Fisheries Research 281 (2025) 107214

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Short communication

# The hovering pontoon trap: The tougher, younger sibling in the pontoon trap family

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ARTICLE INFO

*Keywords:*
Passive gear development
Selective gear development
Pontoon trap
Hovering trap
Seal-fisheries conflict

ABSTRACT

Trap nets are a large, stationary, and fixed type of passive fishing gear that has traditionally been used for catching fish in shallow coastal environments. Despite their large size, catches are often retrieved using small boats, making them less energy demanding compared to active gear types. This, along with the stationary nature of the trap, allows for fishing with relatively low environmental impact due to minimal disturbance of the benthic community. The combination of minimal benthic impact, live catch, low fuel, and selectivity offers great potential for the development of sustainable coastal fisheries.

Here, we describe the development of the hovering pontoon trap, a fishing gear with a robust design to resist strong waves and currents, and usable in both shallow and deep waters to catch both pelagic and benthic species. We present results from early case studies targeting benthic Baltic Sea species, including perch (*Percha fluventaliis*), Atlantic cod (*Gadus morhua*) and vendace (*Coregonus albula*), showing similar or improved catches in relation to earlier studies. Further, we show that the hovering pontoon trap was able to withstand harsher conditions than previous bottom-set models, making it a possible solution for the targeting of benthic fish communities in coastal environments.

## 1. Introduction

While fishing provides sustenance for people around the world, it also has various negative effects on the marine environment, such as overfishing, disturbance of the benthic environment, bycatch, and ghost fishing through lost or discarded fishing gear (Gilman, 2015; Gilman et al., 2005; Grabowski et al., 2014; Lewison et al., 2014; Suuronen et al., 2012; Žydelis et al., 2013). Trap nets are a type of passive fishing gear and are often large, stationary, and fixed structures (He, 2010). The core feature of trap nets is to lead fish or shellfish, through sets of funnel shaped entrances, into a fish chamber where they are trapped and kept alive until collection. Traditionally, trap nets have been used in shallow coastal environments. Trap nets have evolved over time from simple fish herding and holding devices into complex fishing gears constructed from several parts with the goal of improving catch efficiency and with a wide range of designs globally (He, 2010; Slack-Smith, 2001).

Despite their large size, trap nets are often retrieved using smaller boats, making them energy efficient in relation to many active gears (Nomura, 1980; Suuronen et al., 2012). Also, being a stationary gear, it is considered to have low environmental impact due to its reduced effects on the benthic community (Suuronen et al., 2012). Due to their size, often up to a hundred meters in length, they have a very low risk of being lost and becoming a ghost fishing gear. While fishing, trap nets keep their catch alive, resulting in high catch quality and unwanted catch being released (He, 2010). The combination of low impact and high food quality provides an important contribution to sustainable coastal fisheries. However, one of the major concerns with trap nets is the potential conflict with non-target species, such as marine mammals and birds, which may become unintentionally entangled, and the consequences for fisher livelihoods when gear is damaged in the process (Lien et al., 1988; Vanhatalo et al., 2014). Trap nets have been widely used within Baltic Sea coastal fisheries targeting salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*). Traditional trap nets, however, provide access to high densities of prey for seals (Westerberg et al., 2006). In the Baltic Sea, seal numbers, predominantly grey seal (*Halichoerus grypus*), have increased dramatically since the beginning of the

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https://doi.org/10.1016/j.fishres.2024.107214
Received 22 February 2024; Received in revised form 25 October 2024; Accepted 25 October 2024
Available online 30 October 2024

2000s (Bäcklin et al., 2016; Galatius et al., 2020; Swedish Agency for Marine and Water Management, 2019). This rise in seal populations has lead to increased interaction between seals and coastal fishers (Blomquist and Waldo, 2021; Bruckmeier and Larsen, 2008; Lunneryd et al., 2003; Suuronen et al., 2023; Varjopuro, 2011), where seals damage fishing gear and depredate catch, causing economic losses to fishers (Fjalling, 2005; Königson et al., 2009).

To reduce seal impacts in trap net fisheries, one successful method was the introduction of a modified trap net, the pontoon trap, targeting salmon, trout (*Salmo trutta*), and whitefish (Calamnius et al., 2018; Hemmingsson et al., 2008; Lunneryd et al., 2003; Suuronen et al., 2006).

A traditional pontoon trap is a large, passive fishing gear that includes the following components: leading net, wings, adaptor, and a seal-safe fish chamber equipped with pontoons and a rigid frame (Calamnius et al., 2018; Hemmingsson et al., 2008; Lunneryd et al., 2003; Suuronen et al., 2006). The fish chamber prevents fish from escaping, allowing longer soak times, and allows catch to be kept alive until collection, which is an advantage while having the gear deployed during harsh weather conditions. An additional advantage of the rigid fish chamber is the possibility to use detachable selection panels, which can be adjusted to decrease the bycatch of non-target sized fish, e.g. Lundin et al. (2011). The innovative feature of the traditional pontoon trap is the inflatable pontoons at the lower side (legs) of the fish chamber, which are used when deploying and retrieving the trap using a mobile air compressor (Hemmingsson et al., 2008). Since the introduction of the pontoon trap, and with increases in Baltic sea seal populations, modified versions of the pontoon trap have been evaluated targeting vendace (*Coregonus albula*), herring (*Clupea harengus*), perch (*Percha fluventalis*) (Lundin et al., 2011, 2015) and Atlantic cod (*Gadus morhua*) (Ljungberg et al., 2022), which implies that pontoon traps can be made both species and size selective.

The traditional pontoon trap has its fish chamber buoyed and floating at the surface while fishing, forcing potential benthic catch species to swim to the surface to enter the trap. Thus, there is generally lower catch of benthic species in traps with surface-bouyed fish chambers compared to bottom-set pontoon traps (Ljungberg et al., 2022). Bottom-set pontoon traps can be used to target benthic species, but the rigid aluminum construction of the fish chamber is unsuitable for an open coastline as wave and current actions may destroy the gear, mainly through collision with the seafloor (Ljungberg et al., 2022). To address the limitations of bottom-set pontoon traps, we developed the hovering pontoon trap, a gear with a robust design that is resilient to wave and current actions, and that can be used in both shallow and deeper waters to catch benthic species. The major changes in the hoovering pontoon trap are in the fish chamber, while the leader net, wings, and adaptor are similar to traditional pontoon traps. In this paper, we describe the construction of the newly developed hovering pontoon trap and preliminary results from early case studies targeting primarily the benthic species cod, perch, and vendace, which are all species that are less likely to be caught using a traditional floating pontoon fish chamber.

## 2. Material and methods

### 2.1. Hovering pontoon trap construction

In the present study, we built a redesigned the pontoon trap for the purposes of benthic deployment, referred to as hovering pontoon trap. The key feature of the hovering pontoon trap is the redesigned fish chamber and its lower parts (legs), which allow for reduced bottom contact. The base cylinder compartment was composed of a 1.5 m diameter fish chamber similar to the one previously used in traditional pontoon traps in perch fisheries (Lundin et al., 2015) and bottom-set pontoon traps in cod fisheries (Ljungberg et al., 2022). In our design, the fish chamber length was shortened from the traditional length of 4.5–3 m, and included 4 circular aluminium tubes with a 117, 65, and 117 cm centre-to-centre distance (Fig. 1, Fig. 2). The frame material was 35 mm in diameter, with 2 mm gauge aluminium tubing, and of quality AW 6082 T6 and T4. The netting covering the fish chamber was made from polyethylene (PE 3/4) with a 20 mm centre-knot to centre-knot distance and a twine of 1.3 mm.

**Fig. 1.** Hovering pontoon trap fish chamber.

The entrance to the fish chamber was made from 24 nylon threads shaped into a 1.3 m cone to reduce the ability of caught fish to exit the chamber (Fig. 2j). To allow for the use of target species specific selection panels, a 40×40 cm aluminium (20 mm diameter) frame was mounted to the left side of the fish chamber (Fig. 2i).

The middle, flexible chamber consisted of 3 rings with 130, 130 and 17 cm centre-to-centre distance, where the two first rings were used for connecting the fish chamber to the trap (Fig. 2g). The netting was made from green Dyneema with a 35-mm centre-knot to centre-knot distance and a twine diameter of 1.0 mm. The entrance to the middle chamber was equipped with a standardized octagonal seal exclusion device (SED, Calamnius et al., 2018) with two 5 mm steel wires forming a cross. The SED frame was constructed of 20 mm diameter aluminium and the outer dimension was 45×45 cm (Fig. 2h). In a traditional pontoon trap, the side legs are mounted in a fixed position. In contrast, the legs of the hovering pontoon trap were made foldable using 38-mm tube clamps attached to a horizontal 35 mm aluminium tube on the fish chamber (Fig. 2a). The legs were, as in the traditional pontoon trap, bolted to inflatable pontoons, made from 308 mm heavy-duty polyester-reinforced polyurethane industrial hose. So that the trap would hover above the sea floor, each leg was equipped with 6 buoys, each with 7 kg of positive buoyancy, to allow the legs to be positively buoyant when the trap was deployed. Consequently, the legs fold upwards when the trap is submerged. To prevent the legs from folding too far upwards, they were equipped with a 130 cm-long galvanized metal chain (6 mm×55 mm) shackled between the underside of the fish chamber and the legs (Fig. 2b). To offset the increased positive buoyancy of the fish chamber from the leg-set buoys, we attached a metal chain-equipped skirt underneath the fish chamber in its lengthwise direction (Fig. 2c). The skirt had a height and length of 1 m and 3 m, respectively, and was made from polyethylene 3/6 with a 100 mm centre-knot to centre-knot distance and a twine of 1.6 mm. Two linked chains of 16 mm×130 mm were attached to the skirt's lower part, giving the trap a negative buoyancy of 52 kg, enough to keep the trap close to the bottom regardless of deployment depth (Fig. 2d). The near-bottom hovering reduces contact between the fish chamber and the seafloor, which decreases the gear's susceptibility to damage from waves and currents.

When retrieved, the above-water level position of the fish chamber makes it easier to collect the catch. The hovering pontoon trap was equipped with two short vertical folding pontoons, 1.5 m in length, to allow the fish chamber to stand at the surface. One folding pontoon was attached at each side of the fish chamber and bolted to the pontoon holders and the cylinder compartment (Fig. 2e). When lifted to the surface, the folding pontoons can be inflated along with the horizontal leg pontoons, allowing the fish chamber to stand at the surface like a

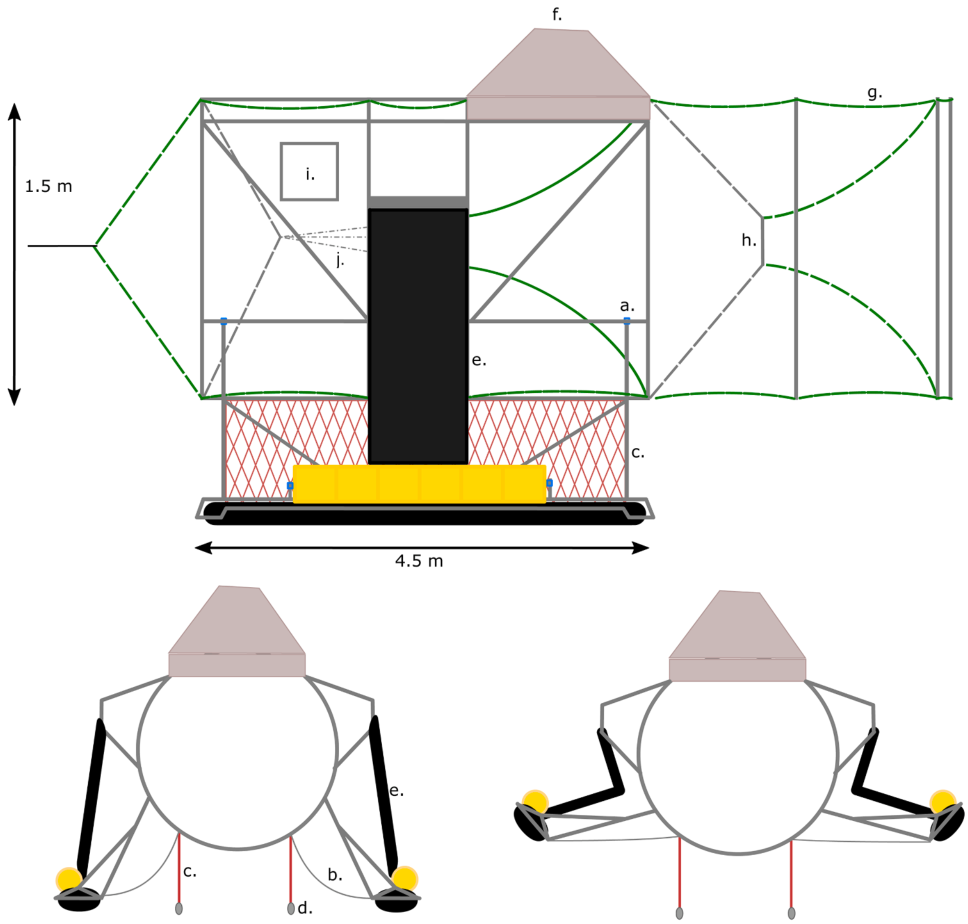


**Fig. 2.** Hovering pontoon trap fish chamber with its different parts: a: foldable conjunctions; b: shackles to preclude over-folding; c: skirt; d: shackle chain for negative bouncy; e: vertical/folding pontoons; f: pyramid-shaped open PVC sack; g: interconnecting part between fish chamber and adaptor; h: seal gate (SED); i: frame for interchangeable selection panels; j: cone-shaped entrance made from 24 nylon treads, in total 1.3 m in length. The upper panel shows the side view of the fish chamber, while the lower panel shows the view of the surface-folded (left) and bottom-relaxed (right) fish chamber.

traditional pontoon trap. The top pontoon of the traditional pontoon trap, used for stable lifting of the trap to the surface, was replaced by a larger 80×80 cm pyramid shaped sack with an open bottom (Fig. 2f). The top pyramid sack was made from PVC and constructed by the local manufacturer Hudiksvalls kapell AB. The design with an open sack in relation to a closed topside pontoon makes it less vulnerable to over-inflation, as over-inflation could potentially cause the pontoon to explode as the air expands with decreasing depth.

The aluminium chute for catch collection, as used in the traditional pontoon trap, was changed to a hose net made from knot-less nylon with a 10 mm centre-knot to centre-knot distance (Ljungberg et al., 2022; Lunneryd, 2018). The hose net, similar to a trawl codend, is a 10 m long fine-meshed netting tube, into which the fish move passively when the trap is lifted to the surface. The hose net was used to lift the fish from the surface into the boat. Hose nets allow catches to be selectively handled, as the fish can be divided into smaller amounts before they are lifted into the boat or released. Furthermore, the hose net is made from knotless netting, which minimizes scale loss, and, therefore, may increase the quality of collected fish and the survival of discards.

Three hoses were used for pontoon inflation, one for each side of the fish chamber, where each hose supplies air to both the horizontal and folding pontoons (Fig. 1). A third hose delivers air to the top side lifting sack, which is used to lift the trap to the surface. The hoses are made from EPDM-rubber with an outer diameter of 27 mm, a material thickness of 4 mm, and with a 20 bar burst pressure. For inflating the pontoons, a portable petrol-driven compressor was used with a maximum pressure of 8 bar and an operating pressure of 4 bar.

### 2.2. Case studies

Although the primary focus of this article is on the physical design of the hovering pontoon trap, it has, to date, been tested in four cases targeting different species and compared to bottom-set traps. In case study A, the target species was cod, while in case study B, both cod and perch were targeted. In case study C, the target species was perch and in case study D, the target species was vendace (Fig. 3, Table 1).

## 3. Results

In all case studies, the hovering pontoon trap fish chamber showed high resilience against both heavy wind conditions and shifting currents, and there was no damage to the fish chamber during its usage (Table 1). In addition to the physical evaluation of the hovering pontoon trap, we provide a comprehensive compilation of catch data from the case study-specific target species (Table 2).

## 4. Discussion

Two of the foremost limitations in the use of traditional bottom-set pontoon traps are: (1) difficulties lifting the fish chamber to the surface, and (2) damage to the trap from wave and current action, and collision with the seafloor (Ljungberg et al., 2022). Our redesigned hovering pontoon trap addresses the first issue by using an open sack, which eliminates the risk of over-inflation if lifted from large depths. Traditional pontoon traps, in contrast, are susceptible to cracking if

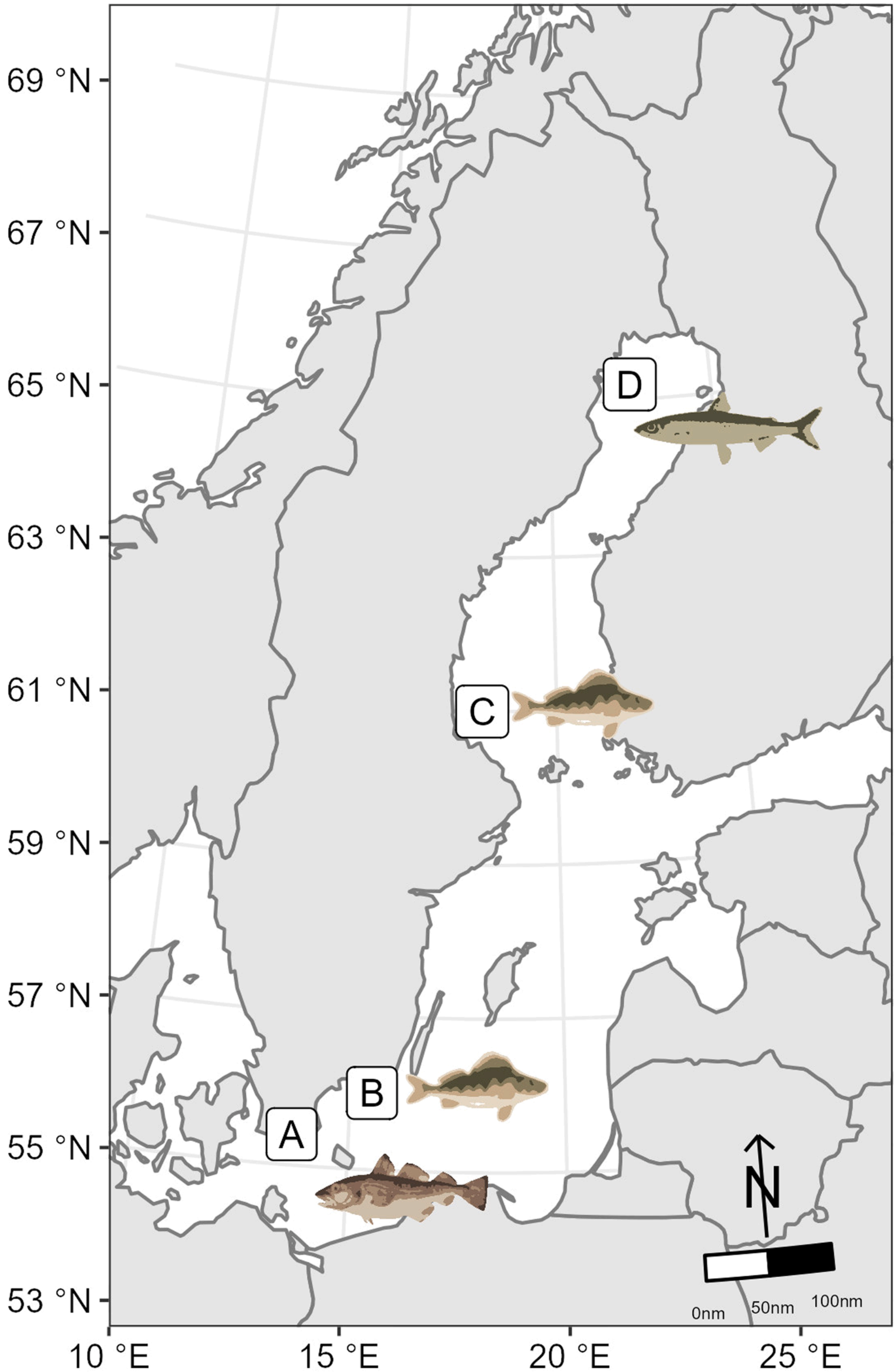


**Fig. 3.** Map over the Baltic Sea and where the four different case studies with the hovering pontoon trap were performed targeting the following species: A: cod, B: cod/perch, C: perch, D: and vendace.

deployed at the bottom.

The second and major change in our redesigned trap is the ability of the fish chamber to hover without affecting its overall rigid construction, which is lifted above water for efficient and ergonomic emptying. The reconstruction of the jointed leg attached to the fish chamber allows the legs to fold upwards and downwards, which is a key feature of the hovering fish chamber (Fig. 2a). When submerged, the passive upward folding is facilitated by the addition of buoys, preventing the aluminium frame from bottom contact (Video 1), and at the surface, active downward folding occurs using vertical pontoons that inflate together with the leg pontoons using a mobile air compressor (Video 2). These trap modifications have enabled the deployment of the hovering pontoon trap in more wave and current exposed areas, as we evaluated in our case studies. In case A, the fish chamber was not physically affected by weather and wave conditions. The skirt height used in all case studies was kept at 1 m. Hence, skirt height may be modified to allow for changes in deployment depth depending on target species or season. The combination of an open sack and hovering ability facilitates

**Table 1**
Case scenarios in which the hovering pontoon trap was tested with the primary target species, area type, season tested, deployment depth, and whether or not the entire trap was new for the case studies.

| Case Study | Year | Target species | Area type | Season | Depth (m) | Trap | Adaptor | Reference trap name | Reference |
|---|---|---|---|---|---|---|---|---|---|
| A | 2020 | Cod | Open, exposed | Spring | 8 | Old | Yes | 3-m trap | (Ljungberg and others, 2022; Benavente Norrman et al., 2021) |
| B | 2020 | Cod, Perch | Archipelago | Summer, Autumn | 15 | Old | Yes | 6-m trap | (Ljungberg et al., 2022; Benavente Norrman et al., 2021) |
| C | 2021, 2022 | Perch | Archipelago | Autumn | 4–8 | New | No | - | - |
| D | 2022 | Vendace | Open, exposed | Autumn | 11 | New | No | - | - |

**Table 2**
Species-specific catch from the different case studies included in the case studies of the hovering pontoon trap. Note that for target species vendace roe, amounts are in grams.

| Case Study | Target species | Collections (n) | Soak time (days ± sd) | Mean catch per trap (kg day-1 ± sd) | Range catch per trap (kg day$^{-1}$) |
|---|---|---|---|---|---|
| A | Cod (>35 cm) | 18 | 3.1 ± 1.6 | 3.6 ± 3.0 | 0–20 |
| B | Cod (>35 cm) | 18 | 7.9 ± 3.5 | 1.66 ± 0.91 | 0.43–2.83 |
| B | Perch (>22 cm) | 18 | 7.9 ± 3.5 | 1.05 ± 1.03 | 0.07–4.0 |
| C | Perch (>20 cm) | 87 | 2.8 ± 1.2 | 2.56 ± 3.24 | 0–13.0 |
| D | Vendace (all) | 17 | 2.7 ± 1.7 | 11.14 ± 11.24 | 2–40 |
| D | Vendace roe (in grams) | 17 | 2.7 ± 1.7 | 258.3 ± 346.8 | 0–1300 |
| D | Herring (all) | 17 | 2.7 ± 1.7 | 20.80 ± 11.40 | 5–45 |

use at larger depths than tested before, which also increases the range of habitats where the trap may be used. An advantage with greater deployment depths may be prevention of algal growth on the netting. Salmon fisheries in Sweden using traditional pontoon traps are only allowed to fish during a short quota-regulated time window in early July. However, for other target species like whitefish, perch and cod, extended deployment times are desirable. This longer standing time will, at least for surface standing gear, be affected by increased algal growth. A bottom-set trap is less likely to be susceptible to algal growth, which may improve catch efficiency over time and reduce cleaning needs, which can be time-consuming.

Supplementary material related to this article can be found online at doi:10.1016/j.fishres.2024.107214.

Although we focus here on the development of the hovering pontoon design, we also evaluate, through four case studies, species specific catchability. In case study A and B, the evaluation included the target species cod and perch (Table 2). In both studies, the traditional pontoon fish chamber was replaced by a hovering fish chamber. Catch comparisons in case study A indicate that the hovering pontoon trap catch rates were comparable with the previously used bottom-set pontoon trap that in 2018 ranged from 0 to 10.7 kg per day (Ljungberg et al., 2022). In case study B, catch of commercial sized cod in trials with traditional, bottom-set pontoon traps in the area ranged from 0 to 3.5 kg per day in 2016 and 2017 (Benavente Norrman et al., 2021) in comparison to 0.4–2.8 kg per day in the hovering pontoon trap. For perch, catch rate with hovering pontoon traps ranged from 0 to 3.18 kg between the years 2017 and 2019 (Benavente Norrman et al., 2021). In case study C, catch data from three different traps in two adjacent locations was compiled. Also, in 2021 the study was conducted during a short period in November, which is late in the season when targeting perch (Craig, 1977). The hovering pontoon trap showed large variation in catch rates of perch compared to case B (Table 2), indicating that catch rates of the same target species vary both temporally and spatially.

The case studies outlined here demonstrate that a hovering pontoon fish chamber has the potential to overcome the previous disadvantages of bottom-set pontoon traps, especially under harsher or more exposed conditions. Future research ought to focus on the regulation of target species selectivity by various components of the trap, such as the leading net length, skirt height, adaptor construction, and fish chamber entrance.

## CRediT authorship contribution statement

**Lundin Mikael:** Writing – review & editing, Conceptualization. **Glenn Fridh:** Validation, Investigation. **Lars Hillström:** Writing – review & editing, Methodology. **Sven-Gunnar Lunneryd:** Writing – review & editing. **Peter Ljungberg:** Writing – original draft, Methodology, Conceptualization.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Mikael Lundin reports a relationship with Maskin & Marin that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

We thank the participating fishers Bengt Andersson, Lennart Ekholm and Mattias Ekholm for their efforts in making this study possible. Also we thank Daniel Stepputtis and Edmond Sacre for comments on the earlier versions of this manuscript. This study was funded by the European Maritime and Fisheries Fund (EMFF) through The Swedish Board of Agriculture; grant agreements: 2016–8273 and 2018–1642, along the Program Seal and Fisheries with economical support from the Swedish Agency for Marine and Water Management (SwAM).

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2024.107214.

## Data availability

Data is compiled from pilot studies with reference to published governmental reports. The intention is not to detail published this data but to show the varity of potential target species.

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