DOI: 10.2507/36th.daaam.proceedings.xxx

IMPACT OF TRAP-NET FISHERY ON MARINE POLLUTION AND SOLUTIONS

Astrida Rijkure, Kristine Cerbule, Janis Megnis

This Publication has to be referred as: Rijkure A; Cerbule K; Megnis J (2025). Impact of trap-net fishery on marine pollution and solutions, Proceedings of the 36th DAAAM International Symposium, pp.xxxx-xxxx, Published by DAAAM International, ISBN 978-3-902734-xx-x, ISSN 1726-9679, Vienna, Austria
DOI: 10.2507/36th.daaam.proceedings.xxx

Abstract

Current data on the impact of "ghost nets" on the biological diversity of the Baltic Sea indicate that no comprehensive inventory has yet been conducted of their proportion in the region, nor have methods been developed to assess it. The results of the study showed that net fishing is one of the main causes of gear loss, as nets are often lost due to storms and strong currents. These derelict fishing gears remain active for long periods of time, accidentally catching fish, marine mammals and other organisms. In addition, the nets of some materials gradually break down, forming microplastics that enter the food chain and negatively affect both the marine ecosystem and human health. In order to effectively reduce the negative impact of riser fishing, their effectiveness largely depends on the participation of fishermen and public awareness. In the future, it is essential to develop new sustainable fishing gear and improve international cooperation to ensure responsible and environmentally friendly fishing in the Baltic Sea.

Keywords: blue economy, fisheries, ghost nets, sustainable, trap-net

1. Introduction

The ecological challenges facing the Baltic Sea, together with the problem of overfishing, pose significant threats to fish stocks, marine ecosystems, livelihoods, and coastal communities. In Latvia's coastal regions, it is essential to foster economic development while simultaneously safeguarding natural and cultural heritage. To achieve this objective, community-led local development strategies have been implemented along the entire coastline. The overarching aim of these strategies is to ensure balanced and sustainable development. They support the growth of fishing and aquaculture communities while preserving the integrity and resilience of the marine ecosystem.

The principal aim of this study is to evaluate the impact of longline fishing on the Baltic Sea ecosystem, with particular emphasis on lost and abandoned fishing gear, commonly referred to as "ghost nets". Such nets continue to capture fish and other marine organisms indiscriminately, thereby generating both ecological and environmental hazards. The study further examines potential solutions and management strategies to mitigate this problem and to foster sustainable fishing practices in the Baltic Sea.

The research methodology is grounded in a critical review of scientific literature, an assessment of technological capabilities, and an exploration of innovative approaches that could enhance the marine environment and support the development of the blue economy. The theoretical and methodological foundation of this study draws upon the work of Raid T., Miethe T., Kotta J., and Moll D.

2. Materials and methods

The Baltic Sea is confronted with considerable ecological challenges, primarily driven by eutrophication, climate change, and overfishing. These stressors have resulted in widespread degradation of marine ecosystems, posing serious risks to fish stocks and the livelihoods of coastal communities [9], [10], [11], [21], [26]. In particular, the overexploitation of key species such as cod has precipitated the collapse of several fish stocks, with recovery remaining insufficient despite the implementation of reduced fishing pressures [7], [18].

Herring is the most abundant and extensively targeted species along the Latvian coastline. The peak fishing season occurs between April and June, when herring migrate towards shallow coastal waters to spawn before returning to deeper areas. To safeguard the population, a prohibition on targeted fishing is introduced once catch limits are reached.

The ecosystems of the Baltic Sea are under increasing pressure from a complex range of interacting anthropogenic stressors, which frequently lead to biodiversity loss and habitat degradation. These intensifying and diversifying human impacts threaten the long-term sustainability of marine ecosystems and the essential services they provide. Among the most prevalent human activities in the Baltic Sea region are marine transportation and fishing [3].

In the Gulf of Riga, which forms part of the Baltic Sea, the principal methods used to harvest herring are ship-based trawl fishing and coastal riser fishing. To safeguard the herring population within the gulf, additional conservation measures—such as restrictions on vessel capacity—have been implemented. Trawl fishing is permitted throughout the year, with the exception of a 30-day prohibition during May and June, coinciding with the peak of the herring spawning season.

The management of Baltic herring stocks is governed by international agreements that establish Total Allowable Catch (TAC) limits designed to prevent overfishing [24], [25]. The herring fishery utilises several techniques, including trawl and pound-net fishing. Pound-net fisheries are particularly effective at capturing older age groups with higher mean body weights and avoiding the by-catch of juvenile fish, thereby contributing to the reduction of fishing mortality [24].

Standpipe fishing typically commences in April along the coast and continues until the end of June. During May, when coastal weather remains cool and water temperatures are relatively low, fishing remains productive. Although herring is not the most economically valuable species, it accounts for approximately 90% of the total coastal catch in the Gulf of Riga.

There are two distinct herring populations in Latvian waters: bay herring and open-sea herring, each managed under separate catch quotas. Bay herring, one of the smallest herring types in the Baltic Sea, predominantly inhabits and reproduces within the Gulf of Riga. Following spawning, a small proportion of the older bay herring migrate during the summer and autumn months to the Irbe Strait and the central Baltic Sea, but ultimately return to the gulf.

Herring from the neighbouring central Baltic Sea stock also migrate into the gulf, which results in both Latvian and Estonian fishers occasionally catching small quantities of open-sea herring while operating in the Gulf of Riga.

Due to the gulf's relatively shallow waters, additional conservation measures—such as restrictions on vessel engine power—have been introduced to protect the bay herring population. Trawl fishing is permitted year-round, except for a 30-day closure in May and June, coinciding with the period of peak spawning migrations. Fishing practices differ considerably between Latvia and Estonia: in Latvia, the largest catches are obtained using trawl gear, with 15% of the national quota allocated to coastal fisheries, whereas in Estonia, 40% of the national quota is reserved for coastal fishing.

Herring populations in the Baltic Sea, including the Western Baltic spring-spawning herring (WBSS), undertake pronounced seasonal migrations to shallow coastal areas for spawning [5], [8], [23]. Environmental stressors such as eutrophication and coastal modifications have altered spawning habitats, potentially influencing the efficiency and preference for different fishing methods [8], [15], [16], [19].

In recent years, there has been a marked decline in the volume of illegally caught or misreported fish. This improvement is largely attributed to healthier herring stock levels and enhanced fleet management, including a significant reduction in the number of active vessels. In 2023, fishers operating in the Gulf of Riga were authorised to use 115 standpipe risers and 610 herring nets. However, according to official logbook data, only 70 of the permitted 115 risers were actually employed along the gulf's coastline. The highest coastal catches were recorded along its southern and western shores.

The herring stock in the Gulf of Riga remains in a stable and healthy condition, and it is regarded by scientists as one of the best-managed fisheries in the Baltic Sea. Since the late twentieth century, herring populations have remained within biologically safe limits, supported by favourable environmental conditions for spawning and juvenile development. Typically, warm winters lead to the formation of strong and productive year classes, whereas colder winters result in weaker cohorts. In recent years, a succession of mild winters has created optimal breeding conditions for bay herring, thereby contributing to the continued resilience of the stock.

A range of effective management measures has been implemented, including restrictions on vessel engine power and fishing gear size. These regulatory interventions have played a crucial role in maintaining stock levels within biologically safe boundaries and ensuring that fishing activities do not exert a detrimental impact on the herring population [4], [8], [25]. Scientific advice recommends a total allowable catch of 41,635 tonnes of herring in the Gulf of Riga for 2025. This figure includes both the permissible catch within the gulf and the projected catch of Baltic Sea herring in the same area. This represents a 9.7% increase compared with the previous year. The proposal by the European Commission aligns with the scientific advice provided by ICES and similarly advocates a 9.7% rise in catch opportunities [17], [20].

Coastal riser fishing, like other fishing practices, can also give rise to ecological challenges. One particularly significant issue is the loss or abandonment of fishing gear, commonly referred to as 'ghost nets'. These nets continue to capture fish and other marine organisms indiscriminately, resulting in unnecessary by-catch, marine pollution, and detrimental impacts on the wider marine ecosystem.

Ghost nets are especially harmful as they persist in the environment for extended periods, continuing to entrap and kill marine species, including non-target organisms. This contributes to increased by-catch and exacerbates biodiversity loss [6], [12], [14]. Moreover, such nets can entangle and damage benthic organisms, including branching corals, which are essential for providing habitat and breeding grounds for a variety of marine species [22].

3. Results and discussion

To address this issue effectively, it is essential to implement a range of targeted initiatives, including:

- Regular net retrieval expeditions – systematic searches and recovery operations for abandoned fishing gear at sea.
- Tagging of fishing gear – enabling the identification of lost nets and the fisheries responsible.
- Environmentally friendly materials – testing and deploying biodegradable nets that degrade naturally, thereby reducing long-term marine pollution.
- Fishing waste collection programmes – encouraging fishers to return used nets to shore for appropriate recycling and disposal.

In September 2024, the authors of this study identified a network of lost riser nets in the Gulf of the Baltic Sea, near the Port of Engure, and subsequently organised an expedition to recover it. The net was located approximately 1.6 nautical miles offshore at a depth of only 6 metres, posing a serious hazard to small vessels. The riser net, measuring approximately 290 metres in length, had remained submerged for around 25 years, during which it had become heavily overgrown and had entrapped multiple fish.

Divers detached the net from its moorings; however, a larger vessel equipped with a winch was required to lift it from the seabed. This operation was carried out in collaboration with professionals from the State Environmental Service, who assisted in documenting and highlighting the presence of these derelict nets.

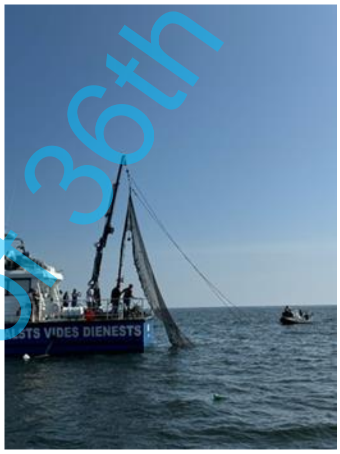

Fig.1. Cleanup of a shipwreck near the port of Engure, Baltic Sea (Latvian territorial waters)

The recovered fishing gear weighed more than two tonnes, although its precise dimensions could not be determined underwater. Constructed from capron, a durable plastic material, the net exhibited minimal signs of degradation despite having remained submerged for an extended period. This underscores its potential to persist in the marine environment for many more years. Several sections of the net were torn, indicating that it had likely come into contact with watercraft at some stage.

Fig.2. Gost nets, Baltic Sea (Latvian territorial waters)

At present, no technology exists that can accurately determine the dimensions of lost fishing gear underwater; current estimates rely exclusively on visual inspection. The development of technologies capable of detecting and measuring such gear, as well as other submerged objects, would provide a valuable preventive tool. [2] Such innovations could significantly enhance the monitoring of underwater debris, allowing for more precise assessments of its size and volume.

The authors of this study have identified the coordinates of several ghost nets along the coast of the Gulf of Riga. These sites should be systematically mapped and prioritised for future clean-up operations. Riser nets, in particular, must not be left in the water, as they are authorised for use only during a two-month fishing season. As highlighted previously, these nets should be properly retrieved and not abandoned.

Currently, no comprehensive inventory or standardised methodology exists for assessing the extent or proportion of ghost nets in the Baltic Sea. This observation is consistent with previous findings, which indicate that such an inventory has yet to be undertaken [13].

It is evident that the Baltic Sea, which ranks among the most polluted seas in the world, provides a highly degraded habitat for its marine life. Numerous shipwrecks are scattered across the Baltic Sea, including in Latvian territorial waters, the majority of which have not yet been fully identified or surveyed. Surveys conducted to date have revealed that a considerable amount of lost fishing gear—commonly referred to as ‘ghost nets’—has accumulated on all examined wrecks. These nets continue to function as passive fishing gear, causing extensive damage to the marine environment, including aquaculture areas, and posing technical hazards to vessels. Due to their synthetic composition, they degrade very slowly, if at all, and can persist in the marine environment for decades.

At present, wrecks and submerged objects are inspected exclusively through direct visual surveys by divers. This method is constrained by limited air supply and the maximum safe time that can be spent at depth, thereby restricting the scope and effectiveness of such assessments [1].

Sustainability and the conservation of fish stocks are fundamental to the long-term viability of any fishery. Overfishing can lead to the collapse of fish populations, with severe consequences for marine ecosystems and for the livelihoods of communities that depend on fishing as a primary source of income.

To ensure the sustainable management of fish stocks, fisheries must adopt responsible and environmentally sound practices, including:

1. Fishing within sustainable limits – Harvesting only what the stock can replenish, and avoiding the capture of juvenile or undersized fish to allow populations to reproduce and thrive.
2. Using selective fishing gear – Employing gear that minimizes bycatch and helps avoid the capture of non-target species, thus reducing unnecessary ecological harm.
3. Protecting critical habitats – Safeguarding vital areas such as spawning grounds and nursery habitats from damage or destruction is essential for supporting healthy fish populations.
4. Promoting responsible behavior – Encouraging fishers to dispose of gear properly, reduce marine litter, and minimize the use of single-use plastics contributes to a healthier marine environment.

5. Conclusion

The presence of ‘ghost nets’ in the Baltic Sea poses a serious threat to marine biodiversity. However, a comprehensive inventory assessing their prevalence and ecological impact has yet to be conducted. These abandoned fishing nets—often lost during storms or as a result of strong currents—continue to capture fish, marine mammals, and other marine organisms indiscriminately over extended periods. Many of these nets are composed of synthetic materials that gradually fragment into microplastics, thereby polluting the marine environment, entering the food chain, and threatening both ecosystem health and human well-being. This study underscores the urgent need for collaborative solutions involving both the fishing industry and the wider public. Raising awareness and encouraging the active engagement of fishers are essential to effectively addressing this issue. Future strategies should prioritise the development and adoption of sustainable fishing gear, the improvement of waste management systems, and the strengthening of international cooperation to ensure environmentally responsible fishing practices across the region. In the Gulf of Riga—where herring constitutes the principal target species—fishing primarily takes place from April to June, with seasonal restrictions introduced to protect stocks during spawning. The area supports two distinct herring populations: bay herring and open-sea herring, each managed through specific catch quotas. Conservation measures such as restrictions on vessel capacity and temporary fishing bans have contributed to the long-term stability of these stocks. In Latvia, trawl fishing accounts for the majority of herring catches, whereas Estonia allocates a larger proportion of its quota to coastal fishing activities. Despite the generally healthy status of herring stocks, the persistent problem of lost or abandoned nets remains a significant ecological concern. To mitigate these impacts, several initiatives are recommended. These include organising regular net retrieval expeditions, promoting the use of selective fishing gear to minimise by-catch and avoid the capture of juvenile fish, and protecting critical habitats such as spawning and nursery grounds. Fishers should also be encouraged to adopt responsible practices, including the proper disposal of used gear, the reduction of single-use plastics, and participation in recycling programmes. Tagging fishing equipment would facilitate the tracing of lost nets and the identification of responsible parties. Furthermore, investment in the research and development of biodegradable fishing gear represents a promising long-term solution, as such materials degrade naturally and reduce environmental harm. Overfishing continues to pose a persistent threat to marine ecosystems and to the coastal communities that depend on them. Ensuring the long-term sustainability of the Baltic Sea's fisheries requires a sustained commitment to responsible fishing practices, robust conservation measures, and the implementation of innovative, environmentally conscious solutions.

Next steps:

The fisheries sector is crucial for global food security and the livelihoods of millions worldwide. Ensuring the sustainability of this industry requires effective management, responsible fishing practices, and the conservation of fish stocks. By embracing sustainable approaches, we can protect the long-term viability of fisheries and the health of our oceans. To minimize the environmental impact of practices such as longline fishing, stronger collaboration is needed between fishermen, scientists, and regulatory authorities. While some regulations are already in place, their success depends heavily on the active engagement of the fishing community and increased public awareness. Looking ahead, the development of innovative, sustainable fishing gear and the strengthening of international cooperation will be essential. These efforts will support responsible and environmentally friendly fishing in the Baltic Sea and contribute to the broader goal of preserving marine ecosystems for future generations.

6. Acknowledgments

Supported by research and development grant No. RTU-PA-2024/1-0084 under the EU RRF project No 5.2.1.1.i.0/2/24/I/CFLA/003 grant "Innovative underwater drone equipment with manipulators for cleaning the sea from ghost nets (UDRON)"(No. C4835.ZPD.PI.0084.P1)

7. References

[1] Beneli T.M.,.Pereira P.H.C ,.Nunes J.A.C.C ,.Barros F, "Ghost fishing impacts on hydrocorals and associated reef fish assemblages" (2020), Marine Environmental Research, Volume 161, 2020, 105129, ISSN 0141-1136, https://doi.org/10.1016/j.marenvres.2020.105129 . [Accessed: March. 1, 2025]

[2] Chernyshev V., Ksenzenko A., Nechaev A., Petrakov M., Pryanichenikov V., Prysev E., The Development of Service and Underwater Robots using Network and 3D vision Technologiest (2019), 31 in DAAAM International Scientific Book 2019, pp.359-366, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-24-2, ISSN 1726-9687, Vienna, Austria, DOI: 10.2507/daaam.scibook.2019.31 https://www.daaam.info/Downloads/Pdfs/science_books_pdfs/2019/Sc_Book_2019-031.pdf [Accessed: October. 18, 2025]

[3] Dabuleviciene T., Jucevicius D., Zolubas T., Vaiciute D., Nika N., "The Effect of Short-Term Upwelling Events on Fish Assemblages at the South-Eastern Coast of the Baltic Sea". Water 2023, 15, pp.452. https://doi.org/10.3390/w15030452 [Accessed: March. 1, 2025]

[4] Filaretov V., Konoplin A., Zuev A. & Krasavin N., 2020 "System of High-precision Movements Control of Underwater Manipulator" Proceedings of the 31st International DAAAM Virtual Symposium "Intelligent Manufacturing & Automation" Volume 31, No.1, ISSN 1726-9679, ISBN 978-3-902734-29-7 Ed. B. Katalinic / Published by DAAAM International, Vienna, Austria, EU, 2020 DOI:10.2507/31st.daaam.proceedings.104; https://daaam.info/31st-proceedings-2020 [Accessed: October. 18, 2025]

[5] Hammer C., Dorrien C., Zimmerman C., "A Review on Herring, Clupea Harengus (Actinopterygii: Clupeiformes: Clupeidae) Recruitment and Early Life Stage Ecology in the Western Baltic Sea" (2013) Acta Ichthyologica et Piscatoria 43(3):pp.169-182, DOI:10.3750/AIP2013.43.3.01 [Accessed: March. 3, 2025]

[6] Kraufvelin P., Pekcan-Hekim Z., .Bergström U,, Britt F.A., Lehikoinen A., Mattila J., Arula T., Briekmane L., Brown E.J., Celmer Z., Dainys J., Jokinen H., Kääriä P., Kallasvuo M., Lappalainen A, L.Lozys, P.Möller, A.Orio, M.Rohtla, L.Saks, M.Snickars, J.Støttrup, G.Sundblad, I.Taal, D.Ustups, A.Verliin, M.Vetemaa, H.Winkler, A.Wozniczka, J.Olsson, "Essential coastal habitats for fish in the Baltic Sea", Estuarine, Coastal and Shelf Science,Volume 204, 2018, pp.14-30, ISSN 0272-7714, https://doi.org/10.1016/j.ecss.2018.02.014 [Accessed: February 23, 2025]

[7] Lehtonen K.K., Schiedek D., "Monitoring biological effects of pollution in the Baltic Sea: Neglected—but still wanted?", Marine Pollution Bulletin, Volume 53, Issues 8–9, 2006, pp.377-386, ISSN 0025-326X, https://doi.org/10.1016/j.marpolbul.2005.11.016 [Accessed: February 22, 2025]

[8] Márcio L.V., Barbosa F., Seminara C.I., Castro Tavares D., Siciliano S., Hauser-Davis R.A., Silva Mourão J., "Artisanal fisher perceptions on ghost nets in a tropical South Atlantic marine biodiversity hotspot: Challenges to traditional fishing culture and implications for conservation strategies", Ocean & Coastal Management, Volume 192, 2020, 105189, ISSN 0964- https://doi.org/10.1016/j.ocecoaman.2020.105189. [Accessed: February 13, 2025]

[9] Lively J.A, Good T.P., '"Ghost fishing" World Seas: An Environmental Evaluation Volume III: Ecological Issues and Environmental Impacts., pp.183–196

[10] Margonski P., Hansson S., Tomczak M.T., Grzebielec R., "Climate influence on Baltic cod, sprat, and herring stock-recruitment relationships"(2010) Progress in Oceanography, Volume 87, Issue 1-4, pp.277–288. Progress in Oceanography,ISSN 0079-6611, https://doi.org/10.1016/j.pocean.2010.08.003 . [Accessed: February 23, 2025]

[11] Miethe T., Gröhsler T., Böttcher U., Dorrien C., "The effects of periodic marine inflow into the Baltic Sea on the migration patterns of Western Baltic spring-spawning herring", ICES Journal of Marine Science, Volume 71, Issue 3, March/April 2014, pp.519–527, https://doi.org/10.1093/icesjms/fst166 [Accessed: February 20, 2025]

[12] Moll D., Kotterba P., Nordheim L., "Storm-Induced Atlantic Herring (Clupea harengus) Egg Mortality in Baltic Sea Inshore Spawning Areas". Estuaries and Coasts 41, pp.1–12 (2018). https://doi.org/10.1007/s12237-017-0259-5 [Accessed: February 23, 2025]

[13] Moyano M., Illing B., Akimova A., "Caught in the middle: bottom-up and top-down processes impacting recruitment in a small pelagic fish". Rev Fish Biol Fisheries 33, pp.55–84 (2023). https://doi.org/10.1007/s11160-022-09739-2 [Accessed: February 23, 2025]

[14] Peltonen H., Weigel B., "Responses of coastal fishery resources to rapid environmental changes". Journal of Fish Biology, 101(3),(2013) pp.686–698. https://doi.org/10.1111/jfb.15138698 [Accessed: February 23, 2025]

[15] Rahikainen M., Hoviniemi K.M., Mäntyniemi S., Kuikka S, "Impacts of eutrophication and oil spills on the Gulf of Finland herring stock" (2017) Canadian Journal of Fisheries and Aquatic Sciences, Volume 74, Issue 8, pp.1218 – 1232 Canadian Journal of Fisheries and Aquatic Sciences 10 January 2017, https://doi.org/10.1139/cjfas-2016-0108

[16] Raid T., Sepp E., Vetemaa M., "Use of autonomous research vehicles in Baltic fisheries acoustic surveys: Potential benefits and pitfalls?" (2022) Trends in Maritime Technology and Engineering, pp.8 DOI: 10.1201/9781003320289-66

[17] Raid T., Shpilev H., Järv L., Järvik A., "Towards sustainable Baltic herring fishery: trawls vs. pound nets" (2011) Conference: IMAM 2011, Sustantainable Maritime Transportation and Exploitation of the Sea Resources, Genova, Italy, 13.-16. September; pp.1055 – 1062, Volume: 2

[18] Rijkure A., Megnis J., "Technical Methods of Cleaning Shipwrecks form Ghost Nets", ETR, vol. 3, pp. 253–256, Jun. 2024, https://doi.org/10.17770/etr2024vol3.8160 [Accessed: March. 1, 2025]

[19] Rosciszewski-Dodgson M.J., Cirella G.T., "Environmental drivers affecting the status of top commercial fish stocks in the Baltic Sea: review" (2024) Marine Fisheries, Aquaculture and Living Resources, Volume 11 - 2024 | https://doi.org/10.3389/fmars.2024.1399707 [Accessed: February 20, 2025]

[20] Ruskule A., Kotta J., Saha C.R., Arndt P., Ustups D., Strāķe S., Bergström L., "Testing the concept of green infrastructure at the Baltic Sea scale to support an ecosystem-based approach to management of marine areas" (2023) Marine Policy, Volume 147, 2023, 105374, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2022.105374. [Accessed: February 23, 2025]

[21] 19.Schiewer U., Schernewski G., "Self-Purification Capacity and Management of Baltic Coastal Ecosystems." Journal of Coastal Conservation, vol. 10, no. 1/2, 2004, pp. 25–32. JSTOR,DOI: http://www.jstor.org/stable/25098434. [Accessed: February 20, 2025]

[22] Sepp E., Vetemaa M., Raid T., Arula T., "Trawler Engine Size Had No Effect on Baltic Herring Size/Age Structure: An Experimental Study in the Gulf of Riga, Baltic Sea.", (2022), Fishes 7(46):pp.2-11, DOI:10.3390/fishes7010046 [Accessed: February 23, 2025]

[23] Vetemaa M., Eschbaum R., Saat T., "The transition from the Soviet system to a market economy as a cause of instability in the Estonian coastal fisheries sector", (2006), Marine Policy, Volume 30, Issue 6, 2006, pp.635-640, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2005.08.001 [Accessed: February 25, 2025]

[24] Vozbinaite G.K., "Recycled landscapes: Beyond the horizon of the Baltic Sea," 2016 Techno-Ocean (Techno-Ocean), Kobe, Japan, 2016, pp. 1-6, DOI:10.1109/Techno-Ocean.2016.7890745. [Accessed: March. 2, 2025]

[25] William C., Long P., Cummiskey A.J., Munk E., "Effects of ghost fishing on the population of red king crab (Paralithodes camtschaticus) in Womens Bay, Kodiak Island, Alaska" (2014) Fishery Bulletin, 112(2-3):pp.101-111, DOI: 10.7755/FB.112.2-3.1 [Accessed: February 19, 2025]

[26] Zimmermann C., "Fish stocks and fisheries in the Baltic Sea" (2022) Geographische RundschauVolume 74, Issue 11, pp.22–26.