

REPORT

Marine pollution originating from purse seine and longline fishing vessel operations in the Western and Central Pacific Ocean, 2003–2015

Kelsey Richardson, David Haynes, Anthony Talouli,
Michael Donoghue

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Abstract Fisheries observer data recorded between 2003 and 2015 on-board purse seine and longline vessels operating in the Western and Central Pacific Ocean reported more than 10 000 pollution incidents within the exclusive economic zones (EEZs) of 25 Pacific countries and territories, and in international waters. A majority of the reported purse seine pollution incidents related to dumping of plastics waste. Other common pollution incidents related to oil spillages and to abandoned, lost or dumped fishing gear. Data analysis highlighted the need for increased monitoring, reporting, and enforcement of pollution violations by all types of fishing vessels operating in the Pacific region; a regional outreach and compliance assistance programme on marine pollution prevention and improvements in Pacific port waste reception facilities.

Keywords Abandoned, lost or discarded fishing gear · Fisheries · Marine pollution · Pacific Ocean · Plastic pollution

INTRODUCTION

Marine pollution is an intergenerational and global environmental problem, and studies around the world caution that the problem is growing (Katsanevakis 2008; Barnes et al. 2009; Jambeck et al. 2015). While land-based sources contribute most of the marine pollutant load, there is increasing concern about ocean-based sources of marine pollution (Macfadyen et al. 2009; Øhlenschläger et al. 2013; Sherrington et al. 2014). The Secretariat of the Pacific Regional Environment

Programme (SPREP) recently completed analysis of marine pollution incidents reported by fisheries observers employed by the Secretariat of the Pacific Commission/Pacific Islands Foreign Fisheries Agency (SPC/FFA) between 2003 and 2015. This included more than 10 000 pollution incidents reported by the observers on-board purse seine vessels, compared to only around 200 pollution incidents reported by the observers on-board longline vessels. The coverage of observer data currently available is sometimes not representative of the areas of activity and the active fishing fleets, particularly in regards to the longline fishery. For example, a significant amount of longline fishing activity occurs on the high seas, but observer coverage in these areas is very low compared to the EEZs. In the longline fishery, the data from some observer programmes have much higher coverage than others (P. Williams, personal communication, September 23, 2015), and as a result, the presentations of pollution events in this paper are biased accordingly.

While based on a limited selection of data from mostly purse seine vessels and some longline vessels, the information suggests that fishing vessels are responsible for considerable amounts of marine pollution in the Western and Central Pacific Ocean. Action is urgently needed to curb this behaviour.

BACKGROUND

Ocean-based marine litter

Marine pollution has lasting detrimental impacts on ocean and coastal environments, wildlife, economies, and ecosystems. In the Pacific region, marine pollution impacts on coastal communities can be especially acute given the reliance of Pacific island countries on marine ecosystems

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and associated services within their extensive EEZs and beyond.

The impacts of marine litter have been extensively researched since the late 1990s and are known to include entanglement of marine wildlife by fishing gear;¹ ingestion of marine litter by wildlife;² introduction of invasive species through use of marine litter as rafting habitats;³ negative impacts to tourism and fishing-dependent economies;⁴ pose hazards to navigation and safety at sea;⁵ damage to marine and coastal ecosystems;⁶ smothering of benthic habitats⁷ and high financial costs of clean-up.⁸

Marine litter originates from both land and ocean-based sources. The bulk (80 %) of marine litter is understood to originate from land-based sources (GESAMP 1991), and plastics are estimated to make up 50 to 80 % of total marine litter (Barnes et al. 2009). Globally it is assumed that only around 27 % of all ship wastes are delivered to reception facilities, with the majority of the rest either dumped or incinerated (Øhlenschläger et al. 2013). However, the data are variable and there are still information gaps about total land and ocean-based inputs of marine litter (Øhlenschläger et al. 2013; Jambeck et al. 2015; Watkins et al. 2015) and little is known for the Western and Central Pacific region about how much marine debris originates from ocean-based sources.

The International Convention for the Prevention of Pollution from Ships (MARPOL) exists to minimize sea-based sources of pollution, including pollution of oil (Annex I) and garbage (Annex V), arising from operational or accidental causes (IMO MARPOL 2015a, b, c).⁹ Of the 14 Pacific island countries that are SPREP members, 11 are Contracting Parties to MARPOL Annexes I/II and V, and therefore have specific responsibilities to implement this important treaty to prevent pollution from ships, particularly in the forms of oil and garbage (IMO Status of

Conventions 2015a, b, c).¹⁰ Despite these regulations, there is limited monitoring of MARPOL, and consequently, little information exists about illegal pollution activities by vessels at sea. One study in Australia did find that in 1992 and 1993, at least one-third of fishing vessels (with on-board observers) did not comply with MARPOL regulations prohibiting the dumping of plastics overboard (Jones 1995).

SPC/FFA regional observer pollution report Form GEN-6

Form GEN-6 was designed in 2000, at the request of SPREP as a tool to monitor fishing vessel violations to MARPOL, and its pollution data categories were based on MARPOL Annexes I and V. These include Waste Dumped Overboard, Oil Spillages and Leakages and Abandoned or Lost Fishing Gear. Each category has its respective sub-categories (pollutant material), and Form GEN-6 revisions have occurred regularly to improve accuracy of data recording and reporting. Subcategories reported here are from the most current form, which was revised in March 2014. Table 1 summarizes the most common written pollution descriptions and quantities by pollution and material types, and a copy Form GEN-6 is provided in Appendix S1. Form GEN-6 has no standardized categorical options for observers to report quantities of pollution and as a consequence, pollutant quantities are reported as written comments by observers, which complicates subsequent data analysis.

RESULTS AND DISCUSSION

A preliminary examination of more than 10 years of data from the Form GEN-6 not unexpectedly highlighted that the pollution incidents reported by on-board fisheries observers were overwhelmingly biased to purse seine fishing vessels due to high levels of mandatory observer coverage in the purse seine fishery. Prior to 2009, observer coverage for the purse seine fishery was around 5–8 %, increased to 20 % in 2009, and to 100 % required coverage from 2010 to the present (P. Williams, personal communication, March 18, 2015, WCPFC 2009). By contrast, observer coverage of the approximately 3 000 longline

¹ Entanglement: (World Animal Protection 2014; Macfayden et al. 2009; Laist 1997).

² Ingestion: (Laist 1997; Rochman et al. 2013, 2014; Van Cauwenberghe and Janssen 2014; Romeo et al. 2015).

³ Introduction of invasive species: (Barnes 2002; Winston et al. 1997; Zettler et al. 2013).

⁴ Negative impacts to tourism and fishing dependent economies: (Hall 2000; Nash 1992; Ballance et al. 2000; Leggett et al. 2014; IMO 2015a, b, c; UNEP 2009).

⁵ Costs to vessels: (Hall 2000; UNEP 2009).

⁶ Destruction to important and fragile ecosystems: (Hall et al. 2015; Donohue et al. 2001).

⁷ Smothering: (Gregory 2009; Schlining et al. 2013); and

⁸ High financial costs of cleanup: (Ballance et al. 2000; Leggett et al. 2014; UNEP 2014).

⁹ MARPOL and its associated annexes can be found through IMO Publishing: Virtual Publications, *MARPOL on the Web*.

¹⁰ These 11 countries include Cook Islands, Kiribati, Marshall Islands, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. Of the 14 SPREP member Pacific island countries, only Fiji, Federated States of Micronesia and Nauru are not Contracting Parties to MARPOL Annex I/II and V (IMO Status of Conventions 2015a, b, c). Fiji, however, has draft legislation in place for MARPOL Annexes I, II, IV and V.

Table 1 Summary of written pollution descriptions and quantities

Pollution type	Pollutant material	Pollution description	Quantities per incident
Waste dumped overboard	Plastics	Salt bags, bait boxes, bait wrappings, strapping bands, food wrappers, bags, bottles, sheets, foam, cartons, pallets, washing machines, raincoats, plates, cups, cutlery	Range 1–60+ assorted items per incident. Sometimes reported with mixed plastics dumped in bags or empty oil drums
Waste dumped overboard	Metals	Empty oil drums, cables, engine parts, beverage cans, oil filters, tanks, washing machines, pipes, chains, air conditioning unit	Drums 1–90 per incident, cables 1–4 000 metres per incident
Waste dumped overboard	Waste oil	Lubricating oils, hydraulic oils, used oil/sludge, grease, fuel oils including diesel, gasoline and bunker fuels	Size and visual quality estimated by observer, often in reference to boat size, colour, thickness and depth. Measurements varied from cm to more than a half-mile away from the boat
Waste dumped overboard	General garbage	Food wastes, plastics, metals, washing machines, clothing, netting from fishing gear, containers	1–1000 assorted items per incident; weights reported varied up to 950 kg, 80 lbs, 50 gallons and lengths up to 70 m (e.g. netting from fishing gear) per incident
Waste dumped overboard	Chemicals	Paints, turpentine, ammonia, detergents, batteries, brine salts, fluorescent light bulbs	Range mL to 100 L; 1–50 assorted items per incident
Oil spillages and leakages	Fuel oils	Fuel oils including diesel, gasoline and bunker fuels	Size and visual quality estimated by observer, often in reference to boat size, colour, thickness and depth. Measurements varied from cm amounts to lengths more than a mile away from the boat and multiple days of a spill/leak
Abandoned, lost or dumped fishing gear	Fishing gear	Nets, lines, fish aggregating devices (FADs), rafts, beacons, floats, rope and line cuttings, ropes, drums full of pieces of gear, hooks, gloves, cables	Range mm to 30 000 m line, 1–10 000 m cable lengths, and weights up to 500 kg

vessels operating in the Western and Central Pacific Ocean is only 5 % for the entire fishery as of 2012 (WCPFC 2014).

Pollution incidents by purse seine vessels

Forty-four percent of the reported marine pollution incidents occurred within Papua New Guinea (PNG)'s EEZ (Table 2). The next highest number of reported incidents occurred in the EEZs of Kiribati (13 %), the Federated States of Micronesia (12 %), the Solomon Islands (7 %), the Marshall Islands (6 %) and Nauru (6 %). Four percent of total pollution incidents occurred in international waters.

Figure 1 shows the pollution incidents mapped by the latitude and longitude positions given by observers at the time of reporting. The incidents are overlaid on a colorized map that shows purse seine activity from April 2013 through March 2014, using FFA fishing vessel databases and Automatic Identification System (AIS) vessel tracks. The high numbers of incidents in these countries' EEZs, especially in Papua New Guinea, is consistent with the fact that these EEZ waters are also highly active purse seine fishing grounds. Purse seine fishery activity in the Western and Central Pacific Ocean is concentrated around the Equator, between 5 N and 10S (SPC 2010).

Composition of Purse Seine Pollution Incidents by Pollution Types

Seventy-one percent of the purse seine pollution incidents were documented as waste dumped overboard, 16 % as oil spillages and leakages and 13 % as abandoned, lost or dumped fishing gear. When the subcategories included under “waste dumped” were analysed further and compared to total pollution incidents, plastics were found to make up the largest portion of total pollution incidents at 37 %, followed by metals (15 %), waste oil (9 %), general garbage (8 %), and chemicals (2 %) (Fig. 2).

Purse seine pollution incidents by flag states

Seventy percent of the total pollution incidents from 2003 to 2015 were reported by purse seine fisheries observers aboard vessels from Distant Water Fishing Nations (DWFNs). Papua New Guinean-flagged vessels comprised the greatest percentage of pollution incidents at 18 %, with 85 % of the pollution incidents occurring within the PNG EEZ. By contrast, the next highest number of pollution incidents occurred by vessels flagged to Taiwan (16 %), USA (15 %), Korea (12 %), Philippines (10 %), Japan (10 %) and China (8 %) (Fig. 3).

Table 2 Pollution incidents by purse seine vessels 2003–2015
Source SPC/FFA Regional Observer Pollution Report Form GEN-6
While not an Exclusive economic zone (EEZ), International Waters
was included in this Table for comparison purposes. Data provided
for 2010–2015 are still incomplete and thus are conservative

Exclusive economic zones (EEZs)	Reported incidents	Percent of total incidents (%)
Papua New Guinea	4 706	44
Kiribati	1393	13
Federated States of Micronesia	1 237	12
Solomon Islands	706	7
Marshall Islands	656	6
Nauru	629	6
International Waters	454	4
Tuvalu	286	3
Fiji	138	1
Palau	75	1
Vanuatu	56	1
Japan	53	<1
Cook Islands	52	<1
Tokelau	51	<1
American Samoa	30	<1
Samoa	15	<1
Northern Mariana Islands	14	<1
Tonga	13	<1
Indonesia	12	<1
Guam	11	<1
French Polynesia	8	<1
Howland and Baker Islands (USA)	6	<1
Philippines	5	<1
Wallis and Futuna	4	<1
Jarvis Island (USA)	2	<1
Palmyra Atoll (USA)	1	<1
Total	10 613	100

Pollution incidents by longline vessels

Thirty percent of the pollution incidents reported by observers aboard longline vessels occurred within Fiji's EEZ. The next highest number of reported incidents occurred in the EEZs of Tonga (14 %), Vanuatu (13 %), Cook Islands (9 %), Kiribati (8 %), Federated States of Micronesia (7 %), Solomon Islands (6 %) and Papua New Guinea (4 %). Seven percent of total pollution incidents occurred in international waters (Table 3). Observer coverage by the Fiji observer programme is much higher than observer coverage by other programmes, which likely leads to bias in the number of reported incidents both within the Fiji EEZ and by Fijian-flagged vessels (P. Williams, personal communication, September 23, 2015).

Composition of longline pollution incidents by pollution types

Eighty percent of the purse seine pollution incidents were documented in the form of waste dumped overboard, 17 % as abandoned, lost or dumped fishing gear and 3 % as oil spillages and leakages. When the subcategories under “waste dumped” were analysed further and compared to total pollution incidents, Plastics were found to make up the largest portion of total pollution incidents at 60 %, followed by general garbage (15 %), waste oil (4 %), metals (8 %) and chemicals (<1 %) (Fig. 4).

Longline pollution incidents by flag states

Fijian-flagged vessels comprised the greatest percentage of pollution incidents (21 %) reported by fisheries observers aboard longline vessels from 2003 to 2015. All of the pollution incidents by Fijian longliners occurred within Fiji's EEZ. It is important to recall again that observer coverage by the Fiji observer programme is much higher than observer coverage by other programmes, which likely leads to bias in the number of reported incidents both within the Fiji EEZ and by Fijian-flagged vessels (P. Williams, personal communication, September 23, 2015). The next highest number of pollution incidents occurred by vessels flagged to China (19 %), Korea (15 %), Vanuatu (13 %), Tonga (11 %), Taiwan (8 %) and Federated States of Micronesia (4 %) (Fig. 5).

Likelihood of unreported pollution incidents by other fisheries

Table 4 summarizes the number of active fishing vessels from 2004 to 2014 for the purse seine, longline and pole-and-line fisheries. The longline fishery, which is only mandated to have 5 % observer coverage as of 2012, has more than 8 times the number of active vessels compared to the purse seine fishery. Despite the low level of observer coverage on the longline, troll and trawl vessels, the combined less than 2 % of total reported pollution incidents by these vessels from the Form GEN-6 data indicate that fishing vessels other than purse seiners engage in pollution activities. The pollution data analysed in this report represent only a portion or snapshot of the actual total pollution incidents by fishing vessels occurring throughout the region.

Figure 6 shows the density of fishing vessels within SPREP member country and territories' EEZs, and in international waters. Compared to Fig. 1 Purse Seine Pollution Incidents Mapped by Longitude and Latitude, this map shows that there is still high fishing vessel activity outside purse seine fishing grounds including high seas

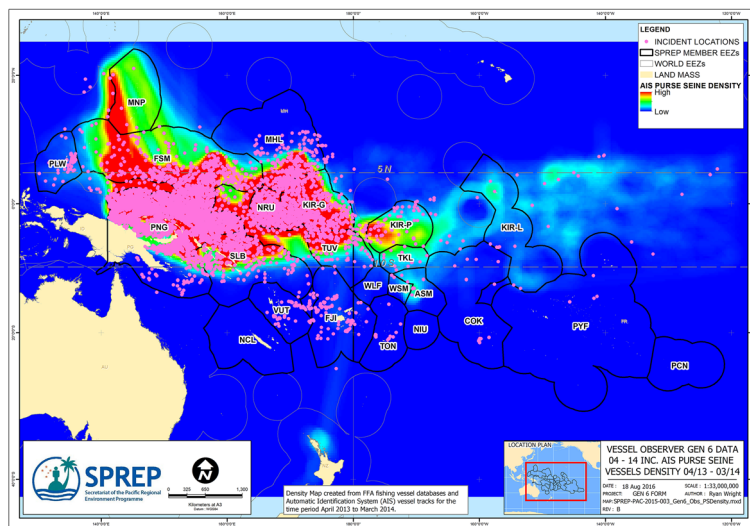


Fig. 1 Purse seine pollution incidents mapped by latitude and longitude Source Secretariat of the Pacific Regional Environment Programme (SPREP), 2015

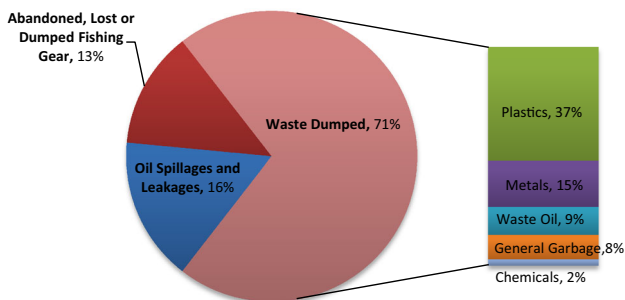


Fig. 2 Percent of purse seine pollution incidents by pollution types, 2003–2015 Source Secretariat of the Pacific Regional Environment Programme (SPREP), 2015

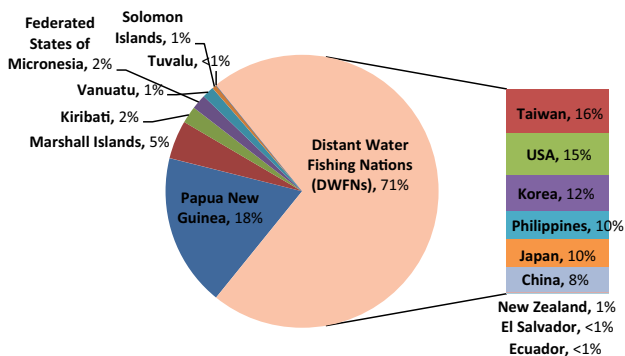


Fig. 3 Percent purse seine pollution incidents by flag states, 2003–2015

areas, where other fisheries, particularly the longline fishery are more active, despite a lack of marine pollution incidents recorded in these areas. Observer coverage on-board other fishing vessels in these areas would provide more information about the frequency, types, quantities

Table 3 Pollution incidents by longline vessels 2003–2015

Exclusive economic zone (EEZ)	Reported incidents	Percent of total incidents (%)
Fiji	64	30
Tonga	30	14
Vanuatu	27	13
Cook Islands	19	9
Kiribati	17	8
Federated States of Micronesia	16	7
International Waters	15	7
Solomon Islands	13	6
Papua New Guinea	8	4
Japan	2	1
Marshall Islands	1	<1
Nauru	1	<1
French Polynesia	1	<1
Total	214	100

Data provided for 2010–2015 are still incomplete and thus a conservative estimate at this point in time

and location of marine pollution incidents that occur in and around other fishing grounds.

Revisions to the Form GEN-6

In 2013, MARPOL Annex V revisions entered into force that prohibited the dumping of any garbage overboard, with some exceptions¹¹ (IMO 2015a, b, c). Almost all of the marine

¹¹ Exceptions include food wastes, non-harmful cargo residues, non-harmful cleaning agents contained in wash waters and carcasses of animals carried on-board as cargo and which died during the voyage (IMO 2015a, b, c).

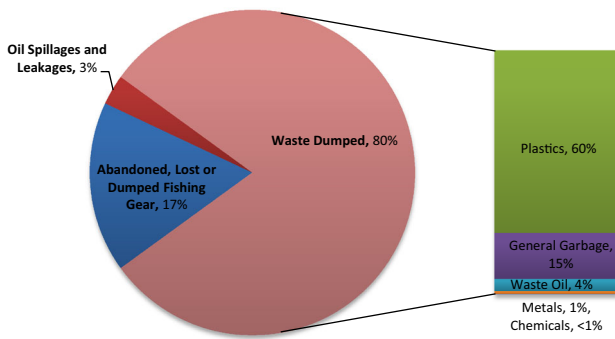


Fig. 4 Percent of longline pollution incidents by pollution types, 2003-2015

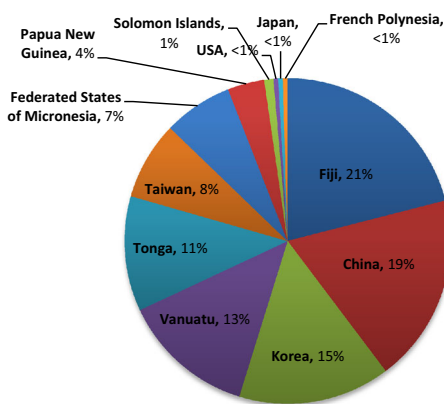


Fig. 5 Percent longline pollution incidents by flag states, 2003-2015

pollution incidents reported between 2003 and 2015 were pollution types of which discharge overboard is now totally prohibited. Prior to the 2013 Annex V revisions, many types of garbage discharge (excluding plastics) were allowed beyond the 12 nautical mile zone. A supplementary note on the back of the current Form GEN-6 states “Vessels may dump garbage as close as 3 nautical miles to the shore if they have a ‘comminutor’ on-board (a machine that shreds garbage to tiny pieces)”. A revision to the supplementary note that clearly communicates which garbage types are allowed for discharge, and that discharge of all other pollution types is totally prohibited, even if beyond 12 nm and even if comminuted, would help clarify for observers the recent 2013 MARPOL Annex V revisions.

Based on Table 1, pollution descriptions and quantities should be revised and offered as categorical drop down menu options with commonly used reporting units for observers to choose from in order to standardize future reporting. The section of the form “Other Comments” provides an area for special circumstances and any additional information required to report an incident.

CONCLUSIONS

With more than 10 000 marine pollution incidents by purse seine fishing vessels and more than 200 marine pollution incidents by longline fishing vessels reported within the EEZs of 25 countries and territories and in international waters in the Western and Central Pacific Ocean from 2003 to 2015, it is

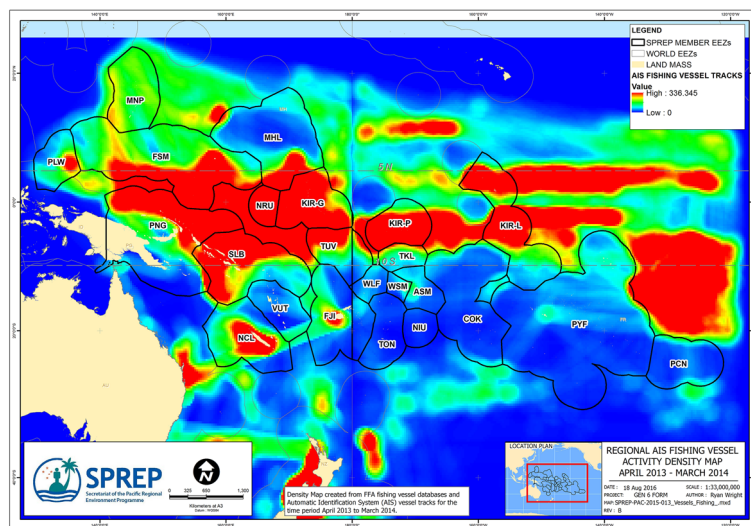


Fig. 6 Regional AIS fishing vessel activity density map April 2013–March 2014 *Source* Secretariat of the Pacific Regional Environment Programme (SPREP)

Table 4 Number of vessels active in the Western and Central Pacific Fisheries Commission (WCPFC) statistical area Source: WCPFC yearbook, 2014

Year	Vessels active			
	Longline	Pole-and-line	Purse seine	Total
2004	3 121	203	255	3 579
2005	3 088	199	259	3 546
2006	2 961	184	251	3 396
2007	2 640	169	279	3 088
2008	2 514	151	291	2 956
2009	2 432	150	302	2 884
2010	2 582	147	316	3 045
2011	2 774	149	318	3 241
2012	2 636	142	325	3 103
2013	2 753	131	337	3 221
2014	2 800	127	344	3 271

clear that pollution from fishing vessels is a significant (and previously unreported) problem within the Pacific region. Accurate assessment of the true extent of pollution occurring is compromised by the limitations of the data caused by variable and limited fisheries observer coverage.

Action is urgently needed to decrease the number and severity of pollution incidents by fishing vessels in the Western and Central Pacific Ocean through three major initiatives: (1) increased monitoring, reporting and enforcement of pollution violations at sea by all types of fishing vessels, especially longliners, which currently have a very low (5 %) mandatory observer coverage; (2) a regional outreach and compliance assistance programme on marine pollution prevention for fishing vessel crews, business operators and managers and (3) improvement in Pacific port waste reception facilities to enable ports to receive fishing vessel wastes on shore.

The following recommendations reflect and expand upon these three initiatives. They are designed for implementation by a variety of stakeholders, including inter-governmental organizations such as SPREP and SPC, regional fisheries managers and RFMOs such as FFA and WCPFC, national maritime and port authorities, national environment ministries, government leaders, policy makers, academics and the private sector, particularly fishing vessel crews and business operators.

RECOMMENDATIONS

Increase observer coverage

Increased observer coverage on-board other fishing vessels such as longline vessels would provide more information about the quantities and types of pollution caused by other

fisheries, which fish more heavily in areas not covered by the purse seine fishery. The current Form GEN-6 is designed for reporting of pollution incidents on-board any fishing vessel. After necessary revisions this would continue to be an appropriate form for use by an expanded, cross-fleet observer program.

Reporting

SPREP should report the Form GEN-6 pollution incidents to both Member countries where the pollution incidents occurred and also to the flag States whose vessels are responsible for the pollution violations. This will allow port States and flag States to follow up with appropriate enforcement mechanisms such as fines and penalties. SPREP should also report incidents to the Noumea Convention and to the IMO's Marine Environment Protection Committee (MEPC). Data and incidents will need to be further organized, quality controlled and standardized to the IMO's Global Integrated Shipping Information System (GISIS) reporting format to streamline reporting.

Enforcement

Opportunities may exist for more effective enforcement of MARPOL and other anti-pollution regulations. If provided with documentation of marine pollution incidents and violations, SPREP Member countries and port States could penalize violators through fines and restrictions. Countries could also prohibit operational dumping of wastes as a condition of their fishing licenses. Effective enforcement programmes send a message to fishing vessels that marine pollution is not acceptable.

In the case of particularly egregious or criminal polluters, a record of vessels and operators could be kept to

ensure against repeat offenders. If certain vessels and operators prove to be repeatedly engaging in pollution events, steeper fines or criminal proceedings could be levied or prosecuted. Vessels could also be added to a marine pollution ‘blacklist’, similar to the WCPFC’s blacklist for vessels that have engaged in illegal, unregulated or unreported (IUU) fishing activities (WCPFC 2010). Such a blacklist system could serve to stigmatize vessels in addition to providing opportunities for more stringent and focused monitoring and regulation. A marine pollution blacklist could then be compared to the WCPFC’s IUU blacklist, to determine range and regularity of illegal activities by particularly problematic vessels.

Outreach and compliance assistance programme

An Outreach and Compliance Assistance Programme should be developed through coordination and collaboration between regional organizations including SPREP, RFMOs, fishing and maritime industry representatives and Non-Governmental Organizations (NGOs) in consultation with the United Nations Environment Programme (UNEP), the Food and Agriculture Organization (FAO) and the IMO. The Outreach and Compliance Assistance Programme should inform shipmasters, mariners, and ports about the proper manner for disposal of all pollution types.

Invest in expanded capacity of port waste reception facilities

Most Pacific island countries and territories have few if any waste reception facilities for ships at their ports, and many of those which are in place are inadequate to meet the needs of ships using those ports (SPREP 2014). The lack of port waste reception facilities may provide further incentives for ships to dump waste at sea rather than store their wastes without anywhere to later responsibly dispose of them.

Given these challenges, the locations and availability of existing port waste reception facilities should be clearly communicated to all fishing vessels, with input from the IMO. SPREP has taken important first steps in this area through its Regional Reception Facilities Plan, which recognizes five Pacific shipping hubs (Apia, Suva, Port Moresby, Noumea and Papeete) as regional centres for safe offloading of wastes from ships (SPREP 2014). This plan is only a starting point however, and more detailed analysis and audits are necessary to identify and communicate all available ports with adequate reception facilities to fishing vessels into the future.

Creation of waste reception facilities at ports where they do not currently exist and improvements in already existing

reception facilities could decrease the dumping of wastes at sea by fishing vessels by providing the vessels appropriate locations to offload wastes. In order to avoid charging separate fees for waste disposal which might act as disincentives for vessels to offload wastes, fees for waste disposal could be included in standard port fees.

Regional funding mechanism for marine debris management

The Caribbean region responded to problems with wastewater as a significant source of localized marine pollution by developing the Caribbean Regional Fund for Wastewater Management (GEF-CReW 2015). The Western and Central Pacific region could follow a similar model through development of a regional funding mechanism for improved marine pollution management.

AREAS FOR FURTHER RESEARCH

Specific pollution categories

Further data analysis should be undertaken of the specific reported pollution categories (i.e. waste dumped overboard; oil spillages and leakages and abandoned, lost or dumped fishing gear). For example, a detailed examination of the nature of Oil Spillages and Leakages data would likely offer a better understanding of how best to improve data reporting fields and specific drop down menus to standardize observer descriptions and quantities of discharge during pollution incidents. This analysis would also result a better understanding of the (causal) conditions associated with spillages and leakages, and the number of oil spills which occur in fishing grounds.

Examination of the abandoned, lost or dumped fishing gear incidents involving fish aggregating devices (FADs)

Within the comments and pollution description sections of the Abandoned, Lost or Dumped Fishing Gear category, numerous reports included the deliberate dumping of FADs (either whole, discarding of damaged FAD nets or retrieval of the GPS buoys before dumping of the old FAD). Lost or discarded FADs in the marine environment can be harmful to marine life through ghost fishing, entanglement and acting as habitat for the spread of invasive species (Macfadyen et al. 2009; Fonteneau et al. 2013; Davies et al. 2014). They also have the potential to wash ashore onto coastlines and reefs as marine debris

(Greenpeace 2015; Sagapolutele 2015). A valuable additional area for further data analysis includes an examination of the Abandoned, Lost or Dumped Fishing Gear incidents that involve FADs.

Survey fishermen, crews, vessel operators, port authorities and observers about causes behind and drivers for pollution incidents

Surveys could be conducted to better understand the drivers of pollution incidents from fishing vessels, and to identify solutions that address underlying causes. For example, interviews with, and surveys of crews and vessel operators could explore motivations for dumping of wastes at sea, such as issues around convenience, time and costs associated with disposal on shore. Interviews with and surveys of port authorities could better investigate adequacy of port facilities to receive wastes from vessels, human resource capacity constraints and time pressures to process vessels quickly through ports.

Identify laws, regulations and procedures by which countries and territories can monitor and enforce penalties against pollution incidents

Enforcement of pollution incidents will largely depend upon existing national laws and regulations within port States where the incidents occur. Procedures for differing levels of enforcement will need to be identified within national contexts, which may be more complicated than prosecution based upon an observer's report alone, in addition to barriers to enforcement.

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AUTHOR BIOGRAPHIES

Kelsey Richardson (✉) worked as a marine debris analysis consultant for the Secretariat of the Pacific Regional Environment Programme (SPREP) during 2015. She earned her master’s degree in International Environmental Policy from the Middlebury Institute of International Studies at Monterey with a concentration in Ocean and Coastal Resource Management. Her research interests include global marine debris issues and issues surrounding abandoned, lost or discarded fishing gear (ALDFG).
Address: 2726 Shelter Island Drive #134, San Diego, CA 92016, USA
e-mail: kelseypr@gmail.com

David Haynes is the former Director of the Waste and Pollution Control Division at the Secretariat of the Pacific Environment Programme. He is currently a Senior Manager with NRM South, Tasmania. His research interests are focused around reduction of terrestrial pollutants in tropical and temperate marine environments.
Address: P.O. Box 425, South Hobart, TAS 7004, Australia.
e-mail: goingtrotppo@y7mail.com

Anthony Talouli is the Marine Pollution Adviser at the Secretariat of the Pacific Regional Environment Programme (SPREP). He manages SPREP’s Pacific Ocean Pollution Prevention Programme (PACPOL) aimed at addressing shipping related marine pollution. Mr Talouli also manages the Marine Environment Protection aspect of the International Maritime Organization’s (IMO) Technical Co-operation Programme in the region. A former oil company employee with over 8 years experience in the industry working at TOTAL Company South West Pacific (formally known as SHELL Company South West Pacific) in various capacities from Project Engineer to Terminal Manager. Mr Talouli is a strong advocate of marine environment issues and activities in the Pacific islands countries and territories.
Address: Secretariat of the Pacific Regional Environment Programme (SPREP), P.O. Box 240, Apia, Samoa.
e-mail: anthonyt@sprep.org

Michael Donoghue M.Sc., is the Threatened and Migratory Species Adviser for the Secretariat of the Pacific Regional Environment; a position he has held since October 2013, following his tenure as Executive Director, Pacific Islands Programme, for Conservation International. One of his core tasks is to mitigate the impacts of fishing operations on threatened species in the Pacific Islands region, in particular, marine turtles, marine mammals and sharks. In 1987, after 7 years as an owner-operator demersal longline fisher in New Zealand’s Hauraki Gulf, he joined the New Zealand Government’s Department of Conservation (DOC), where he was responsible for the development of marine mammal policy in New Zealand, including the management of whale strandings, by-catch of marine mammals in

fishing operations, and the establishment of marine mammal sanctuaries in Banks Peninsula (to protect the endemic Hector's dolphin) and the subantarctic Auckland Islands (to protect breeding populations of the New Zealand sea lion and southern right whale). As Senior International Relations Adviser for DOC, he provided scientific advice over 23 years to three New Zealand Commissioners of the International Whaling Commission (IWC), during which time he led the NZ delegation to the IWC's Scientific Committee. He was also the New Zealand Focal Point for the Convention on Migratory Species

(CMS), and was an architect of the MoU for the Conservation of Pacific Island Cetaceans, negotiated under the auspices of CMS, which came into effect in 2007. Mike is also a Principal Investigator and Trustee for the South Pacific Whale Research Consortium, and he led a research programme on humpback whales in Tonga for 15 years. *Address:* Secretariat of the Pacific Regional Environment Programme (SPREP), P.O. Box 240, Apia, Samoa.
e-mail: michaeld@sprep.org