Agreement on the Conservation of Albatrosses and Petrels

ACAP Review and Best Practice Advice for Reducing the Impact of Pelagic and Demersal Trawl Fisheries on Seabirds

Reviewed at the Tenth Meeting of the Advisory Committee
Wellington, New Zealand 11 – 15 September 2017

INTRODUCTION

The incidental mortality of seabirds in trawl fisheries continues to be a serious global concern, especially for threatened albatrosses and petrels. In trawl fisheries, birds foraging on discards or offal may be injured or killed on collision with net monitoring and warp cables, dragged underwater and drowned when their wings become entangled around the warp, or become entangled in nets.

There have been considerable efforts internationally to develop mitigation measures to avoid or minimise the risk of incidental catch of seabirds in trawl fisheries. Although the focus of efforts to mitigate seabird bycatch was initially directed at longline fisheries, trawl fleets have also now been shown to incidentally kill large numbers of seabirds. The FAO Best Practice Guidelines for IPOA/NPOA-Seabirds were amended in 2009 to include trawl fisheries in addition to longline fisheries (FAO 2009), demonstrating increased serious concern and awareness of seabird mortality on global trawl fisheries. Although most mitigation measures are broadly applicable, the application and specifications of some will vary with local methods and gear configurations. ACAP has comprehensively reviewed the scientific literature dealing with seabird bycatch mitigation in trawl fisheries (see review section below) and this document is a summary of the advice informed by the review.

This document provides advice about best practices for reducing the impact of trawl fishing on seabirds. The ACAP review process recognises that factors such as safety, practicality and the characteristics of the fishery should also be taken into account when considering the efficacy of seabird bycatch mitigation measures and consequently in the development of advice and guidelines on best practice.

This document also provides information regarding measures that are currently under active development, and which show promise as future best practices in trawl fisheries. ACAP will continue to monitor the development of these practices and the results of scientific research about their effectiveness.

The document comprises two components. The first component provides a summary of ACAP's advice regarding best practice measures for reducing seabird bycatch in pelagic and demersal trawl fisheries, and the second component outlines the review of mitigation measures that have been assessed for these fisheries.

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ACAP Summary Advice for Reducing the Impact of Pelagic and Demersal Trawl Fisheries on Seabirds

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BEST PRACTICE MEASURES

The causes of mortality in trawl fisheries depend upon the nature of the fishery (pelagic or demersal), the species being targeted and the fishing area. Seabird mortalities may be categorised into two broad types: (1) cable-related mortality, including collisions with net-monitoring cables[1], warp cables[2] and paravanes; and (2) net-related mortality, which includes deaths caused by net entanglements. Seabird interactions with trawl gear have been demonstrated to be significantly reduced by the use of mitigation measures that include managing the discharge of offal and discards[3], protecting the warp and other cables, and reducing the time the net is exposed on the surface of the water. The following measures have been shown to be effective at reducing seabird bycatch in trawl fisheries and are recommended as best practice measures:

Measures to reduce general attractiveness to seabirds

Management of offal and discards

In all cases, the discharge of offal and discards is the most important factor attracting seabirds to the stern of trawl vessels, where they are at risk of cable and net interactions. Managing offal discharge and discards while fishing gear is deployed has been shown to reduce seabird attendance of vessels and consequent risk of interactions and bycatch. The following offal and discard management measures are recommended:

1. **Full retention of waste** – Avoiding any discharge during fishing activities;
2. **Mealing waste** – Converting offal into fish meal where practicable, and retaining all waste material with any discharge restricted to liquid discharge / sump water);
3. **Batching waste** – Where meal production and full retention of offal and discards are impracticable, waste should be stored temporarily for two hours or longer before strategically discharging it in batches;
4. **Mincing of waste** – Reducing waste to smaller particles (currently only recommended as a mitigation for bycatch of large *Diomedea* spp.).

[1] The netsonde monitor cable connects the echo-sounder or net-sounder on the headline of the trawl net to the vessel.
[2] The warp cables or trawl warps are the cables used to tow nets.
[3] Offal discharge refers to the disposal at sea of any fish waste resulting from processing, including heads, guts and frames. Fish discards refers to any unwanted whole fish (and or benthic material)

Measures to reduce the risk of cable strikes

Warp cables

1. Deploy bird scaring lines while fishing to deter birds away from warp cables.

Net monitoring cables

Net monitoring cables should not be used. Where this is impracticable:

1. Deploy bird scaring lines specifically positioned to deter birds away from net monitoring cables while fishing; and

2. Install a snatch block at the stern of a vessel to draw the net monitoring cable close to the water and thus reduce its aerial extent.

Measures to reduce the risk of net entanglement

1. Clean nets after every shot to remove entangled fish ("stickers") and benthic material to discourage bird attendance during gear shooting;

2. Minimise the time the net is on the water surface during hauling through proper maintenance of winches and good deck practices; and

3. For pelagic trawl gear, apply net binding to large meshes in the wings (120–800 mm), together with a minimum of 400-kg weight incorporated into the net belly prior to setting.

Further measures include avoiding peak areas and periods of seabird foraging activity. It is important to note that there is no single solution to reduce or avoid incidental mortality of seabirds in trawl fisheries, and that the most effective approach is to use the measures listed above in combination. Net entanglements during the haul remain the most difficult interactions to prevent.

The ACAP review of seabird bycatch mitigation measures for pelagic and demersal trawl fisheries is presented in the following section.

Agreement on the Conservation of Albatrosses and Petrels

ACAP Review of Seabird Bycatch Mitigation Measures for Pelagic and Demersal Trawl Fisheries

Reviewed at the Tenth Meeting of the Advisory Committee
Wellington, New Zealand 11 – 15 September 2017

INTRODUCTION

A range of technical and operational mitigation methods have been designed or adapted for use in trawl fisheries. These methods include managing offal and discards to reduce the abundance of seabirds attending trawl vessels, thereby mitigating the associated risk, or deterring birds from the high risk areas, such as the warp cables. Apart from being technically effective at reducing seabird bycatch, mitigation methods should be easy and safe to implement, cost effective, enforceable and should not reduce catch rates of target species.

The suite of mitigation measures available may vary in their feasibility and effectiveness depending on the area, seabird assemblages, fishery and vessel type, and gear configuration. Some of the mitigation methods are well established and explicitly prescribed in trawl fisheries; however, additional measures are undergoing further testing and refinements.

The Seabird Bycatch Working Group (SBWG) of ACAP has comprehensively reviewed the scientific literature dealing with seabird bycatch mitigation in trawl fisheries and this document is a distillation of that review. At each of its meetings, the SBWG reviews any recent research or information regarding seabird bycatch mitigation, and updates the review and best practice advice accordingly.

THE ACAP REVIEW PROCESS

At each of its meetings, the ACAP SBWG considers any new research or information pertaining to seabird bycatch mitigation in trawl fisheries. The following criteria are used by ACAP to guide the assessment process, and to determine whether a particular fishing technology or measure can be considered best practice to reduce the incidental mortality of albatrosses and petrels in fishing operations.

Best Practice Seabird Bycatch Mitigation Criteria and Definition

i. Individual fishing technologies and techniques should be selected from those shown by experimental research to significantly[4] reduce the rate of seabird incidental mortality[5] to the lowest achievable levels. Experience has shown that experimental research comparing the performance of candidate mitigation technologies to a control of no deterrent, where possible, or to status quo in the fishery, yields definitive results. Analysis of fishery observer data after it has been collected on the relative performance of mitigation approaches are plagued with a myriad of confounding factors. Where a significant relationship is demonstrated between seabird behaviour and seabird mortality in a particular system or seabird assemblage, significant reductions in seabird behaviours, such as the rate of seabirds attacking baited hooks, can serve as a proxy for reduced seabird mortality. Ideally, when simultaneous use of fishing technologies and practices is recommended as best practice, research should demonstrate significantly improved performance of the combined measures.

ii. Fishing technologies and techniques, or a combination thereof, should have clear and proven specifications and minimum performance standards for their deployment and use. Examples would include: specific bird scaring line designs (lengths, streamer length and materials; etc.), number (one vs. two) and deployment specifications (such as aerial extent and timing of deployment); night fishing defined by the time between the end of nautical dusk and start of nautical dawn; and, line weighting configurations specifying mass and placement of weights or weighted sections.

iii. Fishing technologies and techniques should be demonstrated to be practical, cost effective and widely available. Commercial fishing operators are likely to select for seabird bycatch reduction measures and devices that meet these criteria including practical aspects concerning safe fishing practices at sea.

iv. Fishing technologies and techniques should, to the extent practicable, maintain catch rates of target species. This approach should increase the likelihood of acceptance and compliance by fishers.

v. Fishing technologies and techniques should, to the extent practicable, not increase the bycatch of other taxa. For example, measures that increase the likelihood of catching other protected species such as sea turtles, sharks and marine mammals, should not be considered best practice (or only so in exceptional circumstances).

vi. Minimum performance standards and methods of ensuring compliance should be provided for fishing technologies and techniques, and should be clearly specified in fishery regulations. Relatively simple methods to check compliance should include, but not be limited to, port inspections of branch lines to determine compliance with branch line weighting, determination of the presence of davits (tori poles) to support bird scaring lines, and inspections of bird scaring lines for conformance with design requirements. Compliance monitoring and reporting should be a high priority for enforcement authorities.

[4] Any use of the word 'significant' in this document is meant in the statistical context

[5] This may be determined by either a direct reduction in seabird mortality or by reduction in seabird attack rates, as a proxy

On the basis of these criteria, the scientific evidence for the effectiveness of mitigation measures or fishing technologies/techniques in reducing seabird bycatch is assessed, and explicit information is provided on whether the measure is recommended as being effective, and thus considered best practice, or not. The ACAP review also provides notes and caveats for each measure, together with information on performance standards and further research needs. Following each meeting of ACAP's SBWG and Advisory Committee, this review document and ACAP's best practice advice, is updated (if required). A summary of ACAP's current best practice advice for trawl fisheries is provided in the preceding section of this document.

SEABIRD BYCATCH MITIGATION FACT SHEETS

A series of seabird bycatch mitigation fact sheets have been developed by ACAP and BirdLife International to provide practical information, including illustrations, on seabird bycatch mitigation measures (http://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets). The sheets, which include information on the effectiveness of the specific measure, their limitations and strengths and best practice recommendations for their effective adoption, are linked to the ACAP review process, and are updated following ACAP reviews. Links to the available fact sheets are provided in the relevant sections below.

1. MITIGATION MEASURES TO REDUCE GENERAL ATTRACTIVENESS TO SEABIRDS

1. Offal discharge[6] and fish discard management

The most important factor influencing contacts between seabirds and warp cables is the presence of discharge (Wienecke & Robertson 2002; Sullivan *et al.* 2006a; Favero *et al*. 2011). Methods used to reduce the attractiveness of vessels to seabirds through management of offal discharge and fish discards include: full retention (avoid any discharge during fishing activities), mealing (the conversion of waste into fish meal waste reducing discharge to sump water), batching (storage or controlling release of discards / discharge during fishing operations), mincing waste to a nominal maximum particle size of 25 mm diameter prior to discharge).

1.1. Full retention

Scientific evidence for effectiveness in trawl fisheries

Proven and recommended as a mitigation method. Repeated studies have shown that in the absence of offal discharge / fish discards seabird interactions and mortality levels are negligible (Sullivan *et al*. 2006; Watkins *et al*. 2008; Melvin *et al*. 2010; SBWG3 Doc 14 Rev 1; Abraham & Thompson 2009). Storage of all fish discard and offal, either for processing or for controlled release when cables are not in the water, has resulted in a significant reductions in the attendance of all groups of seabirds (Abraham *et al.* 2009).

[6] Offal discharge refers to the disposal at sea of any fish waste resulting from processing, including heads, guts and frames. Fish discards refers to any unwanted whole fish (and or benthic material)

Notes and Caveats

Suitable for both pelagic and demersal trawl gear**.**

Minimum standards

None established.

Need for combination

None identified.

Research needs

None identified.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1627-fs-13-trawl-fisheries-warp-strike/file

1.2. Mealing

Scientific evidence for effectiveness in trawl fisheries

Recommended as a mitigation measure. Mealing resulted in significant reduction in the number of seabird species feeding behind vessels, relevant to the discharge of unprocessed fish waste (Abraham *et al.* 2009; Wienecke & Robertson 2002; Favero *et al*. 2011) or minced waste (Melvin *et al.* 2010).

Notes and Caveats

Good evidence from a number of fisheries that fish meal processing and reducing discharge to stick / sump water is highly effective in reducing seabird bycatch. Suitable for both pelagic and demersal trawl gear. Retrofitting of meal plants may not be a viable option for existing vessels due to associated space requirements (Munro 2005).

Minimum standards / Recommendation

None established.

Need for combination

None identified.

Research needs

None identified.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1627-fs-13-trawl-fisheries-warp-strike/file

1.3. Batching

Scientific evidence for effectiveness in trawl fisheries

Recommended as a mitigation when full retention or mealing is not possible. Batching (temporary storage and periodic (controlled) release of discards / discharge during trawling) has been trailed in New Zealand (Pierre *et al*. 2010; SBWG4 Doc 14 Rev 1; Pierre *et al*. 2012b) and in the Falkland Islands (Islas Malvinas)[7] (Kuepfer et al. 2016; Kuepfer & Pompert 2017). Results showed that batching can significantly reduce numbers of seabirds and associated bycatch risk, although adequate storage period and minimal duration of batching events are important.

Notes and Caveats

Effectiveness of batching relies on efficient (fast) dumping of batched material.

Minimum standards

Recommended when full retention or mealing is not possible. Batch waste for at least 2 hours, preferably 4 hours or longer.

Need for combination

Should be used in combination with other mitigation methods.

Research needs

Robust trialling to investigate the extent to which reduced seabird abundance affects seabird interaction rates.

Identify threshold where increased storage is compromised by increased batching (discharging) period required.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1627-fs-13-trawl-fisheries-warp-strike/file

1.4. Mincing

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence to recommend this as a primary mitigation measure at present, although reduced bird abundance should decrease cable impacts and mortality for larger albatross species. Mincing waste to maximum 25 mm significantly reduced the number of large albatrosses (*Diomedea* spp) attending vessels but had no effect on other groups of seabirds (Abraham *et al*. 2009; Abraham 2010). Pierre *et al.* (2012a) showed that whilst reduced particle size (10-40 mm and 30-60 mm) reduced seabird attendance compared with untreated waste, the effect was lowest for small albatross species, and not significant for the 10-40 mm treatment.

[7] A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Islas Malvinas), South Georgia and the South Sandwich Islands (Islas Georgias del Sur e Islas Sándwich del Sur) and the surrounding maritime areas.

Notes and Caveats

Bottom trawled material, such as rocks, may impact the feasibility of mincing.

Minimum standards

None established. Insufficient evidence to recommend this as a primary measure at present.

Need for combination

Should be used in combination with other mitigation methods.

Research needs

At present only demonstrated to be effective against large *Diomedea* spp albatrosses. Efficacy with *Thalassarche* spp albatrosses needs to be proven before measure can be recommended (Abraham *et al*. 2009).

2. MITIGATION MEASURES DESIGNED TO REDUCE INTERACTIONS OF SEABIRDS WITH TRAWL CABLES

2.1. Bird Scaring Lines (BSL) to reduce interaction with warp cables

Scientific evidence for effectiveness in trawl fisheries

Proven and recommended as a mitigation measure. Attachment of a Bird Scaring Line to both the port and starboard sides of a vessel, above and outside of the warp blocks, greatly reduces the access of birds to the danger zone where warps enter the water (Watkins *et al.* 2006; Reid & Edwards 2005; Melvin *et al*. 2010). An off-setting towed device has been demonstrated to improve BSL performance (ACAP 2013; Tamini *et al.* 2015).

Notes and Caveats

Effectiveness is reduced in strong cross winds and rough seas, when BSLs are deflected away from warps (Sullivan & Reid 2003; Crofts 2006a, 2006b). This can be alleviated in part by towing a buoy or cone attached to the end of lines to create tension and keep lines straight (Sullivan *et al*. 2006a; Cleal *et al.* 2013). Hard wearing and non-tangling materials and design can improve performance (Cleal *et al.* 2013), including the use of semi rigid streamers, particularly those constructed from Kraton. Suitable for both pelagic and demersal trawl gear.

Minimum standards

BSL are recommended even when appropriate offal discharge and fish discard management practices are in place (Melvin *et al*. 2010). A BSL should be fitted to the outside of both the starboard and the port-side cable. The main line should extend beyond the warp-water interface and should maintain its tension under normal tow speed. Streamer lines should be attached at maximum 5 m intervals and should be long enough to extend beyond the point at which warp and net monitoring cables reach the water's surface. It is recommended that for every metre of block height, 5 m of backbone be deployed and 1.2 kg of terminal object drag weight be used. BSLs should be deployed once the trawl doors are submerged and retrieved as net hauling commences.

Need for combination

Should be combined with offal/discard management.

Research needs

Further research is required on the effectiveness of the design and performance of an off-setting towed device under operational conditions (see 4.1).

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1627-fs-13-trawl-fisheries-warp-strike/file

2.2. Warp scarers

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence. Not recommended as a mitigation measure. Warp scarers (weighted devices attached to each warp with clips or hooks, allowing the device to slide up and down the warp freely and stay aligned with each warp) create a protective area around the warp (see Bull 2009, Fig.2; Sullivan *et al*. 2006a).

Warp scarers have been shown to reduce contact rates but not significantly, and were not as effective as BSLs (Sullivan *et al*. 2006b, Abraham *et al*., cited in Bull 2009).

Notes and Caveats

Attachment to the warp eliminates problems associated with crosswinds as the mitigation devices do not behave independently of warps. Warp scarers cannot be deployed while the warp cable is being set, or remain in place during hauling, leaving periods when warps are not protected.

Concerns have been raised regarding associated practicality and safety issues (Sullivan *et al.* 2006a; Abraham *et al.*, cited in Bull 2009).

Minimum standards

None. Insufficient evidence to recommend this measure.

Need for combination

None identified.

Research needs

None identified.

2.3. Bird bafflers

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence. Not recommended as a mitigation measure at this time. Bird bafflers comprise two booms attached to both stern quarters of a vessel. Two of these booms extend out from the sides of the vessel and the other two extend backwards from the stern.

Dropper lines are attached to the booms, to create a curtain to deter seabirds from the warp-water interface zone (see Bull 2009, Fig.3; Sullivan *et al.* 2006a).

Generally bird bafflers are not regarded as providing as much protection to the warp cables as BSLs or warp scarers (Sullivan *et al.* 2006a), because they don't tend to extend beyond the warp-water interface area, hence leaving the most dangerous part of the warp exposed.

Notes and Caveats

Various designs exist including the Brady Baffler, the Burka and a modified Burka design or "curtain baffler" (Cleal *et al*. 2013).

While bafflers were designed to minimise warp interactions, the Brady Baffler has been used (inappropriately) within CCAMLR Icefish fisheries to mitigate net entanglements where they have been found to be consistently ineffective (Sullivan *et al*. 2009).

The great variability in the design and deployment of bird bafflers may influence their overall effectiveness. Designs may also be very vessel-specific to ensure adequate coverage of the warp-water interface.

Minimum standards

None. Insufficient evidence to recommend this measure.

Need for combination

None identified.

Research needs

The full range of baffler designs have not been experimentally tested. Trials should be conducted in a range of fisheries and areas to demonstrate efficacy.

2.4. Cones on warp cables

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence. Not recommended as a mitigation measure at this time. A plastic cone attached to each warp cable reduced the number of birds entering the warp-water interface in Argentine Hake Trawl Fishery by 89% and no seabirds were killed while cones were attached to the warp (Gonzalez-Zevallos *et al.* 2007).

Notes and Caveats

Applicable for small vessels.

Minimum standards

None. Insufficient evidence to recommend this measure.

Need for combination

None identified.

Research needs

Needs to be trialled in a range of fisheries and areas to demonstrate efficacy.

2.5. Warp boom

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence. Not recommended as a mitigation measure at this time. A boom with streamers extending to the water forward of the stern and warps can divert birds feeding on offal away from the warps, however Melvin *et al*. (2010) did not identify a statistically significant reduction is seabird interactions with the warp.

Notes and Caveats

Minimum standards

None. Insufficient evidence to recommend this measure.

Need for combination

None identified.

Research needs

Longer-term studies required to identify effectiveness including work to identify suitable configuration and materials.

2.6. Snatch block

Scientific evidence for effectiveness in trawl fisheries

Recommended as a mitigation measure to reduce the aerial extent of net monitoring cables. A snatch block, placed on the stern of a vessel to draw the third-wire close to the water to reduce its aerial extent, reduced seabird strikes, although performance varied by vessel (Melvin *et al*. 2010).

Notes and Caveats

Melvin *et al.* (2010) were confident that third-wires can be pulled closer to the water or submerged at the stern to make this measure highly effective, but noted that, as third-wires are fragile and expensive, any snatch block-like system should aim to minimise cable wear. Recommended on the basis that reducing the aerial extent of monitoring cables should reduce the risk of seabird strikes with these cables.

Minimum standards

None established.

Need for combination

Should be combined with offal/discard management and Bird Scaring Lines.

Research needs

Needs to be trialled in a range of fisheries and areas to further demonstrate efficacy. Development of technical specifications is also required.

3. MITIGATION MEASURES DESIGNED TO REDUCE NET ENTANGLEMENTS

3.1. Net binding

Scientific evidence for effectiveness in trawl fisheries

Recommended for reducing bycatch when shooting gear in pelagic trawl fisheries. Shown to be a highly effective mitigation measure in CCAMLR icefish trawl fishery, reducing seabird bycatch to minimal levels (Sullivan *et al.* 2009).

Notes and Caveats

Not suitable for demersal trawl gear.

Sisal string has been used to bind the sections of the net which pose the greatest threat to seabirds prior to shooting (Sullivan *et al*. 2004). Bindings are simply tied onto the net to prevent the net from lofting and the mesh opening as the tension created by the vessel speed of between 1-3 knots is lost due to waves and swell action. Once shot-away the net remains bound on the surface until it sinks. Once the trawl doors are paid away and the net has sunk beyond the diving depth of seabirds the force of the water moving the doors apart is sufficient to break the bindings and the net spreads into its standard operational position.

Minimum standards

3–ply sisal string (typical breaking strength of c.110 kg), or a similar inorganic material should be applied to the net on the deck, at intervals of approximately 5 m to prevent net from spreading and lofting at the surface. Net binding should be applied to mesh ranging from 120–800 mm as these are known to cause the majority of seabird entanglements (Sullivan *et al*. 2010). When applying string, tie an end to the net to prevent string from slipping down the net and ensure it can be removed when net is hauled.

Need for combination

Recommend combination with net cleaning and net weights to minimise the time the net is on the surface (Sullivan *et al*. 2009), as well as combination with waste management to avoid the discharge of waste during shooting thereby minimising the attraction of seabirds to the stern of the vessel.

Research needs

None identified.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1713-fs-14-trawl-fisheries-net-entanglement/file

3.2. Net weighting

Scientific evidence for effectiveness in trawl fisheries

Recommended for reducing bycatch during both shooting and hauling of trawl gear (both pelagic and demersal). Evidence suggests net weighting on or near the cod end increases the angle of ascent of the net during hauling operations, thus reducing the time the

net is on the water's surface. In addition, good deck practices to minimise the time that the net is on the water's surface have been the key factors in reducing seabird entanglements during hauling in South Atlantic trawl fisheries (Hooper *et al.* 2003; Sullivan *et al.* 2009).

Notes and Caveats

All attempts should be made to retrieve the net as quickly as possible.

Minimum standards

None established.

Need for combination

Recommend combination with net binding and net cleaning to minimise the time the net is on the water's surface during both setting and hauling (Sullivan *et al.* 2009), as well as combination with waste management to avoid the discharge of waste during shooting and hauling thereby minimising the attraction of seabirds to the stern of the vessel.

Research needs

Development of minimum standards for amount and placement of weight (cod end, wings, footrope, mouth, belly), to build on work to date in CCAMLR trawl fisheries (Sullivan *et al*. 2009).

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1713-fs-14-trawl-fisheries-net-entanglement/file

3.3. Net cleaning

Scientific evidence for effectiveness in trawl fisheries

Recommended for reducing bycatch during both shooting and hauling of trawl gear (for both pelagic and demersal). Removal from nets of all fish 'stickers' and other material is a critical step to reducing net entanglement during shooting (Hooper *et al*. 2003; Sullivan *et al.* 2009).

Notes and Caveats

None.

Minimum standards

Remove all stickers from net prior to shooting gear.

Need for combination

Recommend combination with net binding and net weights to minimise the time net is on water's surface during both setting and hauling (Sullivan *et al.* 2009), as well as combination with waste management to avoid the discharge of waste during shooting thereby minimising the attraction of seabirds to the stern of the vessel.

Research needs

None identified.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1713-fs-14-trawl-fisheries-net-entanglement/file

3.4. Reduced mesh size

Scientific evidence for effectiveness in trawl fisheries

Insufficient evidence to recommend as an effective measure at this time. Roe (2005) reported on the use of reduced mesh size from 200 to 140 mm in the pelagic icefish fishery in CCAMLR waters, but did not quantify the effectiveness of the measure.

Notes and Caveats

Theoretically this measure could be effective in reducing the incidence of seabird entanglements in net; however, measure may be impractical. Reduced mesh size was believed to have caused severe damage to the net because of increased water pressure during trawling (Roe 2005), although the use of chain weights in the net may also have been influential.

Minimum standards

Not currently recommended.

Need for combination

Not applicable.

Research needs

Thorough testing in a range of fisheries required to determine if measure is practical and effective, as well as to identify potential impact on target catch and bycatch species.

3.5. Net jackets

Scientific evidence for effectiveness in trawl fisheries

Unproven and not recommended as a mitigation method. Free-floating panels of net attached to the most dangerous mesh sizes have been trialled in CCAMLR's icefish trawl fishery, with uncertain efficiency (Sullivan *et al*. 2009).

Caveats /Notes

Found to cause serious drag and subsequent damage to the net. Drag also slows vessel speed and increases fuel consumption (Sullivan *et al*. 2009).

Minimum standards

Not currently recommended.

Need for combination

Not applicable.

Research needs

Efficacy of measure remains to be demonstrated.

Mitigation Fact Sheet

https://www.acap.aq/en/resources/bycatch-mitigation/mitigation-fact-sheets/1713-fs-14-trawl-fisheries-net-entanglement/file

3.6. Acoustic deterrents

Scientific evidence for effectiveness in trawl fisheries

Unproven and not recommended as a primary mitigation method. The use of acoustic 'scaring' devices on nine vessels in CCAMLR trawl fisheries indicated that loud noises (bells and flares/fireworks) had limited effect and birds quickly became habituated to the sound, no longer causing an aversion response (Sullivan *et al*. 2009).

Notes and Caveats

May be a useful back-up measure for circumstances when another measure is needed immediately (Sullivan *et al*. 2009).

Minimum standards

Not currently recommended.

Need for combination

Not applicable.

Research needs

None identified.

3.7. Net restrictor

Scientific evidence for effectiveness in trawl fisheries

Unproven and not recommended as a primary mitigation method. The net restrictor was identified as a potential mitigation device in response to observed net captures in the New Zealand scampi trawl fishery, where multiple nets are deployed adjacently (Pierre *et al.* 2013). The net restrictor acts to restrict the opening of the net on haul when captures tend to occur. Video footage confirmed that the restrictor was effective in reducing the size of the net opening at hauling; although empirical testing of the device has not been conducted.

Notes and Caveats

May be a useful measure in demersal trawl fisheries where multiple nets are deployed adjacently, and nets (particularly the middle net) are liable to billow open at or near the surface on haul.

Minimum standards

None. Insufficient evidence to recommend this measure at present.

Need for combination

None identified.

Research needs

At-sea testing required to determine effectiveness.

The range of mitigation measures available to prevent net entanglements is limited, and most have not been adequately (and quantitatively) tested. Consequently, there is a need to identify and test measures aimed at addressing the problem of seabirds becoming entangled in nets of trawl vessels, particularly during hauling operations.

4. GENERAL MEASURES

4.1. Time-Area closures

Scientific evidence for effectiveness in trawl fisheries

Recommended as a general mitigation measure (but need to be aware of displacing the risk to adjacent areas). Avoiding fishing at peak areas and during periods of intense foraging activity has been used effectively to reduce bycatch in longline fisheries. The principles are directly transferrable to trawl and other net fisheries.

In some studies, longline-associated mortality has been almost exclusively within the breeding season of seabirds. Several studies have also shown that proximity to breeding colonies is an important determinant of seabird bycatch rates (Moreno *et al.* 1996; Nel *et al*. 2002) and temporal closures around breeding areas contributed to a substantial reduction in seabird bycatch (Croxall & Nicol 2004).

Notes and Caveats

An important and effective management response, especially for high risk areas, and when other measures prove ineffective. There is a risk that temporal/spatial closures could displace fishing effort into neighbouring or other areas which may not be as well regulated, thus leading to increased incidental mortality elsewhere.

Minimum standards

No general minimum standards. Will depend on the particular area and fishery.

Need for combination

Must be combined with other recommended measures, both in the specific areas when the fishing season is opened, and also in adjacent areas to ensure displacement of fishing effort does not merely lead to a spatial shift in the incidental mortality.

Research needs

Further information about the seasonal variability in patterns of species abundance around trawl fisheries is required.

4.2. Lasers

Scientific evidence for effectiveness in trawl fisheries

Unproven and not recommended, bird welfare issues need to be addressed. Preliminary research using lasers in a North Pacific trawl fishery did not show a detectable response in daylight hours, and that reactions to the laser at night varied between species, and whether the seabirds were feeding in the offal plume or following the vessel (Melvin *et al.* 2016).

Notes and Caveats

There are ongoing concerns about the safety (to both humans and birds) and efficacy of laser technology as a seabird bycatch mitigation tool.

Minimum standards

Not Applicable.

Need for combination

Not Applicable.

Implementation monitoring

Not Applicable.

Research needs

Bird welfare issues must be addressed before further at-sea testing.

5. MEASURES UNDER DEVELOPMENT

5.1. Tamini Tabla off-setting towed device for Bird Scaring Lines

In order to improve the performance of Bird Scaring Lines, an off-setting towed device (Tamini Tabla) is under development in Argentina (Tamini *et al.* 2015). This device is attached to the terminal end of the BSL and has a buoyant upper board with three 45° vertical keels, which are weighted for stability. Under forward motion of the vessel, the keels cause the device to move outward of the trawl cables and therefore maintain the BSL from entangling with trawl cables.

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