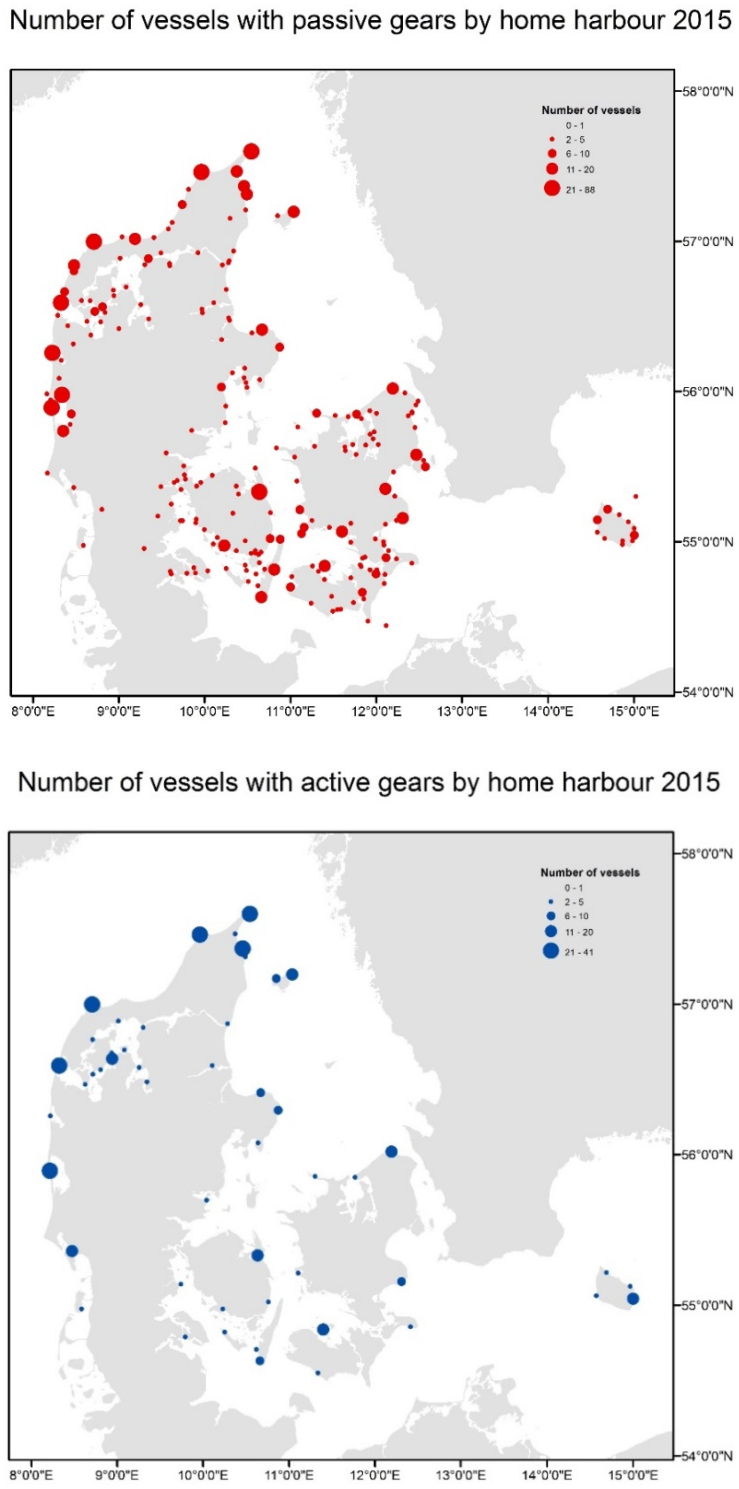

Figure 1. Distribution of vessels fishing with passive (top) and active gear (bottom) in Denmark in 2015.

Other data

Maps showing the geographical distribution of wrecks in Danish waters came from the data base held by the Danish Agency for Culture and Palaces. It includes wrecks found up to year 2000.

Maps showing the occurrence of stone reefs, bubble reefs and biogenic reefs came from the mapping carried out by the Environmental Protection Agency in relation to Natura 2000.

Maps of the intensity of marine traffic in Danish waters were provided by the Danish Maritime Agency. We used the maps from 2014, as they were the most recent published.

Analyses of overlap between active and passive fisheries

We used the spatial data from VMS and AIS in GIS to map the geographical distribution of both active and passive fishing activities. These two maps are shown in Fig. 2. Judging from the concentrations of vessels fishing with passive gears in Kattegat, the Belt Seas and the western Baltic Sea (Fig. 1), our analyses appears to have covered the main areas. However, although including AIS data added some effort, we are still missing a considerable part of the effort from the vessels that do not use VMS. This could to some degree bias the results of the analyses of overlap if the vessels without VMS and AIS are fishing in other areas than the vessels that are included in the analyses. However, as noted above, the smaller vessels that are using passive gears contribute relatively less to the total effort since they have fewer days at sea and use smaller amounts of nets.

We would have preferred to base the analyses on fishing intensity (see Fig. 3) instead of merely presence in a particular square, since fishing intensity provides a better representation of the fishing effort in a particular area. However, we were unable to find a procedure in ArcGIS that would allow us to perform the analyses of overlap based on fishing intensity.

The analyses of overlap were performed using a procedure in ArcGIS, which overlay the two maps to produce a map of polygons where both active and passive fishing takes place. The results are shown in Figs 4.1 – 4.4 by quarter of the year. Figs 5-7 present a more detailed view of three areas where the overlap is more pronounced, *i.e.* off the west coast of Jutland (Figs 5.1 – 5.4), in Jammerbugten, Tannisbugten and north of this (Figs 6.1 – 6.4) and southwest of Bornholm (Figs 7.1 – 7.4). Off the west coast of Jutland, the overlap is most pronounced during the second quarter of the year, off northern Jutland it appears to happen all year round, while at Bornholm it occurs almost exclusively in the first quarter.

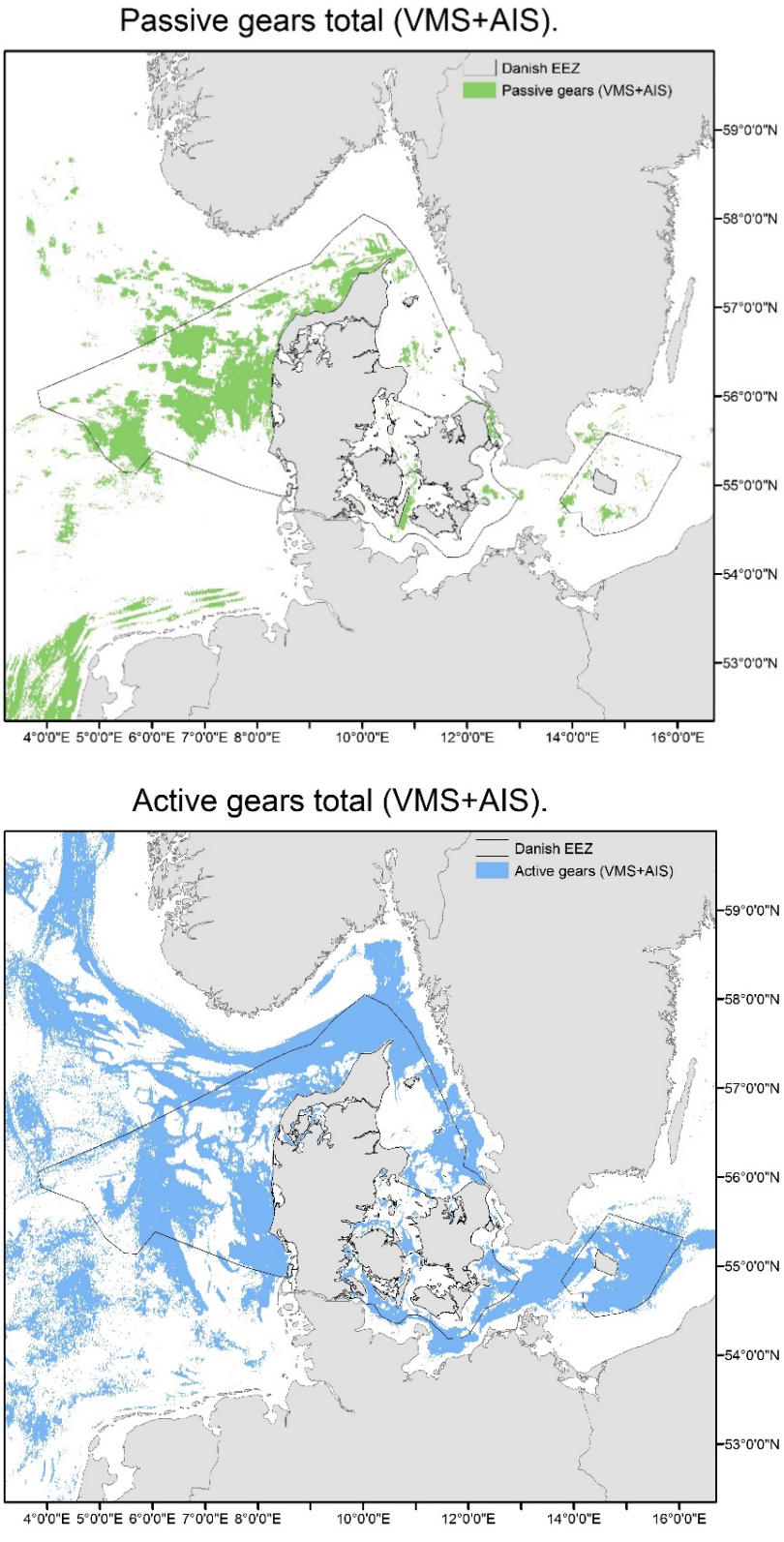

Figure 2. The distribution of passive (top) and active fishing (bottom) based on VMS and AIS data from the period 2007-2015.

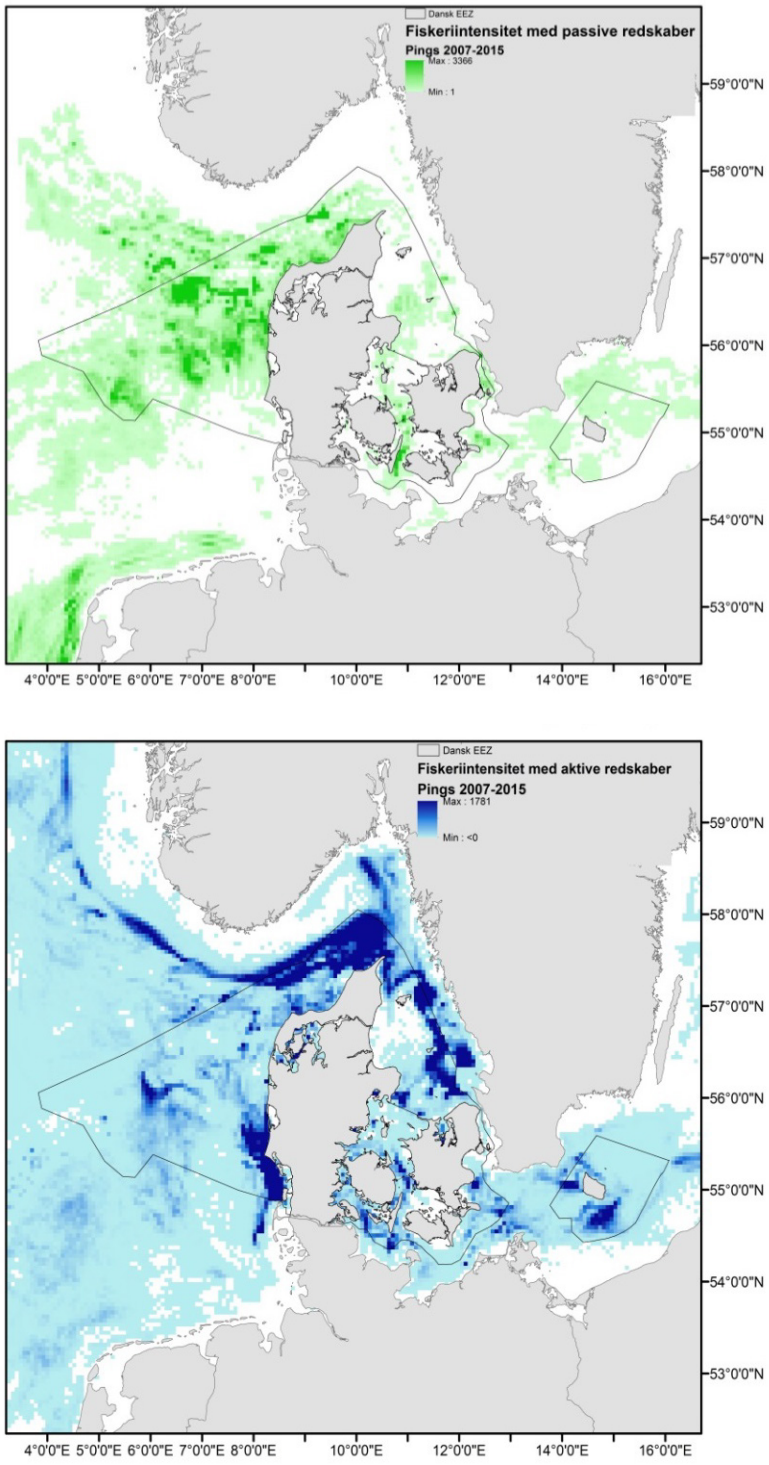

Figure 2. The distribution of passive (top) and active fishing (bottom) intensity based on VMS and AIS data from the period 2007-2015.

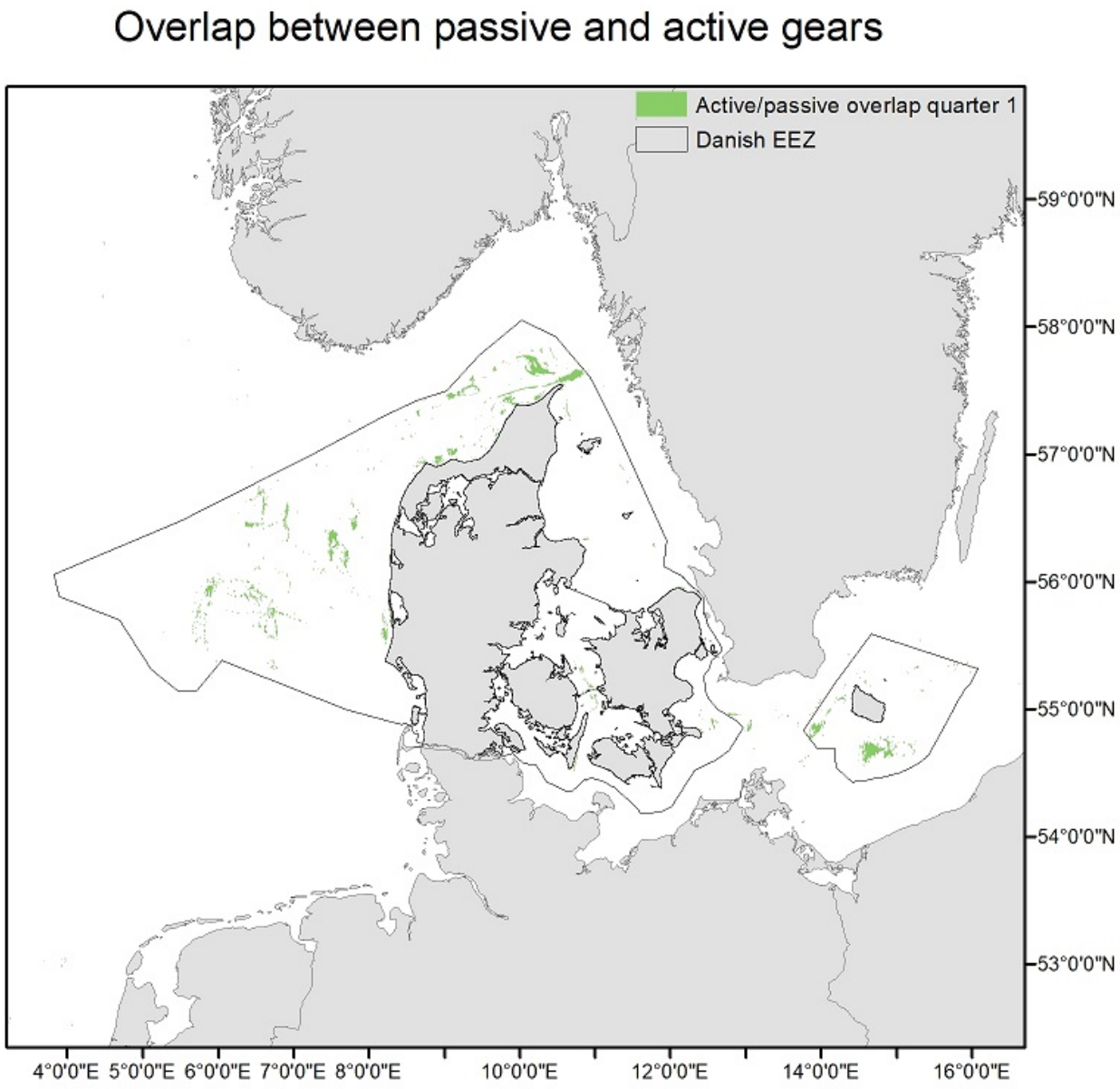

Figure 3.1 Map of the overlap between passive and active fishing activities in quarter 1.

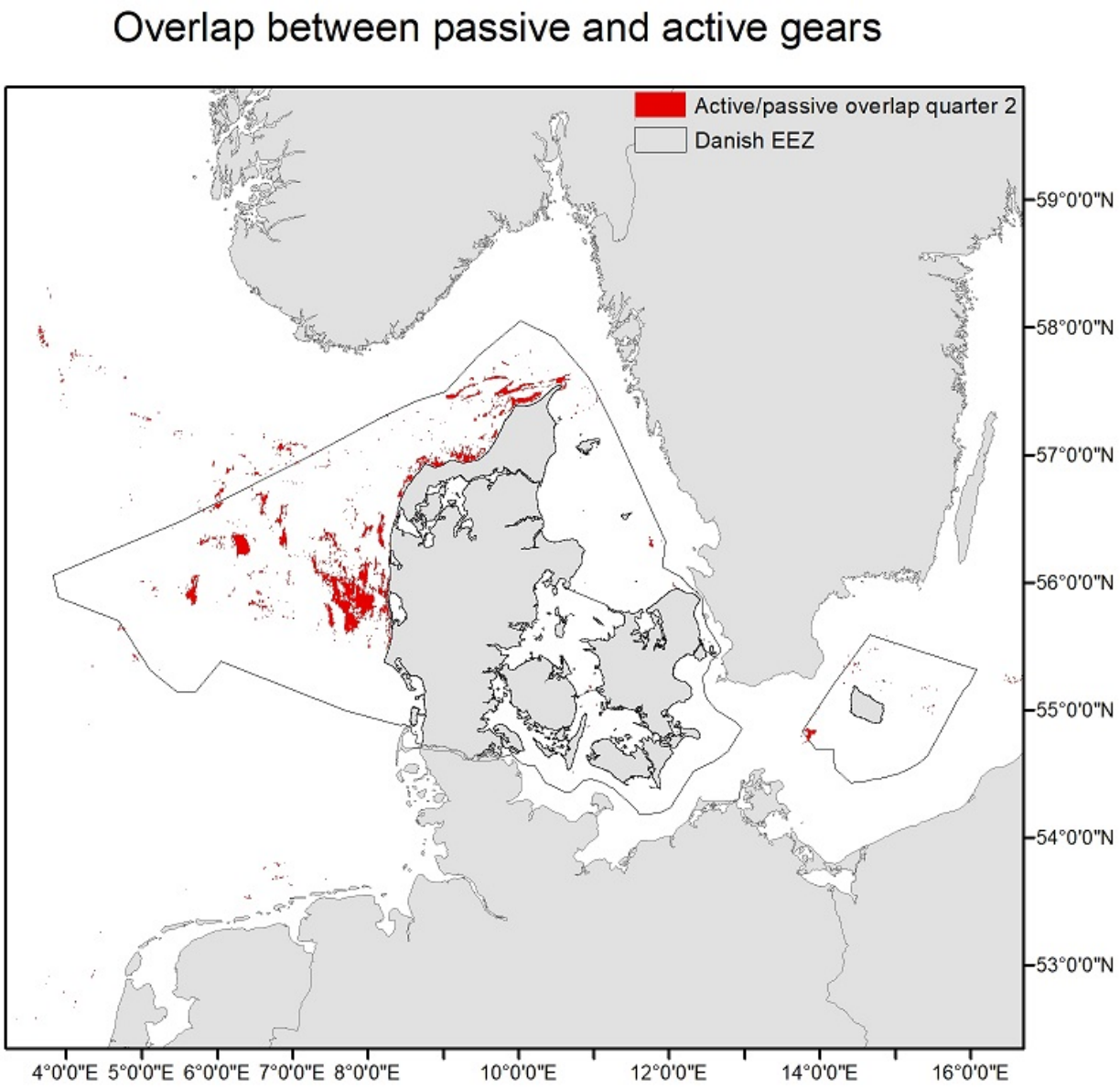

Figure 4.2. Map of the overlap between passive and active fishing activities in quarter 2.

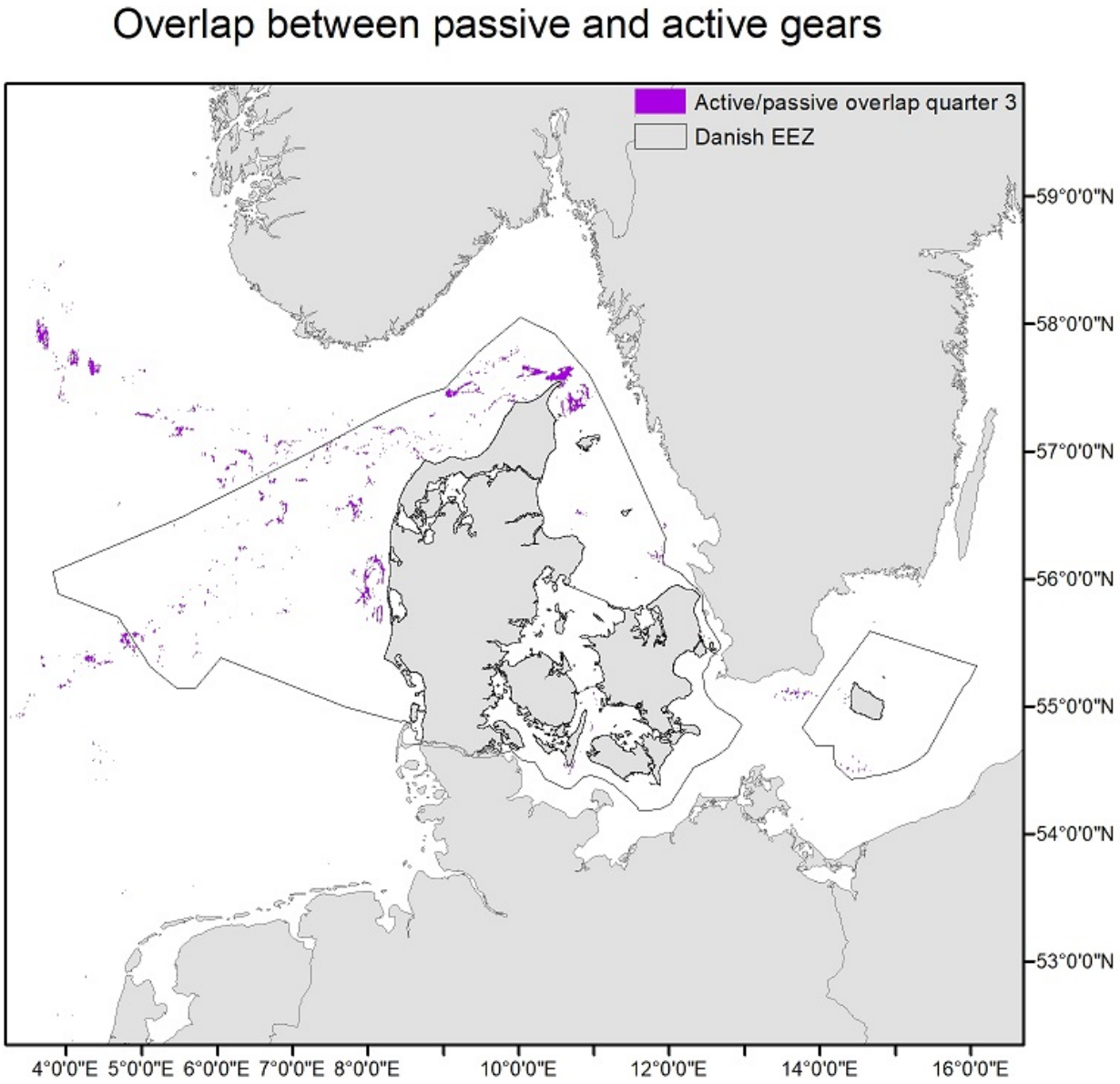

Figure 5.3. Map of the overlap between passive and active fishing activities in quarter 3.

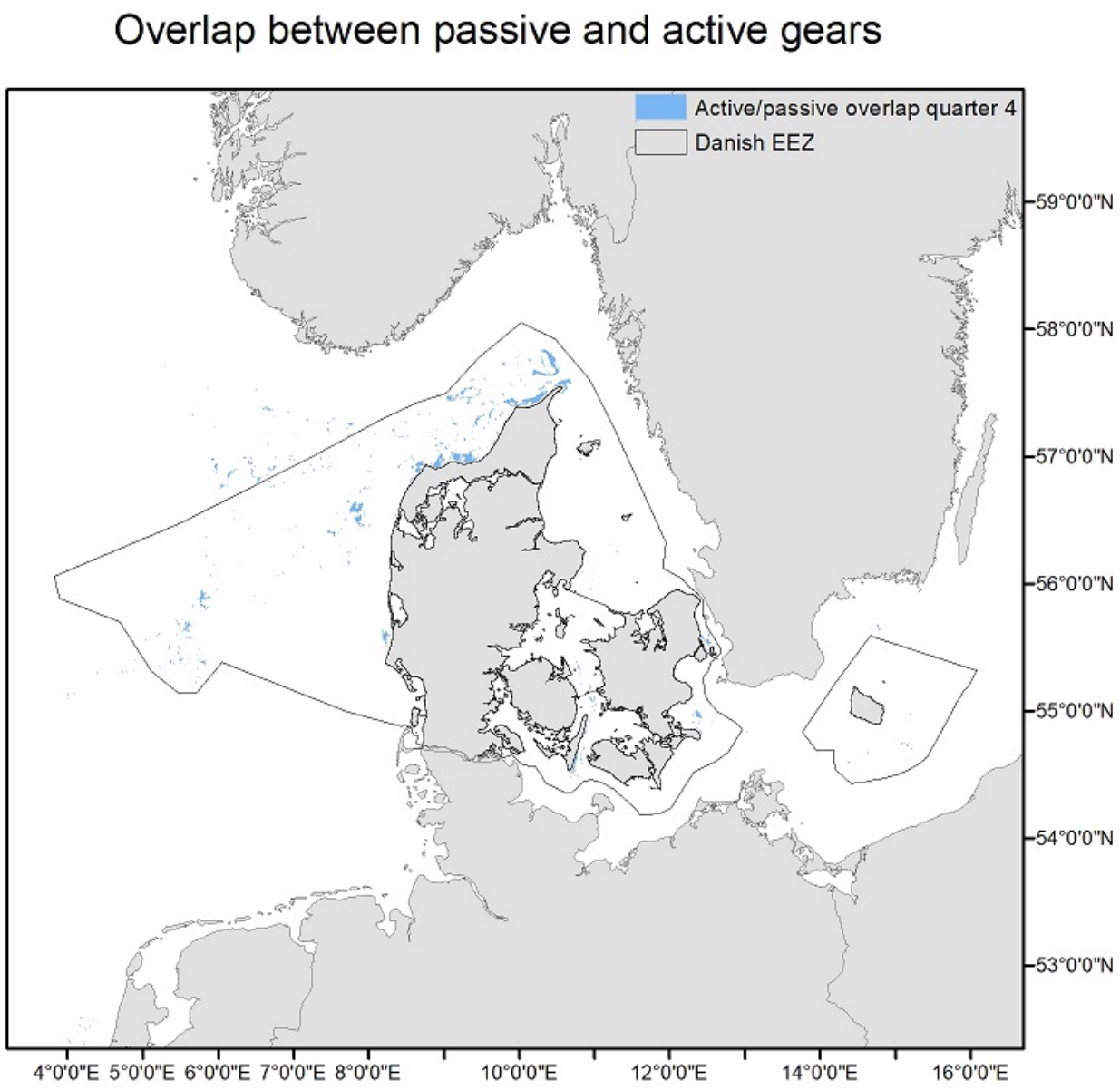

Figure 6.4. Map of the overlap between passive and active fishing activities in quarter 4.

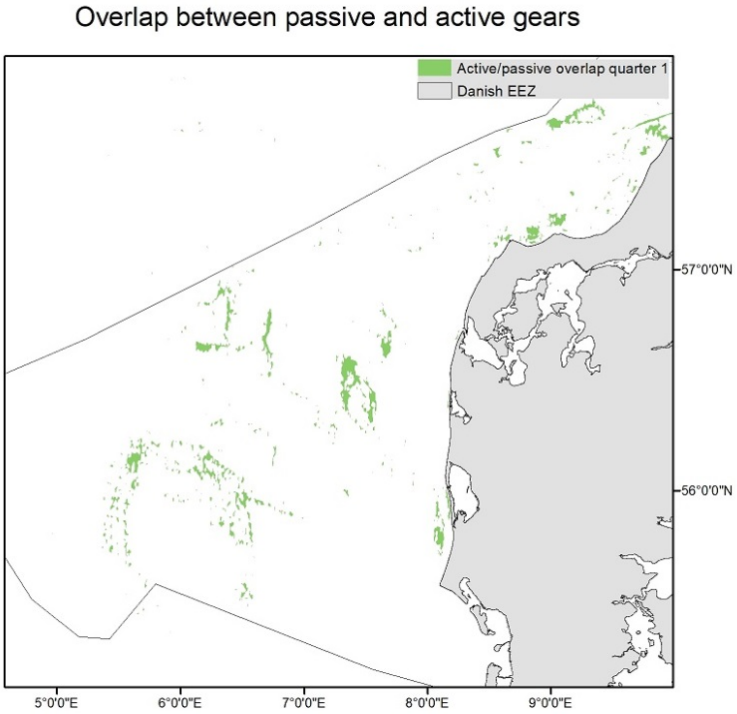

Figure 5.1. Map of the overlap between passive and active fishing activities off the west coast of Jutland in quarter 1.

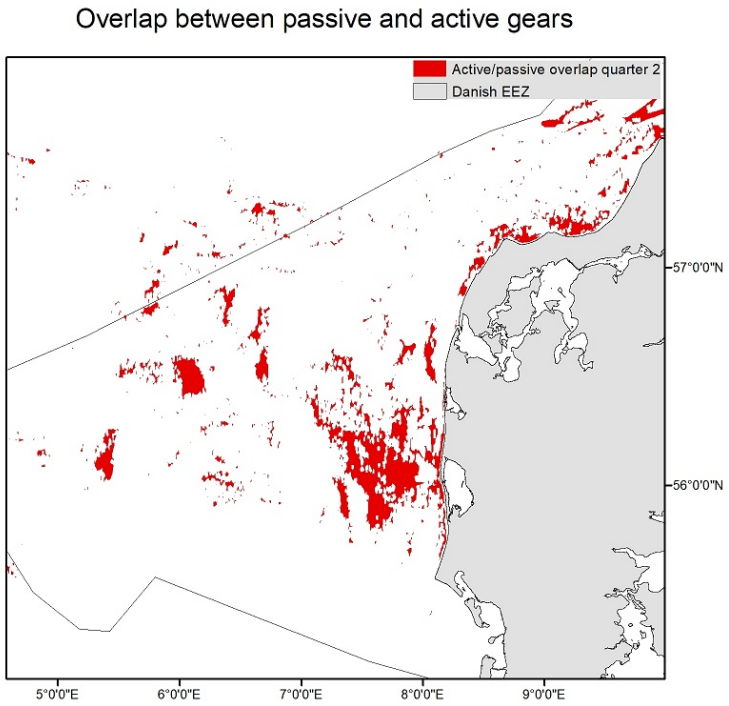

Figure 5.2. Map of the overlap between passive and active fishing activities off the west coast of Jutland in quarter 2.

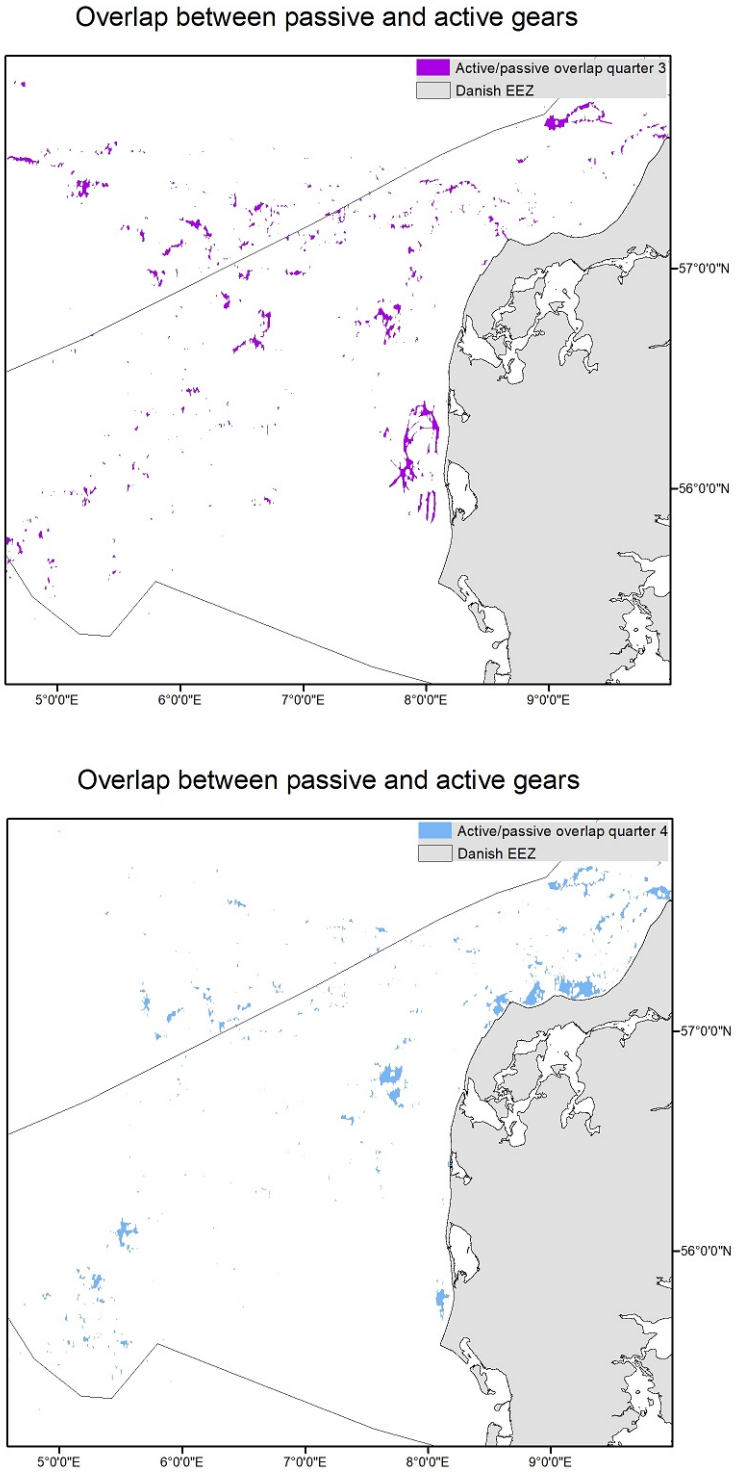

Figure 5.4. Map of the overlap between passive and active fishing activities off the west coast of Jutland in quarter 4.

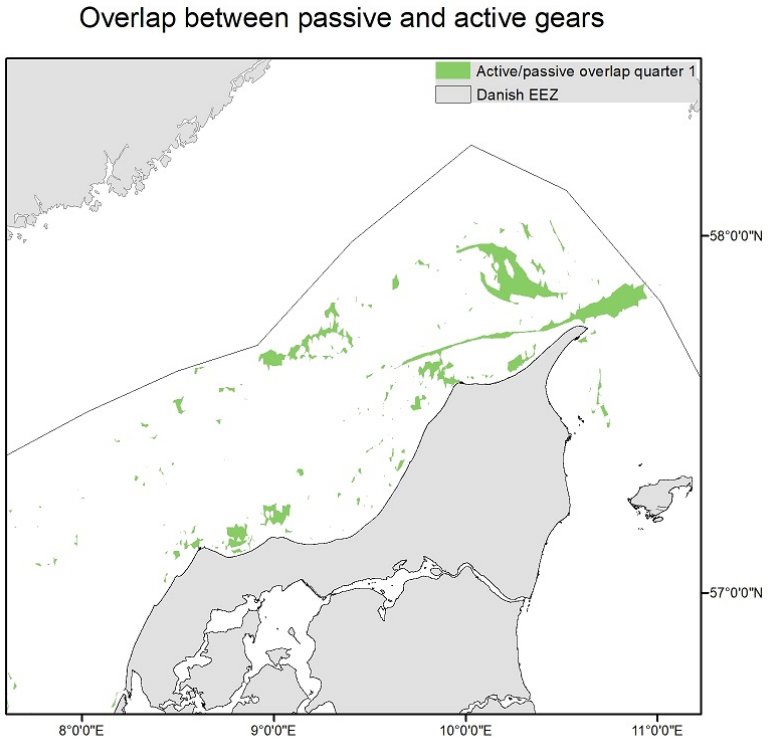

Figure 6.1. Map of the overlap between passive and active fishing activities around the northern tip of Jutland in quarter 1.

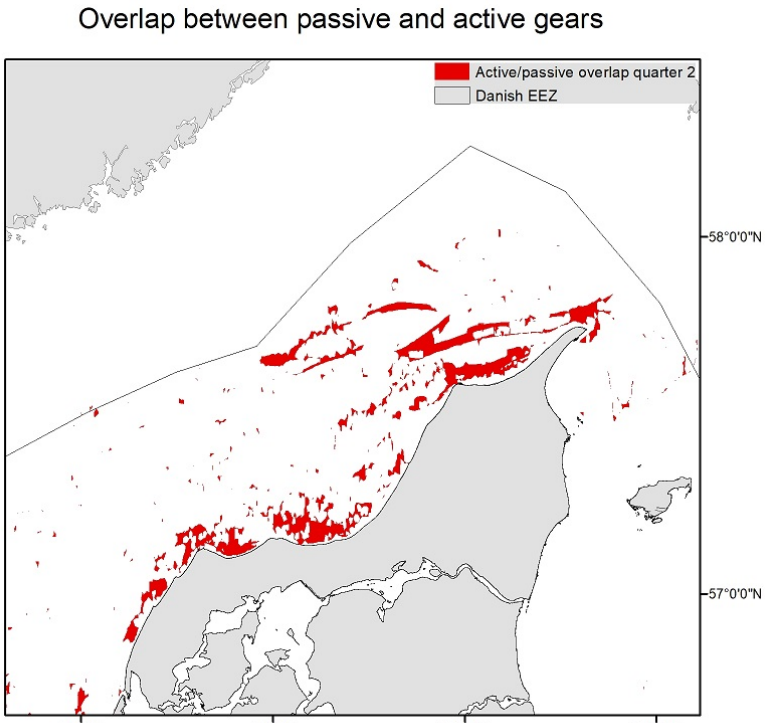

Figure 6.2. Map of the overlap between passive and active fishing activities around the northern tip of Jutland in quarter 2.

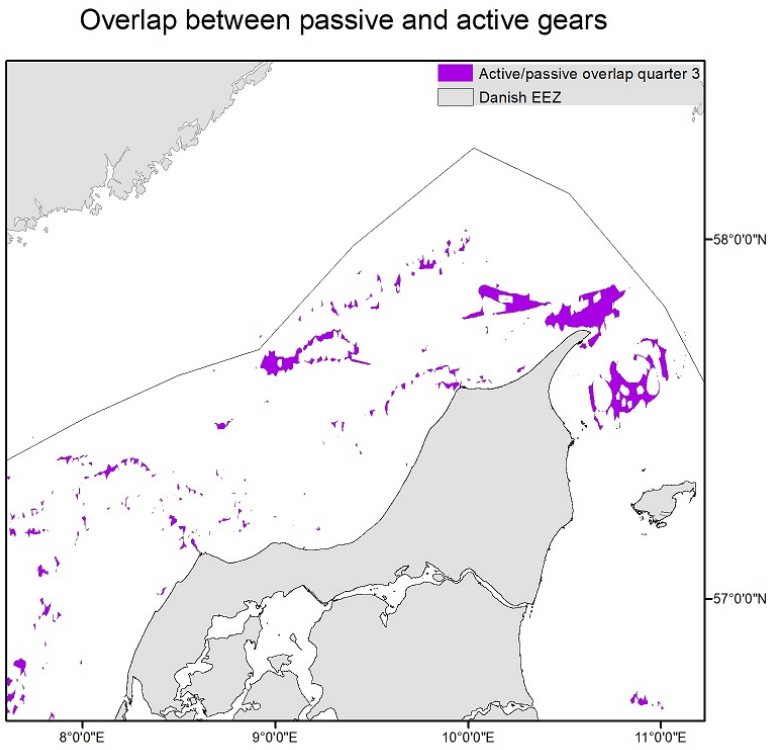

Figure 6.3. Map of the overlap between passive and active fishing activities around the northern tip of Jutland in quarter 3.

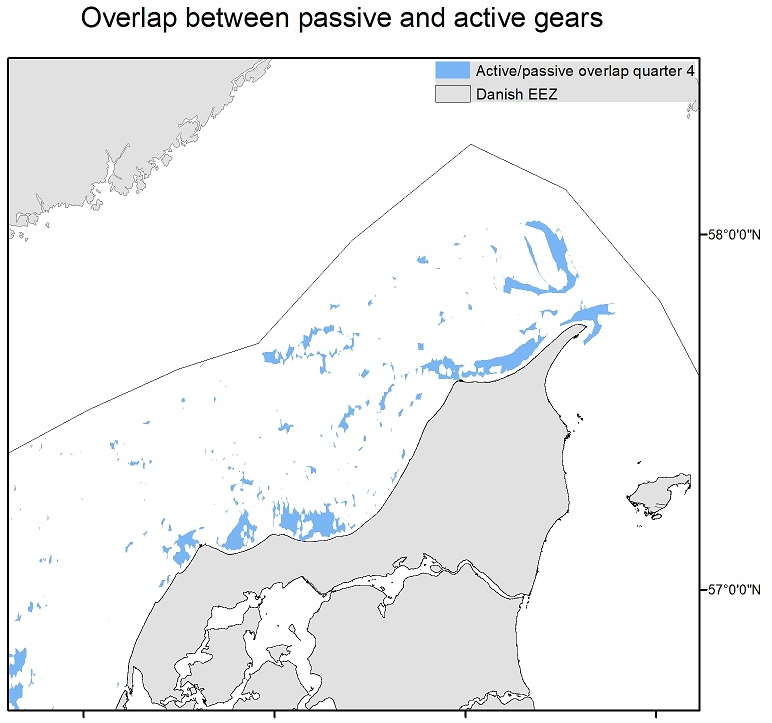

Figure 6.4. Map of the overlap between passive and active fishing activities around the northern tip of Jutland in quarter 4.

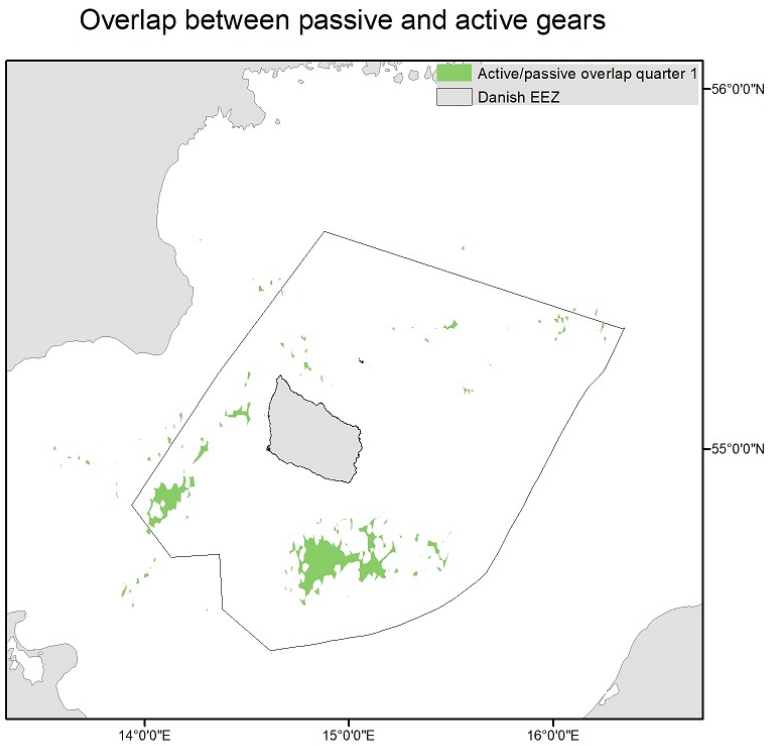

Figure 7.1. Map of the overlap between passive and active fishing activities around Bornholm in quarter 1.

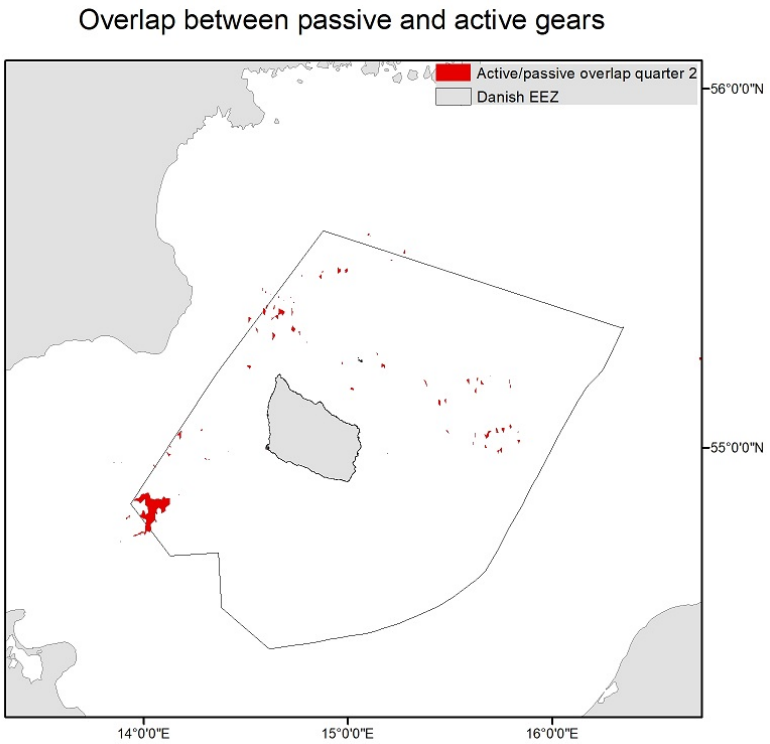

Figure 7.2. Map of the overlap between passive and active fishing activities around Bornholm in quarter 2.

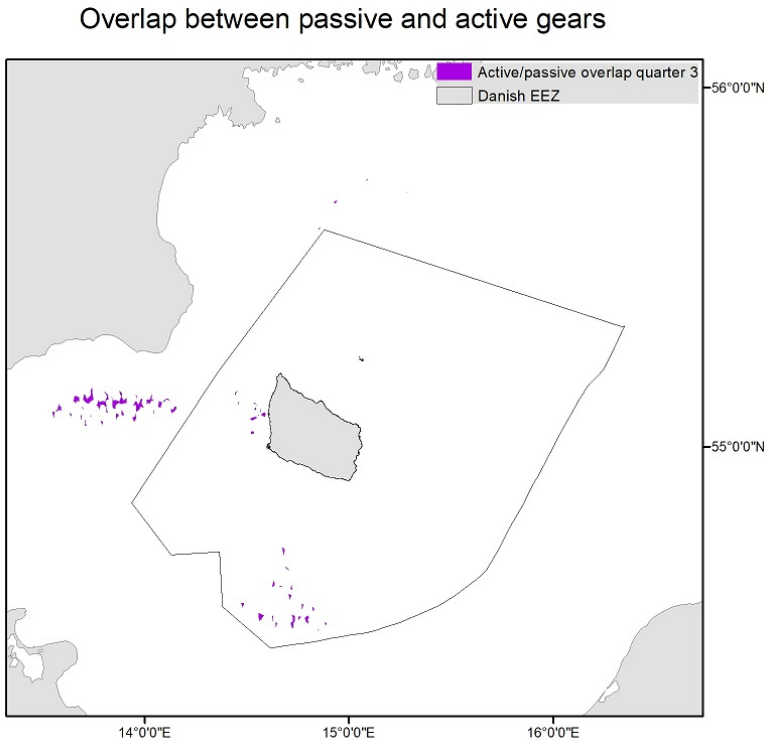

Figure 7.3. Map of the overlap between passive and active fishing activities around Bornholm in quarter 3.

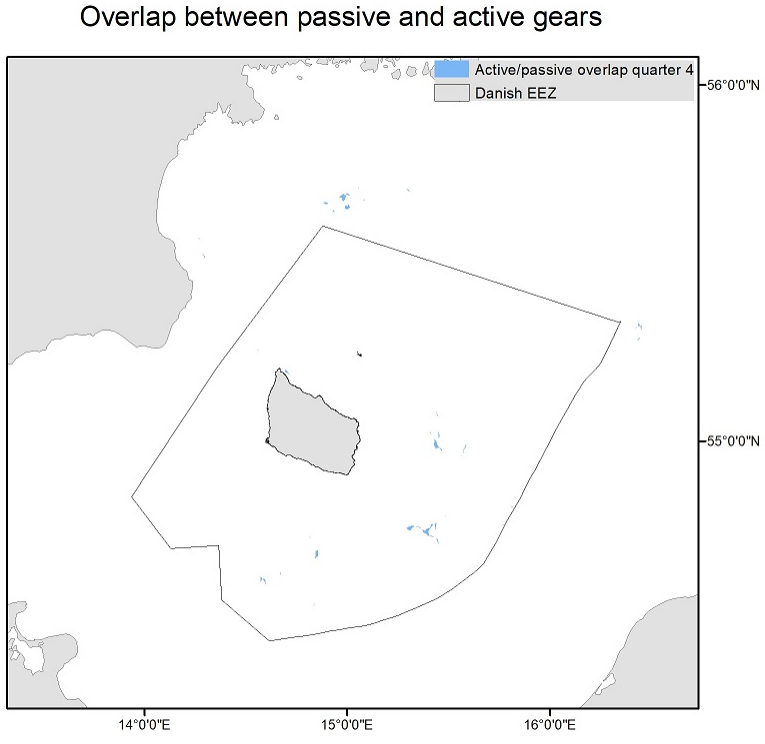

Figure 7.4. Map of the overlap between passive and active fishing activities around Bornholm in quarter 4.

Analyses of overlap between fisheries and wrecks

We compared the geographical distribution of active and passive fishing activities with a map of known wrecks in Danish waters to determine any overlap that could create DFG.

The analyses of overlap were performed using a procedure in ArcGIS, which overlay the two maps of active and passive fishing activities individually with the map of known wrecks. The analyses records in how many quarters the overlap occurred. The results for passive gears are shown in Fig. 8. Figs. 9 -11 present a more detailed view of three areas where the overlap is more pronounced, *i.e.* off the west coast of Jutland (Fig. 9), in the Langeland Belt (Fig. 10) and in Øresund (Fig. 11). These detailed views are combined with the map showing the distribution of fishing intensity (Fig. 3). Please note that the fishing intensity maps are less detailed (based on larger squares) than the overlap analyses, which results in a number of symbols for no overlap (black dots) being placed on a square with some fishing intensity.

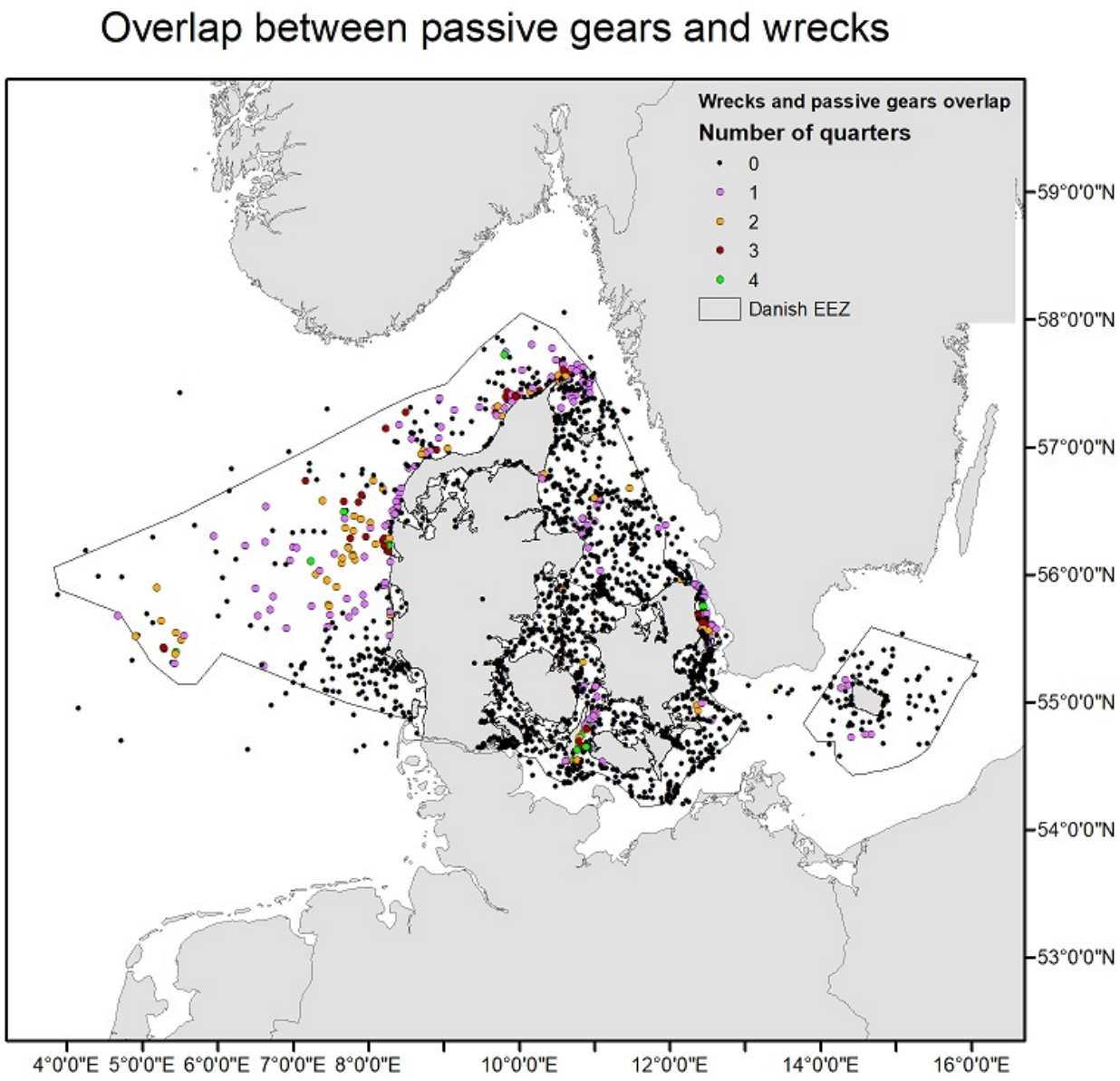

Figure 8. Map of the overlap between passive fishing activities and wrecks. The symbols show the number of quarters with an overlap.

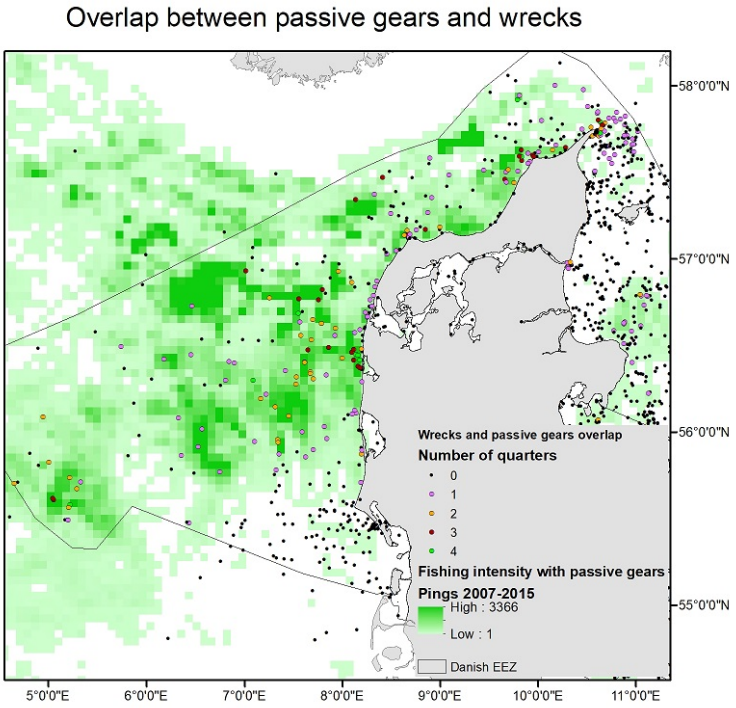

Figure 9. Map of the overlap between passive fishing activities and wrecks off the west coast of Jutland. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

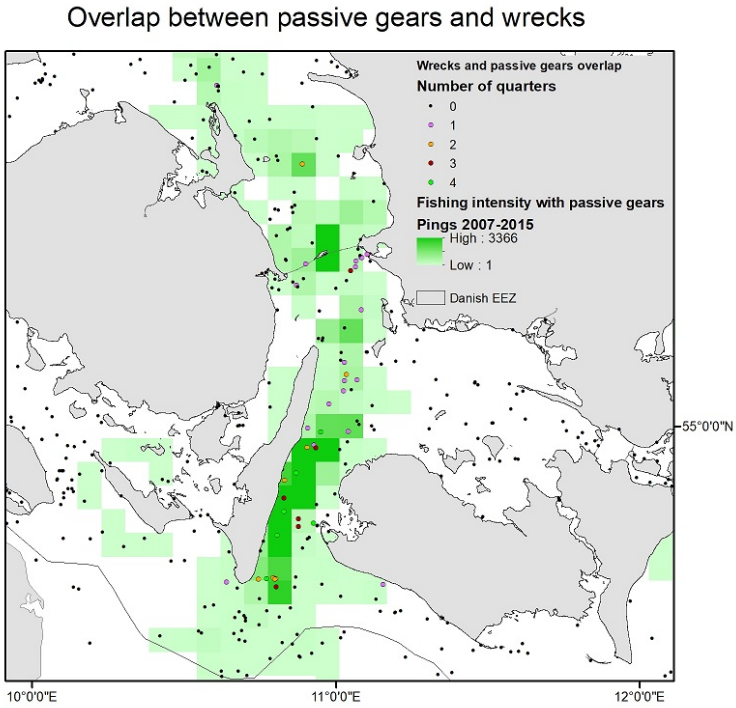

Figure 10. Map of the overlap between passive fishing activities and wrecks in the Langeland Belt. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

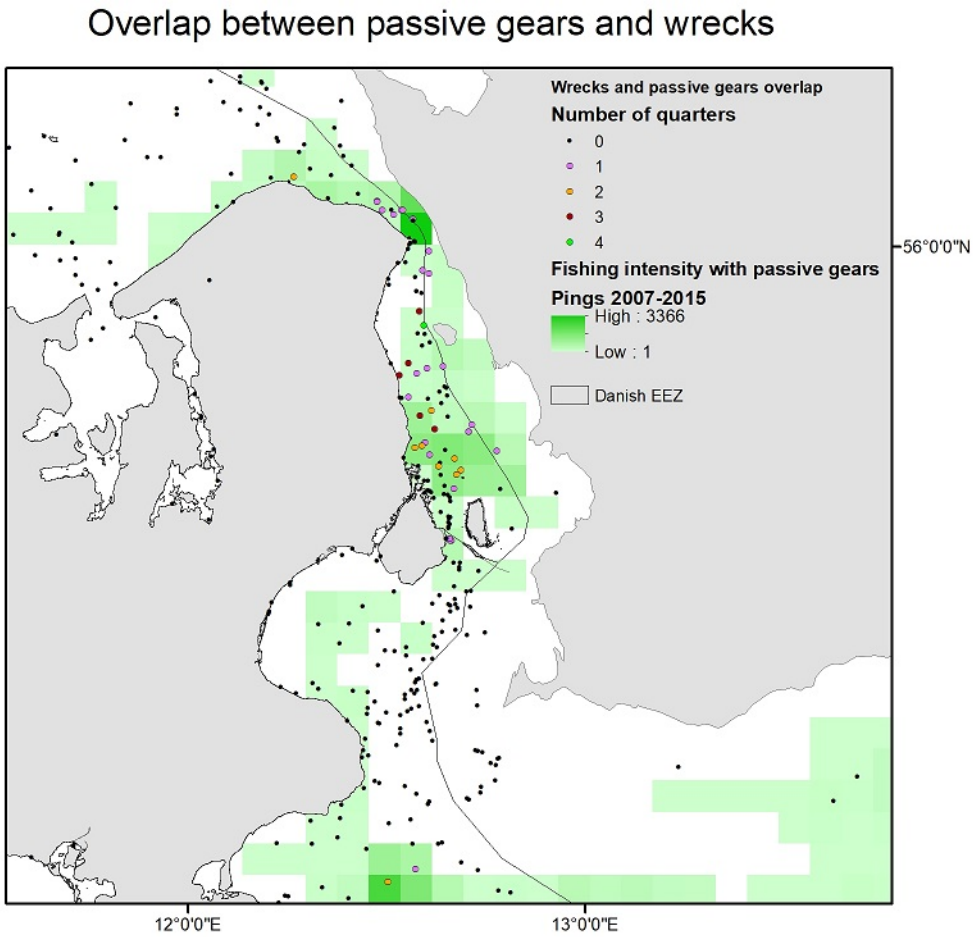

Figure 11. Map of the overlap between passive fishing activities and wrecks in Øresund. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

The results for active gears are shown in Fig. 12, while Figs 13-16 present a more detailed view of four areas where the overlap is more pronounced, *i.e.* off the west coast of Jutland (Fig. 13), around the northern tip of Jutland (Fig. 14), in the western Baltic (Fig. 15) and around Bornholm (Fig. 16). In all areas, the overlap happens primarily in the first quarter of the year. These detailed views are combined with the map showing the distribution of fishing intensity (Fig. 3). Please note that the fishing intensity maps are less detailed (based on larger squares) than the overlap analyses, which results in a number of symbols for no overlap (black dots) being placed on a square with some fishing intensity.

There are several areas where the passive fishing activities interact with wreck positions (Fig. 8). Along the west coast of Jutland there are large areas with interactions, both coastally and offshore (Fig. 9), and this happens primarily in the first quarter of the year. There are also interactions between passive fishing activities and wrecks in the Langeland Belt (Fig. 10), primarily in the first quarter. Some interactions also happen in Øresund (Fig. 11) with no apparent seasonal trends. A large part of these interactions is probably related to the wreck net fishery, where nets are set close to or sometimes directly on the wrecks.

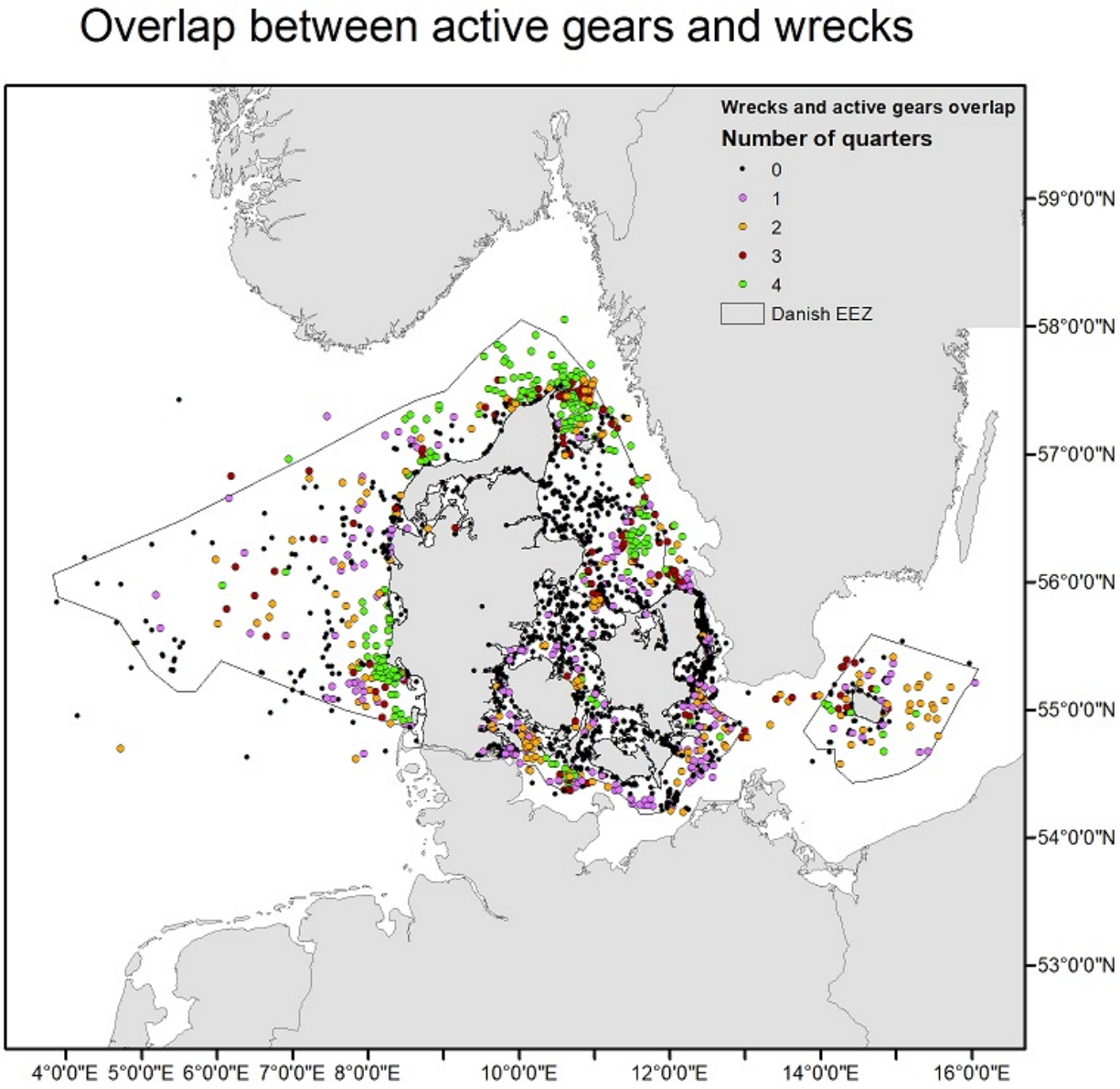

Figure 12. Map of the overlap between active fishing activities and wrecks. The symbols show the number of quarters with an overlap.

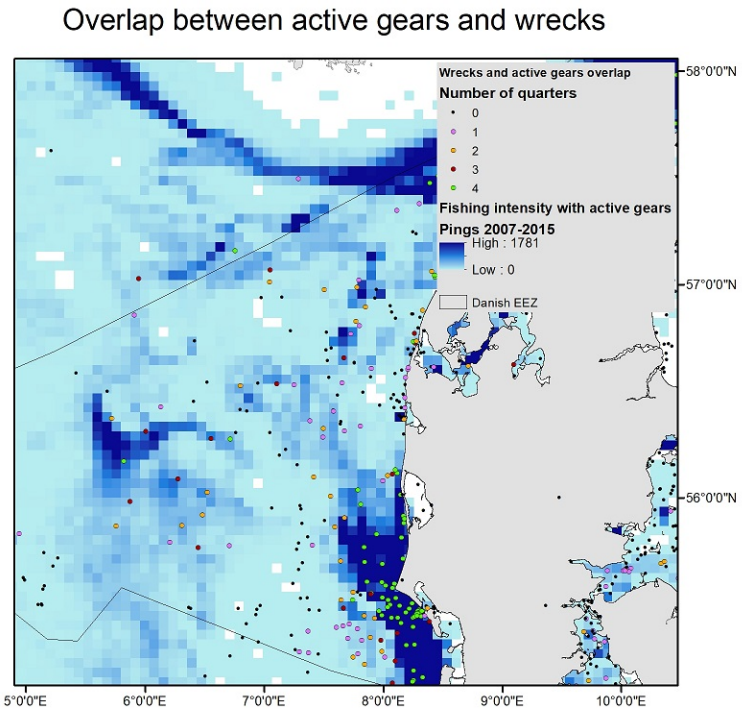

Figure 13. Map of the overlap between passive fishing activities and wrecks off the west coast of Jutland. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

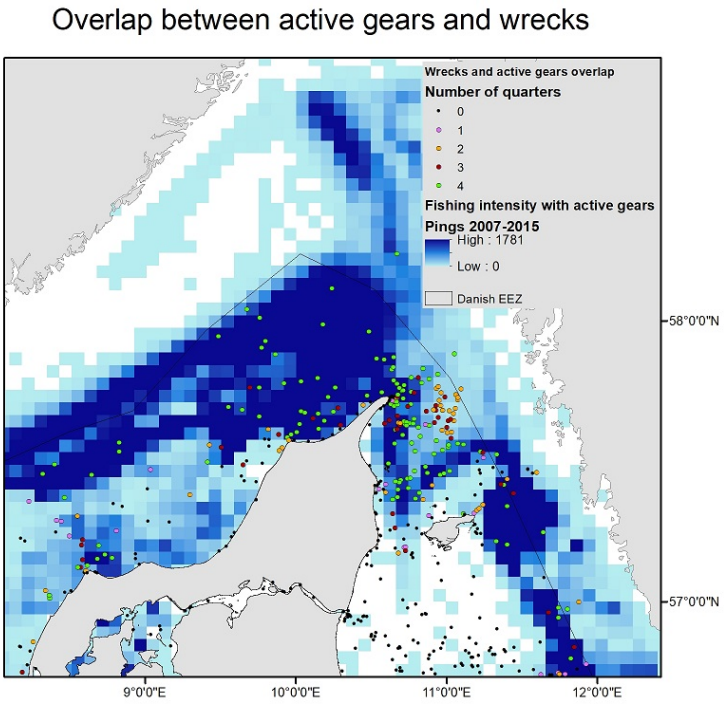

Figure 14. Map of the overlap between passive fishing activities and wrecks around the northern tip of Jutland. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

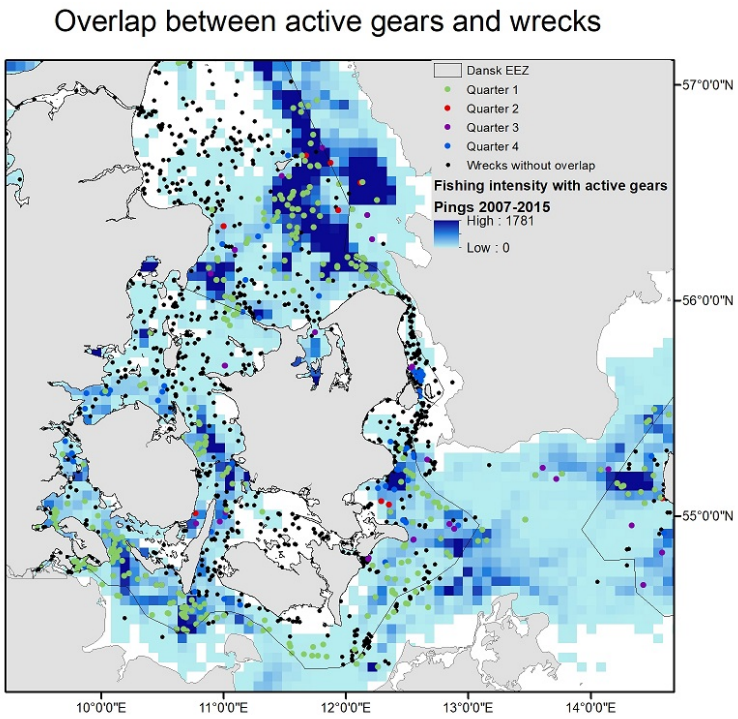

Figure 15. Map of the overlap between passive fishing activities and wrecks in the western Baltic Sea. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

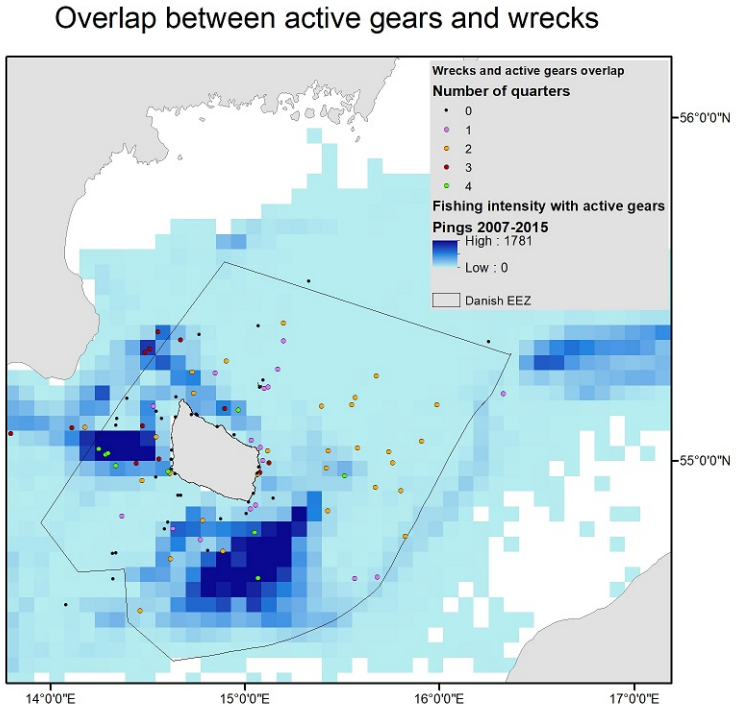

Figure 16. Map of the overlap between passive fishing activities and wrecks around Bornholm. The symbols show the number of quarters with an overlap. Intensity is given as total pings per square.

For the active fishing activities, there appears to be interactions in almost all parts of the Danish waters (Fig. 12) and this happens primarily in the first quarter of the year. The interactions seem to be more pronounced off the southwest coast of Jutland (Fig. 13), around the northern tip of Jutland (Fig. 14), in the western Baltic Sea (Fig. 15) and around Bornholm (Fig. 16). Vessels using active gears will usually try to avoid contact with wrecks, since that can lead to damage or even loss of the gear, but they are interested in fishing as close to the wrecks as possible, because of the larger fish that normally are found at wrecks.

Analyses of overlap between fisheries and reefs

We compared the geographical distribution of active and passive fishing activities with maps of stone reefs, biogenic reefs and bubble reefs to determine any overlap that could create DFG.

The analyses of overlap were performed using a procedure in ArcGIS, which combine the two maps of active and passive fishing activities and overlay them with the maps of stone reefs, biogenic reefs and bubble reefs. The results are shown in Fig. 17, while Figs. 18-20 present a more detailed view of northern Kattegat, southern Kattegat and around Bornholm.

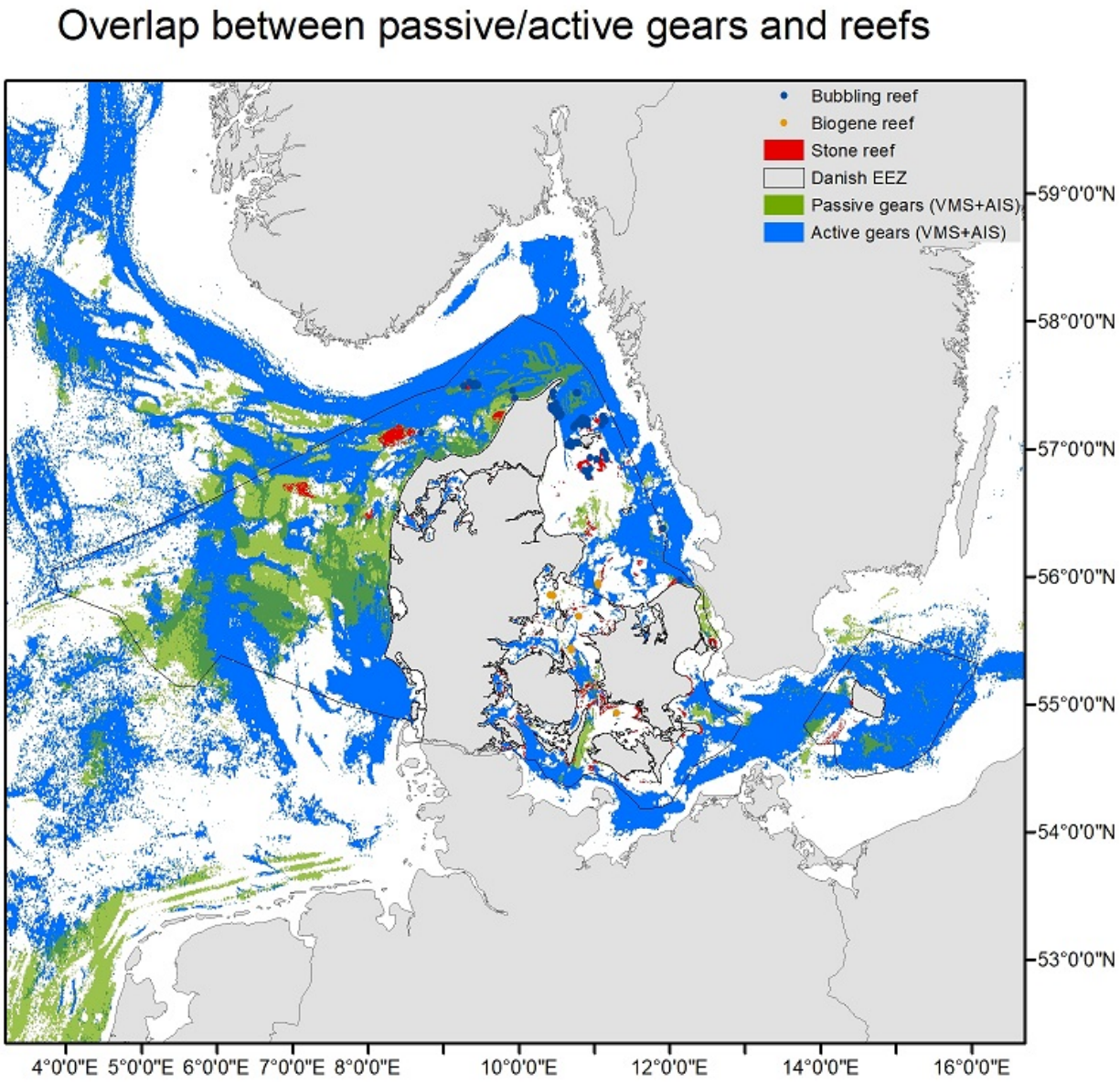

Figure 17. Map of the overlap between passive and active fishing activities and reefs.

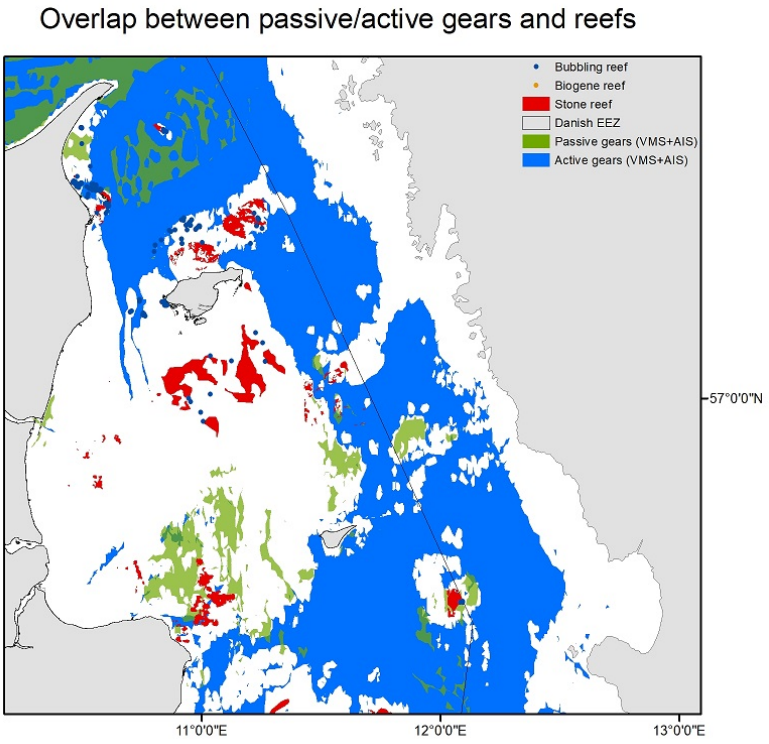

Figure 18. Map of the overlap between passive and active fishing activities and reefs in northern Kattegat.

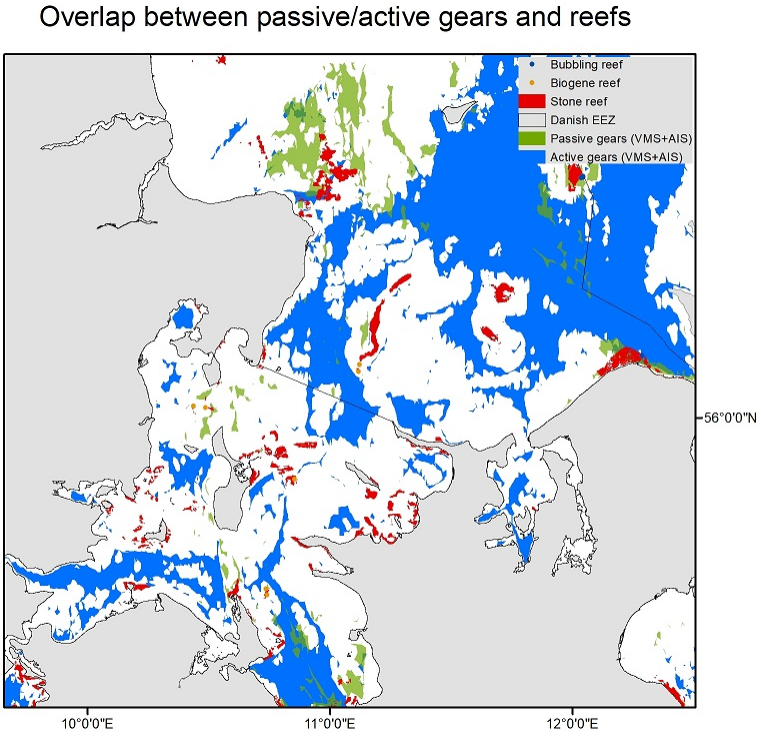

Figure 19. Map of the overlap between passive and active fishing activities and reefs in southern Kattegat.

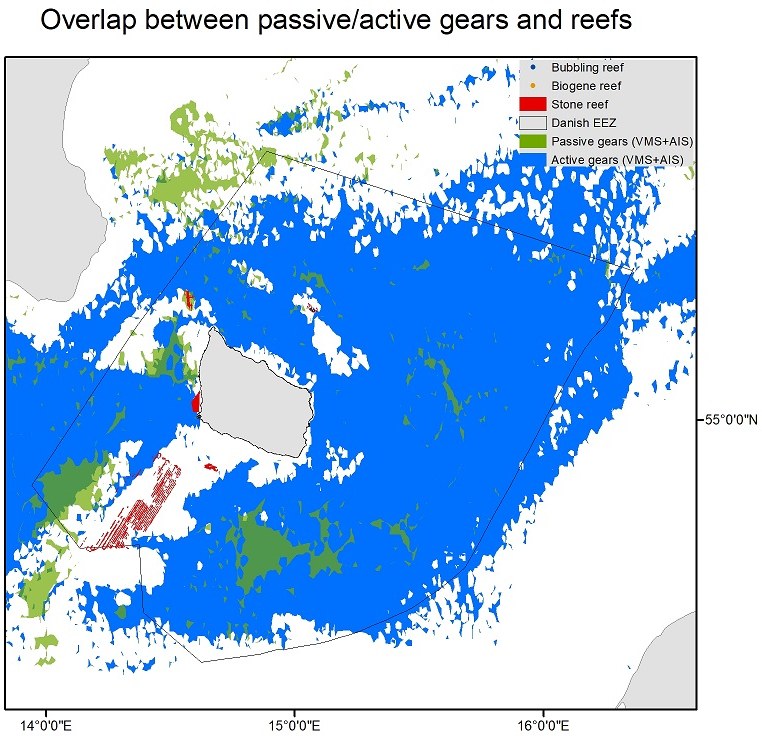

Figure 20. Map of the overlap between passive and active fishing activities and reefs around Bornholm.

It appears from Figs. 17-20 that both active and passive fishing activities seem to avoid the reefs, with the exceptions of Store Middelgrund, the southern part of Langeland Belt and an area north of Bornholm, where some passive fishing activities takes place on stone reefs.

Analyses of overlap between passive fisheries and marine traffic

We compared the geographical distribution of passive fishing activities with the geographical distribution of marine traffic activities to determine any overlap that could create DFG.

The analyses of overlap were performed using a procedure in ArcGIS, which overlay the map of passive fishing intensity (Fig.3) with a map of marine traffic intensity based on data provided by the Danish Maritime Agency. The results are shown in Fig. 21. Because it can be difficult to distinguish between the colours used for the shipping and the colour used for the fishing intensity, Fig. 22.1 shows the ship traffic alone and Fig. 22.2 shows the passive fishing intensity alone. It is apparent that there is a relatively intense fishery with passive gear in the international shipping lane called the T-route, which is one of the busiest shipping lanes in the World. This gives rise to interactions particularly off the west coast of Jutland (Fig. 23) and in the Langeland Belt (Fig. 24).

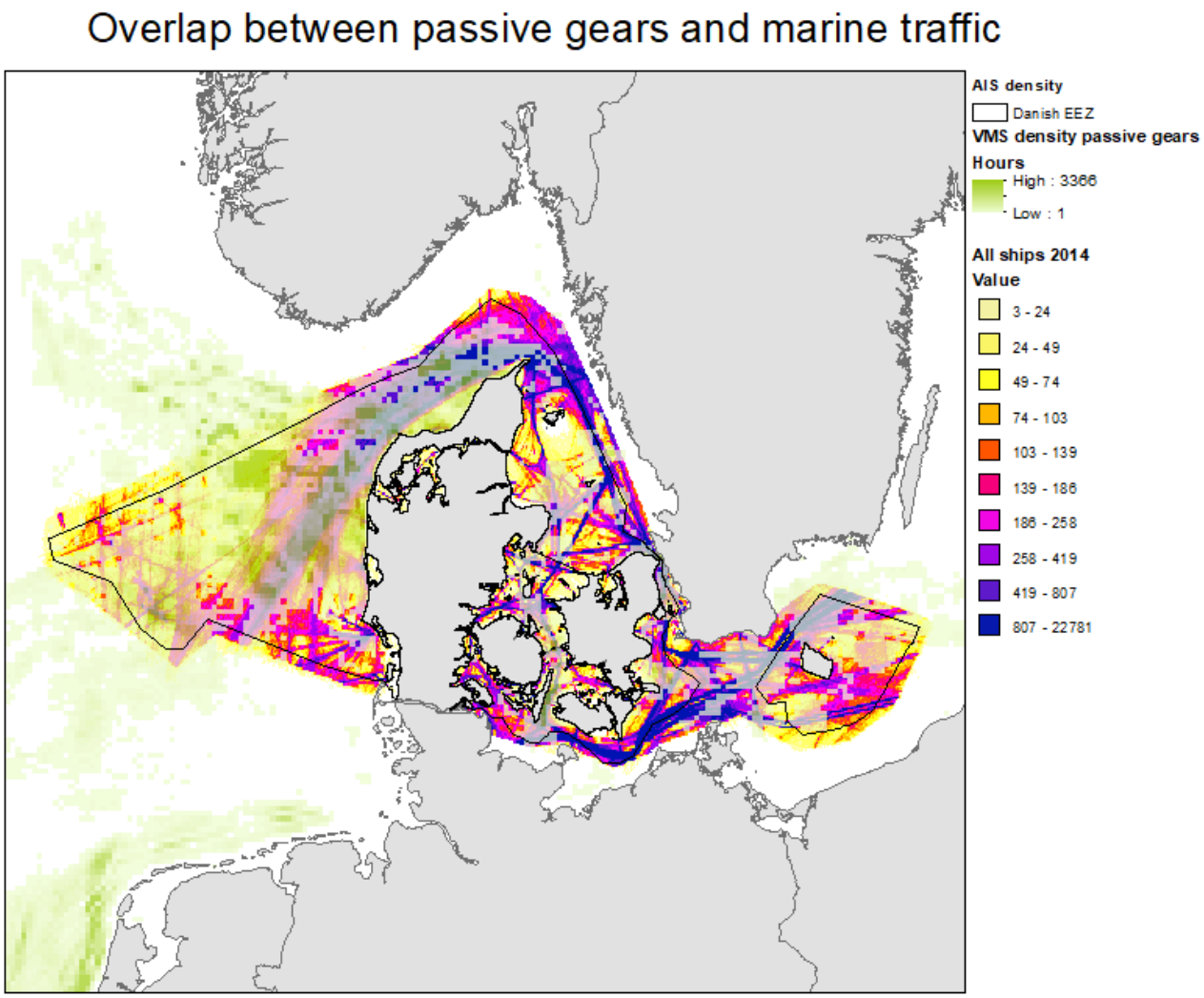

Figure 21. Map of the overlap between passive fishing intensity and marine traffic intensity given as number of ship tracks per cell per year.

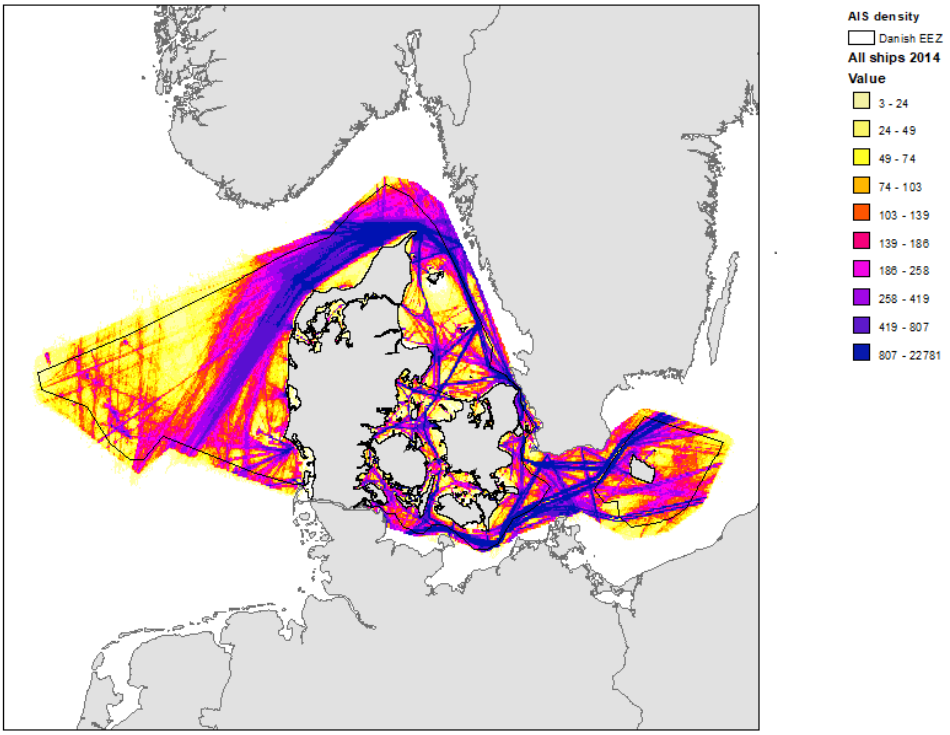

Figure 22.1. Map of the marine traffic intensity given as number of ship tracks per cell per year.

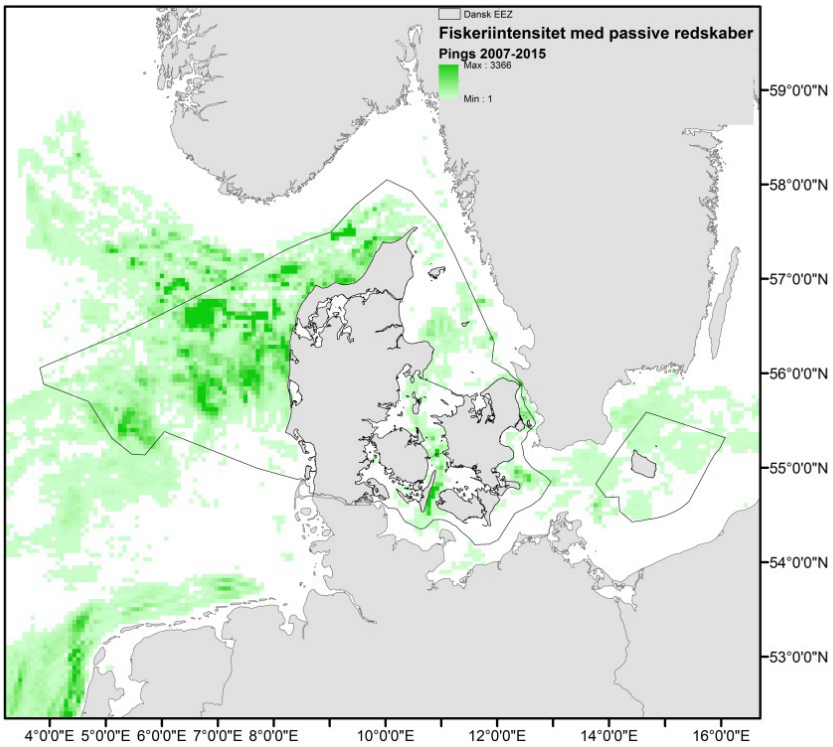

Figure 22.2. Map of the distribution of passive gear fishing intensity (same as Fig 3).

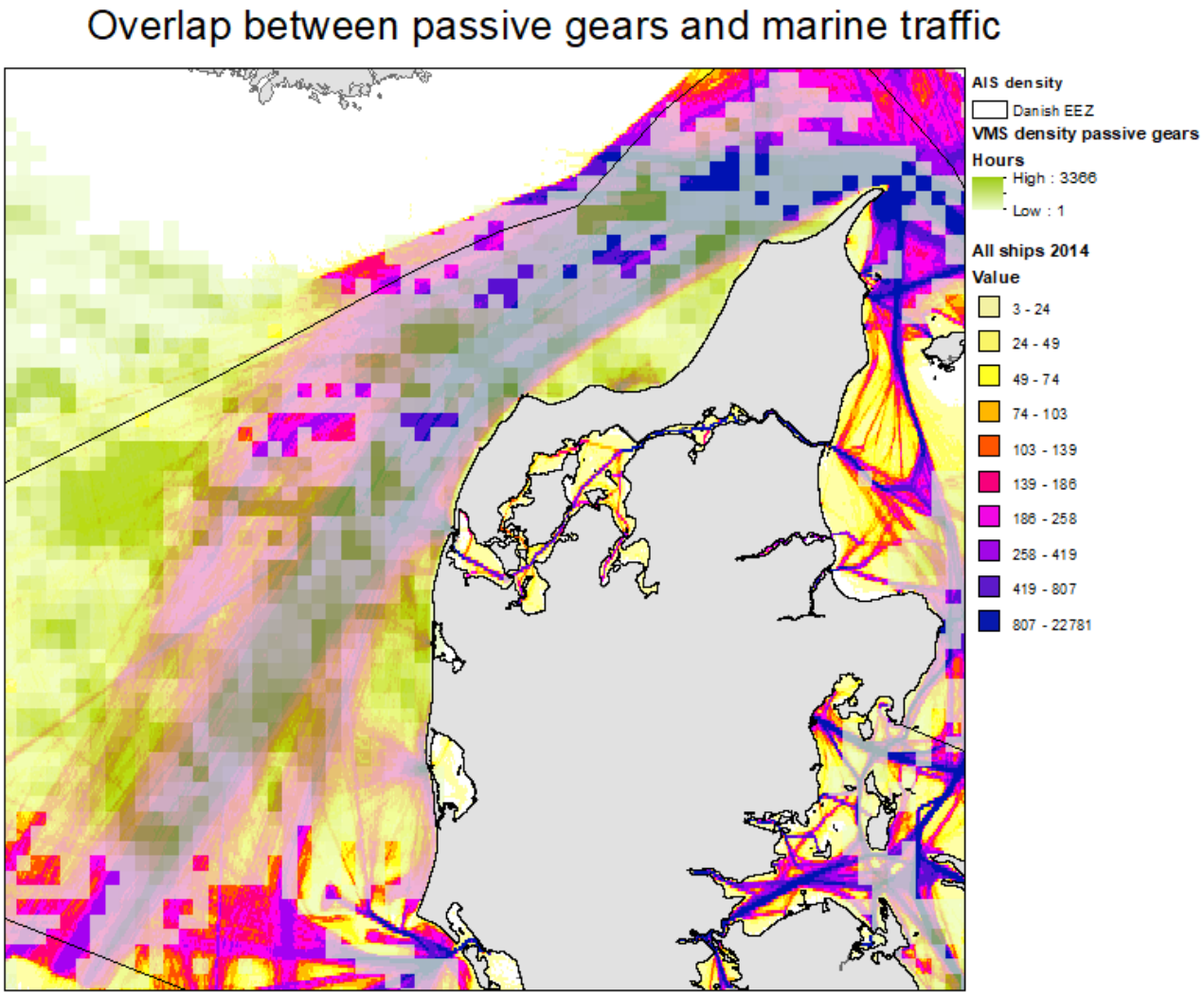

Figure 23. Map of the overlap between passive fishing intensity and marine traffic intensity given as number of ship tracks per cell per year off the west cost of Jutland.

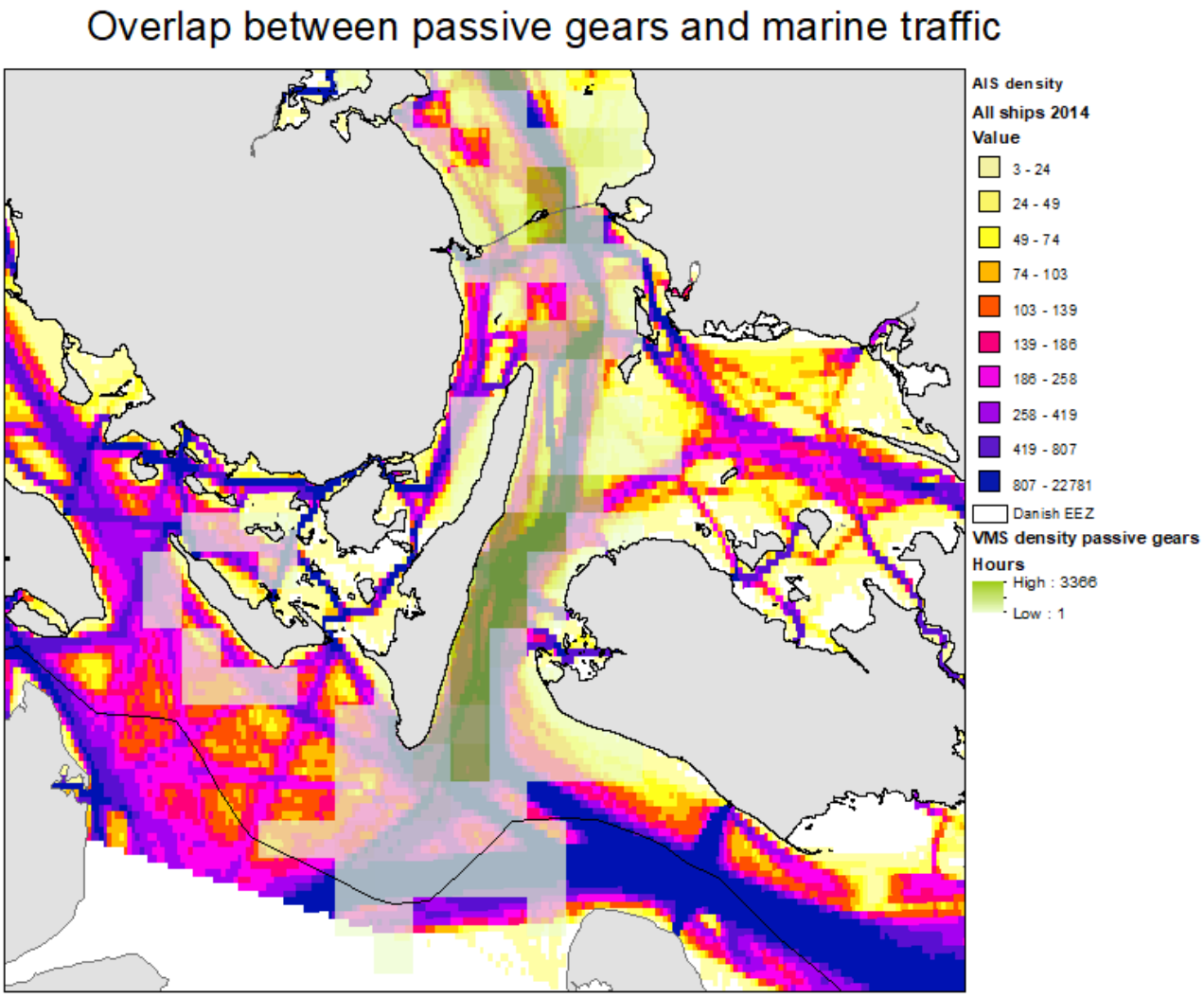

Figure 24. Map of the overlap between passive fishing intensity and marine traffic intensity given as number of ship tracks per cell per year in the Langeland Belt.

Case studies

The purpose of the case studies is to provide an independent check on whether the areas identified as potential conflict areas based on the analyses of overlap indeed has such conflicts that could create DFG. This independent check would come from interviews with commercial gillnet fishermen and sports divers active in the case study areas.

Selection of case study areas

Three criteria were used to select the three case study areas:

1. We wanted a case study where the interactions between active and passive fishing activities appeared to be much higher than in other areas.
2. We wanted a case study where other interactions, i.e. with wrecks, reefs or marine traffic, were important.
3. We wanted a case study from the North Sea, one from inner Danish waters and one from the Baltic Sea.

With respect to criteria 1, there were two obvious candidates: the area off the west coast of Jutland and the area including Jammerbugten, Tannisbugten and waters north of this. We decided on the latter, mainly because it has interactions more of the year, but also because it includes the Natura 2000 area Store Rev, which we know from contacts with local fishermen has conflicts between trawl and gillnet fishing. This area then serves as our North Sea area.

With respect to criteria 2, we selected Langeland Belt, because it has severe interactions with marine traffic, and also interactions with wrecks and reefs. This area then serves as our inner Danish waters area.

With respect to criteria 3, we selected Bornholm as this is the only place that qualifies as a Baltic Sea area.

Interviews/questionnaires

Fishermen

Interviews with fishermen were conducted by telephone using a standard format. The form used for the interviews is shown in Appendix 1. The aim was to conduct interviews with at least three gillnet fishermen from each area, which happened for Bornholm (3 fishermen interviewed) and the North Sea (6 fishermen interviewed). However, for the Langeland Belt we only managed to interview one fisherman as the others we contacted didn't return our calls despite several reminders. This, unfortunately, is not uncommon. A summary of the results of the interviews are given in Appendix 2.

Baltic Sea

The three fishermen interviewed fish primarily with gillnets but also uses longlines for cod and salmon. All three fishermen very rarely lose fishing gear, *i.e.* once or twice per year and when it happens, it is often just a buoy or half a net. The reasons for losing gear are given as trawlers or getting the gear hooked on an obstacle like a boulder or a wreck. They can normally find the gear again using their GPS and the echo sounder, and because of the cost of replacing the gear[2], they are prepared to spend time searching for the lost gear. They rarely encounter DFG, but when fishing with hooks near the bottom, they sometimes catch balls of old netting, which they will try to bring ashore. One of the fishermen said that losing gear was a larger problem earlier when some of the foreign vessels were state-owned, since the

[2] A single panel of gillnet costs around 700 DKK.

fishermen had no incentive to spend time retrieving lost gear. Illegal fishing without buoys also earlier led to many gillnets being lost. It was mentioned that Danish fishermen use at most 600m between marker buoys, whereas Swedish fishermen use up to several kilometres. This longer spacing increases the risk of losing gear. They do not perceive DFG as a problem for the environment or for the fishery.

Langeland Belt

The fisherman interviewed in this area fish with gillnets along the eastern side of Langeland. He claims no to lose nets, but loses around 200 buoys annually due to marine traffic because he fishes very close to the main shipping lane going through Langeland Belt, which is part of the main shipping lane through Storebælt and sees a lot of traffic with very large vessels. He also has a major problem with DFG in the form of jigging lures from sports fishing, and in 2016 removed enough lures from his nets to fill 70 buckets. He does not perceive DFG as a problem for the environment or for the fishery.

Jammerbugten, Tannisbugten and waters north of this

The six fishermen interviewed in this area fish with gillnets and wreck nets. One of the fishermen also fish in the North Sea. Five of the fishermen rarely lose fishing gear, while the sixth loses maybe 10 nets annually. This fisherman fishes in much deeper water (70-150m) than the others, where retrieving the nets is very difficult. They rarely encounter DFG, which are mainly fragments of nets and trawls. They replied that DFG was a larger problem earlier but that attitudes have changed and that fishermen are now less inclined to dumping fishing gear. They do not perceive DFG as a problem for the environment or for the fishery.

Sports divers

Sports divers were not interviewed directly. Because sports divers often dive in many different parts of Denmark, we contacted the Danish sports divers' association (Dansk Sportsdykker Forbund) and asked them to distribute a link to an on-line questionnaire together with a call to fill in the questionnaire (shown in Appendix 3).

We received replies from 32 divers, of which 5 had been diving around Bornholm, 6 in Langeland Belt, 5 in the North Sea and Skagerrak, 25 had dived in other parts of Kattegat and the Belt Seas and one did not reveal where he had been diving. Overall, 30 of the 32 divers (94 %) had encountered DFG during diving. There were no regional differences in this percentage. Of the 32 divers replying, 27 reports diving on wrecks, so it is not surprising that most of them report that DFG is found on wrecks, but of the 21 replying that they were diving on both wrecks, reefs and the seabed in general, 15 (71 %) reported that DFG was found primarily on wrecks, 4 (19 %) reported that they were found primarily on the seabed in general and 2 (10 %) reported reefs as the place where they primarily encountered DFG. One of the divers mentions seeing DFG on the bubble reefs at Hirsholmene. For most of the respondent, DFG stems from commercial fishing activities, but a few of them mentions that hooks, lures etc. from sports fishing is also found on wrecks and reefs. Many of the divers see DFG as a safety hazard for divers, especially during diving in low visibility and for inexperienced divers, but they also see ghost fishing by DFG as a major problem that needs to be solved.

Summary of interviews

The fishermen interviewed reports losing very little fishing gear and when they do lose gear, they are mostly able to retrieve the gear. The development of precise GPS and high-resolution two- and three-dimensional echo sounders play an important role here and provides the fishermen with important tools to locate their gear; tools that they did not have earlier. An exception is fishing in deeper waters, where retrieving lost fishing gear is much more difficult. That deep-water fishing results in more DFG than in more shallow areas is also one of the conclusions of reviews like FANTARED 2 (2003), Macfadyen et al. (2009) and NOAA (2015).

The fishermen believe that the DFG they catch in their gears are from earlier times when it was more common to dump old fishing gear at sea, and they do not see DFG as a major issue in present days. However, it is clear from the interviews with the divers that there are considerable amounts of DFG in Danish waters. This apparent lack of agreement between the two groups is probably to some extent a result of the different information the two groups possess: the divers can observe directly the amounts of DFG whereas the fishermen's information is based on what they catch in their gear and what they lose during fishing. There is not necessarily any disagreement between the observations of the two groups if the DFG observed by the divers stem from earlier when it was more common to dump old fishing gear and when the tools for finding lost gear were not as advanced as today.

There do not appear to be any regional differences in the occurrence of DFG in Danish waters neither in the replies from the fishermen nor in the replies from the divers. Interactions between passive fishing activities and marine traffic appears to be a major problem in Langeland Belt, but according to the fisherman this does not result in creation of DFG as he is able to locate his gear even without the buoys.

Uncertainties

Spatial data on fisheries

As mentioned above in the section on fisheries data, a major uncertainty regarding the spatial distribution of fishing activities is that VMS is not mandatory for vessels below 12m and only 12 vessels below 12m are using VMS. Including AIS data increased the coverage by 66 vessels out of a total number of around 1140 vessels below 12m. This means that in our analyses, VMS and AIS covered a total of around 30 % of the total number of fishing vessels in 2015 and around 7 % of the vessels below 12m. However, because the larger vessels fish more days and use more gear than the smaller vessels, our analyses covered 98 % with respect to landings. Although larger vessels are probably more efficient than the smaller vessels, it means that with respect to effort, our analyses covered a much larger part than the mere number of vessels suggests.

The low coverage especially of vessels using passive gears could to some degree bias the results of the analyses of overlap if the vessels without VMS and AIS are fishing in other areas than the vessels that are included in the analyses. However, judging from the concentrations of vessels fishing with passive gears in Kattegat, the Belt Seas and the western Baltic Sea (Fig. 1), our analyses appears to have covered the main areas.

As mentioned earlier, we would have preferred to base all the analyses of overlap on fishing intensity instead of merely fishing presence, as fishing intensity provides a better representation of the actual fishing effort. However, we were not able to find a procedure in ArcGIS that would allow us to do that. Comparing Figs. 2 and 3 do not suggest that this creates any major bias, but it should be kept in mind when interpreting the results of the analyses of overlap.

Other uncertainties

It would be naïve to believe that interviews and questionnaires will necessarily provide unbiased and objective answers to the questions posed. Both fishermen and divers are well aware of the potential impact, which attention to a particular problem like DFG could have. This should be kept in mind when interpreting the information obtained through our interviews and questionnaires.

Rules and regulations

It is mandatory for commercial Danish fishermen to mark passive gear with the vessel registration number. This normally done by marking the marker buoys, and there is no requirement to mark the gear itself. It is not mandatory to mark active gears.

EU Council Regulation 1224/2009 states in article 48 concerning retrieval of lost fishing gear, that:

1. A Community fishing vessel shall have the equipment on board to retrieve lost gear.

2. The master of a Community fishing vessel that has lost gear or part of it shall attempt to retrieve it as soon as possible.

3. If the lost gear cannot be retrieved, the master of the vessel shall inform the competent authority of its flag Member State, which shall then inform the competent authority of the coastal Member State, within 24 hours of the following:
(a) the external identification number and the name of the fishing vessel;
(b) the type of lost gear;
(c) the time when the gear was lost;
(d) the position where the gear was lost;
(e) the measures undertaken to retrieve the gear.

4. If the gear that is retrieved by the competent authorities of the Member States has not been reported as lost, these authorities may recover the cost from the master of the fishing vessel that lost the gear.

5. A Member State may exempt Community fishing vessels of less than 12 metres' length overall flying its flag from the requirement set out in paragraph 1 if they:
(a) operate exclusively within the territorial seas of the flag Member State; or
(b) never spend more than 24 hours at sea from the time of departure to the return to port.

According to the Danish Ministry of Environment and Food, in an inventory for the period 2015 - March 2017 there have been no reports from Danish fishermen of losing gear.

Experience from neighbouring countries

Norway

The Norwegian regulations related to seawater fisheries states:

CHAPTER XVII. LOSS OF GEAR AND ORDER ON HARVESTING GROUNDS
Section 78. Reporting and retrieval of lost gear
Any person that loses gear or cuts it adrift has a duty to search for the gear. If it is not possible to retrieve lost gear, the following shall be reported to the Coast Guard Central (tel. 07611) immediately:
a) the name and call sign of the vessel
b) the type of gear
c) the quantity of gear
d) the time when the gear was lost
e) the position where the gear was lost

Finds of lost gear shall be reported to the Coast Guard Central

The Norwegian Directorate of Fisheries (NDF) receives this information from the Coast Guard and use it as the basis for planning the yearly retrieval survey for DFG, which has been carried out since 1983. The NDF contacts the vessels that have reported losing gear to verify the information provided to the Coast Guard. The NDF also use other channels of communication with the fishing industry to obtain information on lost gear and to remind the fishermen about the importance of reporting lost gear. DFG resulting from deep-water gillnet fishing has high priority, because large number of slow growing fish are caught in these nets.

During the five-week survey in 2016, NDF used creepers (a type of heavy grabble hook) to retrieve 800 gillnets, 80 large pots, 9000m ropes, 45000m longlines, 30 anchors, large parts of 5 trawls, 1 trawl door, 4000m of steel wire and parts of both pelagic and bottom seines. The amount of fish in the DFG varied considerably but the majority were deep-water Greenland halibut. In addition, there were 3635 large crabs, primarily king crabs, one whale caught in a trawl and one seal caught in a gillnet. The total number of gillnets retrieved since 1983 is 19.600. If the owner can be identified, the gear is returned, otherwise it is sold or re-cycled.

The cost of the retrieval survey in 2016 was around 4 million Norwegian Kroner.

There is no estimate of the total amount of DFG in Norwegian waters.

It should be noted that it is much more difficult for fishermen losing gear during deep-water fishing to retrieve their lost gear compared to the situation in the much shallower Danish waters.

Sweden

EU Council Regulation 1224/2009 (see section Rules and Regulations) applies also to Swedish fisheries, and there are no additional requirements with respect to DFG in Swedish waters (C. Stadig, Hav och Vatten, pers.comm.).

There are no state-funded DFG retrieval operations in Swedish waters, but some initiatives by local communes and private initiatives by e.g. divers and NGOs takes place.

It is estimated that at least 1.000 km of DFG in the form of gillnets are ghost fishing in the Swedish part of the Baltic Sea. No estimate exists for other parts of Swedish waters.

Germany

EU Council Regulation 1224/2009 (see section Rules and Regulations) applies also to German fisheries, and there are no additional requirements with respect to DFG in German waters (C. v. Dorrien, Thünen Institute, pers.comm.).

There are no state-funded DFG retrieval operations in German waters, and no estimates of the amounts of DFG in German waters.

Recommendations

Research

The logical next step following the analyses presented here is to check whether our predictions of conflict areas as sources of DFG are correct. This can be done by conducting surveys in the three case study areas using side-scan sonars and comparing the occurrence of DFG with areas, which according to our analyses have a lower level of conflicts. The results from these surveys could also be used to estimate the total amounts of DFG in Danish waters, which is not possible from existing data. DTU Aqua has received funding from a private source to conduct such surveys in the Autumn 2017.

Another source of information on the relative abundance of DFG in Danish waters are the data on catches of DFG collected during both standardised trawl surveys with research vessels and trawling by commercial vessels where observers record information on marine litter, including DFG. Recordings of marine litter began in 2011, so there should by now be sufficient data to do an analysis. We recommend that such an analysis is carried out as soon as possible.

DTU Aqua has shown micro plastic to be present in the stomachs of a large percentage of the fish species investigated from Danish waters. Most fishing gears are made of various types of plastic, which will gradually break down to micro plastic and could contribute to the micro plastic found in e.g. fish and other marine organisms. We recommend that research is conducted to determine if DFG is an important source of the micro plastic found in the marine environment.

Retrieval

Retrieval of DFG can be carried out using different types of creepers or grabble hooks dragged after a vessel in areas where the seabed is relatively even, although potential damage particularly to epiflora and -fauna should be considered before conducting such operations[3]. In more complex habitat types like reefs, dragging creepers could inflict unacceptable damage to the habitats, and the only acceptable option here is probably to use divers to remove the DFG from the reefs. The costs involved in different retrieval operations vary considerably. In a clean-up conducted in the Republic of Korea, the cost of removing DFG was estimated at 1,300 USD per ton of DFG removed (Hwang & Ko, 2007), while in Hawaii the cost of a clean-up operation averaged 25,000 USD per ton of DFG (Raaymakers, 2007).

There is little experience with retrieval of DFG in Danish waters. DTU Aqua has estimated that the cost of cleaning just one wreck using divers could be at least 300,000 DKK. The costs involved with dragging creepers depend on the size of the vessel needed and the area that needs to be covered. A suitable vessel would probably cost at least 15,000 DKK per day and to this should be added salaries, costs of the equipment needed and transportation of the retrieved DFG to a suitable facility for recycling. We recommend that pilot trials with retrieval operations are carried out using divers on wrecks and dragging creepers on more even seabed to gain experience with these types of operations and the costs involved.

Experience from the Norwegian retrieval operations suggests that having prior information on positions where gear has been lost makes the operations much more efficient. It is clear from the above sections that Danish fishermen are not very diligent in reporting lost fishing gear. We therefore recommend that an information campaign targeting commercial fishermen is initiated to increase awareness regarding the requirements of Council Regulation 1224/2009 to report loss of fishing gear.

[3] The EU Interreg. project MARELITT is at present conducting a review of the environmental effects of the different types of retrieval operations.

Preventative and mitigation measures

There are several preventative measures that could be investigated, including spatial management (zoning), voluntary agreements on access, deposits for fishing gear as an incentive to return them and various technical solutions to avoid lost nets becoming DFG.

There are also a number of mitigation measures that could be investigated as a means of limiting the effects of DFG on the fishery and the environment. These include biodegradable nets, corrodible links, etc. that could reduce the amount of ghost fishing by the DFG.

Literature cited

FANTARED 2. 2003. A study to identify, quantify and ameliorate the impacts of static gear lost at sea. *EC contract FAIR-PL98-4338. ISBN 0-903941-97-X. 501 pp.*

Hwang, S.T. & Ko, J.P. 2007. Achievement and progress of marine litter retrieval project in near coast of Korea – based on activities of Korea Fisheries Infrastructure Promotion Association. *Presentation to Regional Workshop on Marine Litter, Rhizao, China, June 2007. North West Pacific Action Plan.*

Macfadyen, G., Huntington, T. & Cappell, R. 2009. Abandoned, lost or otherwise discarded fishing gear. *FAO Fisheries and Aquaculture Technical Paper 523, Rome Italy. ISBN 978-92-5-106196-1. 115 pp.*

NOAA Marine Debris Program. 2015. Report on the impacts of ”ghost fishing” via derelict fishing gear. *Office of Response and Restoration, National Ocean Service, Silver Springs, MD. 25 pp.*

Raaymakers, S. 2007. Regional Review: Marine Litter in the East Asian Seas region. *Report to the East Asian Seas Regional Coordinating Unit, United Nations Environment Programme. 34 pp. plus appendices.*

Appendix 1: Questions for interview with fishermen

Spøgelsesnet i danske farvand

Introduktion til projektet og formål

Spørgsmål

1. Baggrundsinformation (Navn, Fartøj, Havn, Telefon, E-mail eller hvad der vil oplyses)
2. Hvad fisker du med?
3. Hvor fisker du?
4. Hvor ofte fisker du?
5. Har du VMS/AIS/ andet ombord?
6. Har du nogensinde tabt et fiskeredskab?
    a. Sker det ofte?
    b. Hvor ofte?
7. Er der områder hvor du ved at der er større risiko for at tabe redskaber end andre?
    a. Hvis så, hvad gør disse områder mere risikofyldte end andre?
8. Er der visse situationer der gør det mere sandsynligt at du mister redskaber end andre?
    a. Hvilke situationer kunne det være?
9. Ligner din situation andre fiskeres situation?
10. Fanger du nogensinde fiskeredskaber i dine egne redskaber?
11. Er det ofte?
    a. Og hvilke tilstand er de i?
    b. Hvad gør du ved disse bjergede redskaber?
12. Er der nogen områder hvor der er større sandsynlighed for at du fanger redskaber end andre?
13. Er der omstændigheder der er specielle for at du fanger redskaber.
14. Er der andre ting omkring redskaberne som jeg ikke lige har fået spurgt om?
15. Ser du tabte fiskeredskaber som et problem for det danske havmiljø?
    a. Hvordan
16. Ser du tabte fiskeredskaber som et problem for det danske fiskeri?
    a. Hvordan?
17. Hvilke muligheder ser du for at kunne reducere mængden af tabte redskaber?
    a. I havet?
    b. Inden de rammer havet?

Appendix 2: Summary of results of interviews with fishermen

Gear type	Yearly loss	Type of gear lost	Reasons for loss	Catch of DFG	Reasons for DFG	DFG impact on the environment	DFG impact on fisheries
Baltic Sea							
Gillnet, wreck nets, longlines	2	Buoys, nets	Trawlers	Balls of nets	Previous dumping, illegal fishing	None	Minimal
Gillnet, longlines	NR*	Netting	Trawlers, wrecks	Trawl wires	Previous dumping	None	None
Gillnets, Wreck nets	1	Netting	Trawlers, wrecks	Balls of nets	Carelessness	None	None
Langeland Belt							
Gillnets	200	Buoys	Commercial shipping	Jigging lures	Carelessness	None	None
Jammerbugten, Tannisbugten and waters north of this							
Gillnets	None	NR	Trawlers, beam trawlers	NR	NR	NR	NR
Gillnets	2	Netting	Trawlers, wrecks	Trawl fragments, lines	Previous dumping	NR	NR
Gillnets	Rare	Gillnets	Trawlers	Net fragments	Previous dumping	None	None
Gillnets	Rare	Gillnets	Trawlers, wrecks	Net fragments	NR	None	None
Wreck nets	None	NR	NR	None	Wreck fishing	None	None
Wreck nets	10	Gillnets	Trawlers, wrecks, water depth	Gillnets	Previous dumping	None	None

Appendix 3: Questionnaire for sports divers

The following questions were included in the questionnaire to the sports divers. They are copied from the webpage, thus the simple layout.

Tabte fiskeredskaber i Danmark

1. E-mailadresse

2. Hvor mange år har du dykket?

3. Er du medlem af en dykker klub? Hvilken?

4. Hvor dykker du primært i Danmark?

5. Dykker du primært på? Markér kun ét felt.
Vrag
Rev
Havbund
Blandet alle tre

6. Ser du spøgelsesnet når du dykker dit primære sted? Markér kun ét felt.
Ja, ofte (hver gang jeg dykker)
Ja, en gang i mellem (hvert andet eller tredje dyk)
Ja, men har kun set det et par gange i min karriere
Nej det ser jeg ikke.

7. Hvor ser du typisk spøgelsesnet? Markér kun ét felt.
På vrag
På rev
På havbund
Ikke relevant

8. Hvilke specifikke områder ser du spøgelsesnet? Beskriv gerne flere steder, evt. med GPS position.

9. Er spøgelsesnet et problem for dig som dykker? Hvordan?

10. Ser du spøgelsesnet andre steder i Danmark?

11. Hvilke metoder kan du se som ville afhjælpe spøgelsesnet på havbunden?

12. Andre kommentarer (noget som vi har glemt at spørge om?)

13. Må vi kontakte dig hvis vi har flere spørgsmål? Skriv venligt e-mail eller telefonnummer og navn (frivilligt).

DTU Aqua
National Institute of Aquatic Resources
Technical University of Denmark

Kemitorvet
2800 Kgs. Lyngby
Denmark
Tel: + 45 35 88 33 00
aqua@aqua.dtu.dk

www.aqua.dtu.dk