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Packing Bands Entangling Pinnipeds Around the World: Global Review and Policy

Elizabeth Hogan and Amanda Warlick

1. Introduction

Marine debris is a significant and detrimental source of entanglement for marine animals around the world. Entangling debris includes packing bands, fishing gear, and plastic bags (among other items) and can lead to serious injury, suffocation, and even death. In addition to reducing the ability or likelihood of individual animals to survive and reproduce, entanglement can be a threat to the recovery of small populations. Because entanglement rate estimates typically rely on visual sightings of live animals, they are likely to significantly underestimate the scale of the impacts.

Recent studies have documented entanglement rates in wild populations higher than levels suspected to have population-level impacts (Fowler, 1987; Kraus, 1990; Fowler, 2002; Sayer, 2015), with packing bands and fishing gear often being the most prevalent type of entangling debris (Hofmeyr et al., 2002; Zavadil et al., 2007; and Raum-Suryan et al., 2009). Cetaceans, seals, sea lions, sea turtles, seabirds, and manatees have all been found with scars, wounds, or missing appendages due to entanglement. Among pinnipeds, an estimated 58 percent of seal and sea lion species are known to have been affected by entanglement, including Hawaiian monk seals, Australian sea lions, New Zealand fur seals, and various others around the world (Cole et al., 2006).

Analysis of entangling debris assessed in this study suggests that there are some commonalities in the physical characteristics of packing bands found entangling pinnipeds around the world (i.e., color, size). In some cases, these observed patterns are likely due to manufacturing practices, but they can nonetheless inform future steps and strategies for reducing the prevalence of entangling debris, including implementing regulations, realigning economic incentives, establishing industry best practices, and developing innovative alternative materials. One potential regulatory solution could be to replicate the success of the 1994 Degradable Plastic Ring Rule (US Environmental Protection Agency, 1994) mandating that beverage ring carriers be made of photodegradable material that breaks, which breaks down upon prolonged exposure to sunlight. However, packing bands are used across a wider range of activities and environments compared to six-pack rings, and ensuring

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alternative materials match existing functionality would require significant research, development, and testing.

2. Background

Packing bands are often one of the most common types of entangling debris found on marine animals. The strap typically forms a collar around the neck, or a flipper, and tightens as the animal grows, eventually cutting into the tissue to become embedded in skin, muscle, and fat. Packing bands were responsible for approximately 30 percent of observed entanglements of New Zealand fur seals in New Zealand and South Australia (Page et al., 2004; Boren et al., 2006). Similarly, 43 percent of 1,033 Antarctic fur seal entanglements on Bird Island, South Georgia, from 1989–2013, were attributed to packing bands, with significantly less per year after 1994 when the use of packing bands on bait boxes was prohibited by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) (Arnould & Croxall, 1995; Waluda & Staniland, 2013). Northern fur seals on the Pribilof Islands were most commonly entangled by packing bands with specific size and color characteristics (Zavadil et al., 2007).

Packing bands are pervasive in global shipping operations and are used for a range of products including fish bait boxes. To inform future voluntary mitigation measures or regulations, it is important to fully understand the specific characteristics of packing bands found entangling pinnipeds. Here we present a global review and analysis of packing band material retrieved from seals and sea lions submitted by stranding response practitioners from around the world. We hypothesized that our sample of packing bands would have a range of characteristics and that compiling such a collection could lead to further understanding of their shared features, if any, that might explain their prominence as entangling debris.

The implementation of prohibitions and voluntary guidelines for disposing of packing bands is a positive step toward minimizing this threat. Policies established under CCALMR in 1995 have likely contributed to fewer entanglements throughout Antarctic and sub-Antarctic waters (Waluda & Staniland, 2013), but, unfortunately, these measures are not global, and high entanglement rates persist. Levels of debris observed on remote islands have not necessarily decreased over the last two decades, highlighting the continued need for research, management, and conservation (Ivar do Sul et al., 2011). Monitoring entanglement rates in the wild is the most effective way to evaluate the potential efficacy of voluntary measures implemented to reduce the impact of marine debris. Informed by in situ observations and samples, this kind of review can guide industry practices and can inform international policies to reduce the prevalence and impacts of marine debris.

3. Methodology

To obtain a global sample of entangling material for analysis, samples were solicited from stranding networks around the world via an email Listserv and other personal communications. The request for samples remained open for a one-year period in order to gather a sample sufficiently large enough to be representative of the most common entangling marine debris materials. Thirteen different stranding networks from 11 locations around the world responded to this request and volunteered to ship samples of entangling material that had been removed from a marine animal rescued by their network. The criteria were that the material had to have been removed from an entangled marine mammal, sea turtle, or sea bird and represented a documented entanglement case. No specifications were made regarding the type of material that could be submitted. Samples were shipped directly from the participating networks to the authors on a rolling basis between July 2013 and July 2014. In addition to the samples, each stranding network also provided any data they had collected on each entanglement case, including impacted species, age, sex, injuries, and the date and location of rescue, if known.

In order to identify any trends in the source of the most common entangling material, the selected samples were narrowed exclusively to plastic packing bands. Each entanglement debris sample was assessed for color, structure, and width to build our catalog and to determine whether there are commonalities in their physical characteristics. Packing band materials were submitted to the American Chemistry Council to determine their precise chemical composition.

4. Results

Of the total 93 samples that were submitted, 92 were some form of plastic, and 84 were packing bands. Samples were received from Florida, Oregon, California, Hawaii, Alaska, British Columbia, South Georgia Islands, South Africa, the United Kingdom, and New Zealand.

4.1 Impacted species

While impacted species included sea turtles (three species) and seabirds (four species), pinnipeds made up the vast majority of the species with packing band entanglements, accounting for 71 of the 84 documented cases (Table 1). Samples

Table 1. The number of packing band samples found entangling each of eight pinniped species, with the highest number coming from cape fur seals and California sea lions.

Species	Number
Antarctic fur seal	5
California sea lion	10
Cape fur seal	34
Grey seal	1
Guadalupe fur seal	1
New Zealand fur seal	4
Northern fur seal	6
Steller sea lion	1
Total	**71**

submitted that were removed from whales consisted only of fishing gear rather than packing bands and are therefore not discussed further.

4.2 Width

The most common width of packing bands in the sample was approximately 0.25 inches, with nearly half of all packing bands between 0.2 and 0.3 inches wide (Figure 1). Less than one third of all submitted packing bands were outside the range of 0.2–0.45 inches wide. These findings are likely due to the fact that these sizes are most commonly manufactured or used in fisheries and shipping rather than an inherently higher likelihood of those sizes causing entanglements. However, it is also possible that this size range does represent bands that are visible and or more attractive to inquisitive pinnipeds. Assessing the validity of this hypothesis would require conducting controlled experiments to isolate the potential effect of band width and to determine whether animals interacted more or less frequently with certain sizes rather than others.

All but one of the eight samples submitted from a sea turtle entanglement were narrower than 0.25 inches. This likely speaks to the availability and common use of narrower bands of this width in green sea turtle habitat locations. However, it could point to a capacity among sea turtles to more easily avoid wider bands compared to narrower ones. Such a hypothesis would require additional study, as mentioned above. In addition to understanding whether certain widths are more likely to entangle certain species, it is also important to understand the severity of the injury caused by different size ranges (e.g., narrower or stiffer bands being more likely to cut more deeply into the skin).

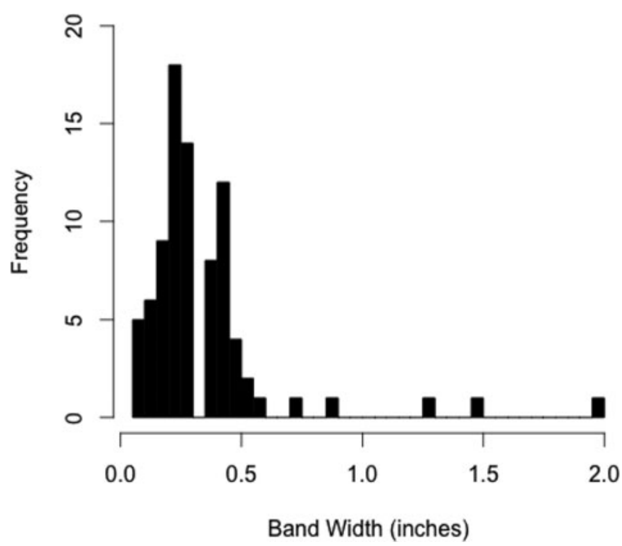

Figure 1. The frequency of packing band widths should be within the sample showing the prevalence of bands measuring less than 0.4 inches wide ($N = 84$).

Table 2. The frequency of colors represented in the packing band sample, with white, yellow, and blue being the most predominant.

Color	Number
White	21
Yellow	16
Blue	15
Green	13
Black	10
Beige	4
Multiple*	3
Red	2
Total	**84**

*Three packing bands had a multi-colored pattern.

4.3 Color

Each submitted packing band was categorized according to their color, with white, blue, yellow, and green being the most dominant within our sample. The occurrence of the various colors of the 84 packing bands are summarized in Table 2.

Similar to the packing bands sharing a common size, the fact that a few colors dominate the sample may be due to manufacturing practices rather than the likelihood of attracting inquisitive marine mammals. However, these results align with similar findings in studies focusing on debris and fish: blue and yellow plastic items have been shown to have higher rates of attack and subsequent ingestion by fish compared with other colors (Carson, 2013). However, whether this is due to greater availability or a preference on the part of the animal is unclear.

A second study on color affinity among a marine mammal species draws attention to the low number of red bands causing entanglements. An attempt to lower the 82 percent entanglement rate among the North Atlantic right whale (Knowlton et. al., 2012) led to the discovery via field trial that ropes of red or orange coloring were detected by the whales at significantly greater distances than rope mimics of other colors. The difference in color, attributed to a higher contrast of the red/orange rope mimics against the ambient blue/green oceanic background, allowed the whales to avoid the potentially entangling material (Kraus et. al., 2014). Red bands caused the fewest number of entanglements in this study, totaling only two out of 71 documented mammal entanglements in packing bands.

4.4 Geographical color trends

A geographical overlay with the colors of the bands showed that black packing bands causing entanglement are found almost exclusively in California. Black bands also far outnumbered any other color band from California. At this time, it is unknown why black entangling material is prevalent specifically in this region, though possible explanations could include that it is most economical to purchase or produce, that there are limited suppliers, or that it is all coming from the same user group or activity. On the contrary, other locations such as Florida and South Africa yielded a wide range of colors. In South Africa, the predominant colors were yellow, white, and blue. While white bands showed up in several locations, very few blue and yellow bands were submitted from other regions aside from South Africa. Samples submitted from Alaska (removed from Northern fur seals) were primarily green, possibly due to limited availability or common industry practices in that area.

4.5 Composition

Based on chemical composition analysis, 60 percent of the submitted samples were polypropylene, 30 percent polyethylene, and 10 percent nylon. All of these plastic resins are extremely common, and their production is global in scope. In addition to the resin, the majority of the packing band samples also contained "filler" materials, particularly $CaCO_3$ (calcium carbonate) and talc. These are commonly used in many plastics in order to not only lower the cost of production, but also to enhance the stiffness of the plastic (Kingsbury, 2014). The stiff quality of these bands increases the risk to an entangled animal (particularly a juvenile) in that it limits the capacity of the material to stretch as the animal grows, forcing the material to embed in the muscle and fat tissue and potentially to cut into arteries, nerves, or organs.

5. Discussion

This study is the first to assess the characteristics of packing bands found entangling marine animals around the world. While many of the shared qualities in terms of width and color may be attributed to manufacturing or industry practices, there are policy implications and possible solutions based on these results.

5.1 Regulatory precedent

The transformation of six-pack beverage ring carriers provides precedence for taking regulatory action to reduce the impacts of packing bands on marine wildlife. Since 1989, all recyclable six-pack rings produced in the United States have been manufactured from photodegradable low-density polyethylene (LDPE) #4. In the event that a ring carrier made of this material winds up in the ocean, the light weight and low density of the product makes it likely to float on or near the surface of the water, where it will be exposed to ultraviolet sunlight. The photodegradable quality should mean that this continued exposure to UV light, as well as wind and rain, will cause the structural integrity of the product to degrade and to break apart in a relatively short period of time (several months, with variation according to quantity of sunlight), as opposed to standard polyethylene, which can persist in the marine environment for hundreds of years (Kershaw et al., 2011).

In addition to 16 state laws, the Degradable Plastic Ring Rule (U.S. Environmental Protection Agency, 1994) and 40 C.F.R. § 238 issued by the Environmental Protection Agency (EPA) in 1994 require that all beverage ring carriers sold in the United States be made of material that degrades quickly and does not pose a greater threat to the environment than non-degradable material; specifically "material which, when discarded, will be reduced to environmentally benign subunits under the action of normal environmental forces, such as, among others, biological decomposition, photodegradation, or hydrolysis" (US Environmental Protection Agency, 1994). Rather than specify a particular type of degradable plastic, the EPA requires a degradability performance standard for beverage ring carriers in order to allow manufacturers the flexibility to make use of varied and evolving technology.

While the precise impact of these positive regulatory changes is unknown, 2010 data from the Ocean Conservancy International Coastal Cleanup show entanglements from six-pack carriers to be less than one percent of total recorded marine wildlife entanglements, reporting a total of just six animals entangled (Ocean Conservancy, 2010). In support of that, samples submitted for this study did not include a single six-pack carrier. Given the documented harm to marine wildlife, including threatened and endangered species, justification exists to regulate the production of packing bands.

5.2 Packing bands—limiting and eliminating

An alternative regulatory option was undertaken in Australia, where the use of packing bands was banned to reduce the incidence of marine mammal entanglement. The CCAMLR undertook measures in 1988 to improve monitoring and fishery compliance with the provisions of Annex 5 of the Marine Convention for the Prevention of Pollution from Ships (MARPOL), significantly reducing the entanglement rate from previous estimates of thousands killed each year (CCAMLR, 1993). CCAMLR further introduced a measure to phase out packing bands (used primarily for securing bait boxes) on fishing vessels by 1996 (Kock, 2000; Waluda & Staniland, 2013). Entanglement rates of fur seals in packaging bands subsequently decreased (Kock, 2000; Waluda & Staniland, 2013).

Additional measures in Western Australia had a similar impact. In 2004, marine debris documented on Australia's southwest coast revealed a large number of packing bands. The Tangaroa Blue Foundation traced the use of 12-mm blue bands and 6-mm clear bands to a local rock lobster fishery (Government of Australia, 2009). In 2011, the Western Australian Minister of Fisheries banned the use of packing bands on recreational and commercial fishing vessels (Government of Australia, 2009). These are examples of how changes in policy can minimize or reverse anthropogenic impacts on the marine environment. While a blanket policy to change the chemical structure of all packing band material regardless of intended purpose is unlikely given their sale and distribution across a wide range of uses, it is possible to target policy at the production of bands used for purposes more likely to end up in the ocean, such as fish bait boxes.

5.3 Packing bands—are there alternative materials?

Because packing bands are intended for a wider variety of uses, the quality control standards for their design and structure are more stringent than for six-pack beverage carriers. However, innovative research in recent years has improved the development and production of biodegradable plastic. One feasible option for alternative material to replace traditional plastic packing bands is an "oxo-plastic," where small amounts of metal salts within the plastic accelerate degradation when exposed to oxygen. While this new technology does not leave fragments of plastic in the environment, the downside is that it is not recyclable. However, recyclability is not the primary goal for products at high risk of being lost in the marine environment; on the contrary, a product with a high likelihood of discard or loss is not a good candidate for secondary use given the low probability of recovery, transport, and entry into recycling infrastructure.

These alternative materials show promise as a long-term solution to improving the sustainability of these products. In the interim, it will be important to pursue regulatory action. While policy and industry practices can move slowly, change can and does happen. Packing bands currently represent a significant threat to marine wildlife and a problem that can be solved with the right combination of research, monitoring, and the implementation of measures to mitigate the impacts of marine debris in the ocean.

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