Interreg

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Re:Fish

D.1.1.1 Popular science report on the dragging of abandoned, lost or otherwise discarded fishing gear (ALDFG)

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1 Introduction

Abandoned, lost, or discarded fishing gear (ALDFG) are fishing gear that have been unintentionally or deliberately left behind in aquatic environments. ALDFG, often called *ghost gear*, includes nets, lines, traps, and other fishing gear that are not actively used but remain in the water. These materials can persist for years and have serious consequences for the environment as well as humans. Although the problem of ALDFGs is present also in freshwaters, most often it is discussed within the marine context, because the magnitude of fishing in marine environment globally is greater than in lakes and rivers.

Environmental impacts of ALDFG are substantial and multifaceted. One of the most direct impacts is the threat posed to marine biota, as abandoned, lost, or otherwise discarded fishing gear can physically injure or kill fish, seabirds, and, in some regions, marine mammals and sea turtles through entanglement and ghost fishing. Ghost nets also smother benthic habitats, which are especially threatening to sensitive ecosystems such as seagrass beds and other ecologically important seafloor communities. In addition, floating or submerged gear poses navigational hazards to boats and larger vessels as well as safety risks to divers. Another major concern is related to the synthetic polymer material used for gear manufacture. Plastics, polyamide (PA, nylon) and polyethylene (PE) netting are commonly used in gillnets, fish traps and seines and trawls, while net lines are made of PE. Fishing gear, like plastic products in general, are degrading slowly with time into smaller fragments, micro- and nano plastics (Wright et al. 2021). This degradation process is enhanced by exposure to UV radiation (Brožová et al. 2025) and temperature fluctuations, but also other parameters like mechanical wear and tear (Napper et al. 2022, Song et al. 2025) have an impact on the degradation of fishing gear.

Based on interviews of fishers from seven fishing regions around the world, Richardson et al. (2022) estimated that on average 0.81 % ± 0.19 % of all gillnets are lost around the world each year. Tschernij and Larsson (2002) assessed that annual loss of gillnets in the southern Baltic Sea by the Swedish cod fishing fleet, mainly due to conflicts with trawlers, amounted to approximately 70–80 km of gillnets (about 2 300–2 700 nets) during 1999–2001. Fishing occurred in open, coastal areas or in distance grounds. The recovery rate of nets by fishers themselves was estimated to be close to 10%. Poland WWF assessed that in 2005-2008 EU operating fleet lost 5 500-10 000 nets annually. Based on the fishing effort data from 2009 it was estimated that the Polish gill net fleet lost 1500 nets annually and the Lithuanians 150 nets, respectively (Predki et al. 2019). In 2008 the use of drift nets was banned. This ban likely has impacted the amount of lost fishing gear, because driftnets are especially prone to becoming lost because their basic design makes it difficult to control once deployed. Their free-drifting nature, large size, and loose attachment to vessels all increase the chance that they break away and turn into ghost nets. Drift nets hang vertically in the water column without being anchored, held only by floats and weights, which means they move with currents and tides rather than staying fixed in place.

Nets and other fishing gear are lost for several reasons. Sudden weather changes, including storms and drifting ice in winter, can dislodge anchored gear. Human error also plays a role: nets with too light weights can drift with the wind or inaccurately marked gear can be lost to motorboat propeller. In coastal regions it is also common to have winter nets under ice that can be lost especially during the springtime when warming weather and wind can suddenly break the ice. Using old and fragile gear can also be one reason for losing gear.

Ecologically, the Baltic Sea is a highly sensitive brackish-water ecosystem. Its low salinity, restricted water exchange with the North Sea, slow circulation, and layered water masses reduce the ecosystem's resilience and its capacity to recover from environmental disturbances. The Baltic Sea is already facing big environmental stressors such as climate change, eutrophication, habitat degradation, and biodiversity loss; hence any additional stress can be very significant for the sea environment, particularly on vulnerable habitats and species with limited tolerance to changing environmental conditions.

Finland, Sweden and Estonia all have extensive coastlines along the Baltic Sea. Estonia has shores on the Gulf of Riga, the Gulf of Finland, and the Baltic Proper including the Gotland Basin, with thousands of islands. Finland borders the Gulf of Bothnia (west) and Gulf of Finland (south), forming a long Baltic Sea coastline and vast archipelago between Gotland basin and Gulf of Bothnia. Sweden has coastline both in the North Sea and the Baltic Sea with many smaller islands but also larger islands of Öland and Gotland.

Commercial fishing has taken place in all the three nations, but recreational fishing in the Baltic Sea carried out by the inhabitants of Sweden, Finland and Estonia is highly diverse, with anglers targeting species like salmon and trout at open, and pike, perch, and pikeperch in coastal areas. Gillnets and fish traps are traditional passive gear used, especially in coastal fisheries. In Finland recreational fishing is a mass activity having its roots in history. In addition, while recreational fishing is an important, and culturally traditional livelihood, the role of tourism as one branch of recreational fishing is on the increase.

All these countries host multiple marine protected areas, including Natura 2000 sites and key bird habitats along migration routes. The Finnish Archipelago Sea contains significant seabird nesting zones, while Estonia's coastal wetlands and Sweden's outer archipelagos support bird and mammal species that are in risk of entanglement to ghost nets and other lost fishing gear.

The main activity of the WP1 in the Re:Fish project was to carry out dragging activities and evaluate the feasibility of the methods tested and assess the amount of fishing-related litter in the dragged sea- areas. The dragging activities were carried out in Estonia and Finland during the years 2024-2025.

2 Dragging activities in Estonia

2.1 Operator requirements

The requirements on board were as follows: a device to store the information of dragged transects (position (GPS), transect lines (chart plotter, sonar, echosounder) and a log with direction, depth, towing speed, visibility and possible weather parameters (wind conditions, temperature). Vessel also needed a way to store the collected information (GPS, chart plotter - PC connection, files, forms, etc.). The selection of vessels for dragging operations was left to the operator. However, the minimum requirement was the availability of three vessels, one of which must have been equipped with a cabin and a net winch. The dragging operations were carried out by the contractor selected through the procurement process, using their own vessels, crew, and equipment.

2.2 Planning of dragging operations

Testing was planned for the period of 1.-15.06.2024. Operational activities were planned to be carried out in two years, 2024 and 2025, annually between 15.06-31.10, when weather conditions permitted. This period corresponds to the ice-free season with less intensive commercial fishing activity and outside fish spawning season. The total length of planned transects was estimated to be 1364 km, resulting in 124 transects with 250-350 m between the parallel transects. This design was intended to provide comprehensive coverage of the study area while maintaining an efficient operational framework.

The operator provided three vessels for dragging operations. One of the three vessels was a hard top boat with a net pulling machine. The hard top boat served as a mothership. At least one of the vessels was equipped with a GPS and a plotter on board to maneuver the vessel and to execute the operations successfully.

The retrieval operations (dragging) were designed to be carried out in Pärnu Bay, SW Estonia (Figure 1). Pärnu Bay is the most intensive fishing area in the coastal sea areas of Estonia in the means of both commercial and recreational fishing. The dragging in the first season was oriented towards more census dragging with dense transect network to find possible hotspots.

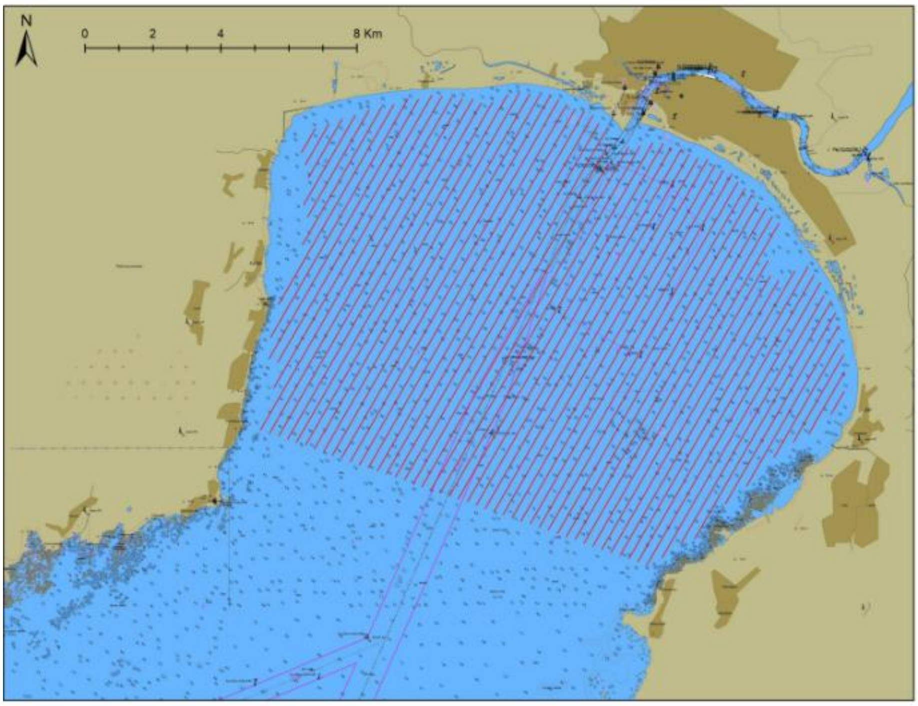

Figure 1. Planned transect scheme for dragging in Pärnu Bay in 2024.

2.3 Dragging

2.3.1 Mapping of the operation area

Pärnu Bay (Figure 2) in the south-west corner of Estonia is a known intensive recreational and professional fishing area. The northern part of the bay is shallow, and the depth varies between 0.9 and 8.4 meters. Fishing tourism, recreational and professional fishing with active and passive gears have been practiced in the area for decades. Angling and jigging, as well as gillnet and fyke-net fishing, are the typical fishing methods in the region. Therefore, expectations to find and retrieve lost fishing gear were considered high.

Figure 2. The location of the dragging area. Pärnu Bay is marked with a rectangle. Basemap: Estonian Land and Spatial Development Board.

The 2024 dragging campaign focused on surveying the area using a dense transect network to identify potential hotspots of lost fishing gear. In 2025, the scheme of dragging was adjusted both spatially and methodologically based on the findings, gained experience, and the results obtained during the first year.

2.4 Dragging methods

Two vessels were used for dragging operations, at a time, an 8.8-meters mothership in 2024 (Figure 3) and a smaller 6.8-meter open-top fishing boat in 2025. A set of 2-4 drags were used for gillnet removal, depending on the sea floor type.


Figure 3. A fishing boat used for dragging operations in Pärnu Bay.

A set of two drags (Figure 4) was used on a rocky, shallow sea floor and four drags on sand, clayish or muddy bottom. The drags were towed 50-60 meters behind the boat at the speed of 4–5 knots. The speed was relatively high, but it was the lowest speed where the boat could maintain steerage. A double rope, a trip line was used, to avoid losing a drag.

The drags were made by welding iron, a stem with prongs (Figure 4). A float with a rope (a trip line) was tied up behind the drag to indicate other boaters to keep safe distance behind and to pull the drags back in case they got stuck.

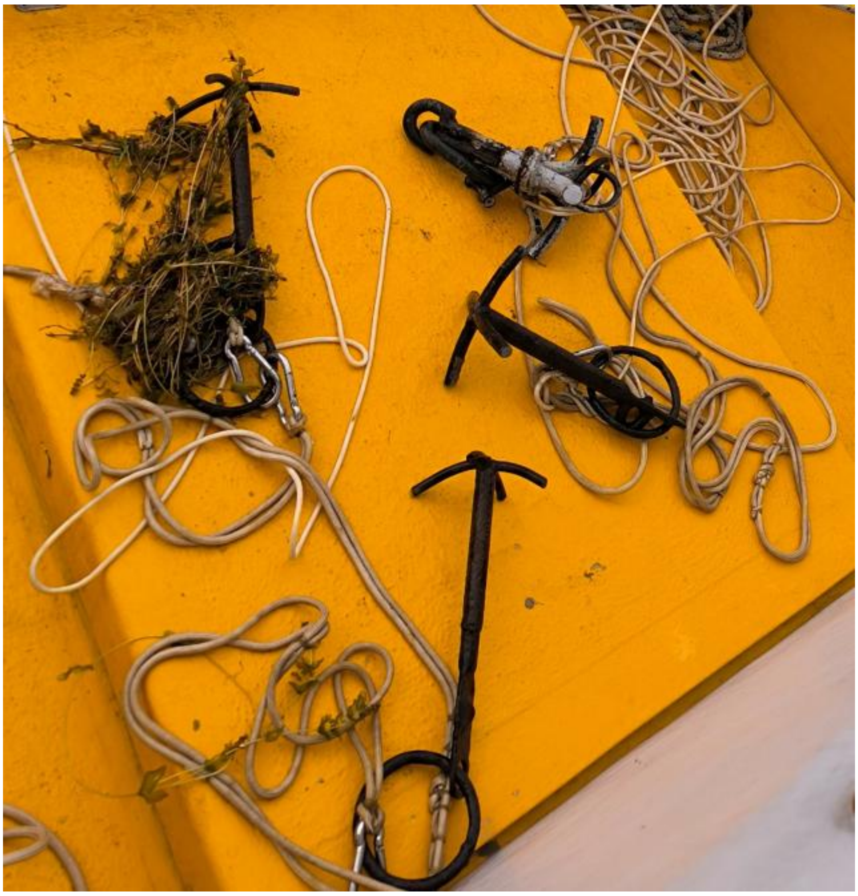

Figure 4. A set of drags used in the Pärnu Bay.

2.5 Results

2.5.1 Dragging in 2024

The dragging's were carried out in 02.07-29.08.2024. In total, 64 transects were dragged in 2024, covering a total distance of 607.298 km (Figure 5) and a surface area of 168 km^2. Distance between the transects was 250-350m.

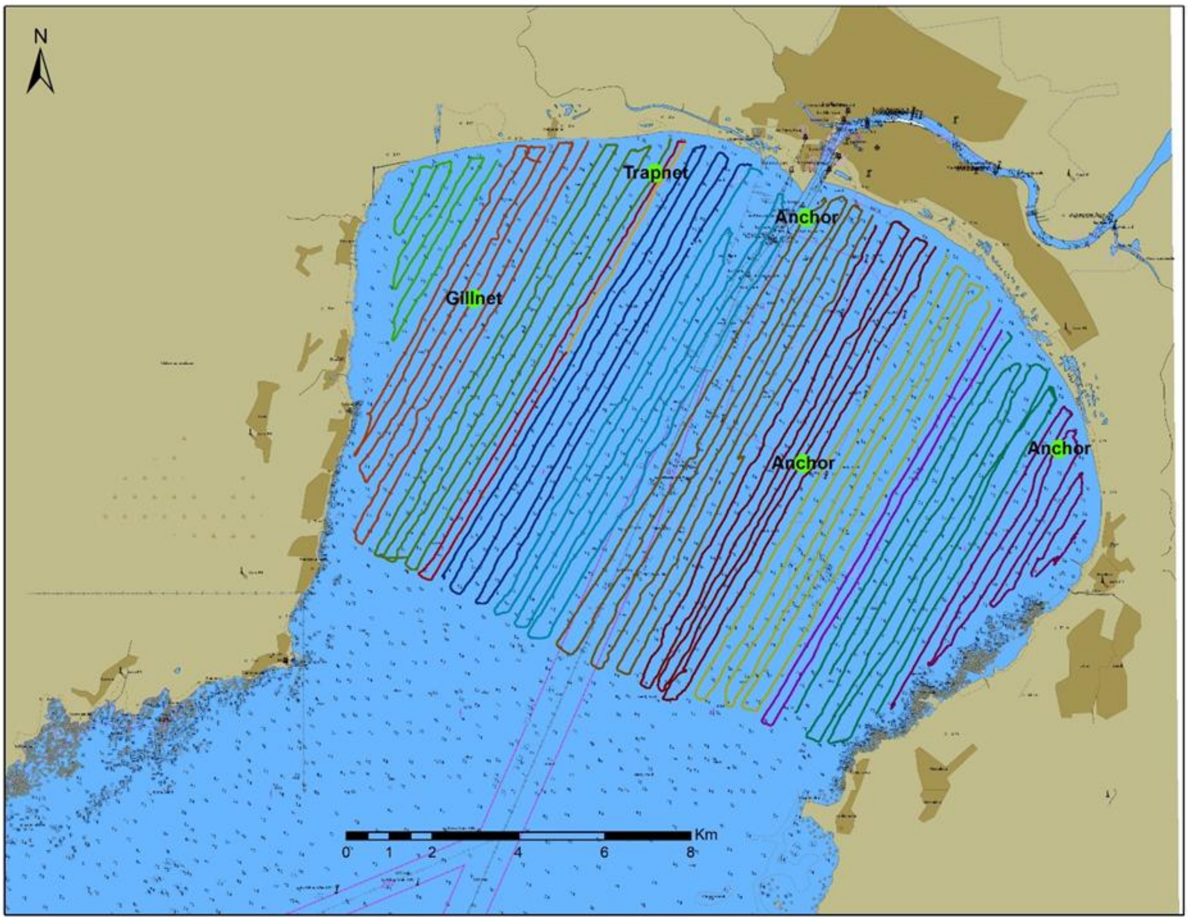

Figure 5. Dragging transects (line) with findings (dots) in Pärnu Bay. Different colours of transects depict different dates of dragging. City of Pärnu is marked as the darker brown area at the top right corner of the map. Basemap: Estonian Land Board.

The locations of the findings are presented in Figure 5. The findings, gear type or item, weight and finding depth, are described in table 1. There were altogether five findings: one fyke net, one gillnet, and three fyke net anchors. By far the largest and heaviest was the fyke net (Figure 6) weighing 300 kg dry.

Table 1. Retrieved fishing gears or fishery related accessories in Pärnu Bay.

Date	Item	Depth	Weight/length	Comments
02.07.2024	Anchor	3.6 m	10 kg	With remains of a fishing jacket
10.07.2024	Anchor	2.5 m	13 kg	
07.08.2024	Anchor	3.4 m	13.5 kg	
08.08.2024	Fyke net	3.9 m	300 kg (dry)/ 800-1000 kg (wet)	Polyamide (nylon 6)
14.08.2024	Gillnet	4 m	26.5 kg, ca 200 m	Polyamide (monofilament nylon)

By far the largest and heaviest was the fyke net (Figure 6). No fish, birds or other macrofauna was found entangled in the net.

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Figure 6. A fyke net (left) and b. gillnet (right) found while dragging in august 2024 (Photos by M. Merirand).

Pärnu Bay is considered as a one large fishing area, and hotspots of fishing were not defined in Bay.

In general, the density of the retrieved items, i.e. number of items/ km2, was low. However, the 2024 findings were concentrated in the NW part of the bay and was considered when designing the transect scheme for 2025 dragging.

2.5.2 Dragging in 2025

In 2025, dragging was carried out from July 13 to August 18 in the same manner as in 2024. However, the 2025 transect scheme was designed to be more dense covering areas between the unsurveyed transects in 2024. Some of the transects were as in the previous year. A total of 61 transects were completed, with a higher density in the northwestern part of the bay compared to 2024. The total dragging distance was 666.621 km (Figure 7).

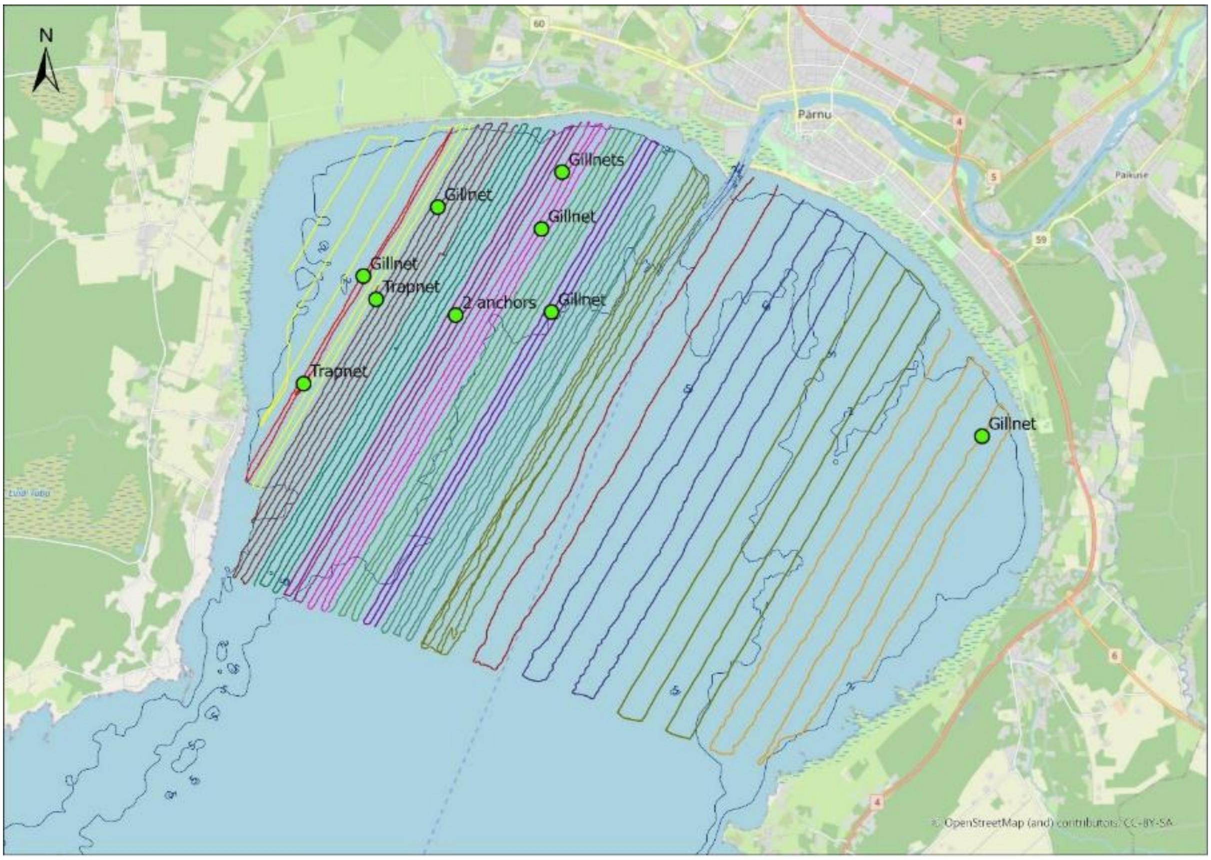

Figure 7. Pärnu Bay dragging transects (line) with findings (dots) in Pärnu Bay in 2025. Different colors of transects depict different dates.

A total of nine items were recovered: two fyke nets, six gillnets or a set of gillnets and two fyke net anchors. The locations are provided in Figure 7, and the findings are described in Table 2. Three of the six gillnets were identified as "low quality", indicating cheap and low-quality monofilament nylon gillnets. No fish or other macrofauna were found entangled in the recovered gears. Three gillnets and two fyke net anchors were found in the transects that were also covered in 2024. The operator estimated that the age of one of the gillnets was approximately 5 years, while the other two were 1-2 years old. Therefore, we suggest that two newer gillnets were lost between two dragging seasons, and the older one was carried to the site by water movements. In both years, the winters preceding the dragging period were mild, and the period of ice cover was short. In Pärnu Bay, gillnet fishing mainly takes place under ice and thus the period of active fishery was shorter than usual. Consequently, the number of lost gears due to short winter was also likely lower than average. Some of the removed gears are presented in figure 8.

Figure 8. A gillnet (left), parts of a fyke net (right) (Photos by M. Merirand).

Table 2. Dragging results from Pärnu Bay area from year 2025.

Date	Item	Depth	Weight/length	Comments
13.07.2025	Gillnet	3.4 m	22.5 kg / 50 m	
16.07.2025	Gillnet	4.5 m	2.5 kg / 25 m	Monofilament nylon (low quality)
22.07.2025	Trapnet	3.2 m	61.5 kg / 30 m	Parts of a trapnet, polyamide (nylon 6)
22.07.2025	Gillnet	3.0 m	2 kg / 15 m	Bottom line, monofilament nylon, mesh size 50 mm
30.07.2025	Gillnet	4.5 m	2.5 kg / 40 m	
30.07.2025	Gillnets	3.4 m	78.5 kg / 300 m	Winter gillnets with weights, monofilament nylon (low quality)
31.07.2025	Anchors	4.3 m	10 kg	2 anchors with a line
13.08.2025	Trapnet	3.5 m	70.5 kg / 50 m	Parts of a trapnet
13.08.2025	Gillnet	3.5 m	19 kg / 50 m	Monofilament nylon (low quality)

To summarize the results, a map of all registered information about ALDGF found in Pärnu Bay was compiled (Figure 10). The UT trawl surveys cover a few standardised biannual transects in the central part of the bay, and every year, a couple of gillnets have been surfaced. Additionally, the Environmental Board has conducted irregular dragging operations and discovered some gears. The Re:Fish project was the first systematic survey of ALDFG in Pärnu Bay.

Based on the results of Re:Fish dragging carried out in 2024 and 2025 in Pärnu Bay, we can conclude that in the NE part of Pärnu Bay the density of ALDFG is higher, than in the SE part of the bay.

Figure 9. A winter gillnets found in the course of dragging in 2025 (Photos by M. Merirand).

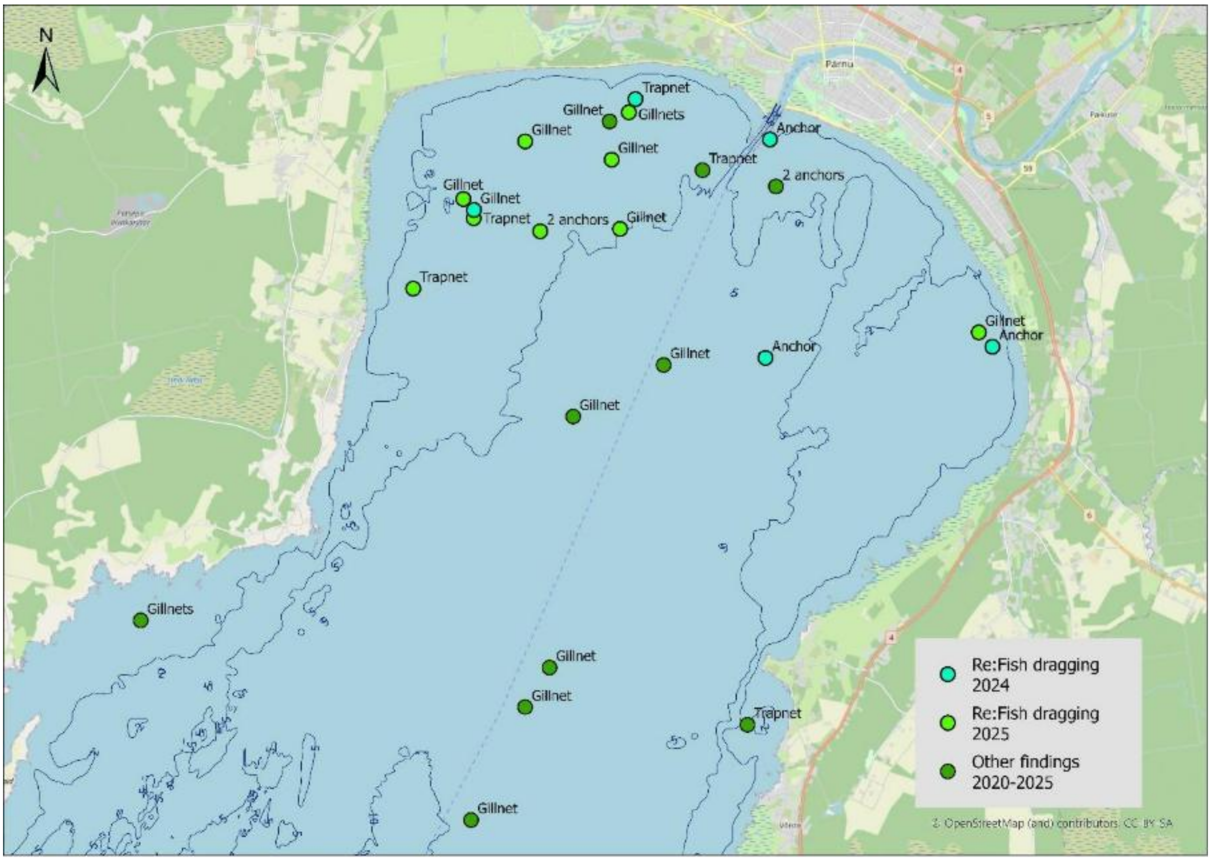

Figure 10. ALDFG found during the Re:Fish dragging campaigns in 2024 and 2025, along with other registered findings from 2020-2025 (Environmental Board, UT research trawling).

3 Dragging activities in Finland

3.1 Background

Natural Resources Institute Finland (Luke) carries out a survey of recreational fishers every second year. Further, Luke regularly releases the statistics of the conducted survey (Natural Resources Institute Finland, Luke 2026a), estimating, among other things, the number of fishers, used gear types, fishing effort and catches per species and recreational gillnet fishers by province in sea areas. The most recent figures of recreational gillnet fishers in 2008 - 2024 in the sea areas are presented in Table 3.

Table 3. Number of recreational fishers using gillnets in sea areas by province in 2008-2022.

GEAR TYPE	2008	2010	2012	2014	2016	2018	2020	2022	2024
Gill net	400000	411000	396000	369000	340000	265000		337000	226000
Fish trap, crayfish trap, trap net (-2010)	463000	431000	-	-	-	-		-	
Fish trap, trap net (2012-)	-	-	339000	440000	290000	269000		326000	216000
Crayfish trap (2012-)	-	-	64000	82000	68000	81000		106000	56000
Jig	517000	468000	415000	509000	520000	555000		606000	502000
Hook and line	1241000	1137000	882000	974000	860000	882000		998000	818000
Spinning rod	722000	692000	713000	677000	761000	768000		947000	795000
Fly rod	74000	76000	40000	86000	69000	96000		79000	88000
Trolling gear	410000	347000	393000	469000	510000	494000		541000	441000
Other	59000	55000	31000	68000	44000	64000		55000	18000

An estimated number of gillnets lost annually in Finland's recreational fishery, around 2 000 nets, is based on data from a national recreational fishing survey (Seppänen, et al. 2022). The estimate is uncertain as the 95% confidence intervals, about 3500, are larger than the estimate. However, it is the best estimated and is broadly consistent with earlier estimates for the southern Baltic Sea reported by Tshernij and Larsson (2002), which included activities by Swedish professional fishermen. This highlights the role of recreational gillnet fishing on Finland.

Based on the Statistics database, Recreational fishing by Luke, there were 340 000 gillnet fishers in 2016 who lost 2000 gillnets. Based on these figures in 2016, the loss rate of gillnets was 2000 / 340 000 = 0.588 %. Assuming that the rate of loss is constant (~0.59%), table 4 shows the estimate of loss in 2008–2024. Despite the decreasing activity of recreational gillnet fishing, a direct estimate for number of lost gillnets in 2022 was 1982 and in 2024 1329 nets, respectively.

Table 4. Number of recreational gillnet fishers of an estimate of lost gillnets based on a survey in 2016.

FINLAND	2008	2010	2012	2014	2016	2018	2020	2022	2024
Gillnet fishers	400000	411000	396000	369000	340000	265000	N/A	337000	226000
Lost gilnets in numbers	2353	2418	2329	2171	2000	1559	N/A	1982	1329
Proportion of lost gillnets (in %)	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59

Focusing on the Central Baltic Region, the number of recreational gillnets fishers in 2008-2024 are presented in table 5.

Table 5. Number of recreational gillnet fishers in four provinces in Southern and Western coast of Finland.

Province	2008	2010	2012	2014	2016	2018	2020	2022
Uusimaa (sea area)	19775	23801	26098	30189	12508	14329	19685	11095
Archpelago Sea (sea area)	30337	29936	30359	33440	24562	26663	29260	29525
Southeastern Finland (sea area)	8989	12759	6391	7431	7732	2358	7275	5266
Ostrobothnia (sea area)*	14382	11042	9853	8592	11826	6711	10608	11848

Based on the figures of table 5 and the estimate by Seppälä et al. (2022), the number of gillnets lost annually and the number of recreational gillnet fishers (table 4), the number of lost gillnets by province of Uusimaa, Archipelago Sea, Southeastern Finland and Ostrobothnia were calculated as follows:

$N_{yp} = (F_{yp} / F_{ytot}) \times 2000$ where,

N_{yp} = Number of lost gillnets each year (y) and province (p)

F_{yp} = Number of gillnet fishers each year () and province (p)

F_{ytot} = Number of recreational gillnet fishers each year (y) in the sea areas

The latest figures are from 2022 in table 6.

Table 6. Estimated number of annually lost gillnets by province in 2008-2022.

Province	2008	2010	2012	2014	2016	2018	2020	2022	AVERAGE
Uusimaa (sea area)	99	116	132	164	74	108	139	66	112
Archpelago Sea (sea area)	152	146	153	181	144	201	206	175	170
Southeastern Finland (sea area)	45	62	32	40	45	18	51	31	41
Ostrobothnia (sea area)*	36	27	25	23	35	25	37	35	30
TOTAL	331	350	342	408	298	352	433	307	353

The oldest gillnets can be from the 1960's-1970, so, the number of nets lost by recreational fishers during the last 60 years could be as high as 60 times the annual average shown in table 6 in each province. Taking a more recent perspective, this would mean that more than 8 500 nets of recreational fishers have been lost since 2000 in the sea areas of the four provinces.

Commercial fishers in Finland are obliged to report their lost gears (EY, 1224/2009, Article 48). Based on the obligation and collected information on commercial fishery number of fishers, sum of net nights, average number of 'net nights' and number of reported lost nets are shown in table 7. Economic Development Centre in Finland (EDC) is responsible for fisheries management, supervision and registers and related databases (Natural Resources Institute Finland, Luke 2026c) stores also reported data of lost commercial gear.

Table 7. Number of commercial gillnet fishers, number of net nights and reported lost gill nets in 2020-2024) in the Finnish sea areas.

	2020	2021	2022	2023	2024	AVERAGE 2020-2024
COMMERCIAL FISHERS	1 505	1 350	1 295	1 295	1 250	1 339
NR NET NIGHTS (*	1716509	1643743	1649375	1589206	1666883	1 653 143
NR OF NIGHTS PER FISHERS	1141	1218	1274	1227	1334	1 238
NR OF REPORTED LOST NETS	24	24	68	70	40	45.2
(* A NET NIGHT = a 30 m net fishing one night						

As a comparison, the obtained figures of recreational fishers, estimates of lost gillnets, and compiled number of commercial fishery and obtained data of lost gears aren't directly comparable However, it strengthens the assumption that most of the gillnets lost annually are recreational of origin. Though the fishing activity of commercial fishers is high, the number of commercial fishers is very low compared with recreational fishers.

3.2 Mapping

3.2.1 Defining dragging areas

There are many types of fishing, like angling, trolling, flyfishing and fishing with traps, long lines, gillnets or trap nets. Fishers may focus also on certain target species and some of them can be easily caught only with a specific method and only in a short season. The goal is to catch fish with minimal effort. For example, whitefish angling takes place in early spring, whereas burbot has traditionally been caught in mid-winter during spawning. Baltic herrings are typically caught with fyke nets near the shore, close to the spawning grounds in spring.

Gear can be lost at all times and in all locations. The more fishing occurs, the more gears are lost. Similarly, it is essential to define where to put the efforts on lost gear retrieval operations. For identifying probable areas with lost gear, information on known fishing grounds in Finland was compiled. Sources included published reports that may give general information about past and present fishing grounds. Other important sources of information were collected from official statistics hosted by Natural Resources Institute Finland (Luke)[1] and from digital databases of the Finnish Heritage Agency (Museovirasto)[2] and some regional actors and NGOs. Other important sources of information were the personal interviews of people working at sea, because they have knowledge of the local environment and circumstances, waterways, currents, and bottom topography. These include fishers, fishing inspectors, Finnish Border Guard or other authorities' knowledge on former or present fishing grounds, gillnetting areas or even locations where gears have been lost. General views and maps of earlier and recent fishing, gillnet areas and trap net locations were gathered. The most valuable information was gathered through interviews. Over 30 interviews and discussions were held in 2023-2025. Information was collected on sea charts and moved to the geographic information system (GIS) application.

Depending on the retrieval methods, certain factors must be considered when planning retrieval operations. In sea areas, especially in the archipelago, there are water and electricity lines connecting islands to the mainland. These installations are typically laid onto the seabed, and in many cases, lack any physical securing structures beyond the weight of the installations themselves. Dragging in areas with seabed infrastructure must be planned and executed carefully. Since the location of all the sea bottom infrastructure is not publicly available, Suomen erillisverkot Oy, the authority responsible for the sea bottom infrastructure, was consulted.

Areas containing sensitive biotopes, such as seagrass meadows which are vulnerable to disturbances and dragging were excluded from the dragging operations. Operating near locations known as historical or cultural underwater objects was also avoided. Echosounders and side scan sonars are practical and valuable instruments when dragging as they make it possible to avoid infrastructure and other objects in the seabed. They were used while dragging but also before, to minimize the risk of snagging to an underwater object or unequal bottom.

3.2.2 Planning

Tentative plans for four separate regions, Rauma, Uusikaupunki, Kustavi and Helsinki were designed and finalized based on the gathered information. The plans were approved by the

[1] https://www.luke.fi/en/statistics/directory-of-statistics
[2] https://www.museovirasto.fi/fi/palvelut-ja-ohjeet/tietojarjestelmat/kulttuuriympariston-tietojarjestelmat/kulttuuriympaeristoen-paikkatietoaineistot

national authorities, who are responsible for national infrastructure. If needed, local electric utility companies were contacted regarding the possible presence of underwater electrical cables in the planned operation area. They were asked to review their infrastructure data and to verify and confirm the accuracy of the provided plan. The regions are shown in Figure 11.

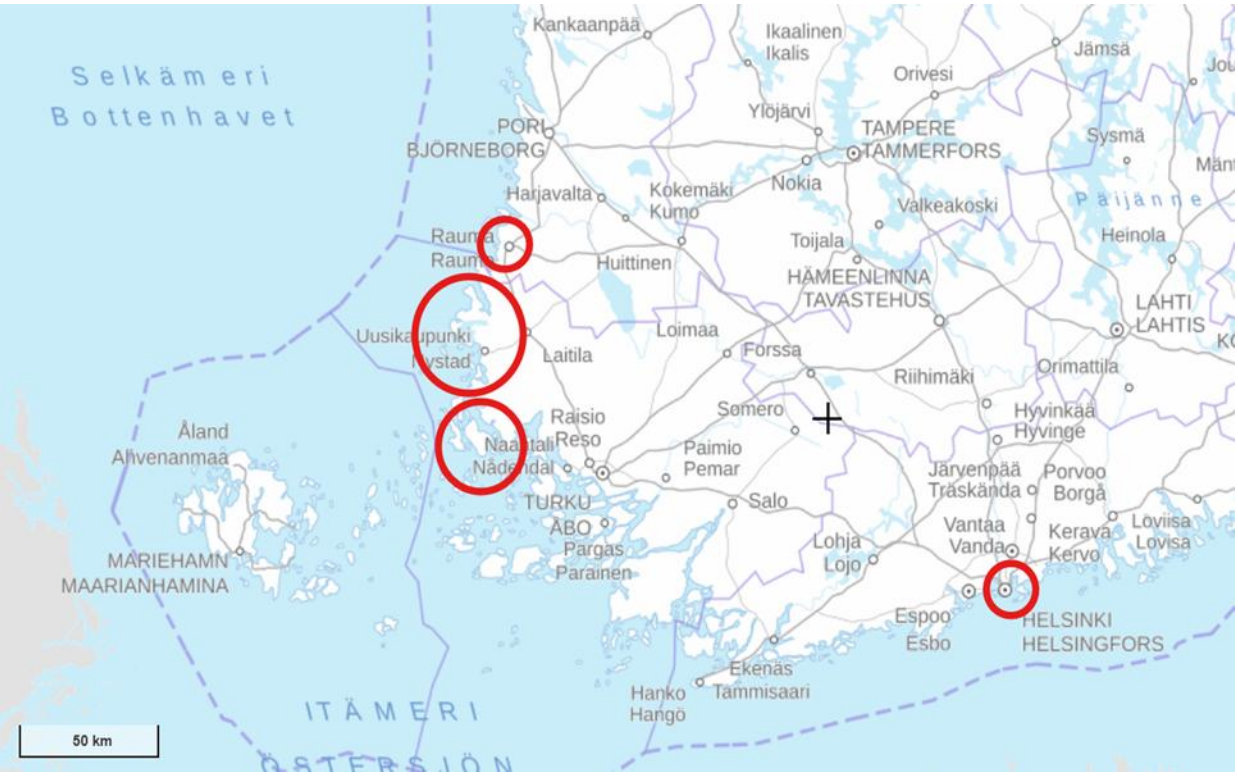

Figure 11. The regions of planned operations.

3.3 Operations

Dragging operations on the west coast were conducted with a Korsö type fishing boat (Figure 12) and in the Helsinki region with an aluminum sampling boat, Aronet 23.5 (Figure 13). The vessels were equipped with GPS, echosounder, navigation plotter and side scanner. Sailed transects were stored on a memory card. The crew consisted of a skipper, a deck hand and a scientist. The drag was made of thick metal chain and welded hooks attached to each other (Figure 14). The drag was tied up with a rope to the boat and a float with another rope attached to the end of the drag, as a trip line. The trip line was a precautional measure in case the drag would snag to the bottom. A drag was used in shallow water areas (<10 m) and an extra weight attached in deeper waters. The deckhand was responsible for the dragging operation with the skipper, and the scientist recorded dragging information and verified the retrieved material. Weather conditions at start, date and time of action, course and speed of a boat, depth and length of the drag rope when dragging were also recorded.

The drag was hauled up when it got snagged on the seabed or on an underwater object. Occasionally, a gillnet was hit, sometimes checking the drag resulted in other litter. If a gillnet was hit, usually in the middle, the net was cut, and one part was marked with a buoy and released to water. The remaining part was lifted and then returned to the buoy. Then the rest of the net was lifted. Entangled litter, fish, birds or any other items were recorded when the drag was lifted.

Afterwards, caught nets were washed with pressure water, straightened length measured and any additional entangled items investigated.


Figure 12. Korsö -type boat used for dragging.


Figure 13. Aronet 23 used for dragging operations outside Helsinki.

Figure 14. Drags used for operations operations on the west coast.

3.4 Results

3.4.1 Volume and density of the retrieved nets in the dragged regions

The dragging operations were carried out in 4 regions (Figure 11 and table 8). In 2024 operations lasted 24 days and in 2025 and 36 days, respectively.

In the four region, 92 identified areas covering 56 km^2 of seabed were dragged during 2024 and 2025, with 37 and 19 km^2 surveyed in each year, respectively. The dragged areas and summary of the findings are presented in the Table 9. Even with careful mapping of hotspots, it was difficult to anticipate where large concentrations of ALDFG would be found. Yet altogether over 7.5 km of gillnets were removed with additional fishing lines, lures, hooks, fish traps and a trap net with anchors and fish and litter attached to it.

The number of gillnets per km^2 of seabed varied greatly from 0.6 to 31.9 nets/km^2 between the dragged areas and from region to another. On average, there were 4.5 gillnets per km^2 of seabed. However, it should be noted that areas were known or suspected to experience high fishing activity and therefore had a higher probability of containing ALDFG. Most nets were found from the sea areas surrounding the city of Rauma while the lowest number of recovered nets was recovered from the areas close to city of Uusikaupunki.

Table 8. Dates, regions and days of operation in 2024-2025.

DATE	REGION	DAYS OF OPERATION
13.-15.5.2024	RAUMA	3
10.-12.6.2024	RAUMA	4
1.7.-4.7.2024	RAUMA	4
9-12.7.2024	UUSIKAUPUNKI	4
20.-23.8.2024	UUSIKAUPUNKI	4
28.-29.8.2024	UUSIKAUPUNKI	2
17.-18.9.2024	UUSIKAUPUNKI	2
20.9.2024	UUSIKAUPUNKI	1
Sum 2024		**24**
5.- 9.5.2025	KUSTAVI	5
12.-13.5.2025	KUSTAVI	2
10.-12.6.2025	KUSTAVI	3
16.-18.6.2025	KUSTAVI	3
23.-27.6.2025	KUSTAVI	5
4.-7.8.2025	KUSTAVI	4
11.-14.8.2025	KUSTAVI	4
13.-15.8.2025	HELSINKI	3
19.-20.8.2025	HELSINKI	2
3.-5.9.2025	HELSINKI	3
9.-10.9.2025	HELSINKI	2
Sum 2025		**36**
TOTAL		**60**

Table 9. Surface areas covered, number of locations and the volume of nets and net densities by areas.

Dragged areas 2024	Area (km2)	Nets (m)	Nr of locations	Nets (m / km^2)	Nets (nr/ km^2)
Rauma	3.9	3705	13	955.6	31.9
Uusikaupunki	33.3	600	43	18.0	0.6
Total	**37.2**	**4305**	**56**	**115.8**	**3.86**
Dragged areas 2025					
Kustavi	15.8	1295	28	82.2	2.7
Helsinki	3.1	1961	8	638.1	21.3
Total	**18.8**	**3256**	**36**	**172.9**	**5.8**
Total 2024-2025	**56.0**	**7561**	**92**	**135.0**	**4.5**

The size of the dragging areas differed. Wide areas were covered in Uusikaupunki (>33 km2) and Kustavi (>15 km2), but the density of found nets was low compared to Rauma and Helsinki, where the dragged area covered was markedly smaller (Table 9). Both in Rauma (Fig.10) and Uusikaupunki most of the nets were found in the vicinity of the city south-southwest from the city centers

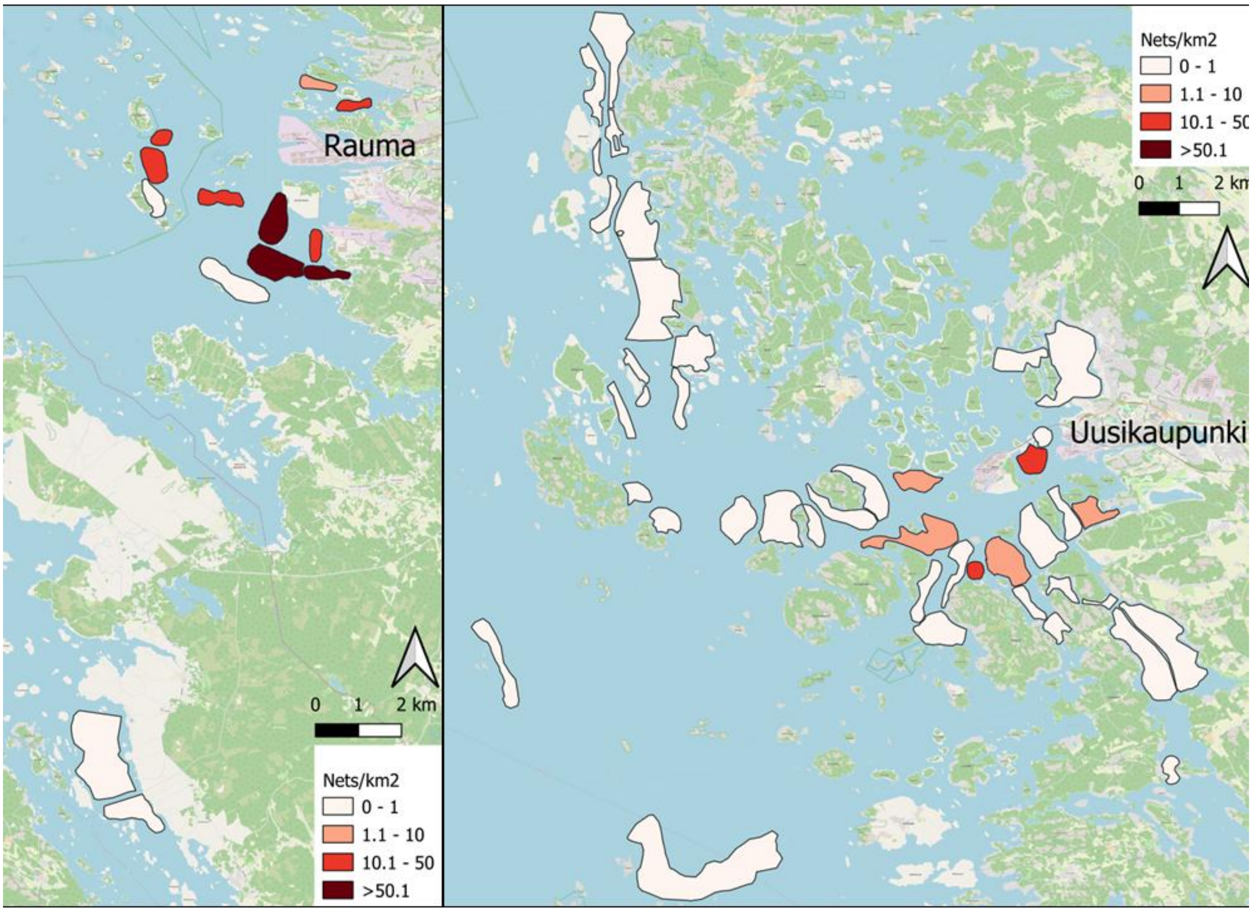

Figure 10. Dragged areas in the Bothnian Sea 2024 in the area surrounding the city of Rauma (left) and Uusikaupunki (right), and the density of ghost nets (nr/ km^2) by area. Areas with more than one net per square kilometer are marked with shades of red and areas with 1 or less nets per km2 with white.

Only a few ghost nets were found from the northeastern part of the Archipelago Sea, spanning over the municipalities of Kustavi and Taivassalo. Nets used for fishing under ice were found from the areas southeast of Taivassalo municipality center, which are most likely used by recreational fishers (Figure 11).

Figure 11. Dragged areas in the Archipelago Sea 2025 in the municipalities of Kustavi and Taivassalo, and the density of ghost nets (nr/ km^2) by area. Areas with more than one net per square kilometer are marked with shades of red and areas with 1 or less nets per km^2 with white.

There were few hot spot areas with many ghost nets (Figure 12) close to the metropolitan area of Helsinki. The highest density of nets was found in the eastern archipelago of the city. A fyke net with three anchors was also found there (Figure 13). In the western archipelago of Helsinki, two further areas with a high concentration of nets were found. In contrast, in some areas identified as active recreational fishing, no nets were found.

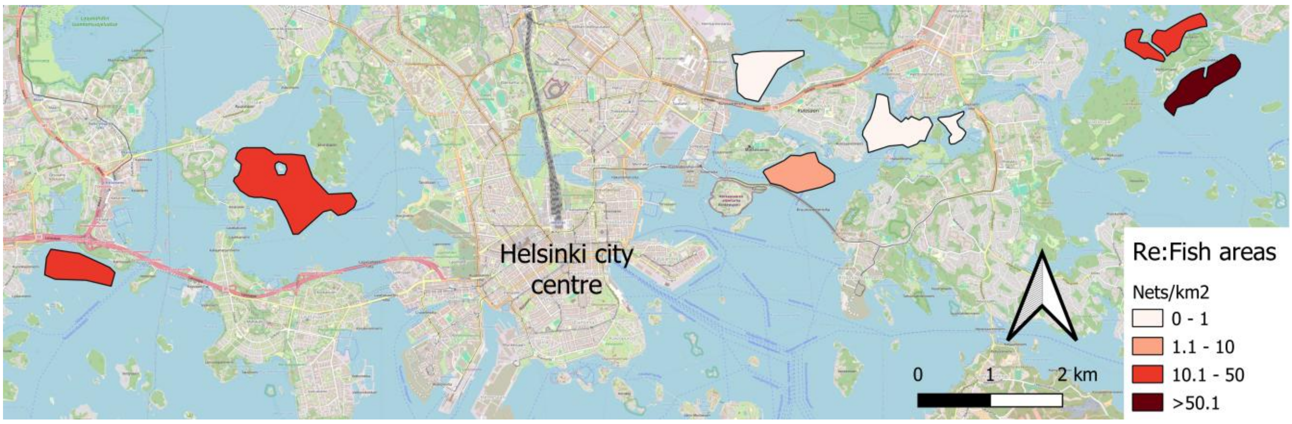

Figure 12. Dragged areas in coastal areas of Helsinki and the density of ghost nets (nr/ km^2) by area. Areas with more than one net per square kilometer are marked with shades of red and areas with 1 or less nets per km^2 with white.

Figure 13. A recovered fyke net. Anchors, ropes and netting were covered with colonies of fouling biota and algae.

3.4.2 Analysis of the recovered fishing gear and attached material

The recovered nets and attached material (litter, biota) were thoroughly investigated. All attached items were removed and the nets and netting measured, in length, height and mesh size. Float type and rigging of nets were also investigated, when possible. When a snagged drag was lifted it didn't always result in a net or litter.

Evidence that ghost nets continue to fish were obtained as in some cases live and dead fish were caught. Occasionally, birds, bird bones, fishery-related and other type of litter were also found attached toa net or otherwise caught in the drag. The highest bycatch of one gillnet contained 16 fish from several species. The decomposing state of the fish varied from very recent and badly decomposed (Figure 14).

Figure 14. Ghost catch of a partly decomposed bream (*Abramis brama*) and a perch (*Perca fluviatilis*).

Decomposed bird carcasses and bird bones were found attached to the ghost nets. One net in Rauma contained seven bird skulls attached to it, highlighting harm to other animals than fish as well. One surprising finding was a fyke net used for fishing herring, with all the anchors and nets still attached to one another. An old fishing net, most likely 50 years or older, made of cotton with wooden floats in the head rope, was found from Helsinki in 2025 (Figure 15).

Figure 15. Old cotton net with wooden floats from the Helsinki area.

A variety of different and sometimes surprising items were found. Typical removed litter was fishery-related as gillnet sticks, ropes, fishing lines, weights but also bird bones (Figure 16).

Figure 16. Various items and a fishing license were found entangled in retrieved gillnets in Rauma 2024.

Other typical litter items were plastics bags or stripes and cans. Eyeglasses, a swimming suit, ladders, rain pants, and shoes were also retrieved (Figure17 and 18).


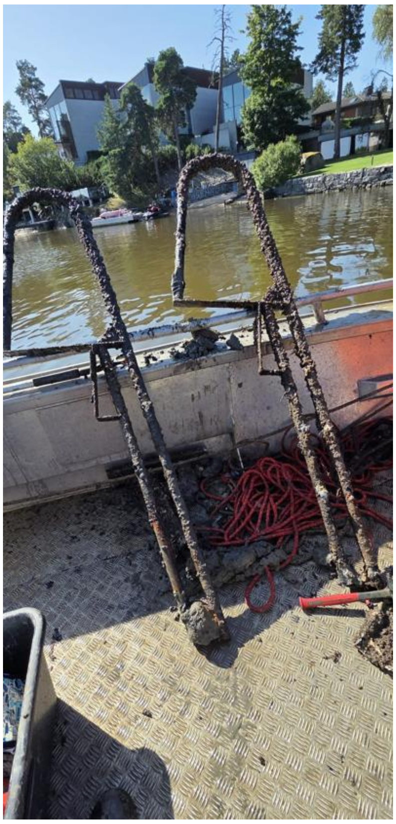

Figure 17 and 18. Retrieved rain pants (left) in Rauma 2024 and in swimming ladders (right) in Helsinki 2025.

Removed items were either retrieved as entangled in nets or as individual items. In some cases, only a single item was caught, sometimes many different types were lifted. All retrieved items were sorted into seven categories.

The proportions of the categories varied greatly between the regions. Litter and plastic were mainly retrieved in Rauma and Helsinki while they were hardly found in Kustavi and Uusikaupunki. Lures were often found in gillnets in the Helsinki region which indicates heavy fishing pressure and conflicting fishing methods. The proportions of different litter types are presented in Figure 19.

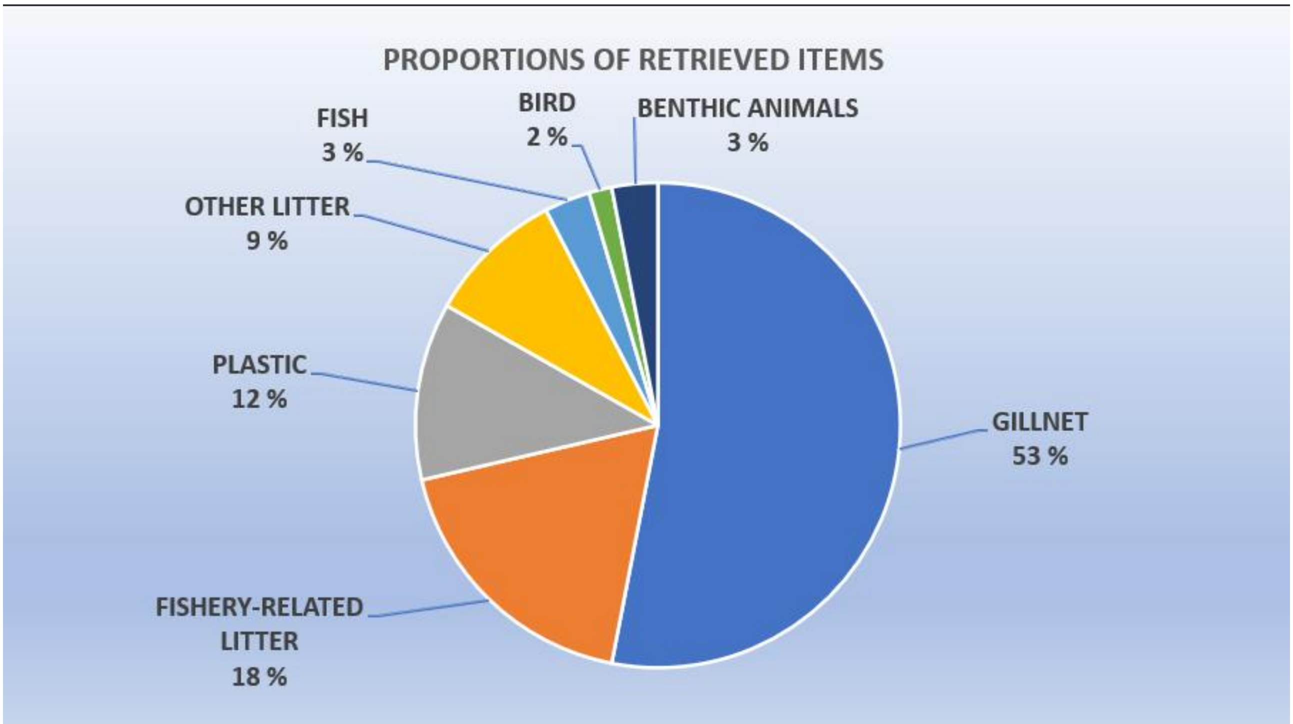

Figure 19. Proportions of various items: gillnets and fishery-related and other litter and fish, birds or biota entangled in the retrieved nets.

Most of the removed nets had a mesh size (bar length) of 45 mm and were made of synthetic materials (Figure 20). In the West Coast of Finland in early 2000 a typically used mesh size in pike-perch fishery has been 43-45 mm (Heikinheimo et al., 2006). In the Helsinki region, the smallest allowed mesh size was 45 mm until 2006. Since then, the smallest allowed mesh size has been 50 mm. From the 1st of April 2026 on, the smallest mesh size will be 55 mm (City of Helsinki. Fishing regulations, 2026).

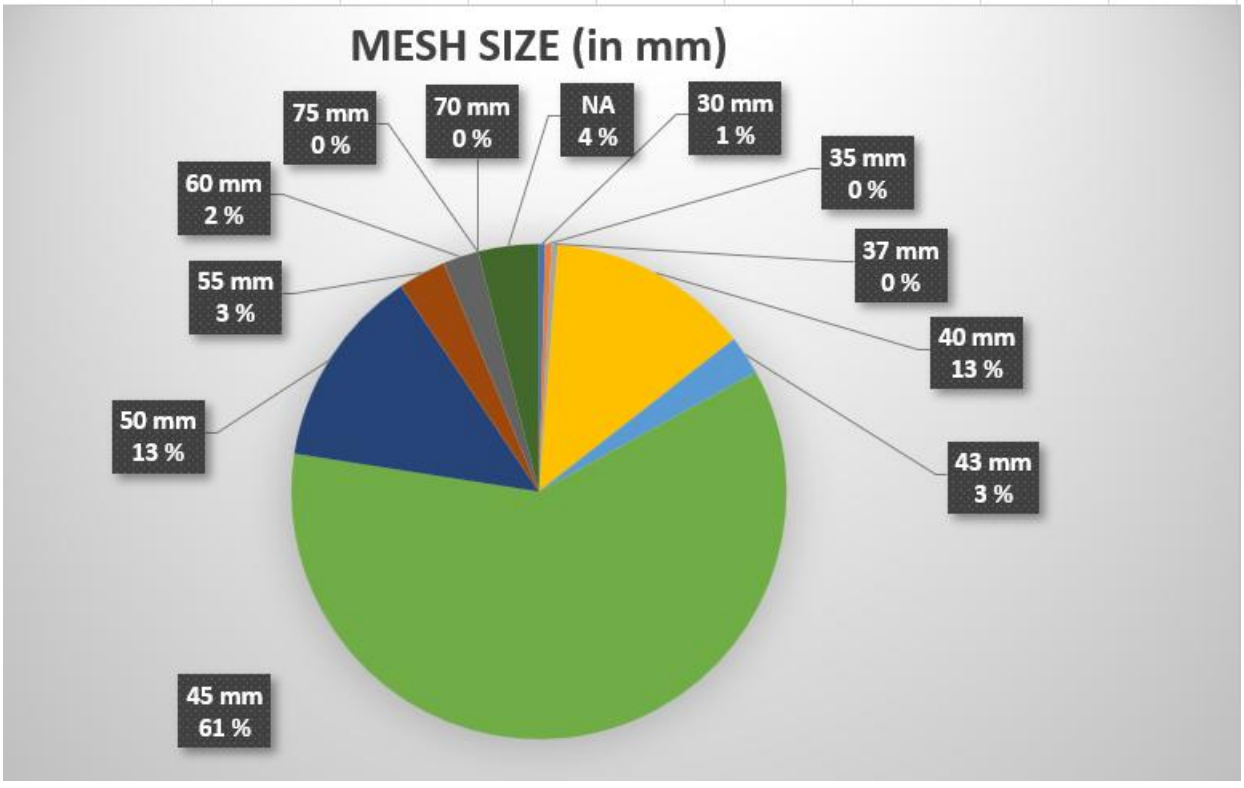

Figure 20. Proportions of different mesh size of removed gillnet.

In Rauma, Uusikaupunki and Kustavi regions, the smallest allowed mesh size of gillnets is 45 mm. Regulation in Rauma allows 45 mm mesh size and in summertime (June-August) 40 mm mesh size in perch (Perca fluviatilis) fishing (Figure 21). Uusikaupunki and Kustavi regions smallest allowed mesh size of gillnets is 43 mm (Fisheries Center of Western Finland, 2021).

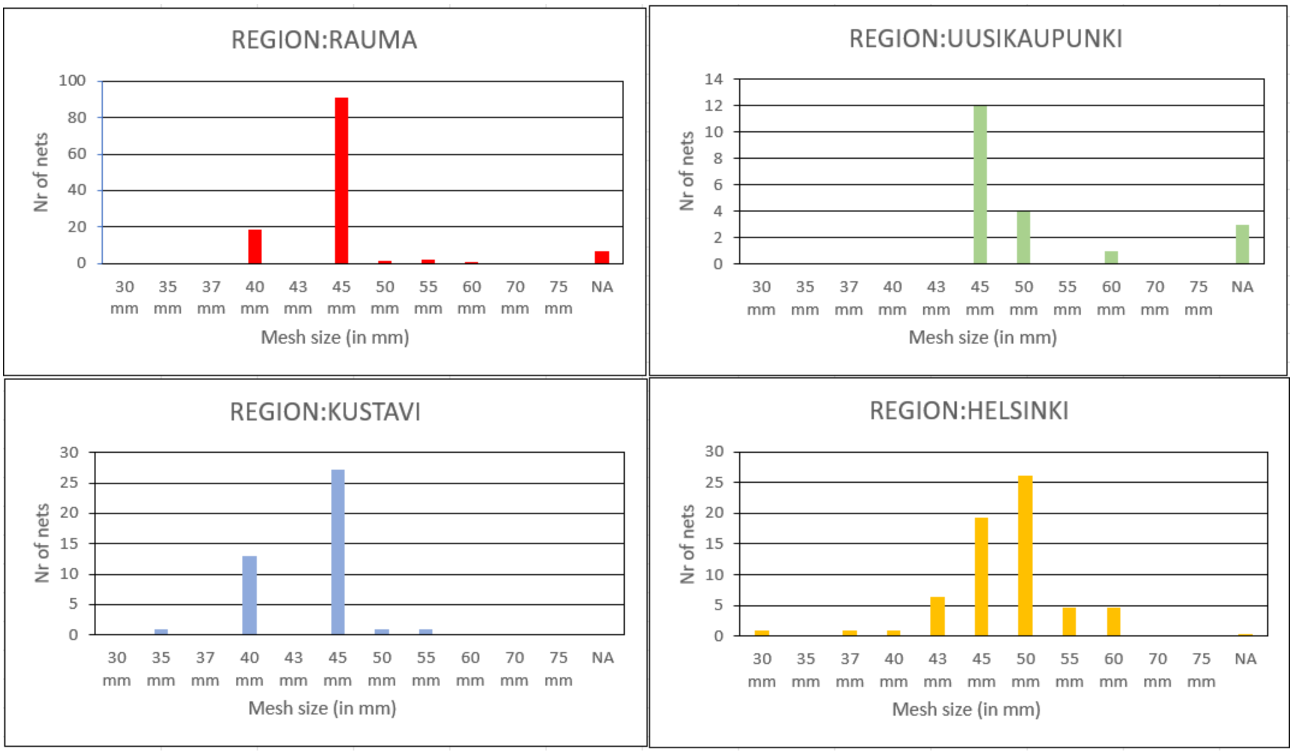

Figure 21. Number of nets by mesh size in the four regions.

Regional differences can also be seen in the retrieved gillnets (Figure 21). Most of the removed gillnets were 45 mm in mesh size. The only exception is Helsinki, as more than 50% of the retrieved nets had at least 50 mm mesh size. As the minimum mesh size was increased to 50 mm in 2006, and if the fishers follow the given regulations, it could be inferred that 45% of the nets have been lost before 2006.

Depth of the nets was also measured. Most popular depth of retrieved net was 3.0 meters, but also shallow-depth nets, 1.2.- 1.5 meters, were common (Figure 22). Depth of the net may indicate that some fishing took place in shallow waters.

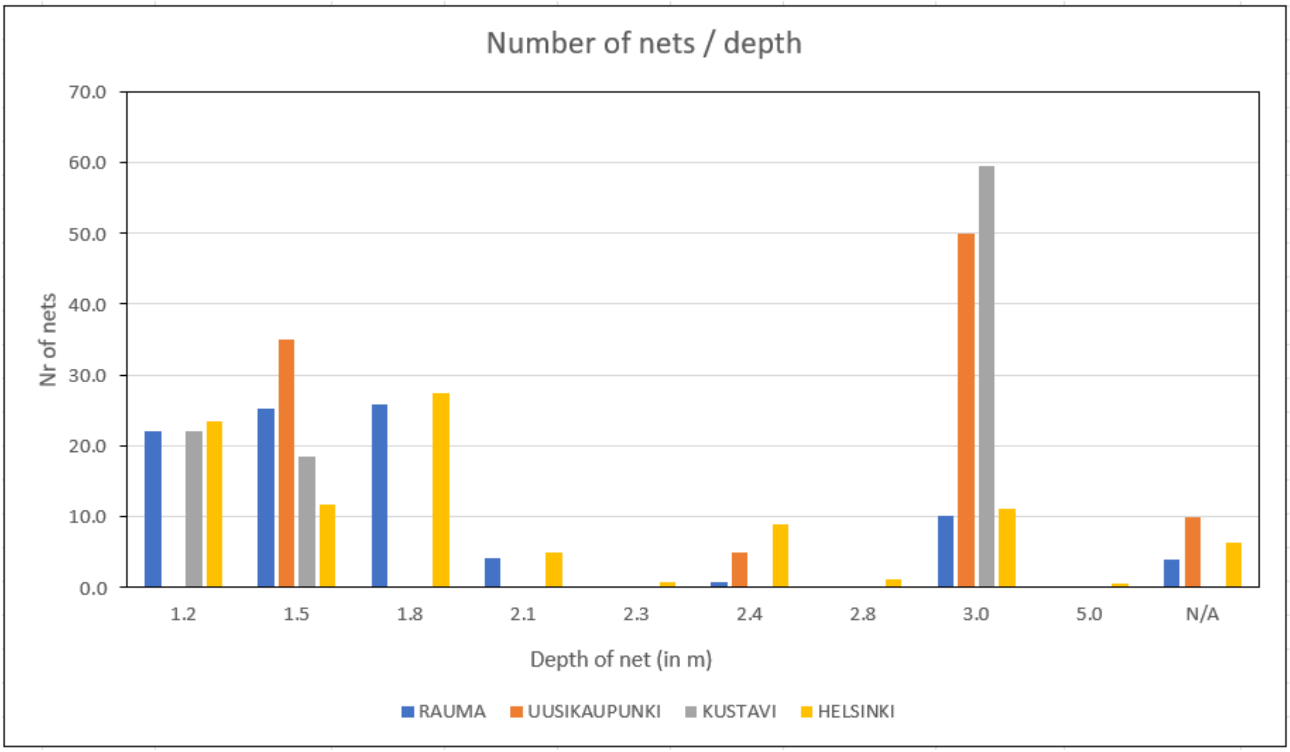

Figure 22. Depth of the recovered nets in Rauma, Uusikaupunki, Kustavi and Helsinki.

Float types and rigging of nets were recorded, when possible. Float types varied between the regions, although shuttle float and float rope were the most common head rope types (Figure 23). Typically, on the west coast float rope seemed to be a popular head rope type. Rigging, i.e. to attach the netting to head rope and lead rope, was not recorded constantly, but in some cases, rigging could also be recorded. Machine rigging differs from manual rigging or hand-made rigging and stands for purchased and ready-made gillnets. Different float types were shuttle float, cork float, double float and a floating head rope (Table 10).

Figure 23. Two headrope types – float rope (above) and shuttle float (photo: Kivikangas oy).

Table 10. Proportions of different float types identified in the four regions.

FLOATS	RAUMA	UUSIKAUPUNKI	KUSTAVI	HELSINKI	TOTAL
SHUTTLE FLOAT	19	60	60	58	39
FLOATROPE	31	40	34	19	29
CORK FLOAT	0	0	6	0	1
DOUBLE FLOAT	23	0	0	13	15
WOODEN FLOAT	0	0	0	1	0
NO DATA	27	0	0	9	16
TOTAL	100	100	100	100	100

4 Conclusions and lessons learned

4.1 Dragging operations

Before operations, environmental, physical and legal constraints should be identified. Water owner permission and an approved plan from authorities should be obtained. Pristine and sensitive environments should be avoided as well as wrecks and historical underwater objects.

To clean an area, it should be criss-crossed. Distance between the dragged transects should be less than a typical string of nets (2-3 nets together).

4.2 Concluding remarks

A total of 8 180 meters of lost gillnets was removed by dragging in Estonia and Finland. The original objective (5 600m) was exceeded.

Dragging in active fishing areas increases probability to find gear, but variation in volume between the regions and areas is high. There might be other reasons than fishing effort behind gear loss. Unattended nets move with wind, waves, currents or shifting ice.

Lost gear can continue to catch fish, especially when set up with proper anchors, e.g., fyke net. Most of the ALDFG get buried in the sediment. A few percent of nets had fish and birds entangled.

Nets remain in the sediment for decades. Found license tags showed that the oldest nets date back to the 1980’s. Some nets were made of cotton fiber; thus, the oldest lost gillnets may be even older.

Although ghost net retrievals were carefully planned, they are expensive to conduct.

As lost fishing gear continues to persist in the aquatic environment, ongoing removal of nets should be continued to mitigate their ecological impacts. The most effective way to reduce the accumulation of ghost nets is to increase public awareness, supported by targeted training and education for fishers, which are essential for improving gear handling practices and reducing future losses.

The accumulation rate of lost gear remains unknown but could be estimated based on the retrieved nets and accessories. Changes in regional mesh size (bar length) regulation may serve as a time stamp to infer the period of loss. The authorities of the city of Helsinki mandated a minimum mesh of 50 mm since 2006. As 45% of the retrieved nets were ≤ 45 mm, it could be concluded that nets with ≤ 45 mm mesh size were lost prior to 2006.

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