BINS ON BOATS

Reducing pollution from marine environment users to reduce marine waste and marine mammal entanglements

Final report to the Victorian Government, Biodiversity Response Planning – Marine (BRPM010)

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Phillip Island NATURE PARKS

November 2021

penguins.org.au/conservation

VICTORIA State Government

SETFIA SOUTH EAST TRAWL FISHING INDUSTRY ASSOCIATION — sustainable fishing practices protect our future

*We acknowledge the Traditional Owners of the land and waters of Millowl the *Bunurong and pay our respects to Elders past, present and emerging. We recognise their role in caring for Country over thousands of years and acknowledge the true history and their continued connection to place as we work and walk together.*

"We are working with our fishermen and Phillip Island Nature Parks because sustainable fishing practices, such as correct waste disposal, protect our future".
~ Simon Boag, EO SETFIA

ACKNOWLEDGEMENTS

Phillip Island Nature Parks and the South East Trawl Fishing Industry Association (SETFIA) would like to thank the Victorian Government for funding this project and all the commercial vessel operators that participated. Thanks to Kimberley Macdonald (DELWP) for advice and the support of Catherine Basterfield (CEO), Jess McKelson (Conservation Manager) and Peter Dann (Research Director) at Phillip Island Nature Parks.

Thanks to Ron Stott for his assistance with the Port Audit and vessel surveys and Alex Kusmanoff, Georgia Garrard, Emily Gregg, Lindall Kidd, Holly Kirk, Matthew Seliniske and Sarah Bekessy from ICON Science at RMIT University for their advice regarding the stickers used on the bins and the published behaviour change paper. We also appreciate the hard work from staff at Gearstore in Lakes Entrance for housing the bins and helping with their delivery to vessels.

A special thank you to the efforts of the coastal clean-up crews from across Victoria, including Turn the Tide Program at Phillip Island that have submitted data to the Tangaroa Blue database. Thanks also to Ross Holmberg, Harley Schinagl, Alona Charuvi, Sally O'Neil and Kahren Richardson at Phillip Island Nature Parks for assistance with the data, figures, community engagement and report presentation.

INDUSTRY STATEMENT

The fishing industry harvests a community resource in a community space and relies on the good will of the Australian community to do so. In return, the community is employed, the economy is churned, and Australians can purchase healthy and sustainable local fish. The industry sees itself as having the same challenges as all Australians; that being how to manage its addiction to the amazing and cheap product that plastic is, and how to dispose of it safely, ideally through recycling. In Australia, the fishing industry only contributes a fraction of the plastic in the oceans. However, the entanglement of marine creatures is highly visible and often has sad consequences. Like all Australians, fishers want to do the right thing with their waste and this partnership was another step toward improving our performance. Put simply there are now more, larger and fuller bins on fishing vessels in southern-east Australia than there was before the project started. ***~ Simon Boag, EO SETFIA***

Australian fur seal entangled in green net fragment (left) and the custom-built bin to capture waste onboard SETFIA vessels while at sea (right).

Bunurong Land Council
ABORIGINAL CORPORATION

BLCAC respectfully offer the below statement of significance which covers all of our traditional land and water Country.

Over the last 35,000 years Bunurong people have adapted to a range of significant changes within their Country. Our stories of the Bay flooding with water, asteroid impacts near Cranbourne, Arthurs Seat once being an Island, volcanic activity in the western suburbs, the great floods, fires and earthquakes all speak of such events.

Over 1000 generations of our people have been here before us. Archaeological excavation within our Country has already demonstrated about 30,000 years worth of occupation. These sites can show us how our ancestors interacted with their environment and how that interaction changed over time. We regard all evidence of our people's occupation as sacred.

No amount of data can compensate for the loss of a site but if we cant *literally* preserve a site, the only other way it may be preserved is by way of careful data collection as part of a Cultural Heritage Management Plan (CHMP). The importance of the accuracy of this data being collected *for protection* is paramount as we regard this information as sacred. It holds the stories of our people and our past. In some places our archaeology is the only thing that remains within a given landscape, the only thing left that hasn't been changed or moved, and because of this, it is now sacred to us.

All of our Country is highly significant, every square inch, every rock, every leaf, every dune and every artefact. If we could attribute the cause of this blanket high significance rating of our Country to any one thing, it would be that in Melbourne especially, so much has been destroyed and lost as the city grew, and so quickly. If you lose enough of something, what little you have left becomes so much more important. Similarly, when someone passes, their earthly possessions become more important to those they left behind.

With regards to knowledge and stories, each of our Elders that passed away during early colonisation is the equivalent of a state library burning down today. One Bunurong Elder of the time was famously quoted saying that, *'Once we are gone, no one is going to know where anything is'*, clearly considering the vast amount of knowledge he and his people had collected about the landscape, all written in their songs and stories. Another Elder was noted as saying, *'one day smart people will lament at our passing'*, no doubt acknowledging again the ocean of information collected on every living thing here, every tree, every animal and the key to the complex balance of all things that his people had managed to evolve and sustain. European people are still learning of the complexities of Aboriginal culture.

Though we retain a wealth of stories of our people and Country, with no written language and with change occurring here so quickly, we have lost many of the ancient stories of this landscape. At the *time*, Bunurong people's focus was more on trying to stay alive than on the luxuries of continuing to practice culture, which included the careful passing on of stories and knowledge, different levels of which would require certain initiations, performed over time.

The pressure is now on archaeological methodologies to make sure our Ancestor's sites that *are* in harms way *are* found, and that they are excavated in a way that allows for science to give us back some of those lost stories. Every part of our Country is of high significance to our people past and present.

The Bunurong Land Council Aboriginal Corporation

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1. INTRODUCTION

Background and aims

In an effort to reduce marine waste and protect wildlife, *Bins on Boats* was funded for three years by the Victorian Government as part of the Marine Biodiversity Response Planning in partnership with the South East Trawl Fishing Industry Association (SETFIA) and Phillip Island Nature Parks (The Nature Parks).

Marine mammals can become entangled in rope and netting from commercial fishing activities. Fragments of nets and ropes are more of a risk to marine mammals than derelict gear because the loss of whole nets at sea is extremely rare. Nets used by trawl vessels hold expensive electronic equipment worth over $100,000 so there is a large incentive to recover equipment. However, there is no co-ordinated approach to managing smaller sized waste at sea, specifically plastic waste and fragments of nets and ropes.

This project aims to reduce the amount of plastic waste and net-rope fragments lost overboard to benefit marine life. As an indicator of the problem, Australian fur seals become entangled in marine plastic pollution, including recreational fishing line, commercial fishing material, balloons, ribbons, clothing and plastic bags. Both trawl net fragments and recreational fishing line have been the most common sources of entanglement for Australian fur seals at Seal Rocks, affecting their ability to forage and survive (McIntosh et al. 2015) (Figure 1).

Figure 1. Australian fur seal entangled in fragment of trawl net at Seal Rocks, Victoria.

When trawl industry representatives examined some of net fragments removed from entangled fur seals, they observed sharp edges (Figure 2), consistent with being cut. The industry believes that these fragments may be lost at sea during net repair. Without proper weatherproof and lidded bins on vessels, the fragments can easily be lost overboard to become marine plastic pollution.

This partnership between The Nature Parks, SETFIA and the Victorian Government has been forged to promote correct waste disposal, reduce marine pollution and entanglement of marine mammals – and more specifically, Australian fur seals.

Marine plastic debris

Pollution in the ocean is sourced from the land (rubbish flushed or blown out to sea) or sea (from vessels) (Figure 3). Plastic marine waste is largely originates from land sources (~80%), with a small percentage (~20%) contributed by marine activities (Gangadoo et al. 2020) (Figure 4). Rubbish such as food packaging, sanitary items and cigarette butts are considered sourced from the land even if lost from a vessel because it is impossible to track the source. It is estimated that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean that year (Jambeck et al. 2015). By mid-2017, an estimated 8.3 billion metric tons of plastics had been produced (Geyer et al. 2017). Globally, plastic waste production is not expected to peak until next century in line with population growth (Hoornweg et al. 2013).

Predictions are that 100 to 250 MT of plastic could enter the ocean by 2025 (Jambeck et al. 2015). Currently in Australia, concentrations of floating debris are predicted to be high in southern waters (Figure 5).

Marine plastic debris is persistent and highly mobile in marine currents, slowly breaking up to ever smaller pieces (Figure 4). Marine debris can be macro (pieces above 5 mm), micro (pieces 5 mm-1 µm) and nano (microscopic) sized (Gangadoo et al. 2020).

Plastics in the environment can have many environmental impacts. They can entangle wildlife or be ingested and enter the food chain (Figure 3) and nanoplastics may penetrate tissues with unknown effects. Plastics attract heavy metals and pollutants, and release toxins and chemicals as they break-up. Plasticisers used to make plastics flexible, can disrupt endocrine function and affect hormones and reproduction (Gangadoo et al. 2020).

Figure 2. Fragments of trawl net were examined and appeared to be cut rather than ripped.

MARPOL

Protection of the sea

The International Convention for the Prevention of Pollution from Ships (MARPOL) includes regulations aimed at preventing both accidental pollution and pollution from routine vessel operations. Australia implements MARPOL through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and the *Navigation Act 2012*. Under MARPOL, Australia's Port Authorities are required to provide efficient, safe and environmentally responsible port waste reception facilities to accept MARPOL waste and ships are responsible for maintaining waste disposal records. Information on Australia's Port Reception Facilities can be found in the GISIS database (https://gisis.imo.org/).

MARPOL is the international convention aimed at the prevention of pollution from ships caused by operational or accidental causes

In some locations there have been reports from fishers of inadequate facilities include facilities not being available, exceedingly difficult access, or undue delays in access. To ensure that the custom designed bins would be easily emptied by the commercial fishers, an audit of the Port authorities was performed prior to rollout.

Good practices for port reception operators

In the Global Integrated Shipping Information System's Consolidated guidance for port reception facility providers and users, the International Maritime Organisation (2018) advises the following "Good practices for port reception operators":

- Port Reception Facilities should prepare a Port Waste Management Plan and should ensure proper communication to ship operators in advance of their arrival
- Port Reception Facility Database (PRFD) should include the information vessels need to prepare and offload their waste including the facilities, capacity and the contact point.
- Advanced notice from ships may be required to ensure suitable facilities are provided.
- The reception facility should be adequately prepared to receive MARPOL Annex V wastes. Reduction, reuse and recycling of ship-generated wastes/residues is encouraged. Reception facility providers should supply suitable receptacles to facilitate recycling and seek out resale/recycling options for reusable/recyclable waste when not prohibited by local laws.
- Reception facility services should be provided at a reasonable cost that "do not provide mariners with a disincentive to use them".

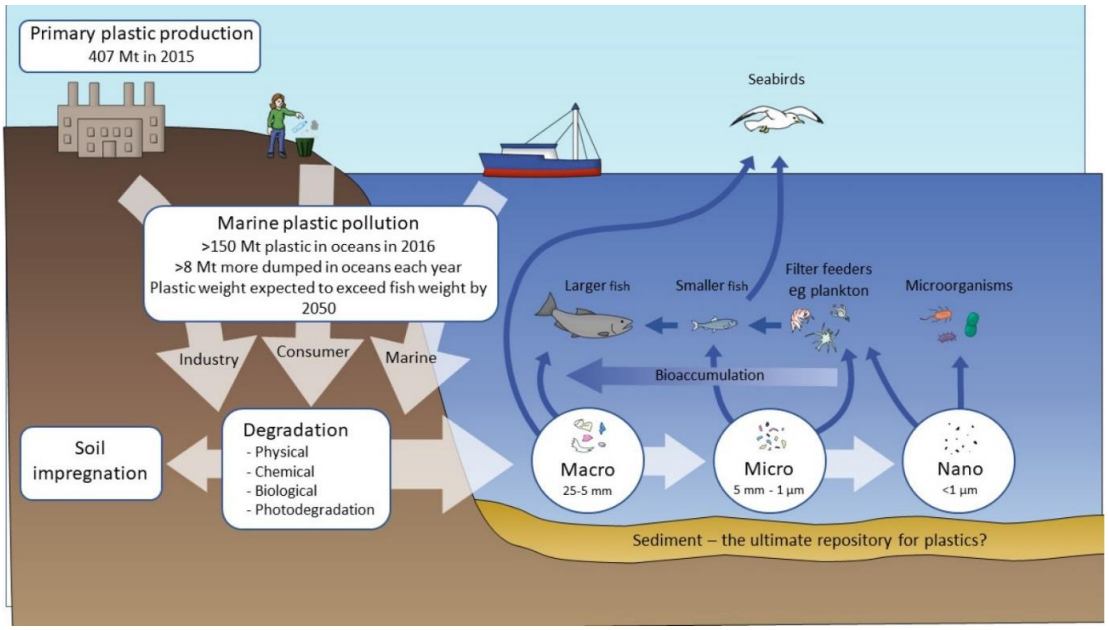


Figure 3. Schematic diagram from Gangadoo et al. (2020) to show the sources and fate of plastics and how plastics reach the marine environment.

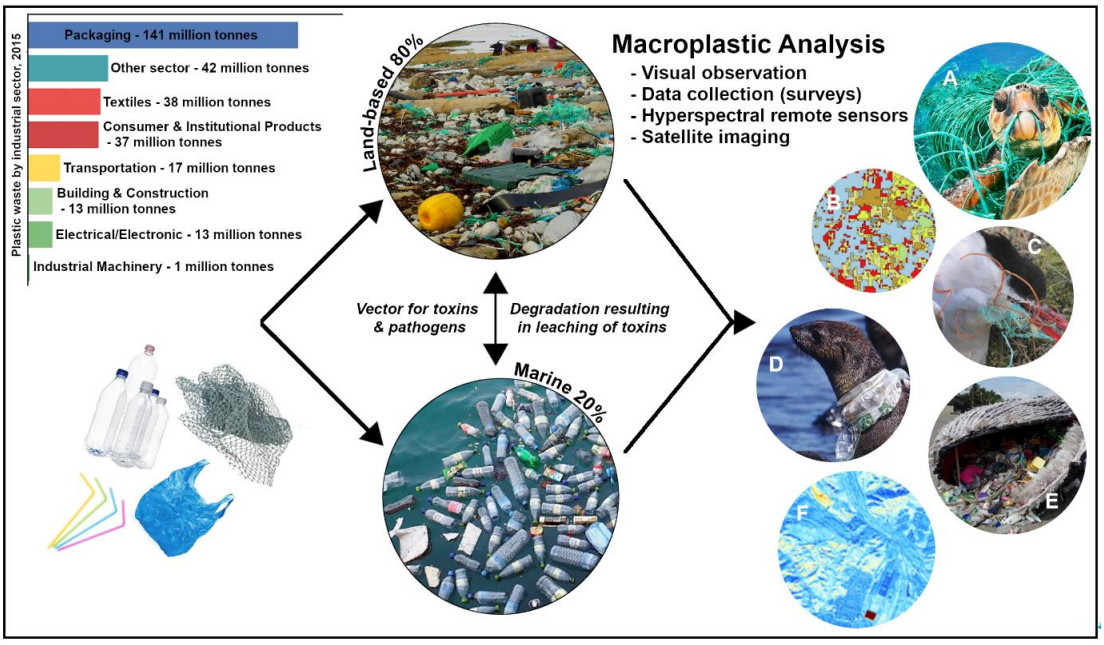


Figure 4. Marine plastic cycle from sediments to marine environment. A: entanglement of turtles with fishnet [National Geographic]; B: satellite imaging of agricultural plastic waste (Lanorte et al. 2017); C: ingestion of fishing equipment with sea birds [abc.net.au]; D: fur seal entangled (Barnes et al. 2015); E: ingestion of various plastic materials by whale [The Guardian]; F: remote sensing of marine MaPs (Ritchie 2019). Figure sourced from Gangadoo et al. (2020), and citations for images are provided therein.

Entanglement of Marine Mammals

Marine debris is a nationally listed threatening process. 'Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris' was listed as a key threatening process under the Federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): https://www.awe.gov.au/environment/biodiversity/threatened/key-threatening-processes/harmful-marine-debris.

Cetaceans

In a study by Tulloch et al. (2019) of the entire Exclusive Economic Zone of Australia from 1887-2016, 27 Australian cetacean species were recorded entangled in live fishing gear (active) and marine debris or ghost nets (derelict gear), with over 30% of records involving interactions with threatened, vulnerable or endangered species. Derelict gear accounted for one quarter of the interactions and were not commonly reported in Victoria compared to Western Australia, Queensland, New South Wales and South Australia (Tulloch et al. 2019).

Given our focus on small fragments of nets and ropes from commercial vessels in Victoria, cetaceans were not considered a suitable model for determining the success of the custom-made bins and therefore not discussed further.

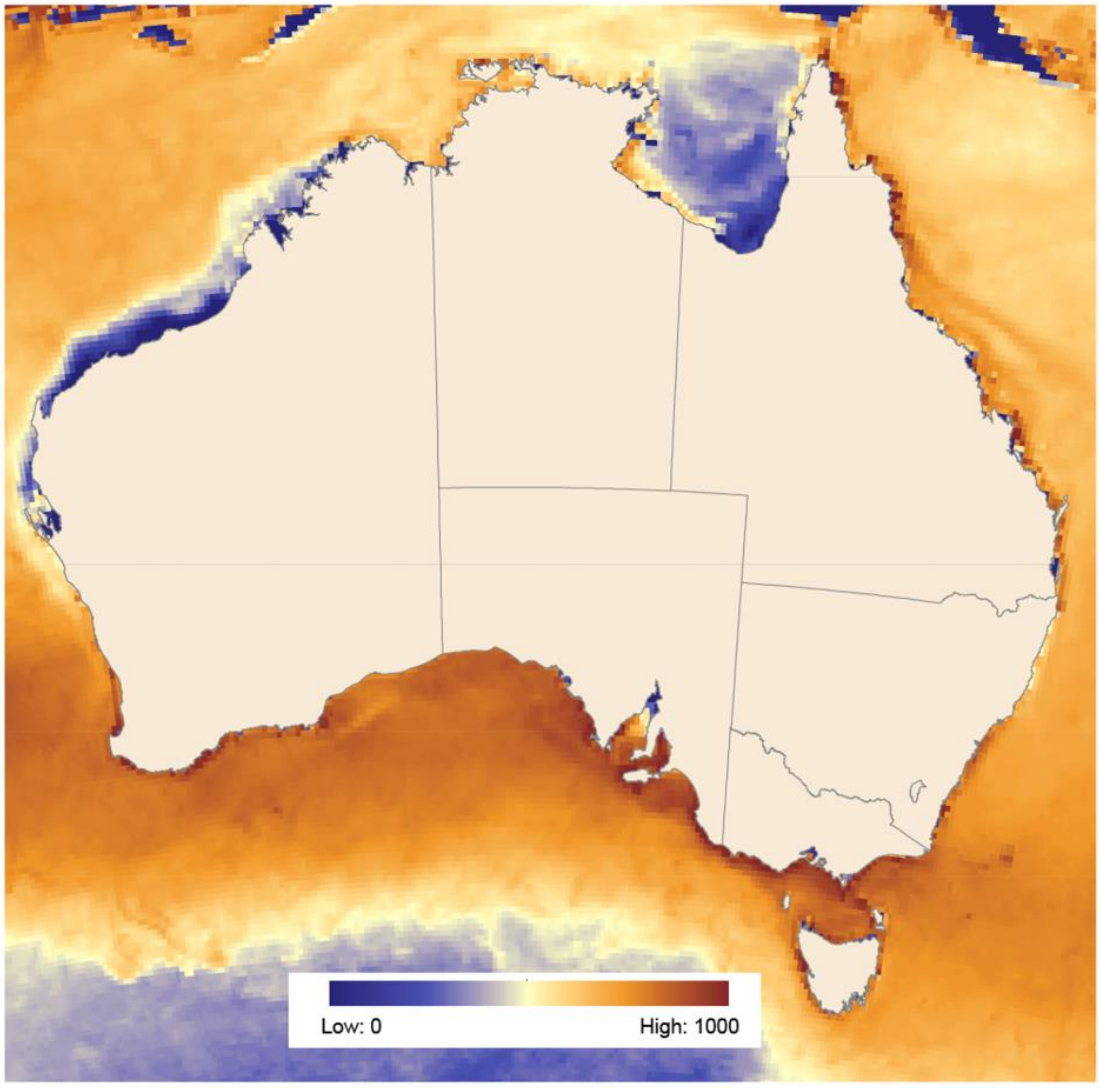


Figure 5. Predicted concentrations of floating debris (more than 200 millimetres in diameter) per square kilometre in Australian waters. Source: Evans et al. (2016), based on data from Eriksen et al. (2014).

Fur seals

Seals come ashore to rest and breed, making them excellent indicators of marine plastic pollution and entanglement of marine life compared to species that are wholly aquatic and difficult to monitor.

Individuals from 22 of the 33 extant pinniped species were recorded with entanglements in live gear or marine debris (67%) (Jepsen and de Bruyn 2019).

An estimated 0.1 to 0.3 % of the Australian fur seal (*Arctocephalus pusillus doriferus*) population are entangled in marine debris (Claro et al. 2019) including recreational and commercial fishing material and general rubbish such as plastic bags and balloon ribbons (McIntosh et al. 2015) (Figure 6). In an estimated maximum population size of 120,000 Australian fur seals (Kirkwood et al. 2010), this equates to 120 to 360 individuals at any point in time; a minimum estimate because we cannot count those that die at sea. Population level effects of entanglement are uncertain; even so, there are serious animal welfare concerns for entangled seals.

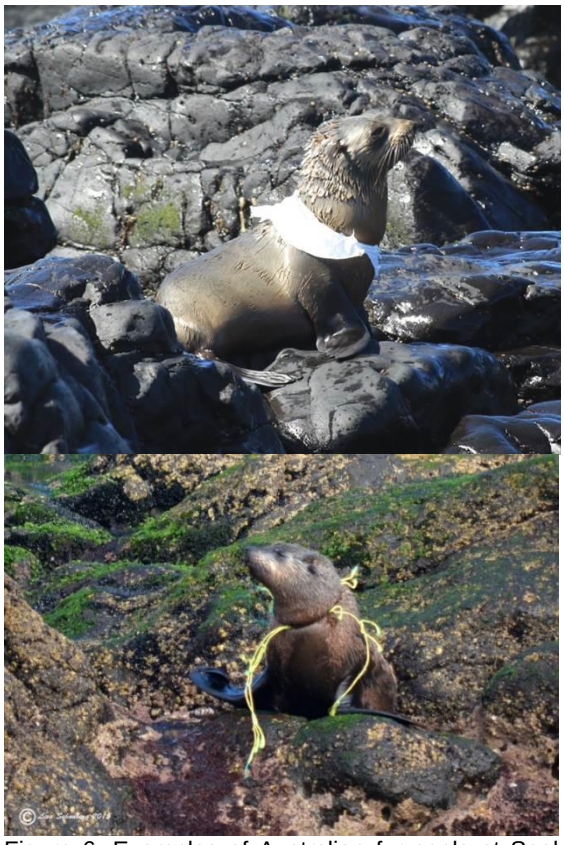


Figure 6. Examples of Australian fur seals at Seal Rocks entangled in a plastic bag (top © Karina Sorrell) and yellow trawl netting (bottom © Lisa Schoenburg).

It is mostly young fur seals that become entangled because they are naïve and playful (McIntosh et al. 2015). As they grow the material constricts; causing serious injury that can result in death if not removed.

Social licence and Industry

Social License to Operate, or simply social license, refers to the acceptance of an industry's practices by its employees, stakeholders and the general public.

Even though most marine plastic waste does not originate from fishing vessels, the perception that it might, threatens an industry's social licence.

The fishing industry believes that access to fishing grounds is provided by the Australian community. Brightly coloured trawl net entanglements are highly visible in the population, which gives the impression of a higher prevalence of that material compared to recreational fishing or urban materials and reflects poorly on the fishing industry.

Entanglement of marine wildlife in commercial materials is of concern to the industry, therefore members desire to improve the waste disposal practices of the industry and protect their social licence (Figure 7).

Aims of the project

Bins on Boats tackles marine pollution in five ways:

1. Auditing Victorian ports for compliance under MARPOL regarding the facilities provided for waste collection from vessels.

2. Providing free bins for boats designed to hold and retain on-board rubbish including net fragments and assessing the use and uptake of the bins.

3. Providing a code of practice for waste disposal on vessels.

4. Reporting the numbers of Australian fur seals entangled in marine plastic.

5. Recommending future actions and next steps to reduce marine plastic pollution.

Stakeholders and partnerships

Where possible Aboriginal businesses were procured: Indigi-Print (https://indigi-print.com.au/) was contracted to printed the stickers attached to the bins and Mabu Mabu (https://www.mabumabu.com.au/) catered for project stakeholder meetings.

Listed in alphabetical order:

-Australian Maritime Safety Authority (AMSA)

-Bunurong Land Council Aboriginal Corporation (BLCAC)

-Commercial fishers of SETFIA (Figure 7)

-Department of Jobs, Precincts and Regions (DJPR)

-Department of Land Water and Planning (DELWP)

-Environmental Protection Authority (EPA) Victoria

-Left Trade Gearstore, Lakes Entrance

-National Seafood Leadership Program (NSILP) Plastic Free Fish Team

-Parks Victoria (PV)

-Phillip Island Nature Parks (The Nature Parks)

-Port Phillip and Westernport Catchment Management Authority (PPWCMA)

-Royal Melbourne Institute of Technology (RMIT)

-Seafood Industry Victoria (SIV)

-SealSpotter Citizen Scientists

-South East Trawl Fishing Industry Association (SETFIA)

-Tangaroa Blue Foundation

-Victorian Fisheries Authority (VFA)

-Westernport Biosphere

-Zoos Victoria – Marine Response Unit

Figure 7. *"As fishers we care for the ocean environment we make our living from, and the bin program will only help in the waste management procedures we already have on board our vessel."* ~ Luke Hill, SETFIA member and skipper of the Metis, San Remo

2. METHODS

Stakeholder workshop

To maximise the success of the project a Stakeholder Workshop was held at the Melbourne office of the EPA at beginning of the project. Invitees included representatives of the organisations listed on the previous page.

MARPOL Audit of waste management practices of Victorian Ports

We contrasted Australia's commitment to MARPOL Annex V versus the waste disposal services available for fishing vessels domiciled in Victoria's ports run by state-owned port companies (Figure 8). Information was obtained by phone or in-person interviews and using the Global Integrated Shipping Information System (GISIS) database (https://gisis.imo.org/). Note, the GISIS database did not include Annex V information for Eden, San Remo, Mallacoota and Port Albert.

Provision of custom-made bins to SEFTIA vessels domiciled in Victorian waters

SETFIA designed a low-cost wheelie bin with a wind proof lid that was strapped closed, and material could not resurface through the rubber hole in the top (Figure 7 & Figure 9). The bins were manufactured in Perth, Western Australia, in four sizes (80, 120, 140 and 240L).

Commercial fisheries in waters adjacent to Victoria are managed either by the Commonwealth (Australian Fisheries Management Authority) or the Victorian State Government (Victorian Fisheries Association) with each manager then further dividing their jurisdictions into small units called fisheries or sectors. To add further complexity, some commercial fishing vessels work across multiple fisheries and multiple states.

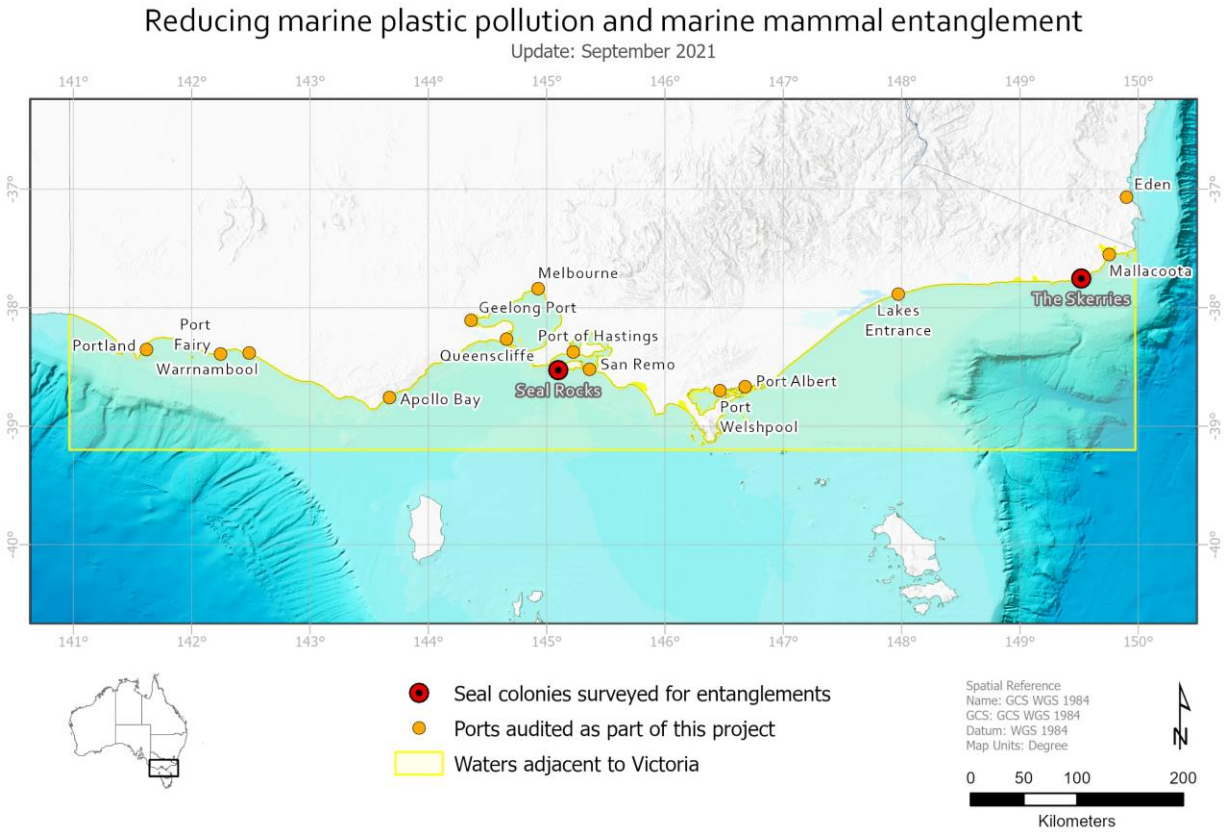


Figure 8. Map of Victoria showing the two Australian fur seal breeding colonies (the Skerries and Seal Rocks) where seals with marine debris entanglements were monitored and the ports that were audited and custom-made "Bins on Boats" bins were distributed.

Mindful of this complexity, The Nature Parks collaborated with the SETFIA, a not-for-profit industry association that represents the Commonwealth Trawl Sector (the CTS, also known as the South-East Trawl Fishery). SETFIA has strong linkages into other Commonwealth and State-run fisheries (sectors). To qualify for a free bin, vessels were required to be domiciled in a Victorian port and/or working in *waters adjacent to Victoria* (WATV) (Figure 8) for some of the year using trawl netting, gillnetting, rope or other potentially damaging waste materials.

An advertisement offering the bins was shared (Figure 9) via the SETFIA Online Newsletter, SETFIA SMS text message communication lists, as well as the AMSA 'Working Boats' magazine. The nesting bins were freighted to various Victorian ports and distributed from Cooperatives or sent to factories and residences with records kept of distribution.

Surveys of vessels waste management practices before and after use of bins

A survey was designed to determine vessel rubbish management practices prior to the custom-built bin distribution and after a minimum of six months of the custom-bin bin use (Appendix 1). Vessels were visited in person by a SETFIA representative at Lakes Entrance and participation was voluntary.

Photographs of pre and post bin use practices were taken to support information gathered as well as information on the size of the bin, the contents of the bins in material types and the volume of waste in the bin.

Comments from users regarding the success or otherwise of the bin design were also recorded. Behaviour Change academics (Dr Alex Kusmanoff and Dr Sarah Bekessy) from RMIT University obtained ethics approval to examine and analyse the survey data (Kusmanoff et al. 2022).

Behaviour change and promoting a sustainable fishery

The starting assumption was that fishers understand the MARPOL requirements (Skippers are trained in MARPOL regs) and that loss of material overboard was accidental due to sub-optimal waste systems.

It was expected that by making waste management easier through the provision of a suitably designed bin, more waste would be captured onboard.

In the event of fishers that did not understand or practice appropriate waste management

Figure 9. The advertisement used to promote orders for the bins within the fleet.

behaviour. It was expected that they would change their behaviour due to the education provided with the bins (Code of Practice, Appendix 2), the industry expectations and the simplicity of the system.

Code of Practice provided to all vessels

A Code of Practice was developed and distributed with the bins after industry approval via General Meeting Resolution (Appendix 2). The code outlines appropriate waste management at sea under MARPOL and the harm caused to the collective social licence of the industry by marine mammal entanglements and marine plastic pollution.

Stickers on Bins

Behaviour Change academics from RMIT University designed two stickers for the bins to test messaging techniques (Figure 10). Bins were randomly assigned a sticker prior to distribution. Sticker a) provided a simple direction and emphasised the benefit to the sea and industry of ensuring proper disposal; sticker b) combined the simple direction with an injunctive social norm that reinforced that proper behaviour was the socially approved and expected behaviour (Kusmanoff et al. 2022).

a) Please do not discard rubbish overboard. Put your rubbish in this bin to help protect our sea and industry.
b) Responsible fishermen do not discard rubbish overboard. Put your rubbish in this bin.

Both stickers used a visual prompt of a photo of spent fishing gear and other rubbish in the bin (Figure 10).

Marine debris data from AMDI Database

Plastic in the ocean is ubiquitous and moves around with the currents making the source of marine plastic pollution difficult to determine. To better understand patterns of marine pollution in Victorian waters, we mapped marine plastic pollution collected by volunteer groups across the beaches of Victoria using four regions: West coast, Central coast, Port Phillip and East Coast.

Figure 10. Stickers used on the bins to advise on suitable bin use.

The Tangaroa Blue Foundation (TBF) maintains the Australian Marine Debris Initiative (AMDI) Database as a repository for beach and water-ways clean-up data across Australia. We access data from January 2018-January 2021. A list of the volunteer groups that collected the data is provided in Appendix 3 (Figure 11).

Marine debris are sorted by material type and the number of individual items or the length of material in metres, recorded in a predefined form for consistency across surveys. Effort in time, location and frequency of beach cleans was not uniform across the state or time-period so data were standardised by distance of beach covered as a total for each identified location over the duration of the dataset.

We focussed on (i) the most common items, (ii) those that could cause entanglement to marine mammals including commercial and recreational fishing materials and (iii) urban items for comparison.

Entanglements observed on Australian fur seals

Entanglements recorded from research trips to Seal Rocks

Entangled seals were counted and rescued when possible, during research visits to Seal Rocks near Phillip Island, Victoria (Figure 8). Trips occurred every two months outside of the breeding season from 2017-2020. The type of material entangling the seals was recorded and grouped by material type. The total number of entanglements for each year were calculated and the maximum observed in a single survey compared per year.

Given the ubiquitous and legacy presence of plastic in the ocean we did not expect to see an immediate reduction in entanglements.

Modelling the entanglement observations from field trips at Seal Rocks

Generalised linear models (GLMs) were applied to ground counts of entangled seals at Seal Rocks from 1997-2020 using the r statistical framework (version 4.1.0 https://www.r-project.org/). The relationship between the number of seals observed entangled per year over time was modelled with effort (number of trips per year) as a random

Figure 11. turn the Tide volunteers at Phillip Island Nature Parks sorting and counting marine debris items for the Tangaroa Blue database at Phillip Island Nature Parks.

variable. Distribution selection (eg Poisson or Negative Binomial for count data) and model fit was checked examining the residual fit and dispersion parameters. We then modelled trends over time for the two most common entangling materials – commercial trawl net and recreational fishing line.

Trawl net entanglements observed from drone surveys

Phillip Island Nature Parks performed remote piloted aircraft (RPA or drone) surveys of Seal Rocks and The Skerries in East Gippsland near Mallacoota (Figure 8) during the breeding seasons (Nov-Dec) of 2017-2020. Images were processed as identified in McIntosh et al. (2018) and total seals, pups and entangled seals were counted by Citizen Scientists using the online 'SealSpotter' portal. Trawl net entanglements are obvious in 'SealSpotter' (Figure 12) and were counted with confidence.

Next, Citizen Scientists and up to two experts were provided with zoomed images of labelled entangled seals including replicates, which they validated using a confidence score (0, 25, 50, 75, 100%). The material entangling the seal was also recorded during validation. The maximum number of validated entangled seals identified per survey was provided per year. The prevalence of entanglement was calculated by dividing the maximum validated entanglements by the total number of seals present, excluding newborn pups. To provide this value as a percent, the prevalence is multiplied by 100.

Figure 12. Remote piloted aircraft (drone) image of entangled seal in green trawl net on Seal Rocks

3. RESULTS

Stakeholder workshop

Outcomes of the stakeholder workshop included broad industry and stakeholder engagement and enhanced media promotion. The value of collaborating with the social sciences became apparent as bin labels and survey design was determined.

Nine attendees represented eight organisations at the workshop (PINP, SETFIA, EPA, RMIT, PV, PPWCMA, AMSA and SIV).

Figure 13. Bins being collected from Gearstore at Lakes Entrance.

MARPOL Audit of waste management practices of Victorian Ports

Waste management procedures for six ports out of the ten where bins were distributed were available in the GISIS database (https://gisis.imo.org/): namely Eden, Geelong, Hastings, Lakes Entrance, Melbourne and Portland. All port receiving facilities catered for garbage under MARPOL Annex V (Table 1), except Eden where vessel operators dispose to local refuse. Mallacoota and Port Albert are managed by the Gippsland Ports Authority with compliance under MARPOL and San Remo has skip facilities to manage vessel waste. At some ports sub-contractors are used for larger volumes with extra charges incurred.

Provision of custom-made bins to SEFTIA vessels domiciled in Victorian waters

100 custom built bins were delivered to Left Trade Gearstore at Lakes Entrance, Victoria for distribution. Some were collected by fishers (Figure 13), with the remainder delivered to vessels by SETFIA staff or freighted with other ordered stock to minimise delivery costs. Distribution was completed within the first six months of the project.

Given the multi-jurisdictional management of commercial fishing in Australia and movement of vessels between states it was difficult to determine exactly how many vessels qualified for a bin (domiciling in a Victorian port or fishing in waters adjacent to Victoria), but SETFIA estimated this to be 75 vessels at the time the bins were purchased.

Of the 100 bins available, 92 were taken up by 48 vessels (CTS and Victorian trawl sectors), who generally took one or two bins (Table 2). Requests from vessels differed for example: small vessels generally only wanted a single smaller sized bin while crayfish vessels who dealt with more waste, e.g. strapping and cardboard used to store bait, requested up to four bins (Table 3).

Figure 14. Three examples of vessels making their own onboard bins: (right) an open tub for waste, (centre) a vessel in Hobart, Tasmania with a self-made bin similar to the ‘Bins on Boats’ version, but not quite as user-friendly because it doesn’t have a punch through on the lid, (right) a simple bucket for waste.

Table 1. Audit of ten Port Receiving Facilities in Victoria and the type of garbage they will receive from two MARPOL annexes (V and I). Green = yes it will be received, orange = no it will not be received. Sites left to right are: Lakes Entrance, Port Welshpool, Hastings, Melbourne Port, Geelong, Queenscliffe, Apollo Bay, Warrnambool, Port Fairy and Portland. All sites were able to accept garbage from the "Bins on Boats" bins (MARPOL Annex V).

Garbage under *MARPOL Annex V*										
Port Receiving Facility	Lakes Ent	Port Welsh	Hast	Melb Port	Geel	Q'cliff	Apollo Bay	Warrn	Port Fairy	Portland
Plastics/bags/bottles										
Fishing nets/trimmings										
Cardboard/Paper/Rags										
Glass bottles/aluminium cans										
Food Wastes										
Rags										
Metals/Cans/Drum Reels										
Garbage under Marpol Annex 1										
Port Receiving Facility	Lakes Ent	Port Welsh	Wn Port	Melb Port	Geel	Q'cliff	Apollo Bay	Warrn	Port Fairy	Portland
Oils/engine/gearbox/hydraulics										no hydraulic
Oil filters/fuel/air										
Oily rags										
Bilge oil							limited capacity			

Table 2. Number of qualifying vessels that requested bins and their sector.

Vessel	Management Authority	Number of vessels
Commonwealth Trawl Sector (CTS)	Commonwealth	22
GHaT Shark	Commonwealth	6
Scallop	Commonwealth and Victorian	3
Rock Lobster	Victorian	4
Octopus	Victorian	3
Inshore Trawl	Victorian	2
Other sectors	Victorian	1
Unknown or multiple fishery		7
TOTAL		**48**

Table 3. Size and number of bins ordered and distributed. The remainder have been used for training and community awareness events and will be distributed to vessels as requested.

Size in volume (Litres)	Number ordered	Number distributed
80	20	20
120	20	20
140	20	20
240	40	32
TOTAL	**100**	**92**

Surveys of vessels waste management practices before and after use of bins

We obtained 37 pre- and 23 post- bin use surveys from SETFIA vessels at Lakes Entrance (Table 4). Eight vessels did not have a bin on board prior to the program. Most vessels did have a bin in use prior to the provision of the custom-built bin, but they were often unlidded (Figure 14). Analyses of data from the surveys identified that the custom-built bins were fit for purpose, easy to use and improved waste management practices onboard vessels (Kusmanoff et al. 2022).

From the pre- and post- bin use surveys, 36 respondents identified that rubbish collected at sea was disposed of with Council (or contractor on behalf of council) (n=6), themselves (n=6) or the Port Company (n=24).

The simplicity of the new bins and their free distribution was considered key to their success (Kusmanoff et al. 2022).

The survey results provided evidence that the program increased retention of broken fishing gear specifically (Figure 15). Before the program, only 1 vessel was observed to retain nets and ropes, compared to 8 observations of nets and ropes afterwards This includes 4 vessels observed both before and after, 3 of which had not initially been noted to collect nets and ropes (Kusmanoff et al. 2022).

The custom designed bins collected more waste at sea compared to the ad-hoc system used before the program (Kusmanoff et al. 2022). On average, the volume of bin storage increased by around 20 litres and the relative fullness of bins increased by 14% (Figure 16) (this effect size is understated by the average 20 litre volume increase). After combining volume and bin fullness, the average volume (per vessel) of rubbish returned to shore was estimated to have increased from an average of 31 litres before the program to 66 litres after the program (Figure 16) (Kusmanoff et al. 2022).

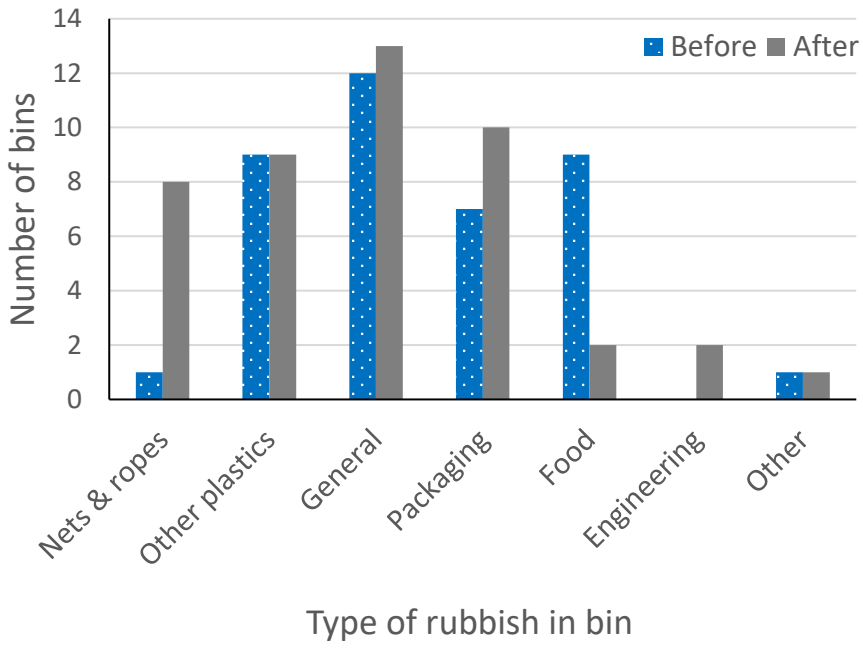


Figure 15. Number of bins containing different waste for self-provided bins (before) and the custom made – “Bins on Boats” bin (after).

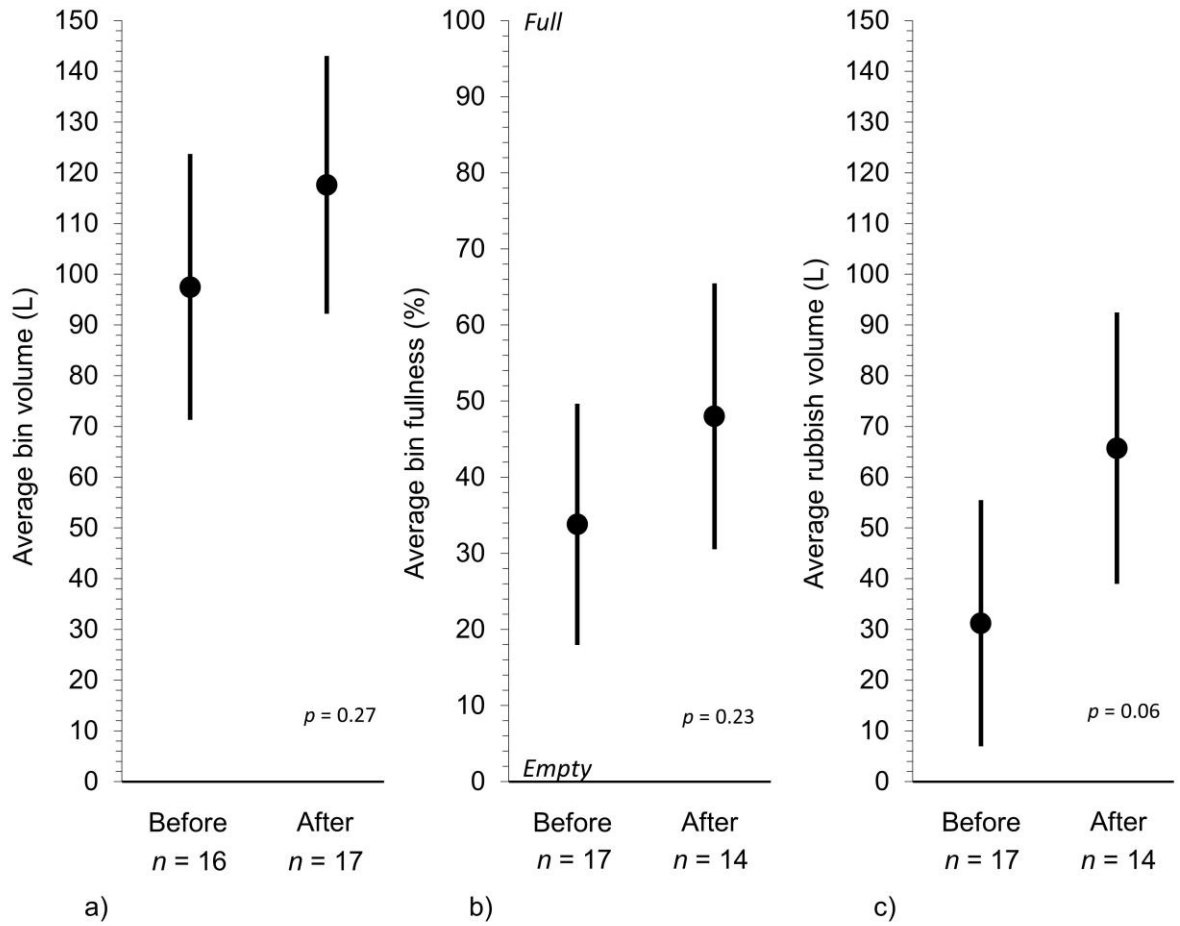


Figure 16. Observations made of commercial fishing vessels before and after the program: average bin volume per vessel (a); average bin fullness per vessel (b); and average rubbish volume per vessel (c), including 95% confidence intervals (CI). All measures were greater after the program, resulting in an approximate doubling of the average volume of rubbish observed being returned to port for disposal. CIs were calculated and figures plotted using the Exploratory Software for Confidence Intervals (Cumming 2016). Source of figure Kusmanoff et al. (2022).

Behaviour change and promoting a sustainable fishery

The survey results suggest that behaviour change was achieved because more waste was collected and returned to Port compared to when ad-hoc waste practices were in use (Kusmanoff et al. 2022).

Comments provided by fishers during the post-use survey also support that the bins were fit for purpose and easy to use, thus making it convenient and simple to properly and securely dispose of spent gear (Table 4).

Code of Practice provided to all vessels

The Code of Practice (Appendix 2) was provided inside the bin upon distribution. We did not test the efficacy or response of the fishers to the Code of Practice. Any such code should be prepared to conform with the specifics of the fishery being targeted, but our example may be used as a model.

Stickers on Bins

Unfortunately we did not have a large enough sample size to test the efficacy of either sticker type (Kusmanoff et al. 2022). From the post-bin use surveys, 16 of the respondents had sticker type 1: “Responsible fishermen do not discard rubbish overboard”; while four of the respondents had type 2 “Please do not discard rubbish overboard” Both types of messaging may be effective and it would be useful to test this in another fishery with a larger sample size.

Figure 17. Image taken by Colleen Hughson from Warrnambool beach clean-up team in April 2021 showing amount and range of marine debris materials collected from the beach. Items are counted and submitted to Tangaroa Blue for entry into the database.

Table 4. Survey responses (n=20) that commented on the custom-made bin provided to the vessels.

Sticker message on the bin	**Number of bins surveyed**	**Comments provided**
RESPONSIBLE FISHERMEN DO NOT DISCARD RUBBISH OVERBOARD	16	Bin is very handy onboard the vessel Bin is very handy, however, difficult to dispose of contents when the shore waste bin is already full No issues with the bin. Very convenient No issues (5 respondents) Good idea. Bin is very handy Bin is secured on deck to stop washing away. Bin is very handy for containment of rope and net trimmings Our vessel is a Tour Ferry vessel. Master situates 2x80 ltr under coffee machine table. Enquiries from patrons of the bins leads to very positive responses from them regarding gippsland lakes pollution mitigation measures. Very pleased with the convenience of the bin
PLEASE DO NOT DISCARD RUBBISH OVERBOARD	4	The bin is aboard the Training Vessel and in the classroom at SEAMEC East Gippsland TAFE Maritime College. BIN is used onboard the vessel and in the classroom to demonstrate MARPOL garbage disposal protocols aboard vessels in the College training program. Manager Brad reports a great response from commercial trainees as well as recreational operators. Unable to photograph or inspect bin due to Covid19 requirements set by EG TAFE. Skipper is very happy with the convenience of the bin No issues Master is happy with the convenience of the bin

Marine debris data from the AMDI Database

71 volunteer groups and organisations (Figure 17, Appendix 2) spent 16,795 hours with 6,833 persons, cleaning up beaches across Victoria during 1,554 individual beach sessions from Jan 2018 to Jan 2021 inclusive. The total number of volunteers provided in Table 5 sums the individuals present at each survey.

Tangaroa Blue data in the AMDI Database are recorded in two metrics: items in metres of length and total number of items – per survey. Given differences in how surveys were performed and the high variability in effort (Table 5), we did not perform statistical comparisons. All data were standardised per km travelled at each location to allow comparison. Port Phillip regions is quite distinct from other regions with the high number of volunteers, but small distance covered and low survey number. This is caused by large school groups and other groups performing short surveys for educational purposes.

Figure 18 shows the total counts for the top 20 items collected (Jan 2019 - Jan 2021 inclusive) across the Victorian coastline. Figure 19 compares the 5 items recorded in length by length of items in metres (Jan 2019 - Jan 2021 inclusive).

For the length of nets, recreational lines and ropes in metres: most were collected on the East coast of Victoria (Figure 20, Figure 21). Monofilament gillnets were so rarely collected that they were not included in the top 20 items or other comparisons.

Rope and net scraps less than one metre were most common on the East and West Coast of Victoria (Figure 22).

Most recreational fishing items, box strapping bands (Figure 22) and cigarette buts and filters (Figure 23) were collected in Port Phillip and Central Coast.

Small plastic bits were common everywhere, but less so on the West coast, likely because those surveys focussed more on large items of marine debris: nets and ropes (Figure 23). Plastic bags and garbage were overwhelmingly more common in Port Phillip, as were other urban items such as rubber balloons, toys and bands (Figure 24).

Table 5. Effort in Tangaroa Blue beach clean-ups in the Australian Marine Debris Initiative Database (AMDI) for the four regions of Victoria.

Region	Total volunteers	Total hours	Total distance km	Total surveys
Central coast	2,125	5,332.1	741.0	508
East coast	101	168.5	69.5	19
Port Phillip	2,091	7,202.6	75.8	106
West coast	2,516	4,092.0	766.2	921
Total	6,833	16,795.23	1652.6	1,554

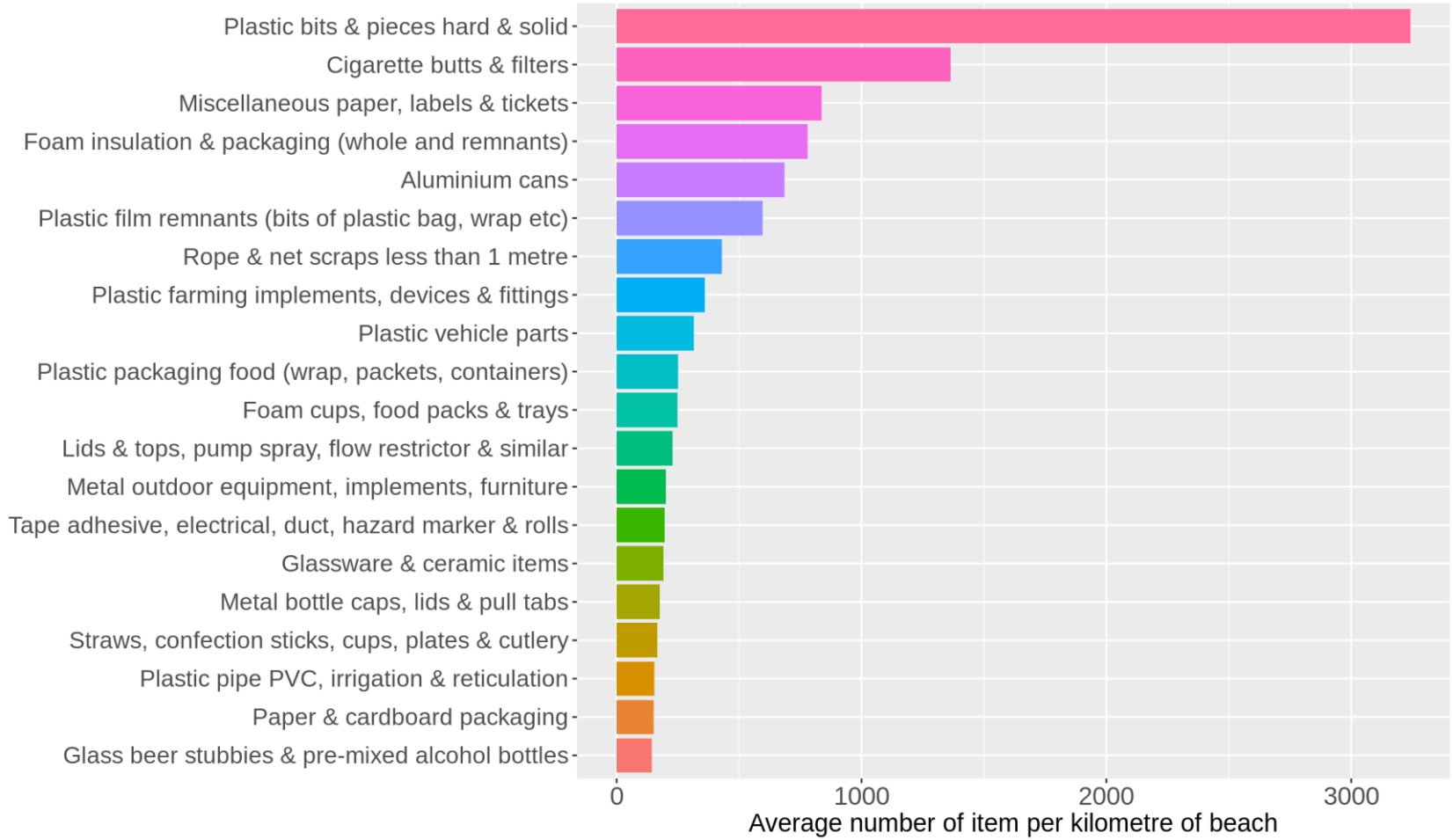


Figure 18. Top 20 marine debris items from the AMDI database collected across the Victorian coastline January 2018 to January 2021 inclusive. Data are presented as average number of items per kilometre of beach to standardise the variable effort in survey frequency and time.

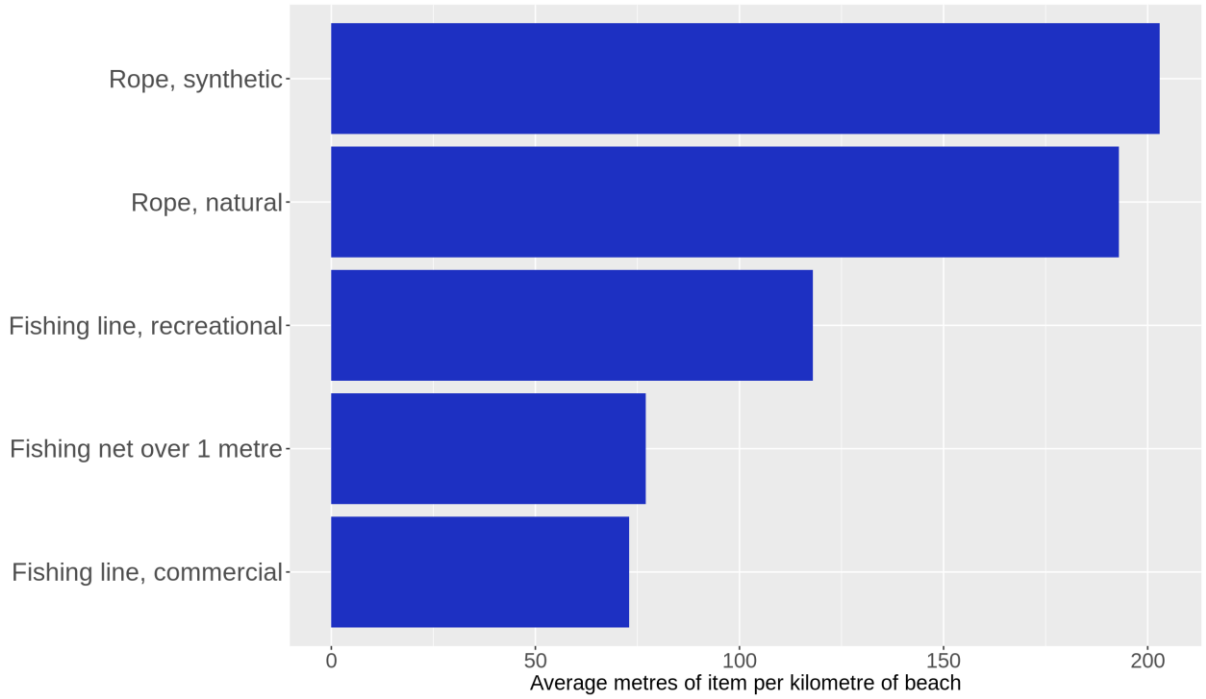


Figure 19. Comparison of the five items of marine debris measured in length (m) reported across the Victorian coastline (Jan 2019 -Jan 2021 inclusive), recorded in the AMDI Database. Data are shown as the average metres per item per km of beach to standardise the variable effort in survey location frequency and time.

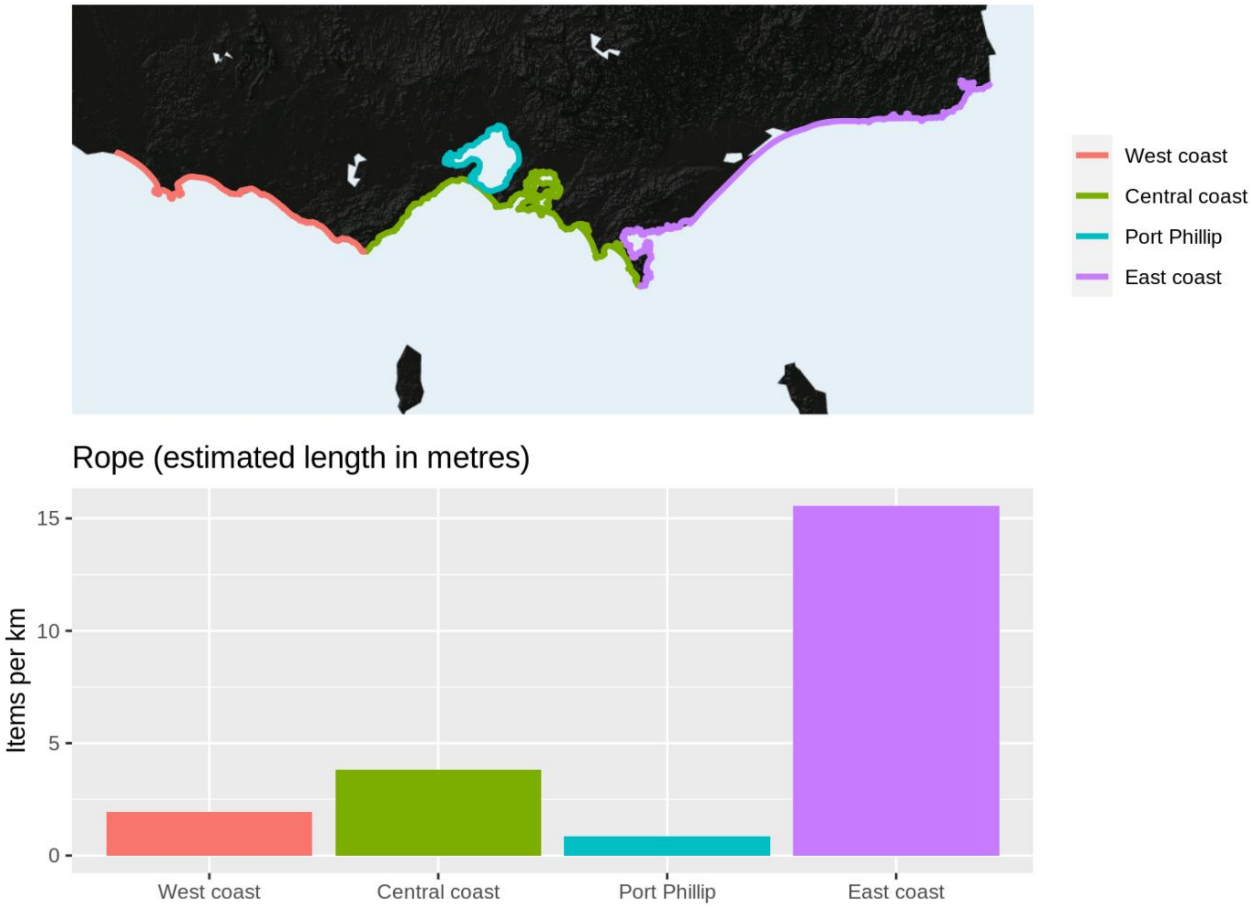


Figure 20. Comparison of rope (by estimated length in metres) per km of beach survey performed across four coastal regions of Victoria. Rope can be sourced to multiple users from January 2018-January 2021 inclusive.

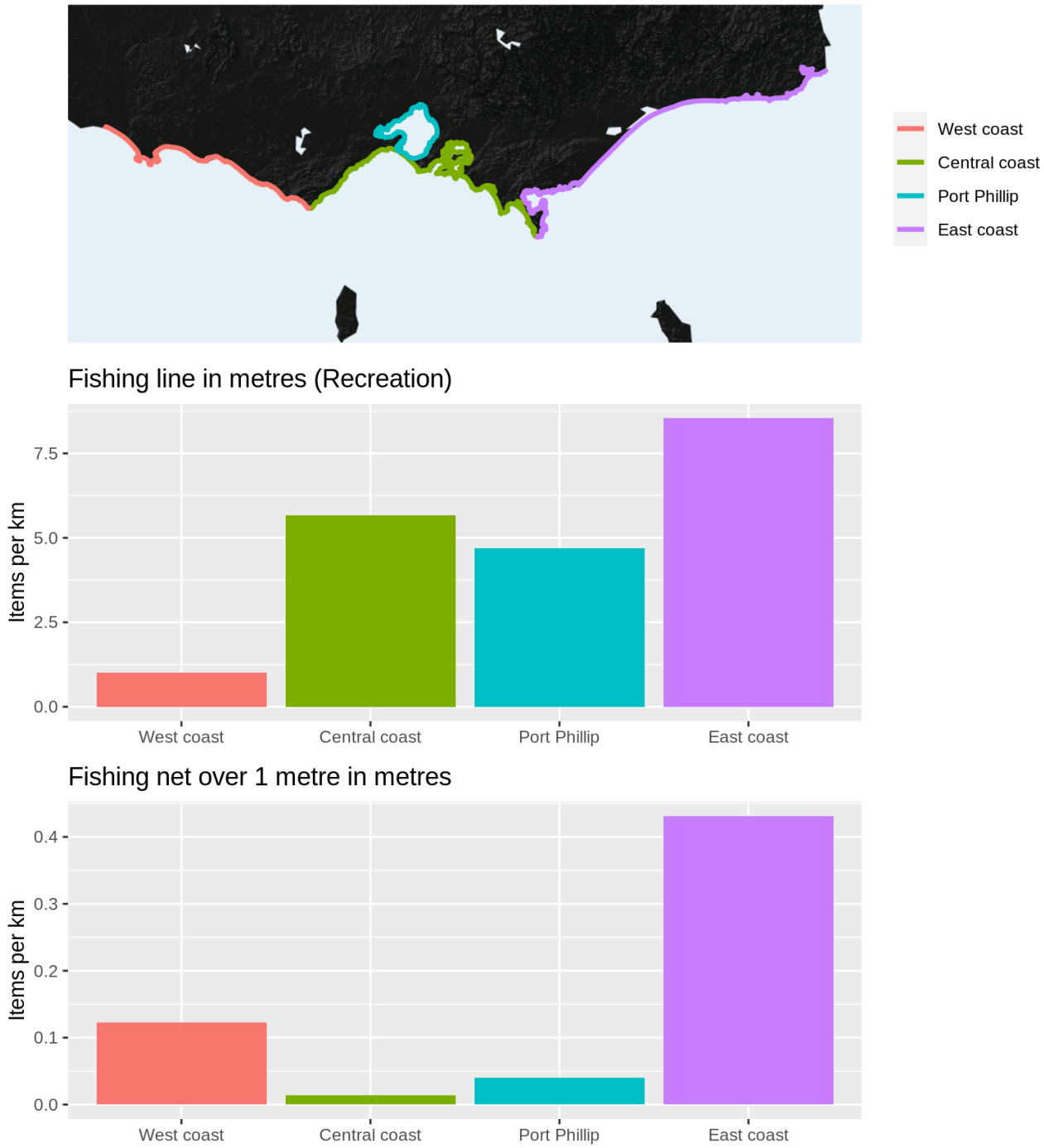


Figure 21. Comparison of recreational fishing line and trawl fishing net over 1m (by estimated length in metres) per km of beach survey performed across four coastal regions of Victoria.

Figure 22. Comparison of rope and net scraps less than one metre and whole strapping bands (by individual item) per km of beach survey performed across four coastal regions of Victoria.

Figure 23. Comparison of cigarette butts and filters and plastic bits (by individual item) per km of beach survey performed across four coastal regions of Victoria. Cigarette garbage has a clear user source; however, plastic bits are broken-down waste from multiple sources.

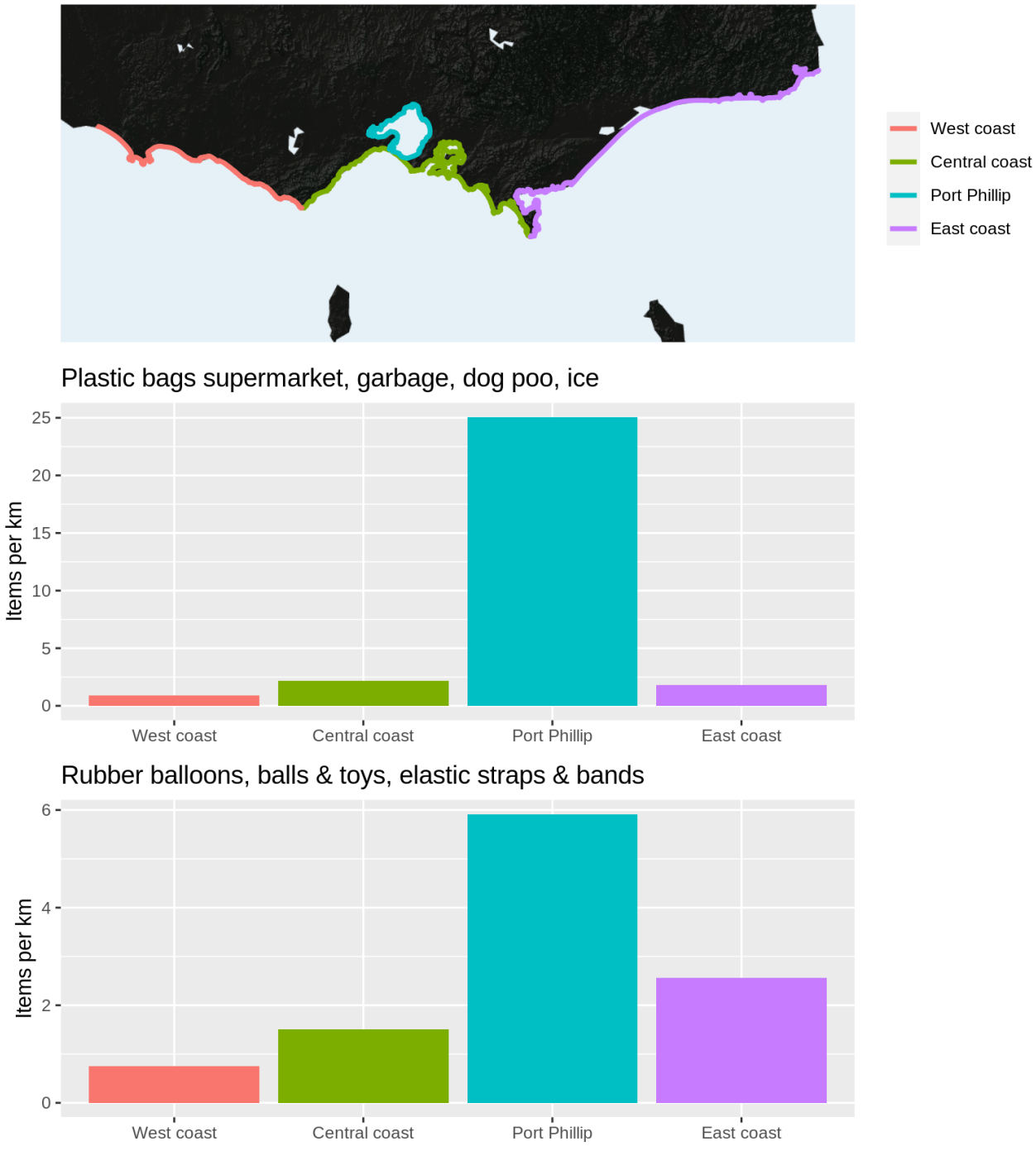


Figure 24. Comparison of plastic bags etc and rubber balloons etc (by individual item) per km of beach survey performed across four coastal regions of Victoria. These items are considered urban garbage.

Entanglements observed on Australian fur seals

Entanglements recorded from research trips to Seal Rocks

From January 2017-December 2020 inclusive, a total of 79 entanglements were observed during an average of 6 field trips per year at Seal Rocks; 42 (53%) of these seals were captured and released by Nature Parks staff.

Although 2017-2020 provides a short time-series; when comparing a single survey for each year, using the survey with the maximum number of entanglements, the correlation reduced (r^2 = -0.72) over time (Figure 26).

The two highest single category of entanglement material observed at Seal Rocks during field trips were recreational fishing line and commercial net, the remaining materials were combined as "other" (Figure 26). The number of commercial net entanglements reduced to two observed at Seal Rocks in 2020 (Figure 26).

Modelling the entanglement observations from field trips at Seal Rocks

Using Generalised Linear Models (GLMs) with a binomial distribution to account for the large dispersion parameter (between 1.5 and 4) and including effort (number of trips per year) as a random factor, entanglement observations at Seal Rocks were compared over time (Figure 27).

From 1997-2020 there was no significant change in the total number of entanglements observed at Seal Rocks. Looking at the two main entangling materials: there was also no significant change in the number of recreational fishing line entanglements; however, trawl net entanglements reduced significantly (p=0.003) over the 23 years.

Trawl net entanglements observed from drone surveys

From 2017-2020, images from drone surveys each breeding season (Nov-Dec) at Seal Rocks and The Skerries, were counted during the 'Annual SealSpotter Challenge' by 1,657 Citizen Scientists living in 93 countries across the globe, through the web-portal:

(https://natureparksresearch.com.au/sealSpotter/).

Individual fur seals were identified as entangled in trawl net with 100% confidence because the material was obvious compared to fishing line and other entanglements that are often embedded in the skin. At Seal Rocks, 4-5 surveys were performed each breeding season, whereas only a single survey was performed at The Skerries. Table 6 shows the results from the drone surveys and the entanglement prevalence from 2017-2020. The number of entanglements validated from drone surveys with 100% certainty has reduced over time (Figure 28).

Table 6. Number of drone surveys (N) performed during the breeding season (Nov-Dec) over Seal Rocks (SR) and The Skerries (SK) counted by Citizen Scientists during the 'Annual SealSpotter Challenge' from 2017-2020. Results provided are the maximum counts from a single survey and include the maximum entanglements in trawl net, the maximum combined entanglements identified with over 50% certainty and the maximum number of seals present (excluding new-born pups). The prevalence is calculated as the maximum entanglement/the maximum number of seals present.

	N		Max count trawl net		Max entanglement		Max seals		Prevalence	
Year	SR	SK	SR	SK	SR	SK	SR	SK	SR	SK
2017	3	1	2	0	12	8	6465	na	0.002	na
2018	2	1	0	0	8	7	5823	4571	0.001	0.001
2019	2	1	1	0	6	2	7190	3484	0.001	0.001
2020	3	1	0	0	10	3	6488	3576	0.001	0.001
				Average	9	5	6491	3877	0.001	0.001

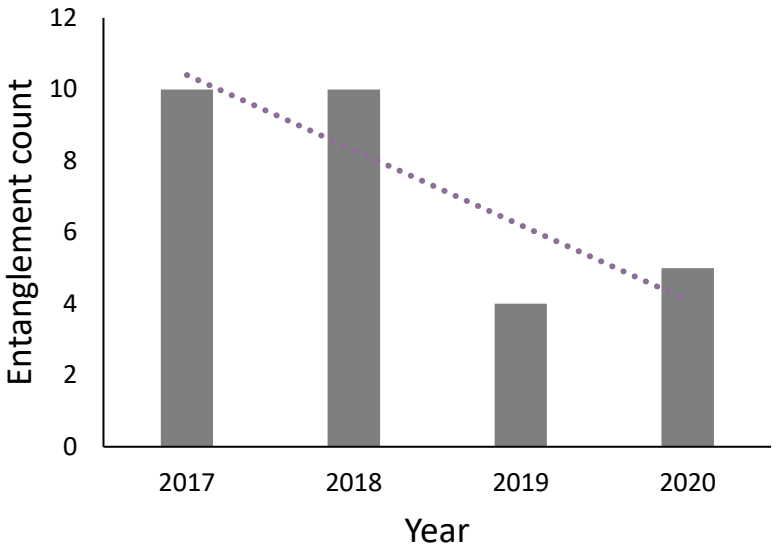


Figure 25. Maximum single survey count of entangled seals seen on Seal Rocks by researchers 2017 to 2020 from at least 6 visits per year. Dotted line indicates a reduction over time using simple correlation $r^2 = 0.72$ (the closer to 1.0 the stronger the trend).

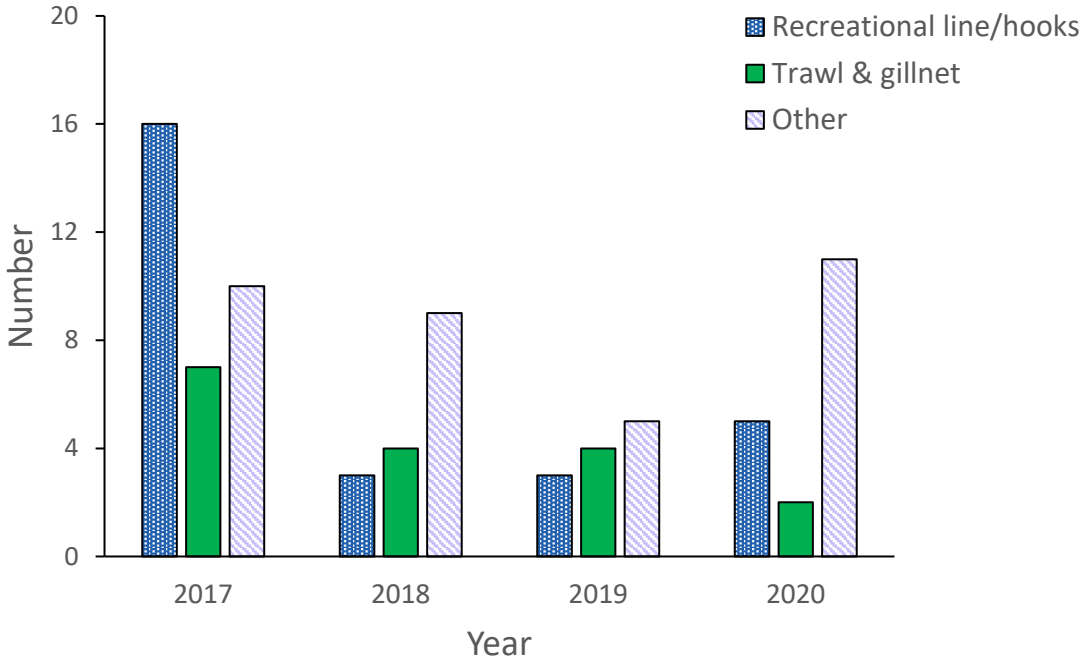


Figure 26. Sum of the number of individual entanglements observed on Australian fur seals at Seal Rocks caused by recreational fishing, trawl net and 2 monofilament gillnet, and other types of entanglements combined from 2017-2020.

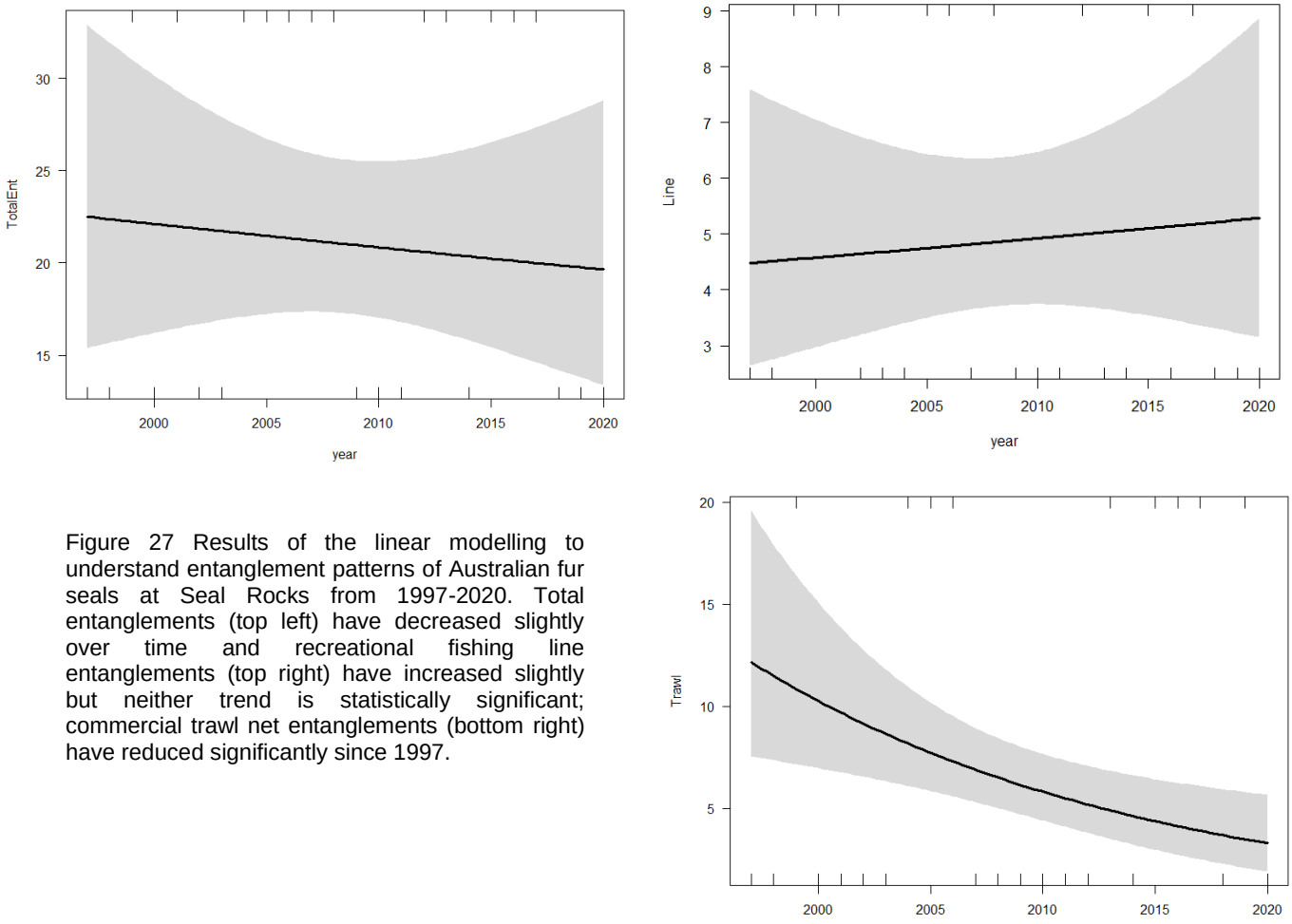


Figure 27 Results of the linear modelling to understand entanglement patterns of Australian fur seals at Seal Rocks from 1997-2020. Total entanglements (top left) have decreased slightly over time and recreational fishing line entanglements (top right) have increased slightly but neither trend is statistically significant; commercial trawl net entanglements (bottom right) have reduced significantly since 1997.

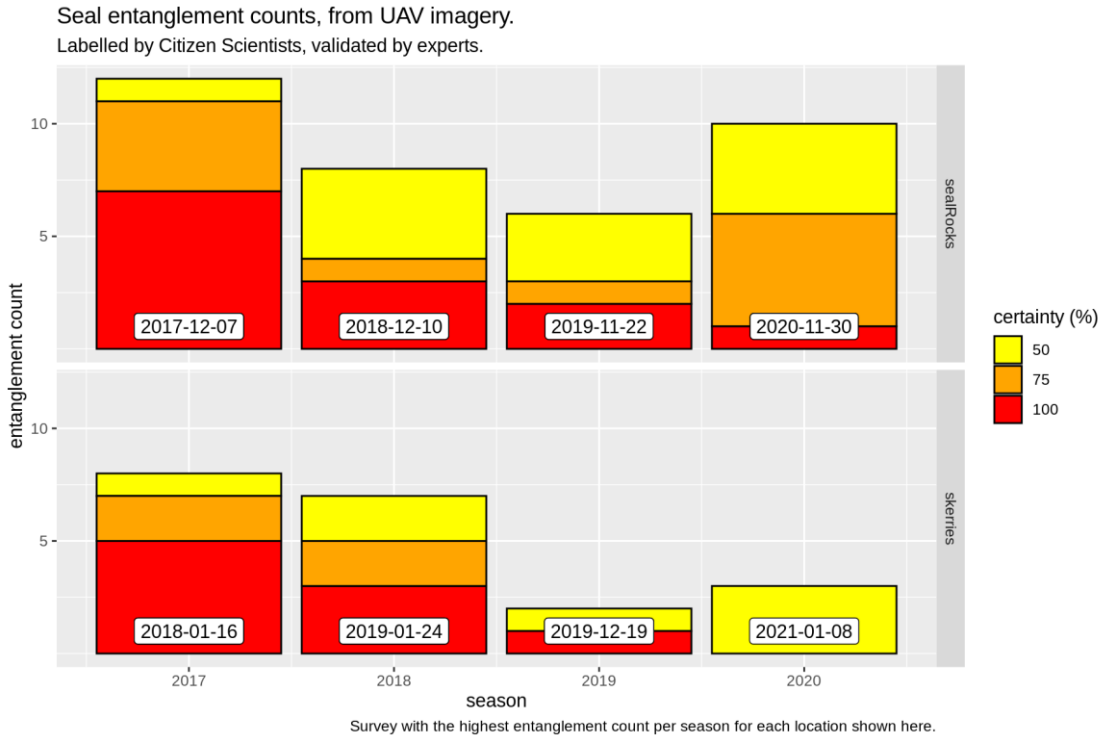


Figure 28. Maximum count of entanglements at Seal Rocks and The Skerries from 2017-2020 using Citizen Science data from drone images counted in SealSpotter.

4. DISCUSSION

Summary of bin use and project aims (success)

Waste management at ports

The Ports audited in this project did provide facilities for disposal of nets and line and general garbage under MARPOL (Table 1). However, larger volumes of waste can lead to costs being incurred by the vessel operators. Additionally, the terms of waste management can be interpreted differently and cause uncertainty or make the task of offloading waste more complex that could lead to lower compliance. Unfortunately, some bins have been misused at ports in the past, which has led to bins being locked or removed by management bodies at some sites (Figure 29). Currently there is no expectation of recycling net materials at Ports.

Uptake of bins on vessels

All qualifying vessels accepted at least one bin and there was rapid uptake. Despite not qualifying, fisheries managers and co-ops in NSW and WA were interested in the project and implementing a similar bin system. This shows an appetite for custom built bins to improve waste management systems nationally. There was no discussion of who would pay for the bins, but more a general interest in the program.

Surveys of waste management onboard vessels

The onboard surveys identified that various bins were being used for capturing waste onboard vessels, with many being simple plastic bags or open tubs. The custom-made bins provided by this project offered an improved bin that was useful and safe to use on the deck of the boats (Figure 30).

Figure 29. Example images of bins at ports that are no longer available for MARPOL waste (left) because of perceived misuse, unsuitable facilities and lack of end-of-life solutions for plastics and other wastes. Placing chains (right) into bins is an example of misuse that can lead to bin removal or locking.

Figure 30. Bins on board fishing vessels.

Comparing before and after surveys; the volume of bin contents increased and included general garbage, food packaging, net fragments and ropes. Sample size was small, but there was evidence that the new bins increased retention of waste fishing gear (Figure 30).

Marine debris data from AMDI database

Results of the AMDI database supported expectations that urban rubbish items (e.g. cigarette buts, plastic bags) were the highest total items counted in more urbanised areas. Items in the database were collated in two metrics that had to be examined separately; items that were individually counted and items that were measured by metre of length. Rope and net scraps less than 1m were the 7th top individual item counted across Victorian coastlines (Figure 18) and synthetic rope was the top item for the five materials measured by length (m) rather than individual count (Figure 19). Recreational and commercial fishing debris were higher in eastern and western Victoria and small plastic pieces that come from broken up hard plastic, likely from many sources, were found in all areas and represent the overall problem of marine debris.

The fishing industry recognises that commercial fishing waste being collected on Victorian beaches constitutes a social licence problem and is not only entangling marine life and reducing the quality of ecosystems but is also breaking up into smaller and smaller pieces and ultimately entering the food chain.

The burden of this issue rests upon us all: the community, the resource users and the governing bodies. Improved waste management solutions include capturing urban waste at freshwater inputs and coastal areas and improved recycling schemes for plastics (for more information on global net recycling schemes, see Appendix 4).

Entanglements observed on Australian fur seals in Victoria

Since 1997, recreational fishing line and trawl net fragments have been the predominant single material types entangling Australian fur seals at Seal Rocks. Over time, the number of total entanglements observed during field trips at Seal Rocks has reduced, but the trend was not statistically significant.

From the drone surveys, we estimated the total entangled seals and the total number of seals present at the time to determine the prevalence of entanglement in the population. From 2017 to 2020, the average prevalence of entangled fur seals at Seal Rocks and The Skerries was 0.1%, similar to previously reported prevalence estimates in Victorian breeding colonies that ranged from 0.1-0.3% (Claro et al. 2019). These drone estimates support the results from the modelling of the field data that overall entanglement rates have not reduced.

Interestingly, the number of trawl net entanglements at Seal Rocks (Figure 31) did significantly reduce from 1997-2020, which is most likely attributed to the fishing fleet buy-back in 2005 that reduced the number of working boats by 50% from 118 trawl licences (Newton et al. 2007, McIntosh et al. 2015). Even so, trawl net entanglements observed on both field trips and drone surveys reduced over the duration of the study (2017-2020) when the corresponding fishing effort of the fleet had not changed (Figures 27 & 28).

In this study, only drone surveys obtained during the breeding season were counted and may not be as indicative as field trips of true entanglement prevalence. This is because pups and juveniles are the most commonly entangled seals and the peak season for detecting entanglements is winter when the pups are actively swimming in the water and being naïve and playful, becoming entangled (McIntosh et al. 2015). From the results in this study, more entanglements were observed during the field visits, including two trawl net entanglements in 2020 compared to zero in the drone surveys performed in 2020 (Table 6).

Even so, these results indicate a rapid feedback loop between the loss of net fragments at sea and active entanglements on the fur seals. By continuing the monitoring over the next two years, we will better determine the success of the bins for reducing fur seal entanglements. We hope that entanglements in commercial net remain rare in the years to come and the that the custom-made bins continue to be used on fishing vessels working waters adjacent to Victoria.

The number of seals entangled in recreational fishing material slightly increased since 1997 (there were 16 observed at Seal Rocks in 2017, Figure 26). Recreational fishing is popular in Victoria with 226,032 licences sold in 2019-20 (Victorian Fisheries Authority 2020). This number is a minimum because a significant proportion of the community are exempt including people under 18 and over 70 in age.

Reducing seal entanglement in recreational fishing line is difficult because the occurrence is accidental and difficult to avoid if a seal is nearly and chooses to engage. When a seal predates a hooked fish, or is tangled in the line, the line either breaks or is cut by the fisher. Seals may also become entangled in lost fishing line. In an attempt to reduce recreational fishing entanglements of the pups at Seal Rocks, approach distances to Seal Rocks in the Victorian Wildlife (Marine Mammals) Regulations 2019 were doubled from 30m to 60m for approved vessels including recreational fishers. Pups do not travel far from the colony edge, so it is hoped this will reduce recreational interactions. Unfortunately, compliance is limited and recreational fishers often do not know the site specific regulations - found here:

https://www.legislation.vic.gov.au/in-force/statutory-rules/wildlife-marine-mammals-regulations-2019/001).

Reducing entanglement of fur seals in other materials including string, hats, rope and plastic bags will require improved waste management practices from a broad variety of sources, including urban areas.

Figure 31. Phillip Island Nature Parks researchers removing trawl net from a young Australian fur seal at Seal Rocks.

Figure 32. Marine debris collected on Phillip Island during a single beach walk.

Short-term achievements vs long-term goals

This project was designed to investigate whether we could improve waste management systems onboard vessels working in waters adjacent to Victoria using the simple, first-step approach of designing a fit-for-purpose bin that fishers could try for free.

The bins were a success being fit-for-purpose, easy to use, captured more waste onboard vessels. From discussions at the vessels, Skippers reported that they were happy with the bins, but one vessel master commented that it is hard to empty them when port waste capture facilities are already full (Table 4). Effective waste management for commercial fisheries requires cooperation at all stages of the waste management stream, both offshore and onshore as identified by MARPOL. Being a first stage approach for waste management and concentrating on keeping waste out of the ocean, waste was mixed in the custom bins and therefore disposed of ashore in general waste streams for landfill. In the long-term, recycling is the ideal management strategy. While current systems are not in place in Australia to facilitate this, industrialised processes to recycle nets and commercial fishing material are in development across the globe (for more information on recycling nets see Appendix 4).

We detected an increase in waste capture at sea using the custom bins, including an increase in the retention of net fragments and ropes. Observations of entangled seals at Seal Rocks declined over time 1997-2020 (Figure 26), possibly caused by the reduced trawl fleet in 2007 and the more recent success of the bins on boats program. However, we did not expect such a rapid feedback loop for the bins on boats program and remain cautiously optimistic.

We recognise that SETFIA nets rarely end up as ghost nets or being dumped in the marine environment because they are expensive and include highly technical equipment. However, the Tangaroa Blue AMDI database shows that commercial nets and net fragments, both large and small, can wash up along our coasts and are contributing to marine debris in Victoria (Figure 32).

We hope to see continued use of the ‘Bins on Boats’ on SE Trawl vessels and less debris from commercial fisheries washing up on coastal areas. We also hope that the reduced entanglement rate of fur seals in trawl net fragments continues. Continued assessment over the next 2-3 years will allow us to confidently determine the long-term gains of the project.

This project has been successful given the uptake of the bins, their popularity and increased use for capturing waste at sea. To leverage off this success, we aim to identify other fisheries in Australia that would be amenable to this program and assist them to provide similar bins to their fleets.

Marine debris: the economic cost

In 2015 there was an estimated US$10.8 billion of damage per annum to industries in the marine economy of Asia-Pacific attributable to marine debris (McIlgorm et al. 2020). In Australia there are uncertainties with regard to the cost of marine debris to fisheries and small businesses (Evans et al. 2016).

There are certainly costs to communities and organisations remediating marine debris and the resultant cost to the social licence of the fishing industry when such items are common. As plastics break up into smaller and smaller pieces, the indirect costs of damage to the marine environment are more difficult to estimate.

Next steps

Reducing marine plastic waste from commercial fishing vessels:

1. SETFIA will provide the remaining 8 bins to qualifying vessels as the need arises and report to The Nature Parks on the wear-and-tear of the bins currently in use to understand their life expectancy.
2. SETFIA, The Nature Parks and stakeholders will consider longevity of the program and the potential for bin replacement programs.
3. SETFIA remains committed to the code of practice for waste management at sea to maintain best practice and promote sustainability.
    - Although not a direct requirement of MARPOL, minimising waste taken to sea or generated onboard represents environmental best practice.
4. The Nature Parks and SETFIA will identify other commercial fishing fleets amenable to the program and share these results to encourage uptake of custom-built bins in more fisheries.
5. The Nature Parks will continue to monitor and remove marine debris entanglements on marine life under Prevention of Cruelty to Animals (POCTA) Act.
6. Port reception facility providers should maintain good practices for shipowners and operators. In the IMO – GSIS Consolidated guidance for port reception facility providers and users.

Conclusion

The ‘bins on boats’ project provides a simple and successful step towards improved onboard waste management for commercial fishing vessels.

This project highlights that collaboration between researchers, industry and government may provide simple but effective responses to reduce the impacts of problems such as marine pollution and wildlife entanglement from net fragments lost at sea.

The fishers liked the bins, they were fit for purpose and provided an easy and visually obvious mode of managing garbage at sea including fragments of nets and ropes. The volume of waste captured while at sea was higher in the custom-built bins provided to vessels than the bins the fishers had been using previously. Also, the new bins captured more nets and rope. Analysis of the entanglement observations for Australian fur seals indicate that entanglement of fur seals in net material has reduced, possibly even in the short time-frame of the project. Continued monitoring of the fur seals over the next two years will allow a more robust assessment of whether the custom bins have contributed to this trend.

In Victoria, urban waste and small plastic pieces make-up the majority of beach washed marine debris. Although Commercial fishing waste is a smaller source of plastic waste in the ocean, it remains an issue across Victoria, and one that the community is expending significant effort to clean up. This project highlights a simple solution to reduce plastic inputs to the ocean from commercial fisheries and help protect their social licence.

Results from actions to counter marine pollution take time due to the persistence of plastics in the environment. A long-term program is needed to replace bins once they reach their end of life and maintain the positive results measured in this study.

Commercial vessels and their nets at Lakes Entrance, Victoria, Australia.

APPENDICES

Appendix 1. Survey performed to assess use of custom made bin.

Bins-on-Boats survey (for internal use)

Collector: Name
Started: Date:time
Last Modified: Date time
Time Spent:
IP Address:

Q1
What is today's date?
Q2
Is this survey being completed BEFORE or AFTER the bins are distributed?
Q3
Vessel Name
Q4
Location
Q5
Vessel type
Q6
Was a bin present on the vessel? Yes/No
Q7
Was the bin a Bins-on-Boat bin? Yes/No
Q8
Which sticker option did the bin have? (1. Responsible fishermen do not discard rubbish overboard or 2. Please do not discard rubbish overboard)
Q9
Does the fisherman have any problems, suggestions or other feedback about the bin? (only if they are present to speak to)
Q10
What was the bin size? (choose closest)
Q11
If a bin was not onboard how does the vessel dispose of rubbish when they arrive in port?
Q12
How full was the bin?
Q13
What were the contents of the bin?
Q14
Please take a photo of the inside of the bin if possible
Q15
Fisherman comment on by whom the bin is emptied? (if they are present to speak to)
Q16
What effort is made to retain rubbish onboard at sea?

Appendix 2. Industry approved Code of Practice to Responsibly Manage Waste

Industry Code of Practise to:

Responsibly Manage Waste

sustainable fishing practises protect our future

Introduction:

Marine debris is any persistent, manufactured or processed solid material disposed of or lost in the marine or coastal environment.

Marine debris can be harmful or fatal for marine creatures if they become entangled in it or ingest it.

The UN estimates that more than 80% of marine debris comes from the land with the remainder coming from maritime sources and catastrophic events.

80% of marine debris is plastic. Plastic does not biodegrade. It is estimated that 9 million tonnes of plastic enter the oceans each year.

What is Social License?

Social License to Operate, or simply social license, refers to the acceptance of an industry's practices by its employees, stakeholders and the general public.

Even though most waste does not originate from fishing vessels the perception that it might, threatens our industry's social licence.

The grounds we fish are provided by the Australian community.

Even though marine animal entanglements are rare they are highly visible and reflect poorly on the fishing industry.

Industry Code of Practise to:
Responsibly manage waste
Continued...

Responsible Operators:

1. **Must not discharge oils including cooking oil**
2. **Must not discharge plastics**
3. **Must carefully retain net fragments**
4. **Must dispose of waste correctly ashore** (noting that Port Companies provide decreasing services to save cost – see image)
5. **Must not dispose of food waste inside 12 miles**
6. **Only dispose of food waste outside 12 miles if it is - comminuted to less than 25mm**
7. **Dispose of seine rope, wire rope and other fishing gear ashore**

Sources of fishing vessel netting

Seal entanglements are rare and decreasing. Most seal entanglements are with recreational fishing lines.
However, analysis of mesh removed from seals on Phillip Island showed that it:

- Was from trawlers (not gillnetters)
- Was from C'wealth vessels
- Pieces that had been cut out during repairs (not lost while fishing)

It is likely that mesh fragments that entangle seals are cut out during repairs and then lost overboard by mistake later on.

MARPOL

Australia has joined an international convention for the prevention of pollution from ships. It is complicated but Annex V sets down rules about the discharge of garbage. If you follow this code you are broadly complying with MARPOL regulations.

Appendix 3. Information for the Tangaroa Blue AMDI dataset analysed in this report.

Download of data for data owners and providers

Organisation	Phillip Island Nature Parks
Contact person	Rebecca McIntosh
Data location	Victoria
Timeframe	January 2018 - January 2021
Data request number	DR485

Acknowledgments

Please refer to the Data Use Agreement and the following list of organisations

List of organisations contributing data

Altona Beach Patrol 3018
Australian Marine Conservation Society
Balcombe Grammar
BASF
Beach Patrol 322Bellarine
Beach Patrol 3280-3284
Berwick Primary School
Brighton Secondary College
Carey Baptist Grammar Kew
Caring for Mirteech
Caulfield Junior College
Chemistry Australia
Christian College, Bellarine
Clean Oceans Collective
Cleaner Beaches
Conservation Volunteers Australia
Cornish College
Deakin Enviro Club (Deakin University Burwood)
Dolphin Research Institute
Dow Chemical
Dromana Primary School
Fishcare Victoria
Friend of the Bluff
Friends of the Merri Marine Sanctuary Warrnambool
Fyans park Primary School
Geelong College
Geelong Lutheran College
Good Will Nurdle Hunting
Great Ocean Road Coast Committee
Jane Goodall's Institute, Roots & Shoots Victoria.
Lady Bay Cleaners
LyondellBasell
Melbourne Zoo
Mentone Grammar
Merrivale Primary School

Nelson Coastcare Inc
Newhaven College
Ocean Grove Coastcare
Parks Victoria
Parks Victoria Junior Rangers
Phillip Island Nature Parks
Pick up sticks
Plastic Free Phillip Island
Point Lonsdale Primary School
Port Fairy Consoldiated School
Powlett River Primary School
PullingOurWeight
Rotary Club of Portland
Safety Beach/Dromana Beach Patrol
San Remo
Santa Monica Campus of St Bernard's College
School for Student Leadership - Snowy River Campus
School for Student Leadership, Gnurad Gundidj Campus
Sea Shepherd Australia
St Aloysius' Primary School
Surf Coast Secondary College
Tangaroa Blue Foundation
The Portsea Camp and Caulfield Junior College
Tooram Scouts
Trash Bags On Tour
Twelve Apostles Lodge
Wannon Water
Warnambool East Primary School
Warrnambool Primary School
Warrnambool Tooram Joey Scouts
WEPS
We-Refill
Werribee River Association
Woodford Primary School
Zero Waste Victoria
Zoos Victoria

Appendix 4. Recycling commercial fishing nets

Failing to recycle fishing nets and other waste plastics is "*a waste of resources given most, if not all, of the components of old fishing gear can be recycled or re-purposed. Currently, fishers do not have a realistic disposal alternative that is reliable, cost effective, and environmentally friendly but the potential is huge. For example, old fishing rope (which is made from polypropylene and polyethylene plastic and lead) can be re-purposed as fencing rope, to reinforce terracing in farms or to create outdoor art installations due to its hardy and UV stable qualities.*"

Sourced at https://setfia.org.au/recycling-fishing-gear/

End of life options for commercial nets

When considering the circular economy of commercial fishing nets and ropes in a global context, the logistically simplest management strategy at their end of life (EOL), is dumping, landfilling or incineration for energy (Brodbeck 2016). However, when the goal is best practice for sustainability, these alternatives are of low prioritisation in the waste hierarchy and the most sustainable options are to reuse or recycle (Appendix 4, Figure 1). However, there are many technical, economical and infrastructural barriers that must be overcome to implement this approach, which would require strong collaboration between fishers, Ports Authorities and regulatory bodies (Brodbeck 2016).

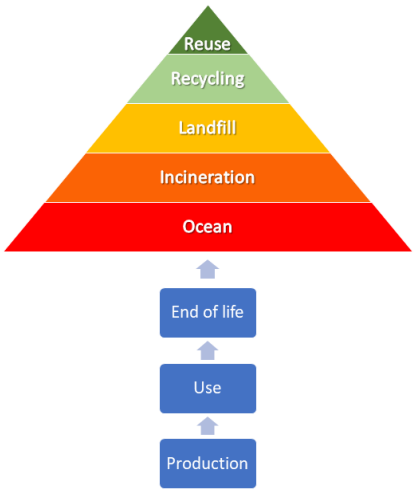
Sustainability in this context refers to the protection of the environment and the minimisation of resource/energy consumption. Depending on the plastic that nets are made from, EOL fishing waste can be melted down into plastic pellets and used to make new consumer products (Table 1).

Barriers to recycling

Barriers to recycling EOL nets include acceptability, economic, infrastructural, regulatory, technical and environmental barriers. In Australia, current EOL options for used nets and other waste materials include landfilling (common) and repurposing (rare). Ghost-nets are more common in northern Australia from illegal or international fishing (Kiessling 2003). One difficulty is the unpredictability of available material that hinders assessment of the market potential needed to attract investment. To recycle EOL nets and waste material effectively, we need to know how much is available and when it is available, as well as the reliability of that material stream (Brodbeck 2016). Port Authorities and net manufacturers could play a more effective central role in this rather than sub-contractors who are commonly employed to dispose of nets (Brodbeck 2016).

Port reception facility providers should maintain good practices for shipowners and operators. In the IMO – GSIS Consolidated guidance for port reception facility providers and users, reception facilities should introduce waste management efficiency and develop Garbage Management Plans that allow waste segregation for recycling in line with the recycling capability of the locality (International Maritime Organisation 2018).

Recycling and/or reuse programs may experience difficulties because of the volatile polymer market, high transport costs, the effort it can take to clean up the material and the many partners involved in the chain of transfer



Appendix 4, Figure 1. The life cycle of fishing nets and end of life treatments shown as a hierarchy of sustainability from red (worst choice) to green (best choice). Here, sustainability includes the protection of the environment and the minimisation of resource and energy consumption. Diagram adapted from Brodbeck (2016).

(Macfadyen et al. 2009, Brodbeck 2016). Typically, gear must be thoroughly cleaned of biotic material (fouling) to comply with antifouling regulations and process the material at an industrial scale. The antifouling process is manual and time consuming, with contaminating marine biota removed by hand. More recently, industrial processes have been developed to skip this manual handling, but this system has been recently developed and implementation costs are still to be provided (e.g. Vecoplan®: Appendix 4, Table 1).

Global examples of net recycling

Net recycling must be authentic and avoid green- or blue-washing. Greenwashing is when a company conveys false claims or provides misleading information about its products or actions to suggest they are eco-friendly and socially responsible. Bluewashing applies more specifically to labour conditions and human rights. Companies that claim to use recycled materials for their products must prove that the items have reached their EOL and been saved from landfill or the environment. This may require regulatory oversight or a certification process.

Waste plastics from commercial fishing compete with waste plastics from general waste from modern living for recycling "space", but some specific examples exist and are provided in Appendix 4, Table 1 below. To the best of our ability, we have only provided examples of authentic enterprises. The materials are clearly post-use, are being recycled into consumable products, and the fishing communities as well as the environment are benefitting from the programs. In these examples, many businesses are situated in developing countries and communities where small financial and large socio-environmental incentives drive the collection and cleaning of the nets before they are sent away for recycling. In these local businesses, nets for recycling are retrieved from beaches, the ocean and directly from fishers at their EOL. A system that works for Australian fishing industries remains to be developed, but the technology to achieve this is advancing.

Appendix 4, Figure 2 Conversations with skippers identified that disused end-of-life nets are disposed of by the skipper at their cost. Some are used in people's gardens but like much plastic waste, most end up in landfill. Image above shows used netting (fish farming, trawl vessels etc) taken to the Port Lincoln refuse centre. "Mount net" is the colloquial term for waste netting disposed of at the site. Source: https://www.abc.net.au/news/2019-09-16/almost-1500-tonnes-of-netting-waste-creates-recycling-headache/11497150

Appendix 4, Table 1. Enterprises recycling fishing nets into plastic base materials and products

Company	Description	Website
Matthew O'Hagan, Victorian University Wellington	Using ocean plastic and fishing for 3D printing	https://www.stuff.co.nz/environment/300155804/marine-waste-feeds-3d-printer-production https://3dprinting.com/environmental/turning-ocean-trash-into-filament/
Million Waves Project	Using ocean plastic to 3D print prosthetic limbs (in development)	https://3dprinting.com/news/million-waves-project-uses-ocean-plastic-print-45-prosthetics/
Modulyss	Making old fishing nets into vinyl flooring and carpets with 75% recycled content	https://gibbongroup.com.au/fishing-nets-carpet-tiles/ https://www.pri.org/stories/2015-09-14/philippines-project-turns-ghost-fishing-nets-carpets
The Odessy Project	Making kyaks from marine plastic including fishing nets	https://www.odysseyinnovation.com/fishing-net-recycling
Plastix	Recycling used, obsolete and abandoned fishing nets, ropes and post-use rigid plastic into high-quality raw plastic material	https://plastixglobal.com/
Bureo	Fishing net recycling in Chile and NetPlus®: recycling fishing nets into many products	https://bureo.co/pages/netplus
Healthy seas and ECONYL® + Aquafil and Norfir	Recycling the nylon 6 from recovered nets and making it into ECONYL® nylon 6 yarn via depolymerization to make apparel and carpeting products. This nylon by Aquafil can be recycled repeatedly.	http://www.circularocean.eu/wp-content/uploads/2016/06/6_Mikos.pdf https://goodonyou.eco/material-guide-econyl/ https://www.recyclingtoday.com/article/abandoned-fishing-nets-recycled-into-nylon/ https://nofir.no/
Net-works and the Zoological Society of London	Coastal communities in the Philippines and Cameroon benefitting from recycling fishing nets into nylon yarn for carpet. Payment for the nets provides income to the local fishermen and will also be used to develop micro finance and village savings and loan schemes in the community	https://net-works.com/ https://www.theguardian.com/sustainable-business/creating-sustainable-livelihoods-recycling
Vecoplan	Putting an end to ghost nets. Nets are manually sorted into coarse nets, fine gill nets and fixed ropes, then industrially processed.	https://vecoplan.com/news/single-view/news/putting-an-end-to-ghost-nets/?tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=6a0bb4e67bd0481cdbedce77727282c0

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