# Established Best Practices & Bycatch Reduction Strategies Related to Seabird Interactions with Longline, Trawl, and Gillnet Fisheries

*Prepared for* Seabird Bycatch Reduction Strategies Workshop (virtual)
February 2026

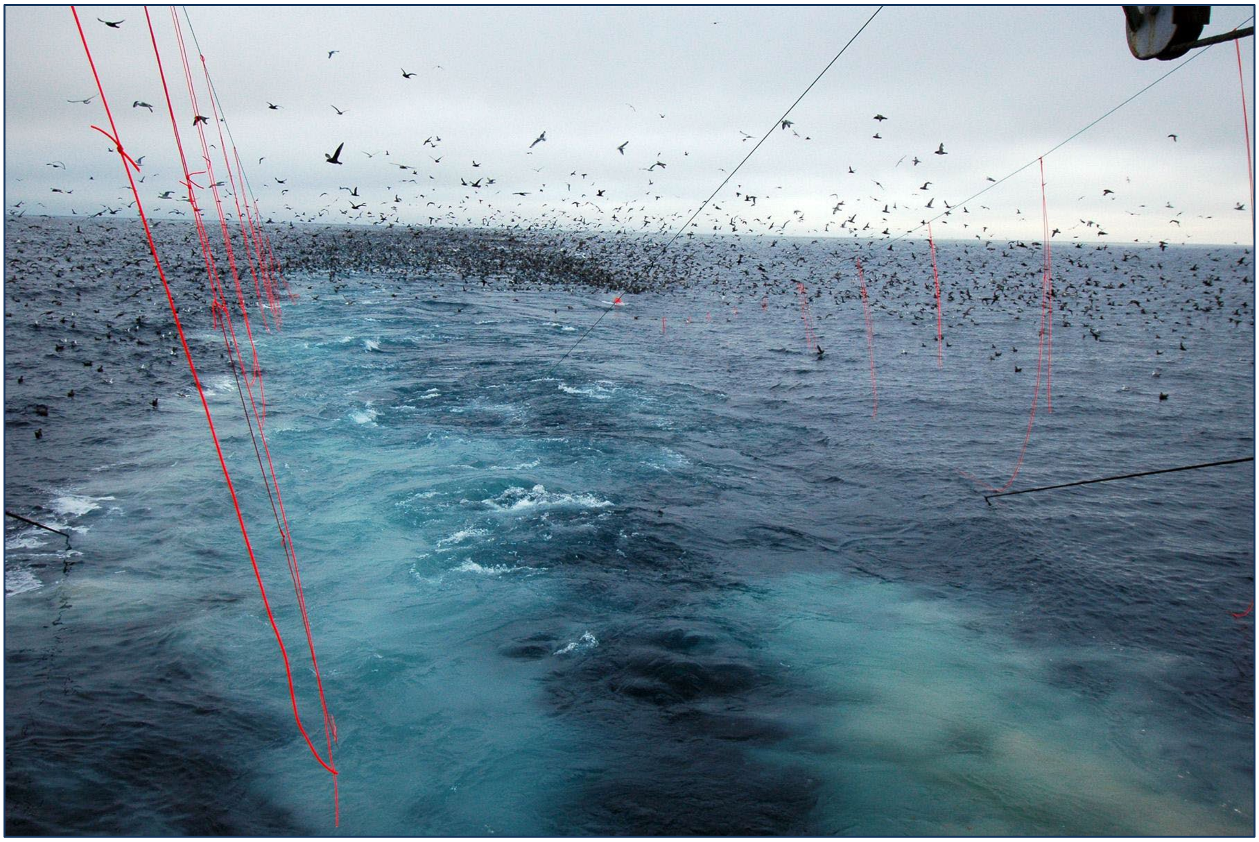

Photo credit: Ed Melvin

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## Background & Purpose

This summary document was developed for the Trilateral Bycatch Working Group (TBWG), and Atlantic Marine Bird Cooperative (AMBC) to inventory and compile current bycatch best management practices and reduction strategies for three commercial fishery gear types (gillnet, longline, trawl) known to interact with marine birds.

The TWBG is co-chaired by government resource managers and scientists from Canada, the United States, and Mexico, who collaborate with partners in non-governmental organizations (NGOs), academia, and other entities to advance actions related to reducing the incidental take (bycatch) of seabirds in commercial fisheries. This group works to identify priority actions including, but not limited to, developing and sharing best management practices (BMPs). The AMBC is an open/collaborative forum for people with expertise and interest in Northwest Atlantic marine birds. Through working groups, including a bycatch working group, the AMBC works to better understand marine bird conservation/management needs, and develop collaborative actions to address these needs.

Specifically, the document was created to support a virtual workshop that occurred in February 2026 (see *Workshop Report: Seabird Bycatch Reduction Strategies February 11-12,* 2026). It summarizes existing BMPs and where those BMPs are being used, as well as describes additional gear modifications and avoidance practices. The document was intended to inform discussions during and after the workshop that identify BMPs, modifications, and/or practices are most promising for testing and establishment within Canadian, U.S., and Mexican fisheries.

Many papers (including Werner et al. 2006, Bull 2007, Løkkeborg 2011, and Melvin et al. 2023) have provided overviews of bycatch impacts on seabirds and possible solutions. However, **for the purposes of this report, BMPs are guidelines promulgated by regional fishery management organizations (RFMOs) that are binding for members and/or parties, as well as regulations implemented by governmental fishery regulators**. **In addition to describing seabird-related BMPs, this report discusses additional gear modifications and fishing practices that have not been incorporated into RFMO guidelines or governmental regulations**.

**The document focuses on three gear types that account for greatest incidence of seabird interactions: longline, trawl, and gillnet** (as indicated in analyses of fishery-dependent data sets from observer programs and other sources; for additional overviews of seabird impacts from these gear types, see Tasker et al. 2000, Zydelis et al. 2013, and Phillips et al. 2024**). It begins with tables summarizing established BMPs, and additional modifications and practices, by gear type.** Table 1 provides an overview of longline gear BMPs. Table 2 summarizes trawl gear BMPs and reduction techniques tested or indicated for trawls. Although no established BMPs exist for gillnets, Table 3 describes studies that have produced some promising solutions for this gear. Table 4 lists non-recommended or unproven mitigation measures. Tables are followed by supporting sections with more in-depth descriptions of established BMPs and additional modifications and practices by gear type.

### Table 1. Best management practices for longline gear

| Practice | Authority | Notes |
|---|---|---|
| | ***Demersal and pelagic*** | |
| Branch line weighting, night setting, and bird-scaring (or tori or streamer) lines **(pages 18-19)** | ACAP (recommends the simultaneous use of all three measures) | Weighting should achieve a sink rate of 0.5 meters per second to a 5.0-meter depth; night-setting not effective for nocturnal foragers or during bright moonlight conditions; bird-scaring line specifications differ for larger versus smaller boats. |
| Bird exclusion devices **(page 22)** | ACAP, CCAMLR | Devices that deter seabirds from flying directly into a line-hauling area, or that prevent seabirds sitting on the surface from swimming into hauling areas; for ACAP, must be used with three measures above; for CCAMLR only required in specific areas, weather-dependent. |
| Time-area fishery area closures **(page 31)** | ACAP | For example, in areas next to important seabird colonies during the breeding season or in highly productive waters when aggressively feeding seabirds are present in large numbers. |
| Side setting with bird curtains and weighted branch lines **(pages 21, 24-25)** | IATTC, NOAA | Only applicable north of 23° North latitude. |
| Night setting with minimum deck lighting **(pages 19, 21-22, 25-26)** | IATTC, SEAFO, IOTC, CCAMLR, NOAA, FFC | For example, Hawaii-based shallow-set longline vessels that do not side-set should begin deployment of longline gear at least one hour after local sunset and complete the deployment no later than one hour before local sunrise. |
| Bird-scaring (or tori or streamer) lines **(pages 21-23, 25-26)** | IATTC, SEAFO, IOTC, CCAMLR, NOAA, FFC | SEAFO requirements only apply to fishing south of 30° South latitude. |
| Line weighting **(pages 21-22, 24-26)** | IATTC, IOTC, CCAMLR, NOAA, FFC | Weight specifications vary based on distance of weight from hooks; CCAMLR requirements vary based on use of Autoline systems, trotline systems, or the "Spanish method" of longline fishing. |
| Deep setting line shooter **(page 21)** | IATTC | Hydraulically operated devices designed to automatically deploy baited hooks. |
| Underwater setting chute **(page 21)** | IATTC | Devices that deploy hooks underwater, out of the sight of seabirds, traditionally through a tube or chute below the surface. |

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| Offal and discard discharge management **(pages 19, 21-22, 24-25)** | ACAP, IATTC, SEAFO, CCAMLR, NOAA | No offal discharge during setting or hauling, or strategic discharge from opposite side of boat from setting or hauling; CCAMLR requires removal of all fish hooks from offal prior to discharge; NOAA specifies special handling for swordfish offal. |
| Safe seabird handling and release practices for live bycaught birds **(pages 21, 24, 26)** | SEAFO, NOAA, FFC | These three RFMOs require such practices, and other RFMOs encourage the practices. |
| | ***Demersal*** | |
| Branch line weighting, night setting, and bird-scaring lines **(page 22)** | SPRFMO | Simultaneous use of all three measures is recommended, along with prohibition of offal discharge where possible (see below); requirements can be relaxed if observers document a low level of seabird mortality. |
| Prohibition of offal discharge where possible during shooting and hauling **(page 22)** | SPRFMO | Where it is necessary to discharge biological waste due to operational safety concerns, vessels should batch waste for two hours or longer. |
| Line weighting (Spanish and Chilean trotline systems) **(page 18)** | ACAP | A weight deployed below a cluster or line of hooks. |
| Season opening adjustments (i.e., changes in fishing season opening time to avoid fishing during seabird breeding seasons or during periods of extended daylight) **(page 22)** | CCAMLR | See Collins et al. 2021 for analysis of delayed opening of fishing season and reduced seabird bycatch. |
| Bird exclusion devices (for ACAP, must be used with line weighting, night setting, and tori lines; for CCAMLR, only required in specific areas, weather-dependent; optional for SPRFMO) **(pages 19, 22)** | ACAP, CCAMLR, SPRFMO | Streamers hung from a horizontal support above the water to prevent seabirds from flying directly into the area where the line is being hauled and prevent seabirds that are sitting on the water surface from swimming into the hauling bay area. |
| | ***Pelagic*** | |
| Hook-shielding devices **(page 20)** | ACAP (recommended as an alternative to the combined use of line weighting, night | For example, devices that shield hooks to a predetermined depth before they are pressure-deployed and add weight for a faster sink rate. |

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| | setting, and bird-scaring lines) | |
| Use of dead bait (as opposed to live bait) **(page 20)** | ACAP | Live bait is more likely to remain near the surface for extended periods. |
| Blue-dyed bait **(pages 21-22, 24-25)** | IATTC, NOAA, WCPFC | Bait must match a shade of blue on a standardized color placard; for NOAA's Hawaii-based longline vessels, bait must be completely thawed due to the perception that thawed bait sinks more quickly and allows for more effective penetration of blue dye; not recommended by ACAP (see Table 4). |
| Offal and discard discharge management **(pages 19, 22)** | ACAP, WCPFC | Offal and discards should not be discharged during line setting and should be retained or discharged on the opposite side of the vessel during hauling. |
| Night setting with minimum deck lighting **(pages 21-22)** | ICCAT, WCPFC | Bell et al. 2025 found simultaneous application of all three ICCAT measures to be most effective, while Huang et al. 2025 found night setting to be the most effective of the IATTC measures . |
| Bird-scaring (or tori or streamer) lines **(pages 21-22)** | ICCAT, WCPFC | ICCAT specifications are based on vessel length; WCPFC advice specifications vary based on vessel length and fishing location. |
| Line weighting **(pages 21-22)** | ICCAT, WCPFC | Weight specifications vary based on distance of weight from hook. |
| Mainline deployment specifications (for Hawaii-based vessels that side-set) **(pages 24-25)** | NOAA | For example, the mainline and branch lines must be set from the port or starboard side of the vessel. |
| Mandatory line shooters (for Hawaii-based vessels that deep set north of 23° North latitude) **(pages 23-25)** | NOAA | For example, the mainline shooter must be deployed as far forward on the vessel as practicable, but at least one meter forward of the vessel's stern. |
| Side setting with bird curtains and weighted branch lines **(page 22)** | WCPFC | See Gilman et al. 2003 for details on effectiveness in Pacific Ocean pelagic longline fisheries. |
| Minimal depth setting for line shooters **(page 22)** | WCPFC | When using line shooters, a majority of hooks must reach depths of at least 100 meters. |

*****ACAP = Agreement on the Conservation of Albatrosses and Petrels; CCAMLR = Convention for the Conservation of Antarctic Resources; FFC = Federal Fishing Council (Argentinian government); IATTC = Inter-American Tropical Tuna Commission; ICCAT = International Commission for the Conservation of Atlantic Tunas; IOTC = Indian Ocean Tuna Commission; NOAA = National Oceanic and Atmospheric

Administration (U.S. government); SEAFO = South East Atlantic Fisheries Organisation; SPRFMO = South Pacific Regional Fisheries Management Organisation; WCPFC = Western Central Pacific Fisheries Commission

** Demersal longlines are deployed near or on the ocean bottom; pelagic longlines are deployed in the water column, from the midwater to surface.

### Table 2. Best management practices for trawl gear

| **Practice** | **Authority*** | **Notes** |
|---|---|---|
| Offal and discard management **(pages 25-27)** | ACAP, SEAFO, CCAMLR, SPRFMO | Can include fully retaining waste, converting waste to fish meal, batching waste for periodic discarding, or mincing waste. |
| Warp strike mitigation (including bird bafflers) **(pages 25-27)** | ACAP, SEAFO, SPRFMO, New Zealand | Includes the use of wireless systems and streamer lines; bird bafflers are two or more booms attached to the stern quarter of the vessel with "dropper lines" affixed to the booms with attached plastic cones (or other durable material). |
| Net entanglement prevention **(pages 25-26)** | ACAP, SEAFO, CCAMLR | Different methods recommended for net shooting (e.g., net binding or net weighting) and net hauling (e.g., streamer lines, minimizing the time nets are on the surface of the water). |
| Prohibition of net monitoring cables **(page 26)** | CCAMLR | Use of remote net monitoring equipment in lieu of cabled equipment. |
| Minimal lighting consistent with safe vessel operation **(page 26)** | CCAMLR | Light minimization methods may include reduction of the extent, intensity, or duration of lighting. |
| Net cleaning **(page 26)** | CCAMLR, SPRFMO | Prior to shooting (CCAMLR); after every shot to remove entangled fish (SPRFMO). |
| Streamer lines **(pages 26)** | FFC, New Zealand | For freezer trawlers using bottom trawl nets (FFC). |

*ACAP = Agreement on the Conservation of Albatrosses and Petrels; CCAMLR = Convention for the Conservation of Antarctic Resources; FFC = Federal Fishing Council (Argentinian government); IATTC = Inter-American Tropical Tuna Commission; ICCAT = International Commission for the Conservation of Atlantic Tunas; IOTC = Indian Ocean Tuna Commission; NOAA = National Oceanic and Atmospheric Administration (U.S. government); SEAFO = South East Atlantic Fisheries Organisation; SPRFMO = South Pacific Regional Fisheries Management Organisation; WCPFC = Western Central Pacific Fisheries Commission

**Table 3. Modifications tested (but not yet adopted as BMPS by RFMOs) - various gear types***

| Practice | Gear | Source | Notes |
|---|---|---|---|
| Visual (i.e., white multifilament nylon seine twine added to the upper portion of the gillnet) and/or acoustic alerts, combined with abundance-based fishery openings and/or time-of-day restrictions **(page 27)** | Coastal salmon drift gillnet (Washington, USA) | Melvin et al. 1999 | Combined measures estimated to possibly reduce seabird bycatch by up to 70-75% without significant reduction in target efficiency. |
| Incorporation of barium sulphate particles into gillnets **(page 27)** | Demersal gillnet (New Brunswick, Canada) | Trippel et al. 2003 | Net opacity and stiffness contributed to a reduction in seabird entanglements. |
| Integrated weight longlines **(page 17)** | New Zealand and Alaska demersal longline | Robertson et al. 2006, Dietrich et al. 2008 | These longlines were effective in reducing seabird mortality in the New Zealand and Alaskan fisheries, especially when paired with streamer lines in the Alaskan case. |
| Streamer lines **(page 26-27)** | Alaska pollock trawl, Uruguayan trawl | Melvin et al. 2004, Melvin et al. 2011, Jimenez et al. 2022 | In Jimenez et al. 2022, one line reduced seabird collisions with warp cables by 89%. |
| Lowering the third wire nearer to the water with a snatch block (i.e., a pulley used to change the angle of a line or cable; see Figure 1) so that wires enter the water closer to the stern of the vessel **(page 26)** | Alaska pollock trawl | Melvin et al. 2004 | The study concluded that the snatch block is highly promising as a method to reduce seabird contacts with the third wire; snatch blocks require retrofitting a vessel and can add wear to expensive third wire cables. |
| Reducing the aerial extent of third wires **(page 26-27)** | Alaska pollock trawl | Melvin et al. 2011 | Aerial extent means the distance from the stern to the point where a cable enters the water, achieved in some cases via a snatch block (see Melvin et al. 2004). |
| Net cleaning (i.e., removing from nets remnant bait, discards, | Purse seine, Alaska salmon gillnet | Weidenfeld 2016, Dietrich et al. 2025 | Analyses indicate cleaner nets may reduce bycatch, possibly by making nets |

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| pieces of bycatch) **(page 29)** | | | more visible to birds. Net cleaning can include the use of a hydraulic pump with pressurized water. |
| Strategic offal discharge **(pages 27-28)** | Uruguayan trawl, Falkland Islands trawl, Portuguese bottom gillnet | Jimenez et al. 2022, Kuepfer et al. 2022; Frade et al. 2025 | If zero discharges are not feasible, Kuepfer et al. (2022) found that batched discarding significantly reduced contact rates. Batching while not fishing may reduce contact rates most. |
| High level of caution during net hauling **(page 29)** | Purse seine | Weidenfeld 2016 | Cautious practices can allow crew to stop haul equipment before a bird can be harmed in machinery (i.e., winches). |
| "Scarybirds" (i.e., a bird-shaped kite attached to a net by a flexible pole) **(page 28)** | Portuguese bottom gillnet | Almeida et al. 2023, Frade et al. 2025 | The device was found to significantly reduce the number of birds close to the fishing vessels. |
| Soak time management **(page 29)** | Atlantic Canadian shallow-set gillnets | Collins et al. 2025 | Maintaining a maximum 24-hour soak time and ensuring that nets remain empty during daylight hours by hauling in the early morning. |
| Reduction in nighttime fishing **(page 29)** | Alaska salmon gillnet | Dietrich et al. 2025 | Effective in reducing capture of birds that dive at twilight or night, particularly in lower-latitude fisheries in Southeast Alaska; however, not recommended for gear that attracts seabirds that forage during the day. |
| Maintaining net tension **(page 29)** | Alaska salmon gillnet | Dietrich et al. 2025 | Tense or tight nets may be easier for marine birds to see and could also be easier to escape than loose nets that entangle birds. |

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| Large-scale closures or gear buybacks **(page 29)** | Canadian gillnets | Regular et al. 2013, Bertram 2023 | Breeding populations of diving seabirds increased following Canadian cod gillnet closures in 1992. |
| "After-baiting" **(page 29)** | Cape Cod (USA) spiny dogfish baited gillnet | Siemann et al. 2025 | Setting gillnets with no bait and then transiting over the net-string track to drop bait after the set, rather than baiting as nets are set; only tested in Cape Cod dogfish gillnet fishery where bating is common. Experiment is ongoing as of 2026 - results not yet published in a peer-reviewed journal. |
| Analysis of seabird spatiotemporal patterns, distribution, and overlap with fishing effort location and timing to understand risk of seabird bycatch **(pages 30-31)** | Alaska gillnet; Pacific longline; U.S. Atlantic trawl, gillnet, and longline; Portuguese purse seine, longline, and fixed gear; Bay of Biscay artisanal tuna troll; Norwegian longline; longline fisheries in general | Blejwas and Wright 2012, Waugh et al. 2012, Hatch et al. 2016, Bi et al. 2021, Araujo et al. 2022, García-Barón et al. 2023, Clegg et al. 2024, Rowley et al. 2024 | Such analyses include relating changes in the path of the Gulf Stream to seabird interaction levels in pelagic longline fisheries, as well as correlating overlap of fishing activity with breeding seabird colony clusters. |
| Gear-switching (substituting one gear type for another, i.e., using otter trawl gear instead of gillnets to target halibut in coastal California) **(page 31)** | U.S. Northeast & California trawl and gillnet | Haseltine and Thornton 1990, O'Keefe et al. 2023 | Approaches should be developed collaboratively with fishers and consider all costs and benefits. |
| Minimum fishing depths **(page 32)** | Icelandic gillnet | Rouxel et al. 2023 | Results showed seabird bycatch was reduced by limiting gillnet fishing to waters more than 50 meters deep; however, this would not be feasible for other gillnet fisheries, e.g., Alaska inshore gillnet fisheries, where fishing |

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| | | | generally cannot occur deeper than 50 meters. |
| Modified purse seine **(pages 29-30)** | Chilean purse seine | Suazo et al. 2024 | Purse seine buoy mounting and mesh size modifications were found to be effective. |
| Purse seine "escape windows" **(pages 29-30)** | Chilean purse seine | Suazo et al. 2024 | Sections of the purse seine buoy line with no floats, which allow seabirds to escape from the encircled purse seine net. |
| Hoses designed to spray water at birds **(pages 29-30)** | Purse seine | Suazo et al. 2024 | Preliminary trials showed that water may affect seabird presence in risk areas around purse seines, although concerns include possibility of oil in sprayed water affecting seabird feathers. |

*This table includes a combination of studies that tested specific mitigation techniques with a control established *a priori*, as well as studies that explored influences on mitigation *a posteriori* using fisheries-dependent data under "normal" fishing conditions, with no control in the statistical sense.

**Table 4. Non-recommended/currently unproven management practices - insufficient testing**

| Practice | Gear type | Source | Reasons cited by the source |
|---|---|---|---|
| Hook size and shape | Demersal longline | ACAP 2024b | Insufficiently researched, with only one source (Moreno et al. 1996) documenting harmful effects of smaller hooks. |
| Olfactory deterrents (e.g., dripping shark liver oil on the sea surface behind vessels) | Demersal longline, pelagic longline | ACAP 2024b, 2024c | Concerns regarding the potential impact of releasing large amounts of concentrated fish oil into the marine environment, the potential for contaminating seabirds attending vessels, and the potential of seabirds to become habituated to the deterrent. |
| Underwater setting chutes | Demersal longline | ACAP 2024b | Cost and applicability issues (not appropriate for certain vessel types) cited; however, the chutes are recommended by IATTC (see Table 1). |
| Line setters | Demersal longline | ACAP 2024b (citing Melvin et al. 2001 and Løkkeborg 2003) | Perceived to be ineffective or even increase seabird bycatch. |
| Line shooters | Pelagic longline | ACAP 2024c | No experimental evidence of effectiveness per ACAP but recommended by several RFMOs and NOAA. |
| Bait-casting machines (BCMs) | Pelagic longline | ACAP 2024c | Variable performance standards in the different BCM models. |
| Bird bafflers (booms attached to both stern quarters of a vessel, with dropper lines attached to the booms to create a curtain to deter seabirds from the warp-water interface zone) | Trawls | ACAP 2024a (citing Sullivan et al. 2006) | Not regarded as providing as much protection to warp cables as bird-scaring lines, although recommended by SPRFMO and New Zealand (see Table 2). |
| Cones on warp cables | Trawls | ACAP 2024a (citing Gonzalez- | Insufficient evidence to recommend. |

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| | | Zevallos et al. 2007) | |
| Warp booms (a boom with streamers extending to the water forward of the stern to divert birds feeding on offal away from the warps) | Trawls | ACAP 2024a (citing Melvin et al. 2011) | Melvin et al. 2011 did not identify a statistically significant reduction in seabird interactions with the warp. |
| Minimization of “pooling area” (turning a vessel in the water to close the headline of a net) | Trawls | ACAP 2024a | Insufficient evidence to recommend. |
| Reduced mesh sizes | Trawls | ACAP 2024a | Insufficient evidence to recommend. |
| Net restrictors (devices that act to restrict the net opening during hauls when seabird captures tend to occur) | Trawls | ACAP 2024a | Insufficiently researched. |

### Table 5. Non-recommended management practices - poor testing results

| Practice | Gear type | Source | Reasons cited by the source |
|---|---|---|---|
| Side setting | Demersal longline | ACAP 2024b | Insufficiently researched for, and operational difficulties specific to, demersal longline gear. |
| Blue-dyed and/or thawed bait | Demersal longline | ACAP 2024b | Unproven and not recommended for demersal longline gear. |
| Lasers | Demersal longline, pelagic longline, trawls | ACAP 2024a, 2024b, 2024c | Promising for bird deterrence but potentially unsafe for birds and humans/human navigation. |
| Acoustic deterrents | Demersal longline, trawls, Alaska salmon gillnet | ACAP 2024a, ACAP 2024b, Dietrich et al. 2025 | Loud noises are thought to have limited effects, with birds quickly becoming habituated to the sound; others have found a slight increase in bycatch rates with the use of pingers, which normally are used to alert marine mammals to the presence of nets (potential mismatch b/t sound frequency & bird hearing range). |
| Warp scarers (weighted devices attached to warps with clips or hooks, allowing the device to slide up and down the warp freely and stay aligned with each warp) | Trawls | ACAP 2024a (citing Melvin et al. 2004 and Sullivan et al. 2006) | Can reduce contact rates but not as effective as bird-scaring lines; practicability and safety issues. |
| Warp deflectors (a buoy clipped to each of the warp cables and connected back to the vessel via a retrieval line, designed to hang at the warp-water interface to deflect birds away from the danger area) | Trawls | ACAP 2024a | Although found to significantly reduce heavy interactions of shy-type albatross (*Thalassarche*) with trawl warps by (Pierre et al. 2014), deemed impractical and of limited effectiveness in the east Australia trawl fishery, although New Zealand has permitted this practice. Insufficient evidence to recommend as an effective measure at this time. |
| Net jackets (free-floating panels of net attached to parts of nets with mesh sizes most dangerous to seabirds) | Trawls | ACAP 2024a | Thought to cause serious drag and subsequent damage to the net; drag also slows vessel speed and increases fuel consumption. |

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| Weighted fishing hooks | Hawaii-based pelagic longline (USA) | Gilman et al. 2022 | Potential as a safe (to crew members) method to reduce seabird bycatch, but testing has shown a significant decrease in target catch rate. |
| "Looming-eye buoy" | Icelandic gillnet | Rouxel et al. 2023 | No effect on target catch or bycatch. |
| Light-emitting diode (LED) lights | Icelandic gillnet | Sigurdsson 2023 | LED gillnets caught significantly more seabirds than control nets. |
| Small-mesh net panels added to net bottom | Greenland gillnet | Post et al. 2023 | Reduction in target catch and lack of perceived bycatch problem. |
| LED lights | Greenland gillnet | Post et al. 2023 | No substantial difference in seabird bycatch compared to control nets and slightly lower target catch rate. |
| Constant green or flashing white LED lights | Baltic Sea gillnet | Field et al. 2019 | No reduction in seabird bycatch. |
| High-contrast monochrome net panels | Baltic Sea gillnet | Field et al. 2019 | No reduction in seabird bycatch. |
| High-contrast black-and-white net banners | Newfoundland (Canada) surface-set gillnet | Montevecchi et al. 2023 | Reduction in target catch and no significant reduction in seabird bycatch. |

**Figure 1. Example of a snatch block (i.e., pulley in the center of the image that is directing the angle of the cables). Photo credit: Ed Melvin**

## Established BMPs for Longlines

In 1999, the Food and Agricultural Organization of the United Nations (FAO) published an International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries (FAO 1999). Løkkeborg (2008) provided a review and assessment of seabird mitigation measures on behalf of the FAO to support the development of strategies, guidelines, and/or BMPs by RFMOs and individual countries.

Numerous RFMOs and agreements including the Agreement on the Conservation of Albatrosses and Petrels (ACAP), the Convention for the Conservation of Antarctic Resources (CCAMLR), the South East Atlantic Fisheries Organisation (SEAFO), and the South Pacific Regional Fisheries Management Organisation (SPRFMO) have required their members and cooperating non-contracting parties to implement BMPs for longline and trawl gear. In addition, tuna RFMOs and organizations including the Indian Ocean Tuna Commission (IOTC), InterAmerican Tropical Tuna Commission (IATTC), International Commission for the Conservation of Atlantic Tunas (ICCAT), and Western and Central Pacific Fisheries Commission (WCPFC), have promulgated BMPs regarding seabird interactions with longline gear.

This section provides a high-level summary of these BMPs, several of which were evaluated by Huang et al. (2024) and found to be generally effective in reducing bycatch while having no significant effect on target catch. The International Seafood Sustainability Foundation (ISSF), a global coalition of seafood companies and vessels, fisheries experts, scientific and environmental organizations, has also published a guidebook that summarizes the tuna RFMO measures (ISSF 2023). Many RFMO measures include language that encourages Contracting Parties and Cooperating Non-Contracting Parties (CPCs) to adopt measures ensuring the safe handling and release of seabirds that are caught alive. Table 1 (p.4) notes where these practices are required.

The ACAP, a multilateral agreement working to conserve albatrosses and petrels by coordinating international activities to, among other things, reduce mortality from fishery interactions (Baker et al. 2024), has promulgated the most comprehensive set of BMPs for longline gear. An introductory fact sheet published by ACAP and the NGO BirdLife International in August 2021 stated that recommended mitigation measures should meet several essential criteria, including:

- The ability to reduce seabird mortality rates to the lowest achievable levels.
- Clear specifications and minimum performance standards for deployment and use.
- Demonstrated practicality, which encompasses safety, cost-effectiveness, and availability.
- Maintenance of target species catch rates.
- No negative effects on other bycatch species.
- Methods of ensuring compliance.

A review conducted by ACAP in 2024 (ACAP 2024b) identified three best overall practices that should be employed simultaneously to reduce incidental catch of seabirds in **demersal longline (i.e., longlines deployed near or on the ocean bottom)** fisheries:

- Appropriate line weighting regimes.
- Bird-scaring lines.
- Nighttime setting.

Another review (ACAP 2024c) identified that three key practices measures should be implemented simultaneously to reduce incidental catch of seabirds for **pelagic longline (i.e., longlines deployed in the water column, from the midwater to surface)** fisheries:

- Branch line weighting.
- Nighttime setting.
- Bird-scaring lines.

Alternatively, the ACAP pelagic longline review (ACAP 2024c) recommended the use of a hook-shielding device that encases baited hooks during deployment and releases the baited hooks at a prescribed depth.

The following subsections describe the main BMP categories for longlines which are required by various RFMOs and governments. These subsections rely on a series of informative ACAP fact sheets and other published studies.

## Line Weighting

Demersal longline fisheries, including specialized systems used by Spain and Chile, can employ a variety of line-weighting schemes. Some forms of line weighting use external weights. These weights are made of metal (preferably), stone, or other material that are attached to lines at regular intervals (40 meters or 20 meters, depending on whether the weights are heavier or lighter) in order to achieve a desired rapid sink rate (i.e., 0.3 meters/second) that will allow lines to descend to the target fishing depth as quickly as possible with minimal availability for seabird interactions at the surface (for more information, see Agnew et al. 2000, Robertson 2000, Melvin et al. 2001). The Chilean system of line weighting, developed to reduce cetacean depredation in the Patagonian Toothfish (*Dissostichus eleginoides*) fishery, uses external weights (4-10kg) attached to secondary branch lines from the main line to create a very rapid initial sink rate, resulting in no, or close to no, seabird bycatch (for more information, see Moreno et al. 2007).

Integrated weight longlines can also serve as a form of line weighting for longline vessels. In this case, longlines with lead beads incorporated into the core of the line to create a rapid initial sink rate, especially useful for "autoline gear", a mechanized approach to deploying and retrieving gear, and shown to be effective in reducing seabird mortality in a New Zealand fishery (Robertson et al. 2006) and Alaskan fishery (Dietrich et al. 2008), especially when paired with streamer lines in the Alaskan case.

Line weighting for pelagic longline gear can use external weights similar to those used for demersal longlines. In this case, weights (40 to 80 grams) added to branch lines to force rapid sinking of hooks below 10 meters of the surface, with heavier weights used the farther away (from between 0.5 to 2.0 meters) they are placed from the baited hook (see Gilman et al. 2025 for more information on effectiveness of various weighting designs, and ACAP 2024c for minimum standards). However, these weights can cause safety concerns for crew due to "fly-backs" after line breaks, and they are best used in combination with bird-scaring lines and night-setting.

## Bird-Scaring (or Streamer or Tori) Lines

Demersal longline vessels use bird-scaring lines to reduce seabird interactions. These lines are brightly colored strips of rubber tubing that are towed behind longline vessels during line setting to deter birds from diving on baited hooks, shown to be highly effective in reducing seabird bycatch in North Atlantic fisheries when using a single streamer line (Løkkeborg 2003) and in reducing bycatch of surface-feeding species in Alaska fisheries when using paired streamer lines (Melvin et al. 2001), although less effective for seabirds that are able to dive skillfully below the streamer lines.

Streamer line BMPs for pelagic longline vessels vary according to vessel length. Vessels under 35 meters long should use lightweight, brightly colored strips of material that are attached at 1- or 2-meter intervals, deployed over a 150-meter extent of longline (with at least 75 meters above the sea surface). The longline should be deployed along with a towed object to create additional drag and maximize streamer extent and sink to a depth beyond 10 meters. Steamer fouling with surface floats and branch line entanglements are challenges to this method, which is fully effective when used in conjunction with line-weighting and night-setting.

For pelagic longline vessels 35 meters long or longer, vessels should deploy two lines (mix of long and short lines spaced less than 5 meters apart) over a 200-meter extent with at least 100 meters over the sea surface. (For more information on pelagic longline streamer effectiveness, see Melvin et al. 2010 and Melvin et al. 2014, as well as ACAP 2024c for minimum standards.)

## Night Setting

Because many seabirds are most active during the day and detect food at close range by sight, setting demersal and pelagic longlines between nautical dusk and nautical dawn, especially on moonless nights and with minimal deck lighting can reduce seabird interactions. However, this practice may also reduce target species catch rates, although perhaps not if paired with deep setting, according to Gilman et al. 2023. In addition, this practice is less effective for nocturnal foragers like White-chinned Petrels (*Procellaria aequinoctialis*). Night setting should be combined with line-weighting and bird-scaring lines for maximum effectiveness.

## Haul Mitigation (including Offal Management)

Although birds become entangled in or hooked on longlines during line setting, line retrieval or hauls can also lead to hooking. Therefore, RFMOs including ACAP (see ACAP 2024b) have recommended various practices including offal management via discharging processing waste or discarded fish away from the hauling area, branch line hauler devices that speed up the hauling process, “Brickle curtains” (streamers hung above a hauling hatch), and the use of water cannons or fire hoses. RFMOs generally recognize offal management as the most effective method, although it can be challenging from a logistical and enforcement perspective.

## Practices and Technologies Related to Line Setting

Researchers, fishers, and private companies have developed a variety of practices and technologies related to line setting in longline fisheries to reduce seabird interactions. Side-setting is a technique used most widely in Hawaiian-based pelagic longline fisheries. This technique moves the line-setting operation from the stern of a vessel to its side, where seabirds are less able or willing to forage, and where there is no propeller wash to slow the hook sink rate. This practice is most effective when used in conjunction with line-weighting and a "bird curtain", which is a horizontal pole with vertical streamers positioned near the line-setting location (for more information, see Gilman and Brothers 2006).

Management entities have also recommended that pelagic longline vessels should use underwater bait setting devices, where baited hooks deploy underwater, enclosed in a capsule or similar device. In addition, researchers have developed products (e.g., the *Hookpod* and the *Smart Tuna Hook*) that encase pelagic longline hooks in devices during line-setting, with the device opening due to a pressure-release mechanism at a depth of at least 10 meters. However, these devices could have some disadvantages, including cost as well as the possibility of creating a loop of branch line during setting, which could entangle seabirds.

Underwater setting chutes deploy hooks underwater, out of the sight of seabirds, traditionally through a tube or chute attached to a vessel one or two meters below the surface. ACAP has not recommended underwater setting chutes for longline vessels (ACAP 2024b, 2024c). However, studies have shown this practice to be beneficial for reducing Northern Fulmar (*Fulmarus glacialis*) bycatch based on trials in Norway (Løkkeborg 1998) and Alaska (Melvin et al. 2001). It should be noted that this practice can be expensive and less effective when used without additional measures or in rough seas when the chute can be exposed above the water's surface.

ACAP also has recommended using dead versus live bait for pelagic longline fisheries, due to the propensity of live bait to remain on the surface of the water longer than dead bait. (For more information, see ACAP 2024c.)

## Longline BMPs Required by RFMOs

The IATTC adopted Resolution C-11-02 in 2011, stating that CPCs shall require their longline vessels over 20 meters long, fishing in the Eastern Pacific Ocean north of 23° North latitude (and certain Mexican waters) to use at least two mitigation measures listed in Table 6 (p. 20), including at least one measure from Column A. In addition, the resolution stated that vessels shall not use identical measures from Columns A and B in Table 6.

### Table 6. Mitigation required by IATTC Resolution C-11-02 (2011)

| Column A | Column B |
|---|---|
| Side-setting with bird curtains and weighted branch lines | Tori lines |
| Night-setting with minimum deck lighting | Weighted branch lines |
| Tori lines | Blue-dyed bait |
| Weighted branch lines | Deep-setting line shooter |
| | Underwater setting chute |
| | Offal management |

In 2012, SEAFO adopted Conservation Measure 25/12, stating that all longline vessels fishing south of the parallel of 30° South shall carry and use bird-scaring lines. The measure also required that longlines are set only at night with minimum ship lighting for safety, unless longline vessels can ensure a minimum longline sink rate of 0.3 or 0.2 meters per second. (The -0.2 meters per second standard applies to vessels using internally weighted longlines.) However, if a vessel catches a total of three seabirds during one fishing trip, it must revert to night-setting immediately until the next trip or for three months, whichever time is longer. In addition, the measure prohibited dumping of offal while longline gear is being shot or set, but if offal discharge must take place, it should occur, where possible, on the opposite side of the vessel to where gear is being hauled. Longline vessel crew members were also required to make every effort to release birds alive and remove hooks from birds where the removal would not jeopardize the bird's life.

In 2013, the ICCAT published a Supplemental Resolution on reducing incidental seabird bycatch. This resolution stipulated that ICCAT CPCs shall ensure that all longline vessels fishing in the area south of 25° South latitude use at least two of three following mitigation measures, according to minimum specified technical standards:

1. Night setting with minimum deck lighting.
2. Bird-scaring (or tori) lines deployed during the entire longline setting process.
3. Line weighting deployed on the snood (short lines with baited hooks attached to the longer main line, also called gangions or leaders) prior to setting.

A few research teams have conducted experiments and analyses of the ICCAT measures. Huang et al. (2025) evaluated four bird-scaring line treatments combined with weighted or unweighted branch lines, with one-third of sets being deployed at night, in a Taiwanese albacore (*Thunnus alalunga*) longline fishery. The study determined that night-setting was the most effective mitigation measure, whereas the efficacy of bird-scaring lines declined when baited hooks remained within the diving range of seabirds beyond the aerial extent of the lines. Weighted branch lines reduced seabird bycatch but also were associated with a potential decrease in albacore catch rates. Bell et al. (2025) used a risk-based approach to predict differences in bycatch rates for different mitigation measures and found that simultaneous application of all three technical standards would result in a predicted seabird mortality reduction of 72 to 93 percent.

Similarly, the IOTC passed Resolution 12/06, designed to reduce seabird incidental catch in longline fisheries, in 2014. This resolution required CPCs to ensure that all longline vessels fishing in the area south of 25° South latitude use two of the three measures required for ICCAT CPC vessels (Table 6, p. 20).

The WCPFC published guidance in 2015 via its Conservation and Management Measure 2015-03, which went into effect in 2017. This measure required vessels of Commission Members, Cooperating Non-Members, and participating territories (CCMs) fishing south of 30° South latitude to use at least two of the following three mitigation measures: weighted branch lines, night-setting, and tori lines. The measure also required longline vessels of 24 meters or more in overall length fishing north of 23° North latitude to use two of the mitigation measures in Table 7 (below), including at least one measure from Column A. In addition, the measure required vessels less than 24 meters in overall length fishing north of 23° North latitude to use at least one of the mitigation measures in Column A of Table 7.

**Table 7. Mitigation required by WCPFC Conservation and Management Measure 2015-03 (2017)**

| Column A | Column B |
|---|---|
| Side-setting with bird curtains and weighted branch lines | Tori lines |
| Night-setting with minimum deck lighting | Blue-dyed bait |
| Tori lines | Deep setting line shooter |
| Weighted branch lines | Management of offal discharge |

In 2015, CCAMLR published Conservation Measure 25-02, which adopted several measures to reduce the possibility of incidental seabird mortality during longline fishing, including:

- Adding weights to lines to ensure rapid sinking.
- Prohibiting dumping of offal and discards when longlines are set.
- Discharging offal to the opposite side of the vessel from where longlines are hauled.
- Deploying streamer lines during longline setting.
- Depending on weather conditions, deployment of bird exclusion devices (for more information, see Reid et al. 2010).

For the CCAMLR-managed Patagonian toothfish longline fishery around the islands of South Georgia, CCAMLR has set the season's start date on May 1 (to avoid overlap of fishing activity with the seabird breeding season) for the most part since 2000, which has resulted in a reduction of seabird bycatch in that area to almost negligible levels (Collins et al. 2021). Collins et al. (2021) also identified night-setting, line-weighting, and marked hooks (which associate hooks with the fishery and indicate non-compliance with hook-management requirements such as removing hooks from offal prior to discharge), along with 100% observer coverage, as contributing to reductions in mortality and improved regulatory compliance.

Finally, in 2017, the SPRFMO implemented Conservation and Management Measure 09-2017, which included requirements for demersal longline and trawl vessels. The measure prohibited demersal longline vessels from discharging any biological material during shooting and hauling where possible, and either (1) implement a line-weighting regime, bird-scaring lines, and night-setting; or (2) if five years of appropriate observer coverage documented a low seabird mortality rate (less than 0.01 birds per 1,000 hooks), employ only one of the preceding three mitigation measures and maintain an observer coverage rate of at least 10%. (The measure does not specify whether this coverage level applies to the number of sets or number of fishing days.)

## Longline BMPs Required by Governments

The **National Oceanic and Atmospheric Administration's National Marine Fisheries Service** (NOAA Fisheries), the U.S. federal agency regulating commercial fishing in the U.S. Exclusive Economic Zone (EEZ), published several regulations designed to reduce or mitigate seabird interactions with U.S. fishing activities in the Pacific Ocean. This section summarizes these regulations.

Due to high levels of estimated annual seabird bycatch in Alaska longline fisheries during the 1990s, fishers, researchers, and managers collaboratively tested a variety of seabird bycatch mitigation measures, with streamer lines determined to be the most effective method (Melvin et al. 2001, 2019). The Alaska longline fishing industry voluntarily adopted streamer lines with performance and material standards in 2002, and NOAA Fisheries mandated streamer lines in 2004 (Melvin et al. 2019). With some limited exceptions, NOAA Fisheries regulations require that larger Alaska longline vessels (greater than 16.9 meters in overall length) fishing in the EEZ must use paired streamer lines (if not using snap gear) or a single streamer line (if using snap gear). Snap gear is a type of bottom longline gear where the hook and the short line, or gangion, attaching the hook to the main line are attached to the groundline using a mechanical fastener or snap. Smaller Alaska longline vessels (greater than 7.9 meters but less than 16.9 meters in overall length) must use a single streamer line or, in limited instances, a buoy bag line. A buoy bag line extends from a high point on the vessel and hangs over the area where baited hooks may be accessible to seabirds to shield them from interactions.

To minimize take of the Endangered Species Act-listed Short-tailed Albatross (*Phoebastria albatrus*) in the U.S. West Coast groundfish fleet, NOAA Fisheries published revised seabird avoidance regulations in 2020. These regulations required vessels from 7.9 meters to 16.8 meters length overall to deploy streamer lines when using bottom longline gear north of 36° North latitude. The regulations also exempted all Pacific coast groundfish vessels from the streamer line requirements when night-setting and when fishing south of 36° North latitude.

In 2024, NOAA Fisheries revised its regulations to reduce seabird interactions with federally permitted Hawaii-based longline vessels. The new regulations applied to all shallow-set vessels targeting swordfish and to deep-set vessels targeting tuna when fishing north of 23° North latitude. The specific regulatory revision also affected deep-set longline vessels that set gear from the stern and fish north of 23° North latitude, requiring them to use tori lines and weighted branch lines but exempting them from a previous requirement to use thawed, blue-dyed bait and strategic offal discharge. Requirements for shallow-set vessels and deep-set vessels that set gear from that side did not change. The regulations require deep-set vessels that side-set to deploy mainlines, or to mount mainline shooters, as far forward on the vessel as practicable, but at least 1.0 meters from the stern. The regulations also require side-setting vessels to use weighted branch lines and deploy bird curtains. Additionally, all shallow-set vessels must use strategic offal discards when seabirds are present, completely thawed blue-dyed bait, and night-setting. NOAA Fisheries requires all longline vessels that accidentally catch a seabird to follow specified safe seabird handling guidelines (see Figure 2 below). Table 8 (p. 24) summarizes the Hawaii-based longline vessel regulations.


**Figure 2. NOAA Fisheries handling guidelines for seabirds caught alive in Hawaii pelagic longline fisheries**

**Table 8. Summary of NOAA longline seabird regulations for Hawaii**

| Requirement | Stern-Setting | | Side-Setting | |
|---|---|---|---|---|
| | *Shallow-Set Anywhere* | *Deep-Set North of 23° North Latitude* | *Shallow-Set Anywhere* | *Deep-Set North of 23° North Latitude* |
| Deploy mainline from port or starboard side at least one meter forward of stern corner. | | | Yes | Yes |
| If line shooter is used, mount it at least one meter forward from the stern corner. | | | Yes | Yes |
| Use a specified bird curtain aft of the setting station during the set. | | | Yes | Yes |
| Deploy gear so that hooks do not resurface. | | Yes | Yes | Yes |
| Attach 45-gram or heavier weights within one meter of each hook. | | Yes | Yes | Yes |
| Use a line shooter to set the mainline. | | Yes | | |
| Deploy a tori line system that meets required specifications before the first hook is set. | | Yes | | |
| Keep two tori lines on boat. | Yes | | | |
| Keep two one-pound containers of blue dye on boat. | Yes | | | |
| Use completely thawed and blue-dyed bait. | Yes | | | |
| Keep fish parts and spent bait with all hooks removed for strategic offal discard. | Yes | | | |
| Cut all swordfish heads in half and use heads and livers for strategic offal discard. | Yes | | | |
| Night set: begin one hour after local sunset and finish one hour before next sunrise while keeping lighting to a minimum. | Yes | | | |

**Argentina's Consejo Federal Pesquero (Federal Fishing Council)**, the agency that manages fishing activities in Argentina, has adopted two regulations to reduce seabird interactions with fishing vessels. Regulation 08/2008, adopted in 2008 and enforced since 2009, created several requirements for longline vessels, including:

- Sinking the main line out of reach of seabirds as soon as possible after touching the water.

- Adding weights to the main line or using longlines with integrated weights for setting.
- Releasing weights before a line is tensioned (for vessels using the Spanish longline system).
- Setting longlines only at night, using only lights that are necessary for vessel safety.
- Using bird-scaring lines during longline setting.
- Using devices designed to prevent birds from taking bait during longline hauling in particular areas.
- Ensuring safe release of seabirds caught alive during fishing.

These requirements do not specify whether they apply to pelagic or demersal longline gear.

## Established BMPs and Other Reduction Techniques for Trawl Gear

In addition to its longline best practices, ACAP has also established BMPs for trawl gear. These BMPs include:

- *Offal and discard management*—if waste cannot be fully retained during a fishing trip, then waste discharge should not occur during active fishing periods; other management options include converting offal into fish meal or storing waste for two hours or longer before discharging it in batches.
- *Warp strike mitigation*—collision of seabirds with trawl warp cables or other cables, identified as a major source of unobserved seabird mortality (Sullivan et al. 2006, Watkins et al. 2008), should be mitigated with wireless systems (in the case of net monitoring cables) or streamer lines deployed parallel to and within two meters of the warp cable.
- *Entanglement prevention during net shooting/hauling*—most prevalent in pelagic rather than demersal trawl fisheries (due to the size of the mesh and nets used in pelagic trawling) when nets float on the sea surface for long periods of time during deployment (or shooting) or hauling. Net shooting mitigation methods include net cleaning, net binding (where nets are bound at 5-meter intervals and opened once trawl doors enter the waters), and net weighting. Haul mitigation methods include streamer lines, small mesh sizes, maintaining tension in the net while it is on the sea surface, and carefully removing and releasing bycaught birds.

SEAFO also addressed trawl gear interactions with seabirds through a 2012 Conservation Measure, which required deployment of streamer lines outside of both warp cables, along with the same offal requirements as for longline vessels. The Measure also required trawl vessels to clean nets prior to shooting, adopt procedures that minimize the time a slack net lays on the surface of the water, and develop gear configurations that minimize the chance of birds encountering parts of trawl nets that lead to interactions (e.g., weighting a net so it sinks more quickly or adding streamer lines to parts of the nets where interactions are most likely to occur).

In 2016, CCAMLR published Conservation Measure 25-03, which adopted several measures to reduce incidental injury to and mortality of seabirds during trawl fishing, including:

- Prohibiting the use of net monitor cables.
- Minimizing the level of vessel lighting.
- Prohibiting discharge of discards and offal during shooting and hauling of trawl gear.

- Cleaning nets prior to shooting.
- Minimizing the time that slack trawl nets lie on the surface of the water.
- Encouraging gear configurations that minimize bird interactions (e.g., adding weights and/or streamers to nets).

The 2017 SPRFMO Conservation and Management Measure 09-2017 trawl vessel requirements include deployment of bird-scaring lines, or when those lines are not feasible, a bird baffler. The Measure also prohibits discharge of biological material during shooting and hauling where possible, as for longline vessels. Where possible, the measure encourages cleaning nets after every shot and minimizing the time a net is on the surface of the water. However, the Measure stated that if a Member or Cooperating Non-Contracting Party (CNPC) has maintained 100% observer coverage for five consecutive years with less than one recorded seabird mortality event per vessel per year, their trawl vessels are exempt from these requirements.

Argentina's Federal Fishing Council's Regulation 03/2017 introduced requirements for the freezer trawl fishery. Specifically, freezer trawlers with bottom trawl nets must deploy two bird-scaring lines, one on the port side and one on the starboard side of the trawl cables, during fishing operations. Analyses by Tamini et al. (2023) found that a combination of bird-scaring lines and elimination of fishing discards reduced seabird interactions to near zero. However, Iwan et al. (2025) identified possible uncertainty regarding the actual use of bird-scaring lines in this fleet.

New Zealand requires large or offshore trawl vessels equal to or longer than 28 meters to protect both warp cables with at least one of three warp mitigation devices allowed by regulation, including tori lines, bird bafflers, and warp deflectors. Hickcox and MacKenzie (2023) describe these devices and other possible mitigation methods for New Zealand trawl vessels. Analyses conducted by Large et al. (2024) found that bird bafflers were mostly commonly used by trawlers, but that tori lines provided more effective mitigation.

In a study of techniques to mitigate seabird interactions with Alaska pollock (*Gadus chalcogrammus*) trawl vessels, Melvin et al. (2004) found that deploying streamer lines and lowering the third wire to near the water with a snatch block to be the most effective third wire contact deterrents. Deployment of fish oil into the starboard discharge plume also seemed to lead to seabird avoidance behavior, but Melvin et al. suggested that additional research was needed to determine whether this practice would harm seabirds. In another study, Melvin et al. (2011) tested two different offal treatment measures on Alaska pollock trawl vessels and found that the treatments had mixed effects while streamer lines were most effective at reducing seabird cable strikes. Reducing the aerial extent of third wires also reduced interactions, but less effectively than streamer lines. Regardless, NOAA Fisheries currently does not require seabird mitigation measures for Alaska trawl vessels.

Tests of bird-scaring lines and offal discharge practices in the Uruguayan trawl fishery targeting Argentine hake (*Merluccius hubbsi*) found that deployment of a single bird-scaring line reduced warp cable collisions by 89% and associated mortality by 94% (Jimenez et al. 2022). Jimenez et al. (2022) also simulated scenarios with deployment of bird-scaring lines and batching offal discharges, concluding that these combined practices could lower seabird mortality to negligible levels. Kuepfer et al. (2022) also examined the benefits of strategic offal discharge on vessels from the Falkland Islands trawl fleet, finding that eliminating fishing discards consistently reduced seabird numbers around trawlers and eliminated contacts with warp cables. The investigators also found that batching discards significantly reduced seabird numbers and contact rates, whereas intermittent release of coarsely chopped viscera reduced efficacy of the mitigation practice (Kuepfer et al. 2022).

## Reduction Techniques Tested or Indicated for Gillnets

Melvin et al. (1999) compared fish catch and seabird bycatch in the coastal salmon drift gillnet fishery in Puget Sound in Washington. Visual alerts (highly visible netting in the upper net) and acoustic alerts ("pingers"[1]) produced varying results, with Common Murre (*Uria aalge*) responding to both visual and acoustic alerts and Rhinoceros Auklets (*Cerorhinca monocerata*) responding to visual alerts that were placed in an area of the net that extended below the upper net area. The study concluded that specific gear modifications, abundance-based fishery openings, and time-of-day restrictions when used together could substantially reduce seabird bycatch without a significant reduction in target fish catch.

Experimentation near New Brunswick, Canada, by Trippel et al. (2003) concluded that opaque netting incorporating barium sulphate particles could successfully reduce seabird interactions in a demersal gillnet fishery. The addition of barium sulphate also increased net stiffness, which also may have contributed to a reduction in entanglements.

In 2015, the American Bird Conservancy, BirdLife International, and the U.S. Fish & Wildlife Service convened a workshop focused on reducing bycatch of protected species, including seabirds, in gillnets (Wiedenfeld et al. 2015). Workshop participants identified region-specific mitigation testing priorities related to seabirds, including the following:

- North Pacific
    - Pingers, which had been moderately successful in reducing Common Murre bycatch in the Puget Sound salmon fishery.
    - Net modifications with high-visibility sections.
- Northwest Atlantic.
    - Light-emitting diode (LED) lights
    - Striped nets (nets with twine or monofilament of a different color woven in).
    - White monofilament nets (entire net constructed of white monofilament).
    - Double-weighted lead lines, which would maintain a net vertically in the water when filled with fish, which could help prevent seabird interactions.
    - Pingers, with the first step being testing to determine what sound frequencies seabirds can hear underwater.[2]
- Northeast Atlantic
    - LED lights.

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[1] It is important to note that pingers used by Melvin et al. 1999 used a frequency of 1.5 kHz frequency, as opposed to the 50-120 kHz frequency used for the more commonly employed marine mammal pingers.

[2] Dietrich et al. 2025 found that pingers used for marine mammal mitigation led to higher bycatch rates of some seabird species in Alaska salmon gillnet fisheries.

    - Net panels and sunken headlines (or sink gillnets).
- South America
    - High-visibility net panels.
    - LED lights.
    - Subsurface drift gillnets.

In 2021, BirdLife International held a workshop to explore marine megafauna bycatch in gillnet fisheries (Rouxel 2021). Workshop presenters covered various topics including visual and cognitive aspects of seabird bycatch, net color, above-water deterrents, and spatiotemporal measures to reduce interactions. Workshop participants recommended, among other things, that researchers should further study above-water deterrents, such as '*scarybird'* kites as a possible method to reduce seabird interactions.

The European Commission, along with various partners including BirdLife International, published a 2017 report (Almeida et al. 2017) that shared the results of two gillnet experiments: high-contrast panels in a Portuguese fishery and net-lighting in a Polish fishery. The net-lighting experiment demonstrated a promising, but not statistically significant, decrease in seabird interactions. Investigators in Portugal recorded no seabird bycatch in either the control or experimental sets, precluding assessment of the efficacy of high-contrast panels. Martin and Crawford (2015) provided additional information about the ability of diving birds to see gillnets.

Lucas and Berggren (2023) conducted a review of sensory deterrents for mitigation of marine megafauna bycatch, including seabirds, finding that lights on gillnets were the only technology to result in significant bycatch reduction for all four taxonomic groups (marine mammals, sea turtles, seabird, and elasmobranchs) examined. Almeida et al (2023) tested visual deterrents called "*scarybirds*" (i.e., a kite attached to a gillnet by a flexible pole) in a Portuguese bottom gillnet fishing vessel. They found the kite to be an effective deterrent, especially when it was deployed in the area closest to the vessel (0-20 meters), resulting in a significant reduction in the number of gulls and Northern Gannets (*Morus bassanus*) close to the vessel. Subsequently, Frade et al. (2025) conducted a study of bottom set gillnets in Portuguese waters, comparing three different mitigation measures: a megaphone acoustic deterrent, a scarybird kite visual deterrent, and discard management. The study found that discard management was the most effective seabird bycatch reduction measure, with the megaphone and kite showing less efficacy. Neither bycatch reduction measure negatively affected landings per unit effort,.

Collins et al. (2025) experimentally tested effects of soak timing and duration on seabird bycatch of shallow-set gillnets used in the Atlantic herring (*Clupea harengus*) bait fishery in Newfoundland and Labrador, Canada. The investigators found that nearly all seabird bycatch occurred during the control sets and that target catch did not differ between control and short (12 hour) overnight sets but was much lower during short daytime sets. The investigators suggested that maintaining a maximum 24-hour soak time and ensuring that nets remain empty during daylight hours by hauling in the early morning could reduce seabird bycatch in this fishery. In contrast, in a study of interactions of diving birds and Alaska salmon gillnet fisheries, Dietrich et al. (2025) found that seabird bycatch was nearly 2.5 times higher at night and suggested reductions in night fishing when feasible, along with cleaning nets regularly and maintaining nets under some tension. These conflicting results demonstrate that "one size does not fit all" when it comes to seabird bycatch mitigation in gillnets, due to several factors including differences in behaviors and foraging times among different seabird species.

Regular et al. (2013) correlated closures of Canadian gillnet fisheries for Atlantic cod (*Gadus morhua*) and Atlantic salmon (*Salmo salar*), which began in 1992 due to concerns over fish stocks, with changes in seabird populations. Specifically, breeding populations of diving seabirds such as the Common Murre increased after the closure while populations of surface-feeding birds such as American Herring Gulls (*Larus smithsonianus*) decreased. Accordingly, Bertram (2023) has suggested that large-scale gear buy-backs may be an effective strategy to prevent bycatch-related seabird declines for some species.

Unpublished work by Siemann et al. (2025) has suggested that changing net baiting practices may reduce bycatch of Great Shearwaters (*Ardenna gravis*) in a small fleet of baited gillnet vessels targeting spiny dogfish (*Squalus acanthias*) out of Chatham, Massachusetts. Preliminary data from an ongoing study, has shown that "after-baiting" (setting gillnets with no bait and then transiting over the net-string track while dropping bait) could reduce seabird interactions and associated mortality while maintaining or even increasing target catch rates, compared to other traditional practices of baiting gillnets as they are deployed.

## Purse Seine Suggestions

Relatively few studies have examined seabird bycatch in purse seine gear. However, a 2016 presentation developed by the American Bird Conservancy, with support from the Walton Family Foundation (Weidenfeld 2016), covered a wide variety of topics related to seabird bycatch, including seines and other surrounding nets. According to the presentation, seines pose the greatest risk to seabirds during shooting and hauling. Net-cleaning was identified as a beneficial practice for reducing attractiveness of nets to seabirds during shooting. During hauling, the presentation suggested that operators should be alert to seabirds caught in netting to maximize the possibly that they could be released alive, before the net is pulled through machinery like winches.

A paper by Suazo et al. (2024), developed for the ACAP's Twelfth Meeting of the Seabird Bycatch Working Group meeting in Lima, Peru, described the feasibility and efficacy of several seabird bycatch mitigation measures related to purse seine fisheries. The paper suggested a "toolbox" approach. Potentially helpful tools included:

- The "modified purse seine", which involves a series of adjustments including buoy mounting and mesh size.
- "Escape windows", which are sections of the purse seine buoy line with no floats, which allow seabirds to escape from the encircled purse seine net.
- Spraying birds with water hoses to deter them from approaching the vessel: preliminary trials showing that water spray may reduce seabird presence in risk areas around purse seines, though there were potential concerns that fish oil waste from the vessel deck could mix in with the water affecting seabird feather insulation and waterproofing.

## Spatiotemporal Approaches for Various Gear Types

Identification/prediction of seabird bycatch hotspots, coupled with education and outreach to fleets about avoiding fishing in such areas during particular time periods, could help mitigate seabird bycatch. In its 2024 reviews of longline mitigation measures and best practice advice, ACAP identified time-area and seasonal closures as effective practices to reduce seabird interactions (ACAP 2024b, 2024c). ACAP emphasized temporary closures of important foraging areas as effective for reducing incidental mortality of seabirds in fisheries in those areas. However, ACAP cautioned that further research was needed regarding the seasonal variability in patterns of seabird distribution and fishery-related behavior.

Blejwas and Wright (2012) assessed the risk of Kittlitz's Murrelet (*Brachyramphus breviostris*) bycatch in Alaskan commercial salmon gillnet fisheries by evaluating the spatiotemporal overlap of the seabirds and gillnets within four areas using fishery observer data. Waugh et al. (2012) used a spatially explicit Productivity-Susceptibility Analysis (PSA) to analyze overlap of seabird distributions with Western and Central Pacific tuna and swordfish pelagic longline fisheries. García-Barón et al. 2023 also used a PSA to support an Ecological Risk Assessment to estimate the potential risk to Great Shearwaters from the artisanal tuna fleet in the Bay of Biscay in Spain.

Hatch et al. (2016) found that analyzing movement and space use of a relatively small number of satellite-tagged seabirds, in concert with fishery-dependent data, could help identify high seabird bycatch areas, which in turn could help focus education and mitigation efforts. Bi et al. (2021) developed a model to identify seabird bycatch patterns in the U.S. Atlantic pelagic longline fishery where inter-annual changes in predicted hotspots were correlated with Gulf Stream meanders, suggesting that fleets could plan their fishing activities to avoid seabird interactions by considering these spatiotemporal patterns.

Clegg et al. (2024) overlaid datasets of Norwegian longline fishing activity with Northern Fulmar distribution, as well as bycatch estimates, to validate the use of calculated overlap indices as an indirect evaluation of risk. Such indices could support targeted mitigation efforts if required. In order to provide industry and managers with information on achieving seabird-safe fishing practices, the Southern Seabirds Trust and the New Zealand Department of Conservation developed a Seabird-Safe Fishing Toolkit. The kit identifies ocean zones of high, medium, and low risk of bycatch to ACAP-listed species from pelagic longline fisheries (for more on the process for developing ocean zones, see Rowley et al. 2024.)

For Portuguese purse seine, longline, and fixed gear fleets, Araujo et al. (2022) identified areas of high bycatch risk, which could be helpful to managers in designing targeted management measures such as special protection areas. O'Keefe et al. (2023) reviewed case studies on effects of time and area restrictions on seabird bycatch in fisheries such as the coastal California halibut fishery, well as gear-switching (Haseltine and Thornton 1990). They found that combining these two approaches could be feasible for reducing bycatch if sufficient information about overlap between seabirds and gillnet gear is available, and time and area restrictions don't reduce target catch/catch efficiency or lead to bycatch of other non-target taxa.

## Less-Promising Gear Modification and Fishing Practice Trials

In a NOAA Technical Memo, Jannot et al. (2018) described a variety of largely untested mitigation techniques that could potentially help reduce seabird bycatch in trawl fisheries, including bird bafflers (arms projecting to the port and starboard sides of a vessel with attached streamers) and warp scarers (streamers attached directly to the warp cable). However, in a 2024 review of best practice recommendations for trawl fisheries, ACAP (2024a) suggested that several similar mitigation measures could not be recommended due to insufficient evidence of efficacy or impact on target catch. These included warp scarers, bird bafflers, cones on warp cables, warm booms, warp deflectors, reduced mesh size, net jackets, acoustic deterrents, and lasers.

A similar ACAP (2024b) review of best practices for demersal longline fisheries also identified several practices that could not be recommended due to lack of field testing. These practices include side-setting, underwater setting funnels and chutes, line-setters and shooters, olfactory deterrents, blue-dyed bait, and underwater line-setters. ACAP also did not recommend lasers due to their ineffectiveness and potential harmfulness to crews and navigation. Further, ACAP identified practices that should not be considered primary mitigation measures for demersal longline fisheries, including thawed bait, strategic management of offal discharge, and modification of hook size and shape.

ACAP (2024c) also did not recommend bait-casting machines (BCMs) and line shooters as a beneficial practice for seabird bycatch reduction in pelagic longline fisheries (ACAP 2024c). These hydraulically operated devices, designed to automatically (rather than by hand) deploy baited hooks (in the case of BCMs) and a mainline at a fast speed (next to the vessel rather than up to 30 meters behind the vessel in the case of line shooters), showed variable performance in models and field testing, and slower sink rates of baited hooks set with line shooters (Robertson et al. 2010).

The ACAP also did not recommend blue-dyed bait as a primary mitigation measure due to equivocal benefits. While some studies have shown that use of fully thawed and dyed squid (squid readily absorbs dye) can make bait more difficult for seabirds to detect and try to consume (e.g., Boggs 2001), other studies (e.g., Gilman et al. 2003) have suggested its use is less-effective than other reduction measures, relatively expensive, and challenging to deploy and enforce.

Gilman et al. (2022) compared weighted pelagic longline hooks to conventional longline gear using line-weighting. They found that the experimental weighted fishing hooks sank more quickly than control hooks, potentially reducing exposure to the gear by birds, but resulted in a significant decrease in target catch rate, making it unfeasible for widespread use.

Despite some promising indications that a “looming eye buoy” (LEB) device, i.e., a buoy with a rotating set of looming black and white circles (designed to resemble the staring eyes of a predator), reduced sea duck abundance around Baltic Sea gillnet fishing gear by 20 to 30% (Rouxel et al. 2021), trials of LEBs for gillnets in Icelandic waters showed that the devices had no effect on target catch or bycatch (Rouxel et al. 2023).

Rouxel et al. (2023) did find a strong correlation between seabird bycatch rates and gillnet fishing depth. They suggested that limiting gillnet fishing to waters more than 50 meters deep could eliminate the bycatch of thousands of seabirds each year with marginal effects on target fish catch for this fishery. Such depth restrictions may not be relevant options for nearshore fisheries that occur primarily in shallow waters, such as salmon set-net and many drift-net gillnet fisheries in Alaska.

Another Icelandic trial in the Baltic Sea (Sigurdsson 2023) showed that LED-equipped gillnets caught significantly more seabirds than control nets. The LED lights seemed to attract mostly Northern Gannets and Northern Fulmars, which became entangled in the gillnets during setting and hauling. These results supported those of Field et al. (2019), who found that neither constant green or flashing white LED lights, nor high-contrast monochrome panels attached to gillnets resulted in a reduction in seabird bycatch.

Montevecchi et al. (2023) tested the efficacy of high-contrast banners to alert seabirds to the presence of surface-set gillnets in the Atlantic herring fishery off Newfoundland, Canada. The investigators found that the high-contrast black and white banners, which were attached to the top-line of the gillnet, reduced target catch, making it a non-viable option for fishers.

Post et al. (2023) tested effects of adding a small-mesh net panel to the bottom of gillnets targeting Greenland lumpfish (*Cyclopterus lumpus*) for reducing Common Eider (*Somateria mollissima*) interactions. These net panels reduced interactions by 71%, perhaps due to the seabird's foraging behavior along the sea bottom and its ability to better see the gillnets. However, the experimental nets reduced target catch by 25%, which made this modification unviable for widespread adoption by fishers. The investigators did note that a temporal reduction in seabird bycatch suggested that delaying the start of the fishing season by two weeks could reduce interactions more effectively than net modifications. In a subsequent study, Post et al. (2024) tested the use of LED lights as a seabird bycatch reduction method during the 2023 Greenland lumpfish fishing season in the North Atlantic. They found that LED-illuminated nets did not result in decreased bycatch of three focal seabird species compared to control nets. In addition, the LED-illuminated nets resulted in a slightly lower catch rate for the targeted female lumpfish.

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## Glossary

**ACAP:** Agreement on the Conservation of Albatrosses and Petrels
**BCM:** Bait-casting machines
**BMP:** Best management practice
**CCAMLR:** Convention for the Conservation of Antarctic Resources
**CCMs:** Commission Members, Cooperating Non-Members, and participating territories
**CNPC:** Cooperating Non-Contracting Party
**CPCs:** Contracting Parties and Cooperating Non-Contracting Parties
**EEZ:** Exclusive economic zone
**FAO:** Food and Agricultural Organization of the United Nations
**FFC:** Federal Fishing Council (Argentinian government)
**IATTC:** InterAmerican Tropical Tuna Commission

**ICCAT:** International Commission for the Conservation of Atlantic Tunas
**IOTC**: Indian Ocean Tuna Commission
**ISSF:** International Seafood Sustainability Foundation
**LEB:** Looming eye buoy
**LED:** Light-emitting diode
**NGO:** Non-governmental organization
**NOAA:** National Oceanic and Atmospheric Administration
**RFMO:** Regional Fishery Management Organization
**SEAFO:** South East Atlantic Fisheries Organisation
**SPRFMO:** South Pacific Regional Fisheries Management Organisation
**TBWG:** Trilateral Bycatch Working Group
**WCPFC:** Western and Central Pacific Fisheries Commission