

An assessment of fishing vessels plastic waste generation in the WCPO region and potential measures to improve waste management in the fleet

A report prepared for the Forum Fisheries Agency



by

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Salt bags in the wet deck of Purse Seiner, Majuro 2019

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Acronyms and abbreviations

ALDFG	Abandoned, Lost or otherwise Discarded Fishing Gear
CA	Competent Authority
CCM	Contracting Member, Cooperating Non-Member
CCRF	Code of Conduct for Responsible Fisheries
CMM	Commission Management Measure
COFI	FAO Committee on Fisheries
DWFN	Distant Water Fishing Nations
DPI	Domestic Pacific Island
EEZ	Exclusive Economic Zone
EM	Electronic Monitoring
EPA	Environmental Protection Authority
EPR	Extended Producer Responsibility
EU	European Union
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organisation
FFA	Pacific Islands Forum Fisheries Agency
FSM	Federated States of Micronesia
FSMA	FSM Arrangement
FOC	Flag of Convenience
FOW	Fishing Operations Waste
GGGI	Global Ghost Gear Initiative
GISIS	Global Integrated Shipping Information System
IMO	International Maritime Organisation
MARPOL	International Convention for the Prevention of Pollution from Ships
MAWC	Majuro Atoll Waste Company
MIFV	Marshall Islands Fishing Venture
HMTCs	Harmonized Minimum Terms and Conditions for Fishing Access
NEPA	National Environmental Protection Act
O&M	Operation and Maintenance
O&MW	Operational and Maintenance Waste
PNA	Parties to the Nauru Agreement
PNG	Independent State of Papua New Guinea
PWMS	Pohnpei Waste Management Services
RFMOs	Regional Fisheries Management Organizations
RMI	Republic of the Marshall Islands
RSW	Refrigerated Sea Water

SIDS	Small Island Developing State
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
STCW-F	International Convention on Standards of Training, Certification and Watch-keeping for Fishing Vessel Personnel
SWM	solid waste management
TCC	Technical Compliance Committee
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean

Executive summary

This desktop study was conducted over the period January to March 2021, during the Covid-19 pandemic. The genesis of this report was the desire of FFA to gain an understanding into the situation regarding plastic waste that might be dumped into the West and Central Pacific from fishing vessels. Given the current situation with the Covid-19 pandemic, this desktop study could only at best review existing literature, and gain some insight from actual practises by attempting to survey fishing boat officers and/or companies, and draw from the extensive experience of the authors in the fields of fishing vessels and waste management. Given that the ultimate aim of the study was to¹:

"Provide consideration as to possible strategies and actions that could be taken at both national and regional levels to eliminate all plastic waste disposal at sea"

The authors have endeavoured to address this central point through a thorough and careful analysis of the information available. It is essential to bear in mind from the outset, the reason why an attempt was being made to determine the amount of waste that is dumped in the ocean: in order to prevent it.

Estimates of Waste Generation by Fishing Vessels

It must be stated clearly at the outset that waste generation in any field is only ever amenable to broad estimates, as the amount change every day, as well as a large number of variables such as vessel size, crew numbers, type of fishing, length of voyage, condition of the vessel and operating standards on board. Similarly, given that waste management practises on board vessels can vary widely, it is not realistic to make any meaningful estimate of the waste that might be dumped unless an extensive, real-time study of a number of vessels in operation is conducted. To make a broad sweeping claim regarding the amount of waste dumped from all fishing vessels might actually discourage those operators who are doing their best to deal with the waste problems on board, whilst make those - if any - who dump everything over the side, actually look better.

Faced with this conundrum, and mindful of the ultimate purpose of this study, the authors have taken the approach of trying to generate some estimates of the amount of waste that certain vessels - given size, type, etc. - might actually *generate*. The report differentiates between Operation & Maintenance waste - related to crew and vessel size and condition, and days at sea - and Fishing Operations waste, which is directly related to the type of fishing and total fishing effort. Using what literature is available, and the varied experience of the authors, some broad estimates have been made that might allow a determination of the *expected waste generation* of a vessel. These estimates are of a conservative nature so as to be applicable to a broad range of vessels.

The study has not looked at the issue of waste generated into the ocean through lost and discarded fishing gear, as this was not part of the terms of reference, although it is noted in passing what those sources might be. The issue could be addressed through recommendations and standards that are already in play with MARPOL and IMO² and the strategies and actions proposed below do take account of this issue, and would allow the integration of measures to combat this into the proposals, through the marking of fishing gear.

Existing International Frameworks and Guidelines

Having determined some idea of the type and scale of the problem regarding the waste that might be generated, the study then looks at the practicalities of dealing with those quantities and types of waste on board vessels. At this point of the study, the current institutional framework that exists under the

¹ Last point of the list in the RFP Terms of Reference

² Actions: point 5: "...Facilitate incentives for fishing vessels to retrieve derelict fishing gear.." Resolution Mepc.310(73) (2018) Action Plan To Address Marine Plastic Litter From Ships

MARPOL convention³ WCPFC CMM 2017-04⁴, and other IMO agreements is looked at in detail to determine if a good framework and clear guidance already exists. It is abundantly clear that all the institutional framework, guidance documents, standards, agreements etc. that might be needed by ships' operators to address the issue of waste management on board ship, are in fact already in place.

Waste Reception Capacity at Pacific Ports

Having developed some estimate of waste generation, and determined how to deal with that waste onboard, the study then looks at the potential to off-load that waste at Pacific Ports. Here the picture is grim: whilst five fishing ports in the Pacific Islands have been looked at, only one - Suva, Fiji - has access to a landfill facility that is in any way compliant with any desirable standards. Of the other four - FSM, Solomon Is., Kiribati and the Marshall Is. - these nations struggle with their own local waste management to varying degrees, and their landfill facilities are mostly already overwhelmed. To add a foreign commercial waste stream to existing domestic waste crises cannot be considered a viable solution where that is avoidable. Whilst some fishing vessels do operate out of Pacific Island ports as a home base - for example two companies in the Marshall Islands and from Noro, Solomon Islands - and these vessels have to dump their waste into those local dumpsites, the majority of the fleet is actually foreign based, and the materials that are now waste were provisioned onto those vessels either at overseas ports or from Carrier vessels.

Waste Disposal for the DWFN Fleet

Taking a conventional solid waste management approach of investigating 'reverse logistics' pathways, and following the internationally accepted principal that the country in which a company that generates the waste is also responsible for that waste⁵ (in this case, the flag state or *de facto* home port) the Carrier fleet can be seen to provide an excellent opportunity to improve waste management at sea. Carriers are typically much larger vessels, with good deck space; it is also essential to remember that all the materials that become waste on a fishing vessel supplied by a Carrier⁶ were transported by a Carrier or merchant vessel from the very beginning. As the actual waste takes up less space than the products that originally generated that waste, there is clearly an opportunity to involve the Carrier fleet in a formal waste management function.

It is fully accepted that the Carrier fleet fills its holds with fish that take up some of the space of supplies that were carried out. But whilst Longliners consume vast numbers of boxes of bait, and Purse Seiners many tonnes of 50 kg sacks of salt, there is space on decks and in dry holds to take back to distant ports carefully managed waste. Carriers have potential to have small compactor baling machines, that can compress waste, increase the density, and so reduce stowed volume. Where incineration is used, they can operate IMO-compliant incinerators that are much safer for both ship and crew than the rusty oil drums with holes that are common on the decks of many fishing vessels. Oil drum incinerators are undesirable from a ship safety point of view, and are a known health hazard to crew as they generate carcinogenic smoke in significant quantities.

In short, if the waste produced by fishing boats is to be professionally addressed, then it must become part of the every-day life of running a tight ship, and managed and stowed for off-loading at the right place and time. Good ship operators will already be doing this, and all the guidance needed to help others improve their waste management on board already exists in great detail under the MARPOL and IMO frameworks. The overall challenge is fundamentally one of good on-board culture and professionalism on the one hand, and indifferent attitudes to proper waste management on the other; the logistical problems are all quite easily solved, and there is no shortage of guidance on how to address them.

³ International Convention for the Prevention of Pollution from Ships

⁴ <https://www.wcpfc.int/doc/cmm-2017-04/conservation-and-management-measure-marine-pollution>

⁵ c.f. the Basel Convention on the Transboundary Movement of Hazardous Wastes

⁶ excepting home port provisioning

On this note, the report does provide some simple, practical advice on waste management onboard, derived from the direct experience of the authors in this field, one of which spent several years at sea during which one of his tasks was to manage the waste on board, ensuring that nothing went over the side except food waste.

Economic Incentives for Improved Waste Management

Having determined that, for the Carrier-supplied fleet at least, there is a clear alternative to dumping waste in Small Island Developing States (SIDS) ports; and that because the waste is generated from commercial operations, that commercial and financial considerations are a significant driver in how waste is managed onboard, the report then takes a brief look at the economic incentives that currently exist and may drive how waste is managed from fishing vessels. It can be clearly seen that the economic incentives are entirely aligned to encourage poor waste management and ocean dumping. This is an important insight, and one recognised by the IMO as several MARPOL documents call for the creation of incentives to improve waste management. The report quotes ground-breaking recent economic analysis⁷ from the British government to support the conclusions reached here. Where vessel operators might incur additional costs through improved waste management, this is simply part of the cost of running a responsible business, and cannot be used as a justification to pollute the natural capital of small Pacific Island nations. Currently, the 'avoided cost' (i.e. financial benefit) of poor waste management is a *de facto* subsidy from the island nations to those businesses who evade their responsibilities under MARPOL. In fact, a 'secondary market' in waste may appear whereby Carriers charge fishing vessels to take their waste away, and so allow those vessels to fulfil their Waste Bond conditions.

Strategy to Eliminate Dumping of Waste at Sea

With all of the above now providing some clarity to the situation, the nub of the matter is reached: how might any ocean dumping of waste from fishing boats cease? In the light of the above, the overall Strategic Points can be drawn out and enumerated: in this way, the resulting actions that can be taken to implement this strategy can become clear.

The resulting Strategic Points determined are as follows:

1. Either waste is dumped into the sea, or it is returned to port at some point, and in some form. MARPOL does not allow the ocean dumping of any of the solid wastes considered in this study, including incinerator ashes, thus:

All vessels should be returning some quantity of waste to port.

2. If something is to be managed, then it will need to be measured. Therefore, the questions are: *how much?* and *how do we measure that?* There are two separate waste streams to consider, Fishing Operations Waste, and O&M waste. The first is related to fishing effort and the second related to crew and vessel size, and the number of days at sea, thus:

A measure of expected waste generation by vessel is required.

3. The overall framework of institutional and technical standards and guidelines already exists with the MARPOL Convention and IMO. The overall aim must be to ensure that those vessels who do not currently have good waste management practices, must do so, thus:

Under the FFA HMTCs all licensed fishing vessels must comply with MARPOL, whether the flag state is a Party or not.

4. There is actually an economic incentive to operate a vessel with poor waste management; an economic incentive must be created to improve waste management, thus:

⁷ The Economics of Biodiversity: The Dasgupta Review February 2021: <https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review>

Create an economic incentive to follow MARPOL requirements.

5. Measures must be simple to implement where possible for both FFA and fishing companies. Onerous and complex reporting systems that require significant additional manpower and cost to report, monitor and enforce are unlikely to be adopted, thus:

Use simple metrics, and focus effort on a smaller number of key locations.

6. The issue of waste management on board a ship is fundamentally a logistical challenge; all the materials that become waste were put on the ship either in port or during a Carrier transshipment, thus:

Use existing reversed logistical pathways.

7. Pacific Island ports already have a domestic waste crisis and are in very large part unsuitable to take foreign wastes generated by overseas business operations, so aside from local-based fishing vessels, wastes need to be returned to originating home ports, thus:

Wastes from DWFN vessels should not be off-loaded at Pacific Island ports.

8. Larger vessels are much better placed to have better waste management systems, as they have more space, can operate small compactors to increase waste density, can operate safe, compliant incinerators, and can handle and stow larger waste containers, thus:

Carrier vessels to accept wastes from fishing vessels.

9. There must be a long-term element to the strategic actions which is aimed at changing the culture on board over time on those fishing vessels that do not currently have good waste management systems in place, thus:

Start with easier measures and lift the bar over time.

10. Ship owners and operators who can show that they have MARPOL compliant systems already in place, and already take waste management seriously, must be recognised. Those who do not must be held accountable:

Reward good businesses and target poor operators.

These Strategic Points rest on two fundamental pillars: simple ways to measure and monitor the wastes in order to know that that change is occurring; and the development of incentives to reward those already doing the right thing, encourage change in those who need to, and sanction those who resist.

Proposed Actions to Take

From this strategic analysis, and a close look at the realities of dealing with waste onboard ship, the report recommends a divergence from the MARPOL method of measuring waste by volume, cubic metres, to that of weight in kilograms. The reasons for this are elaborated in the text, and the key considerations are provided by Strategy Points 5 & 9. Measurement must be as simple as possible consistent with reasonable estimates, as reasonable estimates are the bedrock of waste measurement. This approach meets the requirements of the first pillar on which the strategy rests.

For the second pillar, at the heart of the proposals are the FFA HMTCs that require demonstrated effort to comply with WCPFC CMM 2017-04 and MARPOL requirements. Alongside this, using the widely used waste management principal of Extended Producer Responsibility, a 'Waste Bond' is proposed, whereby a vessel must show that a reasonable quantity of waste is disposed of in an acceptable manner in order to avoid sanction. This is the economic incentive: the 'Waste Bond' would be held in escrow in some conventional form⁸ (and the appropriate mechanism that might work best here is beyond the scope of

⁸ There are a range of potential financial mechanism by which businesses operate escrow arrangements, for example Trust Accounts and Bank Guarantees to name but two.

this study) so as to ensure that good operators are not penalised, but poor ones are. Greater detail of this proposal is provided in the report, but in essence the following actions are proposed:

A. Provide as part of licensing (under HTMCs) vessels with a simple template electronic Garbage Record Book.

A piece of work would need to be conducted to develop a suitable electronic Garbage Record Book template, aiming to minimise the quantity of information required to be recorded so that it is as *simple as possible* to fill out and check. (*For example, the garbage categories used in MARPOL can be simplified significantly for the purposes of this Action: there is no need to identify so many categories*).

Weight in kilograms should be the measurement; and the book - probably a simple excel sheet - should be uploaded regularly to a shared SPREP/SPC/FFA database. Where each ship has given its own file name, then each uploaded file could replace the last for example, to avoid multiple files. This work is an IT task based on input from a waste advisor. This is consistent with Strategic Points 1, 2 & 5.

B. Set up a database to accept uploaded Garbage Record Books.

An electronic repository for the standardised Garbage Record Books is needed on FFA servers or the cloud that vessels can upload their data to. This is an Electronic Reporting (ER) task and compliments Action A.

C. Require all FFA licensed vessels to provide a Garbage Management Plan.

This plan should be as simple as possible consistent with representing the realities of waste storage on the vessel in question. A concise template plan should be drawn up to assist standardisation and encourage simplicity, to avoid recording any unnecessary information. Carriers should be expected to include provisions in their plans to take waste from fishing vessels during transshipments. Carriers will be expected to show compaction capacity and/or large waste holding capacity.

Standardising plans should help ensure that only the important information is in the plan: for example, how waste is contained and stowed, any compaction measures, scrap metal separation, description of any incinerator used, etc. There is *no necessity* to go into recycling capacity, waste type and separation. A draft Template Plan should be drawn up and 'field tested' on a small number of suitable candidate companies/vessels who are prepared to assist, so as to develop the simplest Plan but one fit for purpose. This is consistent with Strategic Points 3, 5, 6 & 8.

D. Develop a Formula for Calculating Expected Waste Generation per Vessel.

Identify a small number of vessels that have good waste management systems, and study them to get good data. Use that data to develop a simple formula based on vessel size, number of crew, days at sea, fishing type, fishing effort. This current report can provide some guidance to developing this piece of work, as a desk-top study is not ideal. The use of existing observers to collect the data for such a study would be ideal, and training could be easily provided to them for this purpose.

This Action can be combined with Action point C so that the same field testing of a Management Plan can be used to collect some data. The study period need not be too long, the intention is to determine a number for a reasonable floor of expected waste generation, and feed into the development of on-board systems. Good measurements will provide good data to help vessels plan their waste stowage requirements over an expected voyage length.

Vessel owners could be incentivised to participate in such a study by being given a waiver from having to post an initial Waste Bond, if that approach was subsequently taken. This is consistent with Strategic points 2, 9 & 10.

E. Require all incinerators on vessels to meet IMO standards.

Ensure that any waste incineration that does take place on board ship only takes place in a decent incinerator fit for purpose, and *not* in a non-compliant device that is a potential health and safety

hazard. As compliant devices will be larger and more complex and expensive, it can be expected that these will tend to be only installed on Carrier vessels, so directing any waste reduction by incineration towards Carriers. These concentrates monitoring effort on a smaller number of subjects, especially as incinerated waste is harder to measure.

This Action requires that vessels submit pictures and specifications of their *installed* incinerator, on the vessel in question, at the same time - and as part of - their Waste Management Plan. Non-compliant incinerators could cause rejection of the Plan. A lead time can be provided so that a future date by when vessels *must* comply can be set. The MARPOL standards for incinerators are extant⁹; this Action requires no additional effort to develop standards. This Action is consistent with Strategic Points 3, 4, 8 & 10.

F. Develop a 'Waste Bond' System that is payable at time of licensing.

The Action Points above will feed into the development of a 'Waste Bond'. With a reasonable estimate of the amount of waste expected to be generated, consistent with ship operations and size, a level of 'Waste Bond' that should be posted can be determined. There are a significant number of factors that must be considered when setting the Bond level, both practical, economic and political. The Waste Bond would be held in escrow, possibly using one of the conventional commercial mechanisms, and rolled over annually for each license period, or as required. Those vessels that signally fail to manage and produce their waste may lose their bond.

The Actions A to E could be conducted over one year, so that by the end of that first year the formula for expected waste has been developed, and templates for Garbage Record Books and Management Plans have been developed and field tested. The study of a selected small number of vessels who currently have good waste management can be conducted using a cohort of waste trained observers. At the start of a new licensing period, vessels will be required to post a Waste Bond which will be fully refundable when, at the end of the period, the expected amount of waste has been off-loaded. Vessels re-licensing can roll-over their Waste Bonds. Non-compliant vessels will lose their Bond, and be required to pay another. Fishing vessels that pass their waste to a Carrier, can be deemed to have effectively fulfilled their responsibility, and transferred that liability to the Carrier. Carriers will also be required to have Waste Bonds as part of their licensing conditions, and will acquit those responsibilities at the point of off-loading waste to a port, recorded in their Garbage Record Book.

It is potentially possible that determination of the amount of Waste Bond payable could conceivably be subject to a vessel's record at the end of each licensing period, creating a sliding scale in the similar vein to a golfing 'Handicap', so rewarding good operators, and increasing pressure on the worst by increasing their bond requirement.

Vessels that at the start can demonstrate full compliance with MARPOL and produce records and plans to support that, including pictures of the current waste management situation on the relevant vessel, may not be required, at the discretion of FFA, to post a Waste Bond. This rewards businesses who are already making the required effort to manage their wastes responsibly. This is consistent with Strategic Points 4 & 10.

G. Communicate the New Waste Regime to FFA Stakeholders.

If the above Actions are decided and underway, then the rationale for taking them needs to be communicated to key stakeholders during the development stage. This could be refined and spelt out in written briefing papers, possibly at least two: one more detailed along the lines of an Executive Summary that might go to key stakeholders, and one a Fact-sheet style of publication that can be more widely circulated to those who are less interested in the detail, but need to know about the coming changes to the licensing conditions.

⁹ Resolution Mepec.244(66) 2014 Standard Specification for Shipboard Incinerators

Subsidiary Actions

Strengthening enforcement and reporting of WCPFC CMM 2017-04

MARPOL requirements above must be viewed in the light of WCPFC CMM 2017-04 that expressly addresses waste from fishing vessels. The section of this report that discuss this alignment clearly demonstrates that these proposals to drive as much waste as possible back along the logistical pathway provided by the Carrier fleet is the cheapest option for both SIDS and DWFN and Flag State operators.

The CMM explicitly recognises that CMMs should be following MARPOL; it explicitly recognises that SIDS are challenged through an inability to provide adequate facilities for receiving and managing waste from ships in their ports; and it explicitly states that¹⁰:

*CCMs shall cooperate, consistent with national laws and regulations, directly or through the Commission, and in accordance with their capabilities, to **actively support SIDS and Territories through the provision of adequate port facilities** for receiving and appropriately disposing of waste from fishing vessels.*
[Emphasis added.]

It is incontestable that it will be far cheaper for both SIDS and Flag States to drive waste back through the logistical chain to ports that do have adequate facilities to accept commercial wastes from fishing vessels. The cost of building landfills and other waste management facilities in SIDS is not only immense, but a long-term programme of improvement completely unsuited to the vagaries of short-term commercial considerations.

Through the 'Waste Bond' system proposed, which would of course also apply to Carriers and any other FFA licensed vessels, the Carrier fleet can actively participate in ensuring that waste only goes to ports that have adequate facilities. As Carriers take on the waste from fishing vessels - even if from a different Flag State to the Carrier - a secondary market will spring up whereby the Carriers will be paid by the fishing vessels to take the wastes away - just as the vessel normally would pay to have its waste disposed of in port¹¹.

The Garbage Record book will record transshipment to a Carrier as a transfer of ownership just as it does fish, and so fulfil the fishing vessels' obligation to dispose of their waste correctly under the Waste Bond conditions. What that might cost will be entirely up to the market, but will also be influenced by the level at which the Waste Bond is set: if it is set too low, the market will not function. Carriers will then in turn pay to dispose of the waste at a port with adequate facilities. This proposal is using market mechanisms to enact point 8 of the CMM, and at a far lower cost than that of actively financing waste management facilities and landfill construction in SIDS.

Similarly, the Actions recommended in this report will help address CMM points 9¹² and 10¹³ of the CMM address the loss and recovery of fishing gear. The proposals in this study that a standardised Garbage Record Book be developed could easily incorporate a lost fishing gear log; if fishing gear were both marked and logged as lost, then the proposals in this study to potentially use forfeit Waste Bonds to incentivise those vessels that recover lost fishing gear are supporting Points 9 & 10.

Inclusion of CMM 2017-04 / MARPOL issues as part of EM role out objectives

As discussed in section 4.4, EM is aimed for substantial deployment in the region and has already a role to play on pollution monitoring, albeit the policy, logistics and operational issues discussed.

¹⁰WCPFC CMM 2017-04 Adoption Point 8

¹¹ If a Fishing vessel is not already paying to have its waste disposed of in port than it is clear why the WCPFC states in CMM 2017-04 Preamble: "*convinced that certain activities associated with fishing may affect the Western and Central Pacific marine environment ... and impacts on marine ecosystems*"

¹² CMM 2017-04 Adoption Point 9: *CCMs are encouraged to develop communication frameworks to enable the recording and sharing of information on fishing gear loss in order to reduce loss and facilitate recovery of fishing gear.*

¹³Ibid, Point 10: *CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.*

Off-loading of fish to Carrier or home port should be accompanied by off-loading of waste, and thus could be easily verified through footage

There should be no expectation of video observers that they should be actively looking through a large quantity of footage for incidents of waste going over board during normal ships' operations. This is consistent with Strategic Points 5 & 6.

Strengthening the existing requirements Marking of Fishing Gear and use biodegradable FADs

The IMO Action Plan¹⁴ suggests that fishing gear should be marked with the deploying vessel's identifiers, in particular this should be enforced in FADs. If this measure was enacted, it would be possible to reward those who collected discarded fishing gear by using the Waste Bond money of those who lost the gear.

It could be that a system was devised so that only where gear is lost, and not recorded as lost, and another vessel finds it, that only then that some fraction of the Bond was forfeit. This way, vessels who 'loose' lots of gear to avoid taking home end-of-life equipment can be sanctioned or identified. Development of such a proposal clearly needs some effort to come up with a workable incentive system using this principle.

There is a large area of potential study and policy development to look at working out some sliding scale to sanction those who lose a large amount of fishing gear. For example, loss of a FAD built using only biodegradable materials, designed to break down over time in the ocean and not entrap by-catch of any sort might not incur penalties, but loss of FADs made of plastic components - or incorporating trash - would. The Waste Bonds could provide the source of funds. Such work would need to be conducted after the effort to develop an initial Waste Bond level. Similarly, the determination of Waste Bond levels themselves could be subject to a vessel's record at the end of each licensing period, creating a sliding scale in the similar vein to a golfing 'Handicap', and so rewarding good operators.

Conclusion

Clearly, if the above proposals were to be accepted and acted upon, there are many details to be worked out; but the proposals developed here are offered as a workable way forward to address what has been seen as, until now, somewhat of an intractable problem. These proposals show a clear way forward using the principals of waste management and economic incentives that have been tried and tested, and proved successful, albeit in quite different fields. They could well work in this one too.

¹⁴ Resolution Mepc.310(73) Action Plan To Address Marine Plastic Litter From Ships

1 The study and its context

In 2018, FFA commissioned a study of Fishing Vessel Waste Management at three Pacific Island Ports. The objective of that study was to prepare a report on developing a business model for the application of environmental services for fishing vessels operating in the waters of Pacific Island countries for disposal of waste - in particular plastic waste, oils, food waste and other materials as appropriate. The report provided a brief 'waste supply profile' of the wastes originating from fishing vessels, it also provided some background on best practice waste management and disposal systems, the current regulatory frameworks and discussed some regulatory options that could further improve and facilitate best practice waste management for fishing vessels and port reception facilities, within the framework of the International Convention for the Prevention of Pollution from Ships (MARPOL) guidelines.

While the 2018 study focused broadly on all types of waste management, there remains a gap with regards to plastic waste. This is particularly important since the adoption of the West and Central Pacific Fisheries Commission (WCPFC) Conservation Management Measure (CMM) 17/04 on Marine Pollution¹⁵,

The focus of the present study, is therefore, to provide an assessment of the present situation in respect to plastics by the tuna fleets operating in the WCPO in general and in the FFA waters of members.

1.1 Regional realities

Globally, FAO and UNEP have estimated that Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG) in the oceans make up approximately 10% (640,000 tons) of all marine litter. The Global Ghost Gear Initiative (GGGI) reported in 2018 that [The Ocean Cleanup](#) found ALDFG constitutes 46 % of surface debris and 70 % of macro plastic.

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP [1991](#)¹⁶, estimated that (80 %) of marine litter is land- based and plastics are estimated to make up 50 to 80 % of total marine litter. Richardson *et al* (2016)¹⁷, assumed that in his study on port waste reception facilities that about 27 % of ships' waste are with the majority of the rest either dumped or incinerated. However, data on origins, quantities and types of waste have many gaps in reporting of data. In general, data is not standardised making it difficult to get a good grasp of the situation.

ALDFG has been on the Agenda of the Food and Agriculture Organisation (FAO) and its Members since 1991 and is specifically addressed by the Code of Conduct for Responsible Fisheries (CCRF) and MARPOL Annex V and its Implementation Guidelines. ALDFG has taken on a new level of urgency since reporting of the Giant Garbage Patch in the Pacific and with the heightened awareness of marine litter and microplastics in general. In February 2018, FAO hosted the Technical Consultation for the Marking of Fishing Gear in Rome, Italy. This resulted in the publishing of The Voluntary Guidelines for the Marking of Fishing Gear in 2019.

As of January 1, 2019, all fishing vessels operating in the WCPFC Convention Area are explicitly prohibited from dumping any plastics into the ocean, in accordance with Clause 2 of the WCPFC Conservation Management Measure (CMM) 17/04 on Marine Pollution (championed by the Republic of the Marshall Islands) which specifically states: "*CCMs shall prohibit their fishing vessels operating in the WCPFC Convention area from discharging any plastic (including plastic packaging, items containing plastic and polystyrene) but not including fishing gear*"

However, the reality of current plastic disposal methods is in stark contrast to the intention of the measure. Observer reports constantly report on MARPOL contraventions, as is noted in detail in a 2016

¹⁵ CMM 17/04 Clause 2; entered implementation on 1 January 2019

¹⁶ <http://www.gesamp.org/publications/report-of-the-21st-session>

¹⁷ <https://link.springer.com/article/10.1007/s13280-016-0811-8>

report analysing Observer pollution reports¹⁸. This report (discussed in the next section) presented at WCPFC Technical Compliance Committee (TCC) mostly focussed on Purse Seiners and found that 37% of the waste dumped corresponded to plastics, with an incidence of 1-60+ assorted items per incident, and sometimes reported as mixed plastics being dumped in bags or empty oil drums.

Space on longline vessels is at a premium and mainly used for storing fish, bait, fuel, water, food, and replacement fishing gear. Longliners in the region are relatively old and the smaller vessels tend not to have waste management technologies installed on board

Whilst some incineration of waste is common on some fishing boats, the 'incinerators' are typically an old oil drum or similar fireproof container on the stern. Smaller Longline vessels may not have the capacity to install suitable waste incinerators that would meet MARPOL standards¹⁹ and adequately burn waste materials to anything like a level that would be acceptable from a crew health or pollution perspective. Incinerators also produce significant quantities of residual ash which is a health hazard, can be toxic, and requires proper disposal.

Waste can be dealt with correctly and well, even in the confines of a small vessel. The essential point is to be clear that *everything that becomes waste was already on the ship*. The technologies are simple, and on a small vessel entirely manual. The handling key actions are: compaction of the wastes, some simple cleaning procedures to minimise smell, and strong, reusable containers to put the waste in when stowed before it is off-loaded. The overall strategy is to use the logistical pathways that put those materials on the ship in the first place to remove what becomes waste, and feed it back, where possible, through the Carrier - 'reefer' supply chain.

In addition, there potential for Electronic Monitoring (EM) by cameras to complement the Observer's form GEN-6 (pollution report) responsibilities (see section 1.1.1.) with waste transshipment and disposal, in addition to fishing operations.

Two prior studies have laid out the groundwork for the understanding of waste of fishing vessels in the region:

1.1.1 The 2015 SPREP Study

The Secretariat of the Pacific Regional Environment Programme (SPREP), the Secretariat of the Pacific Commission/Pacific Islands and Forum Fisheries Agency (SPC/FFA) commissioned studies to have a deeper understanding of the problem. One such study is the prior referenced "WCPFC-SC11-2015 ST-IP-05 - Marine Pollution originating from purse seine and longline fishing vessel operations in the Western and Central Pacific Ocean, 2003-2015". The study based its findings on an analysis of the SPC/FFA regional observer pollution report Form GEN-6 and vessel activity to determine intensity of dumping by fishing areas and by fleet. Using the GEN-6 Forms prepared by Observers between 2003–2015, the study team tabulated and charted the following:

1. Numbers of Pollution incidents by purse seine and longliners in the EEZs and on the High Sea mapped by latitude and longitude.
2. Percent of purse seine and longline pollution incidents by pollution types
3. Percent of purse seine and longline pollution incidents by Flag States

The study had 5 main conclusions as follows:

1. Between 2003 and 2015, pollution from fishing vessels is a significant (and previously unreported) problem within the Pacific region, with +10 000 and + 200 reported marine

¹⁸ Richardson et al (2015): Marine pollution originating from purse seine fishing vessel operations in the Western and Central Pacific region, 2004-2014 WCPFC-SC11-2015 ST-IP-05 Online <https://www.wcpfc.int/system/files/ST-IP-05%20Marine%20pollution%20PS%20in%20WCP%202004-2014.pdf>

¹⁹ Resolution Mepc.244(66) 2014 Standard Specification For Shipboard Incinerators

pollution incidents by purse seine and longline vessels respectively²⁰, within 25 Pacific countries and territories and in international waters in the Western and Central Pacific Ocean

2. The Lack of data and observer coverage in the longline fleet masks the true extent of pollution.
3. There is urgent need for increased monitoring, reporting and enforcement of pollution violations at sea
4. Lack of a regional outreach and compliance assistance programme on marine pollution prevention for fishing vessel crews, business operators and managers and
5. Lack of inadequate Pacific port waste reception facilities

Overall 1-60+ assorted items were dumped per incident. Sometimes reported as “mixed plastics dumped in bags or empty oil drums”. The fishing operations related waste from purse seiners consisted largely of salt bags, whilst bait boxes, bait wrappings and strapping bands were from longliners. Food wrappers, bags, bottles, sheets, foam, cartons, pallets, washing machines, raincoats, plates, cups, cutlery were generated by both vessel types.

80% of longline pollution incidents were documented in the form of waste dumped overboard. Plastics were found to make up the largest portion of total pollution incidents at 60 %.

In addition, the report pointed out that “*of the 14 SPREP countries namely The Cook Islands, Kiribati, Marshall Islands, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu, only 3 Fiji, Federated States of Micronesia and Nauru are not Contracting Parties to MARPOL Annex I/II and V (IMO Status of Conventions, 2015). Fiji has since joined up to Annex V* Implementing more rigorous reporting and auditing are some of the measures that can be taken.

The following recommendations - paraphrased - made in the report were directed to a wide range of stakeholders to reflect and expand upon these three initiatives, they were:

1. Increased observer coverage on-board other fishing vessels such as longline vessels and revise GEN-6 report form to be better aligned and standardized to the IMO’s Global Integrated Shipping Information System (GISIS) reporting format to streamline reporting. This should be accompanied by data quality control and management.
2. SPREP Member countries and Port States could reduce pollution through imposition of fines, restrictions and non-pollution conditions attached to fishing licenses.
3. Develop an Outreach and Compliance Assistance Programme to inform shipmasters, mariners, and ports about the proper manner for disposal of all pollution types.
4. Implementation of the Regional Reception Facilities Plan, with more detailed analysis and audits are necessary to identify and communicate all available ports with adequate reception facilities to fishing vessels into the future. The Plan should include a funding mechanism for improved marine pollution management.
5. 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.
6. The study also recommended further research into the following areas:
 - a. Data analysis the specific reported pollution categories (i.e. waste dumped overboard; oil spillages and leakages and ALDFG
 - b. Further study on abandonment or dumping of FADs

- c. Better understand the drivers of pollution incidents from fishing vessels, and to identify solutions that address underlying causes.
- d. Review and modernisation of existing national laws and regulations related to marine pollution within Port States where the incidents occur.

The recommendations of the 2015 WCPFC-TCC11-2015-OP06 should be given due consideration.

1.1.2 The 2018 FFA study

In 2018, FFA commissioned a study of Fishing Vessel Waste Management at three Pacific Island Ports²¹. The objective of the study was to prepare a report on developing a business model for the application of environmental services for the servicing of fishing vessels operating in the waters of Pacific Island countries for disposal of waste - in particular plastic waste, oils, food waste, and other materials as appropriate.

Towards this objective, the study undertook a scoping mission to attempt identify the types and amounts of wastes originating from fishing vessels at three major fishing ports: Suva (domestic and foreign longline vessels); Majuro (mainly foreign purse seine transshipment and domestic longline vessels); and Noro (small domestic purse seine and pole/line fleets and foreign longline offloading).

The report provided a brief 'waste supply profile' of the wastes originating from fishing vessels observed and researched at each of the three major fishing ports visited. With reference to MARPOL, guidelines it also provided some background on best practice waste management and disposal systems, the current regulatory frameworks and discusses some regulatory options that could further improve and facilitate best practice waste management for fishing vessels and port reception facilities.

Prior to this study there was very limited data documenting the types and amounts of wastes originating from fishing vessels and the accounts of waste management practices advised in the course of the study varied greatly as did the practices observed at the ports.

1.2 This study contribution

This study builds on the above reports, detailed MARPOL documentation, other reports from around the world, and current solid waste management tools and practises. It is the focus on waste management techniques that has allowed this report to develop a raft of concrete strategies and options to tackle this difficult subject. This report works through the existing international legal framework of MARPOL, appraises the situation regarding solid waste management in a selection of Pacific Ports that is indicative of the challenges that these Small Island Developing States (SIDS) face on this issue, analyses the current logistical flows of materials that end up becoming waste, and the pathways for returning waste to the land from whence it came. The economic incentives to poor waste management are discussed in order to determine the ways in which incentives to better waste management can be introduced.

This report does not ultimately rely on enforcement measures in order to generate the outcomes sought: economic incentives and the promotion of a culture of professionalism on fishing vessels, whilst using the leverage that FFA has as a licensing body to promote these aims, is laid out as the way forward. As a result of this careful situational analysis, a list of Strategic Points, and the Actions required to implement those strategies, can be found near the end of this report.

²¹ A Brief Profile and Discussion on Best Practice Waste Management (Bulman, 2018)

2 Methodology

2.1 General Approach

The following is a description of the methodology used in this report. This study is a desk study that operated under a flexible framework the information acquisition process developed, and as to which data sets are actually available, formally and informally, from the different stakeholders in the fishery.

We followed a methodological approach to respond to each of the items in the Terms of Reference of the RFP.

1. An estimate of the amounts of plastic waste generated on a per vessel basis by vessel type and operation.

The methodology used information collected from regional vessels operators as well as based on the experiences in the study team for:

- a. The identification of the main sources of the plastics generated per type of fleet (but not including fishing gear)
- b. The estimation of individual weights of those items
- c. The estimations of the levels of “use” and the volumes generated of the identified items in the Longline and Purse Seine fleet.
- d. The identification of best estimates of crew generated plastics (Operational and Maintenance Waste - O&MW)

2. A summary of current fishing vessel plastic waste disposal practices in FFA Member Countries and adjacent high seas areas.

The team analysed through their network of contacts in the region:

- a. The practices of the present vessels licenced to a sample of FFA countries,
- b. The practices of DWFN flagged vessels operating high seas practices.

3. An estimate of the volumes of fishing vessel plastic waste that is being directly dumped into the ocean and a review of the potential impacts of this practice.

Based on the outcomes of activities 1 and 2, and the information provided by the SPREP study using observer records, the team estimated the volumes potentially being disposed at sea for the longline, purse seine fleet, as well as crew waste based on crewing numbers sourced from the regional vessels registers (FFA and PNA).

4. A summary of the range of mechanisms for plastic waste disposal from fishing vessels other than oceanic dumping and how these could potentially be applied.

Based on the combined experience of the team on board vessels and the facilities in port, a summary of potential mechanisms was developed. The process included a mix of practical on-board measures and regulatory approaches that will involve some type of monitoring aspect.

5. Provide consideration as to possible strategies and actions that could be taken at both national and regional levels to eliminate all plastic waste disposal at sea.

Based on the findings of activities 1 to 4, a series of recommendations including mitigation strategies and actions to take are presented.

2.2 Specific tools

2.2.1 Interviews and questionnaires with key stakeholders

During the study period, the team developed a questionnaire (attached in Appendix 1), contacted key personnel (list in appendix 2) including fleet managers, Port Authorities and Environmental Officers in

Ministries responsible for waste disposal in Pacific Island Countries in order to gain knowledge about ongoing plastic waste disposal for the longliners and purse seiner fleets.

2.2.2 Bibliography review

The team consulted numerous documents available formally and informally available for this study. Documents consulted are referenced in footnotes.

2.3 Limitations of the methodology

This study is based on the interpretation of the secondary sources provided and gathered. Hence, the final quality of this assessment and estimations depended on the quality of the sources.

The consultants are familiar with the realities of fishing and waste management among the FFA membership, and this knowledge is utilized as applicable, yet it will be subject to their interpretation of the available materials and personal experience. As much as possible, the team members have endeavoured to verify information about any particular information from several sources.

The results rely on information collected through interviews with key personnel at industry and staff at various administrations in the FFA Membership as well as local NGOs, peer and non-peer-reviewed documents.

Other outliers that provided additional information include published academic papers, regional reports (open access and confidential), documents from international agencies and NGOS, news articles and journals.

3 Analysis

3.1 Main sources of plastics in the fleet

Richardson et al (2015) reports that plastics were found to make up the largest portion of total pollution incidents, and that the plastics category included: salt bags, bait boxes, bait wrappings, strapping bands, food wrappers, bags, bottles, sheets, foam, cartons, pallets, washing machines, raincoats, plates, cups and cutlery

Our findings, based on the team's experience and our consultations, validate that finding and focussed on the assessment of volumes of the following items:

- For longliners the waste assessed consists of plastic liners and plastic straps on bait cartons and plastic bags for bagging tunas in Refrigerated Sea Water and Slurry Tanks²².
- For tuna purse seines the main sources of plastic waste were salt bags used to store the salt which is used in brine tanks and also used in Fish Aggregating Devices (FADs) along other plastics.
- In addition, other plastic waste from food and beverage packaging and living on board, what we call Operational and Maintenance Waste (O&MW) is also a major source of plastic and other waste not only onboard longliners but on all vessels at sea.

The study therefore will focus these major sources of plastic waste that are directly related to fishing operations. It is important at the outset to note that 'plastic' is a very generic term, and that 'plastic waste' will, under a MARPOL definition²³ will include mixed wastes that include plastic. For general ships' wastes, 'plastic waste' will be broadly defined as non-metallic and inorganic wastes.

²² Plastic flour or rice bags are also used to store salt used in the brine tanks on longliners. However, these are usually brought back and reused several times before disposal in landfills.

²³ MARPOL Regulation 1 Definitions: 13; Regulation 4: 4.



Photo 1: Bags of used longliner fishing gears offloaded at port



Photo 2: Pieces of salt bags being used in FAD construction

3.2 Estimation of plastic waste generated by the fleet

There are many variables associated to the use of plastics on board fishing vessels. The following is a non-exhaustive list of variables: The length of time the vessels remain at sea, the size and fishing

method used, the number of crew, availability of products and the packaging formats (e.g. bait) physical spaces and equipment aboard to store, handle and manage waste. In addition, the knowledge level of the captain and crew and managers about environmental and legal obligations and the extent of awareness of the problems associated with poor plastic waste management and the dumping of plastic at sea.

While the team endeavours to be as precise as possible, in reality the results should be always seen at best as 'ballpark' estimates (i.e. that the general scale of the problem is captured by the estimate. Due to the many variables, the team has used averages for vessel sizes, proxies and figures obtained from similar situations and studies.

3.2.1 Long Line Fleet

SPC (2020)²⁴ reports that the commercial longline fleet (excluding Vietnamese and Indonesian domestic and Japanese coastal longliners) peaked in size in 1994 at a total of 5,068 vessels. The fleet has steadily declined since then, and totalled 1,669 vessels in 2019. Yet, the total number of hooks fished in the WCPFC-CA varied around a level of 400 million from the mid 1970s to the late 1990s. Starting in 2001, the number of hooks set doubled to the 800 million level with the peak occurring in 2012 at 885 million hooks; 2019 was the second highest level on record at 838 million hooks.

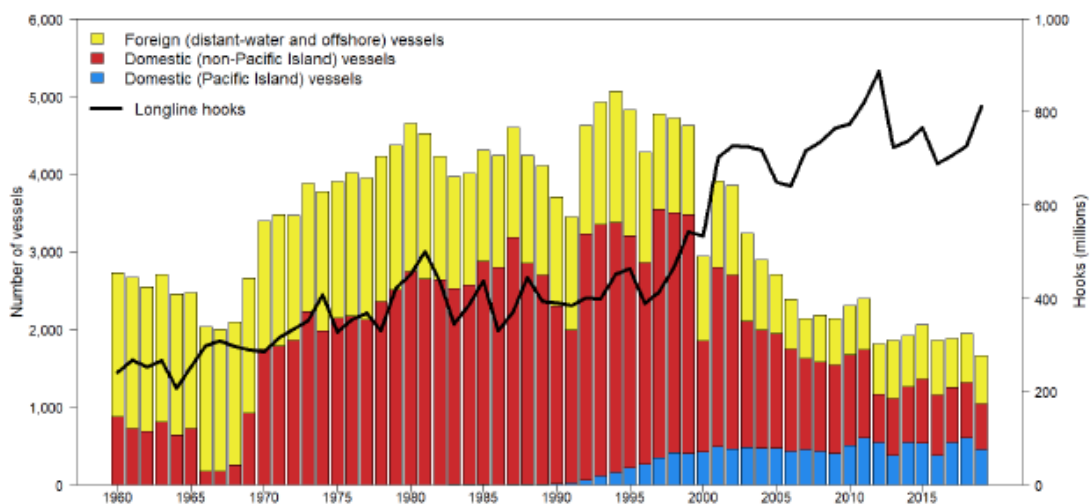


Figure 1 CPUE Hooks vs. Number Longliners 1960 -2019

Source: SPC 2019 Tuna Fisheries Assessment Report no.20

3.2.1.1 Type of Longliner operations related to disposal of plastic waste

3.2.1.1.1 Domestic Longliners fishing own EEZ for Fresh Fish Value Chain

Trip Duration

Domestic longliners fishing exclusively in their flag state waters tend to be smaller, use ice and slurry or Refrigerated Sea Water (RSW) as the main means of fish preservation. These vessels target the fresh fish export market. As the freshness is of paramount importance in this value chain, the voyages are limited from 12 - 14 days. Managing plastic waste on board these fresh fish boats is therefore much less challenging than on freezer vessels, which can stay out to sea for several months. Vessels using RSW

²⁴ Hare S.R., Williams P.G., Ducharme-Barth N.D., Hamer P.A., Hampton W.J., Scott R.D., Vincent M.T., Pilling G.H. 2020. The western and central Pacific tuna fishery: 2019 overview and status of stocks. Tuna Fisheries Assessment Report no. 20. Noumea, New Caledonia: Pacific Community. 49 p.

normally place the fish in large plastic bags. However, the fish remain in these bags until discharged on shore and are not considered a major source of plastic waste that is dumped overboard.

3.2.1.1.2 Foreign Longliners fishing EEZs and High Seas

Trip Duration

High seas longliners that fish the high seas typically freeze their catches. As a result of their distant water operations these vessels will remain fishing until their holds are full, coming to port only for offloading, repairs, dry-docking, or medical emergency. They frequently bunker, receive spares, food and other supplies from other vessels within their own fleet, whilst navigating to the fishing grounds. They may enter port in emergencies related to injuries, or for logistical purposes, depending on the proximity to port and the need for products to be shipped. Due to the nature of their operations and the irregular port schedules, management and disposal of plastic waste is a much more challenging issue for this fleet segment than the domestic fleets fishing for fresh fish exports.

A recent report commissioned by FFA²⁵ on High Seas Transshipment confirms this appraisal, as it quotes the following:

“Unfortunately, pollution incidents were common. MARPOL signage was abundant, but plastics were continuously thrown into the sea. There were properly marked bins on deck, but they were not emptied when we were in port. A poignant moment was watching three juvenile oceanic whitetip sharks chewing on the kitchen waste, which included plastics.”



Photo 3: Three juvenile oceanic whitetip sharks chewing on the kitchen waste, which included plastics

3.2.1.2 Bait Species

Bait species used in surface pelagic longline fisheries vary depend on the fleet, availability, price, and the bait preferences of the vessels' Captains or Master Fishermen. In general, tuna fishing fleets use small pelagics as bait, such as: *Cololabis saira*, *Scomber scombrus*, *Scomber japonicus*, *Sardina pilchardus*, several species of *Decapterus* and *Trachurus*. Some fleets widely use locally produced milkfish *Chanos chanos*²⁶

²⁵ Brogan, D. 2020. Standardised Monitoring Procedures for Longline Transshipments in the WCPFC. FFA

²⁶ Romanov, Evgeny. (2014). Re: What are the type of bait used in pelagic longline fisheries?. Retrieved from: <https://www.researchgate.net/post/What-are-the-type-of-bait-used-in-pelagic-longline-fisheries/54082a72d685cca3518b4651/citation/download> .

However, locally produced frozen bait is less commonly available than frozen imported bait. Squid is also used, but due to its high demand for human consumption, and consequently its high price - which can be 2.5 times the price of small pelagic baitfish - small pelagic fish are much more common as bait in tuna fisheries. However, fleets targeting Swordfish tend to prefer *Illex argentinus* and other squid species.

3.2.1.3 Bait Format and sizes

Just as the bait comes in different species, so does the packaging format. Small pelagic fish is not exclusively sold for fishing and some bait species are also sold for human consumption. The table below shows some of the different formats by species, bait size and carton weight. There are some companies that specialise in selling bait and small pelagic fish for both fishing and human consumption. Bait is variable not only in size and package format but also in quality. It important to understand packaging formats, as the amounts of plastics used will differ according to the packaging format and size.



Photo 4: L to R. Sardine bait with plastic liner/bag, Carton type and Carton of bait in plastic bag (may or may not be in bag)

Species	Grams/Pcs	Weight per Ctn (KG)	Format	Origin
<i>Scomber Japonicus</i>	100/200, 200/300, 300/500, 500/700	15	Carton with outer sack <u>Ocean Blossom</u>	ROC
<i>Sardinella Aurita</i>	120g-150g; 100g-130g 80g-100g; 60-100g; 50-70g; 40-50g	10	Polybag for inner packing, <u>HealseaFoods</u> Carton for outer packing	ROC
<i>Sardinops Melanostictus</i>	5-6pcs/kg,6-8pcs/kg,8-10pcs/kg,10-12pcs/kg,12-14pcs/kg,14-16pcs/kg	10	Polybag for inner packing, Carton for outer <u>HealseaFoods</u> packing	ROC
<i>Sardinella Aurita</i>	10-12,12-14,14-16PCS/Kg	10 & 15	Not specified, as per customer request <u>HealseaFoods</u>	ROC
<i>Cololabis Saira</i>	100-150g,150-200g,200-300g,300-500g	10	Plastic Bag Inside Then Into Carton	ROC
<i>Sardinops Sagax</i>	40-80, 50-100,70-150	10/15/20	Carton with inner polybag <u>Hanaba</u>	ROK
<i>Trachurus Trachurus</i>	100-120	10/15/20/25	Carton with polybag inner <u>E.K Co Ltd.</u>	ROK
<i>Todarodes Pacificus</i>	100-150g, 150-200g, 200-300g	10/12.5/15	Bag	ROC

Table 1: Examples of bait formats typically available in the market

The following is a summary of the main aspects of the bait fish size and packaging format

- The choice of species and size of individual pieces of bait is dependent on the preference of the Captain / Master Fisherman, as well as the availability in the port of loading and, of course, the price.
- Bait comes in different packaging formats. However, the most common size for longline is the 10kg carton with an inner poly bag, which is available for all species of bait fish. The 10 kg carton of bait is light enough for relative safe handling (lifting and shifting) by crew on a fishing vessel rolling at sea. The bait cold storage is usually below decks and the bait is brought up on deck manually. Heavier cartons pose a danger for crew during the transfer of bait from the hold to the stern of the vessel and lighter cartons are preferred. In addition, smaller packages are much easier to pack and fill up precious space in the bait storage and fish holds.
- For the above reasons, and for the purposes of this study, we have use the 10kg carton with inner poly bag and strapping as the most common standard format for bait used on all longliners in the WCPO.
- In addition, we have interviewed various stakeholders who have confirmed the use of the 10 kg Format. This is also in line with the knowledge of the team’s Master Fisherman and fleet management adviser.
- Defining this 10kg format is important in calculating the quantity of plastic generated only from the bait cartons.
- Longline hooks are baited one whole bait fish per hook.

3.2.1.3.1 Number of Bait pieces per carton

Stakeholders informed us that the number of pieces of bait used in longlining depends on the size and species targeted. Vessel captains that are targeting large fish use large baits of about 43 pcs per 10 kg carton and vessels that target albacore use about 100 pcs per carton. However, some vessels targeting large Bigeye tuna -BET in deep sets also use 90-100 pcs per 10 kg Carton.

3.2.1.4 Measurement of weight of plastic in bait for longliners

In order to calculate the weight of plastic the study team contacted various informants and requested them to purchase or obtain full 10 kg cartons of bait, then to open them and weigh separately the carton, plastic strapping and plastic liner bags. The informants were requested to take photos of the weighing processes.

The main forms of plastic from bait cartons were the plastic liner of bags and the strapping materials used to hold the carton together.

Results of the measurements from the informants:

Carton Format (Kg)	Cardboard (g)	Strap (g)	Plastic Liner (g)	Adhesive Tape (g)	Total Plastic/ carton (g)
10.00	353 g	20 g	22 g	6 g	48 g +

Table 2: Breakdown of Plastic and cardboard per 10 Kg Carton of Bait

The weighting methodology used is lustrated in the photos below:



Photo 5: Photos of the weighing of bait carton components

3.2.1.5 Estimation of Plastic waste from bait cartons in the WCPO

In order to estimate the amount of plastic waste generated by the use of bait cartons we used data from the 2020 SPC Report. The report quotes 1,669 vessels and at 838 million hooks. It should be noted that the SPC Assessment Report excluded Indonesian, Vietnamese domestic and Japanese coastal longliners in relation to hooks deployed. These three fleets are not included in the following estimate as the authors opted not to make any estimate for these three fleets due to lack of documented information on these fleets related to hooks deployed in 2019.

Using the weight of plastic per carton, the number of pieces of bait per carton and the total number of hooks set in 2019 an estimate of the total weight of cardboard, plastic liners and strapping materials for the entire longline fleet during 2019 was made.

Description	High Waste Est.	Low Waste Est.
No. of Longliners WCPO 2019	1,669	1,669
Number of Hooks	838,000,000	838,000,000
Number of baits/Ctn.	43	100
Number of Cartons (1 whole bait per hook)	19,488,372	8,380,000
Total Weight (T) of Cardboard @353 grams/carton	6,879	2,958
Total Weight (T) of Plastic Carton liner @22 grams/carton	390	168
Total Weight (T) of Plastic Strapping @20 grams/carton	429	184
Total Weight (T) of Adhesive tape @ 6 grams/carton	117	50
Total Waste from Bait usage only (T) (Cardboard + Plastic)	7,698	3,310
Total Plastic produced only from Bait Usage (T)	935	402

Table 3: Estimation Plastic generated from cartons of bait in 2019

Total estimated plastic from bait usage is between 935 and 402 tonnes during 2019.

Longline vessels remain at sea for long periods. They are much smaller vessels than purse seiners and generally have less storage space for garbage on board.

The actual plastic waste products from bait boxes are estimated as between 402 and 935 tonnes, of which the median value would be about 670 tonnes per annum.

Cardboard waste is much larger and estimated at between 2958 and 6879 tonnes for the 1669 active vessels in the WCPO, of which the median value would be about 4,920 tonnes per annum.

From our interviews there was a good indication that these Domestic Pacific Island fishing vessels (DPI) brought back a substantial portion of their waste. The fleet segment represents 452 longliners. It is assumed that the DPI, which is 27% of the total longliner fleet, has similar dumping rates to Purse seiners at 37%, and the rest of the fleet dumps 100% due to the lack of space on longliners, the cramped working conditions, and the long time away from port.

3.2.1.6 Estimation of amount of plastic waste dumped by longliner fleet

From interviews with Domestic Pacific Island (DPI) fleet managers in Fiji, Kiribati, and Republic of Marshall Islands all plastic is brought back to shore.

Malo Hosken, SPC's EM/ER specialist commented to the authors: *"After a trip, I remember plastics being offloaded from our LL in Suva - I was actually really impressed that it was the first thing to come off the boat and that the port inspectors were paying close attention to this being done"*

In Marshall Islands there is a financial incentive scheme to and in Fiji there is a requirement that the waste be returned to shore. However, there is no way to verify that claim that there is zero dumping of plastics.

The SPC report to the Scientific Committee Meeting 2004-2014 WCPFC-SC11-2015 ST-IP-05 stated that 60% of incidents of waste dumped was plastic. In order to estimate the amount of waste dumped by the 1669 longliners active in the WCPO during 2019 when have used inferred that 60% of the 402 to 935 plastic waste generated is dumped overboard.

Using 60% as a proxy we estimate that between 241 and 560 tonnes of plastic waste from bait only is being dumped at sea, while the figures for carboards is in between 334 tonnes and 776.

3.2.1.7 Plastic Bags/Sleeves used for bagging tuna in RSW and slurry tanks

On many longliners, it is common to pre-chill the tuna in RSW or ice slurry to decrease the temperature before storage in the ice/Freezer hold. Alternatively, after initial bleeding, gutting and gilling and washing the fish is placed in the blast freezer. In order to reduce bruising of the gutted, gilled and washed fish in the RSW and slurry tanks, they are placed in fairly thick plastic bags until such time as the core temperatures are reduced to between 0 and -1C. Once the core temperature reaches the required temperature the fish is then removed from the bags and the RSW or slurry and placed in the ice hold where they are buried in ice until being discharged. However, some vessels only use RSW tanks and no ice hold. In this case the fish remain in the bags inside of the RSW tank until they are discharged.

These plastic bags are a source of plastic waste on board longliners and because of the thickness of the plastic they are made of, are potentially of significant concern. Respondents interviewed confirmed that they used plastic bags on vessels that use RSW and slurry, but these had been brought back to shore. It should be noted that these vessels customarily stayed at sea for not more than 14 days.

Vessels use different combinations of preservation systems. The following tables shows the different combinations, and the risk factor for generating waste from plastic protection bags/sleeves:

Description	Use Plastic Bag	Plastic Waste	Risk Factor
Use ice only	X	X	No risk
Ice with small Slurry dip	X	X	Low risk

Brine Tank and Ice Hold	√	√	High risk
Brine Tanks only	X	X	Low risk
Brine Tank and Air	√	√	High risk

Table 4: Risk factor for generating waste from plastic protection bags/sleeves

In order to determine the extent in the use of plastic bags/sleeves in RSW/Slurry tanks, the team analysed the FFA Vessels list on good standing.

Description	No.	%	Comment
Total Longliners	583	100	WCPFC and FFA data bases differ
Vessels using ice	82	14.07	In general, will not use plastic bags
Vessels using Ice and Brine	0	100	Will definitely produce plastic bags waste
Vessels using Brine Only	23	3.95	Fish stay in the bags until discharge
Vessels using Brine and Air	2	0.34	May use plastic bags. Not clear from data base.

Table 5: Breakdown of no. FFA vessels using different ice, brine and air preservation equipment

The following is a summary of plastic bags used in brine tanks:

- The number of longline vessels using preservation system combinations that use protective plastic bags/sleeves is quite small.
- The bags /sleeves used are 20-40 microns thickness and considered very thick.
- The vessels that used the plastic bags/sleeves will mainly be vessels that return to port once or twice per month and are targeting the fresh export high value markets.
- Vessels that use a combination of Ice and Brine, and Ice and Air cooling, are the vessels with the highest risk of producing plastic bags/sleeves as waste.
- Since each fish is placed in a sleeve, and the size of the sleeve varies according to the size of fish, it is very difficult to make an estimate of the amount of plastic bags/sleeves used without knowing the size composition of the catches.

More data is needed here to come up with precise estimates of plastic bags/sleeves.

The weighting methodology is lustrated in the photos below:



Photo 6: Photo of roll of plastic sleeve material



Photo 7: Weighing of Plastic Sleeve 1.5m length

3.2.2 Purse Seiner Fleet

SPC (2020) reports 277 purse seiners operating in 2018. The increase in number of purse seine sets and purse seine fishing days has mirrored the rise in number of vessels, although the peak in both measures of fishing effort, sets and days, occurred a few years earlier (2011-2013) at around 65,000 fishing days (suggesting improvements in efficiency). Purse seine vessels can make more than one set per day, and a day of searching (with no sets made) is counted as a fishing day.

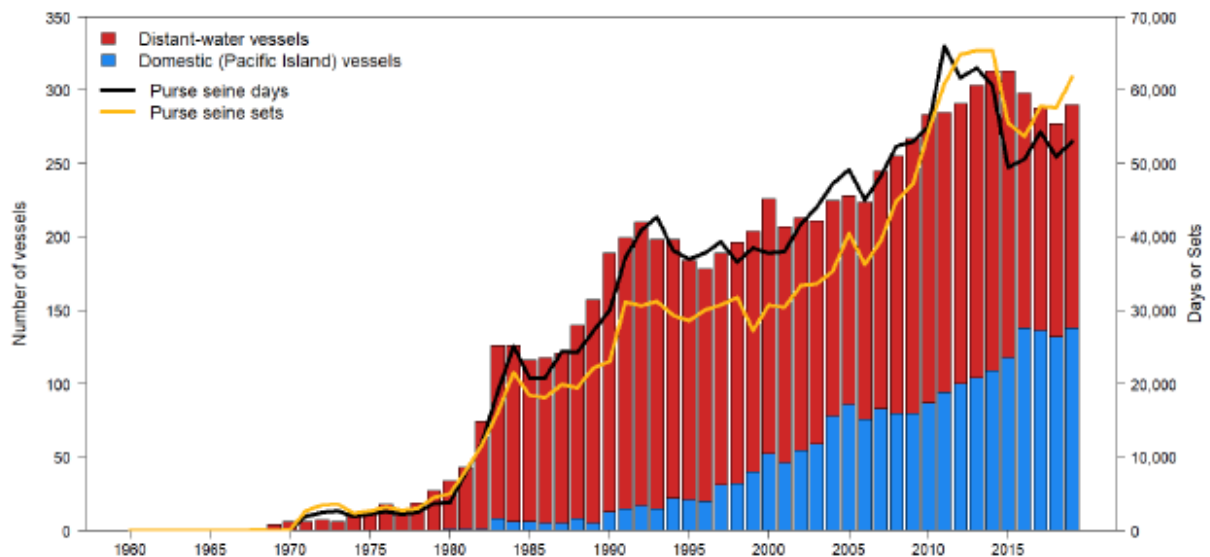


Figure 2: Indices of fishing effort, in fleet sizes and number of sets and days for the purse seine fishery.

The purse seine fleet listed in the FFA register of vessels in good standing for 2020 to 2021 numbered 253 vessels. These vessels range in length from 46 - 116 meters.

3.2.2.1 Estimation of plastic waste from salt bags in the WCPO

Salt is used to lower the freezing point of water by a predictable amount and therefore freeze the fish. The seawater (with a natural salinity of 3.5% sodium chloride by weight) with a freezing point (fp) of about -2 C, must be replaced with brine of greater salinity and a lower fp. Brines are often identified by their freezing points rather than their salt concentration. For example, brine with a salinity of 19% and a -15C may be called a -15C brine.

The salt used for making brine is of varied origins, with a grain size equivalent to a rice kernel and containing less than one half percent organic and inorganic impurities. Salt is either provided in bulk (normally at the vessel's home port) but most commonly in sacks of various sizes: for the WCPO 50kg bags are the standard, and are mostly delivered to the vessels by the carriers originating in Bangkok, and increasingly ports in Vietnam.



Photo 8: Photo showing 50 kg salt bags just transferred from a carrier

3.2.2.1.1 *How much salt is used?*

As in many areas in fisheries, there is not a simple answer to relatively simple questions. Different fleets operate under different “ways” and based on traditional practices. While the American fleet was the original in terms of Brine freezing, the Taiwanese fleet, for example, developed its own ways, yet the principles are similar and dictated by physics and chemistry.

The first batch of brine is prepared at the beginning of a fishing trip by adding a desired amount of salt (sodium chloride) to an empty pair of wells, filling those wells with clean sea water, circulating the sea water until the salt has dissolved, applying refrigeration to the brine, and storing it at between -12C to -17C.

To calculate the amount of salt to add to a brine storage well, the volume of the well and the desired brine salinity must be known. The desired salinity depends upon whether the brine will be intentionally diluted by leaving some RSW (Refrigerated Sea Water) in a well during brining, or whether all the RSW will be removed and therefore dilution will be minimal.

For example, a 1 l of eutectic brine, salinity = 23.3 percent, contains 342 gm. per kg of sodium chloride. Since sea water (3.5 percent salt) already contains approx. 35 gr of salt per 1l, an additional 307 g of salt must be added to each litre of seawater. So multiplying 307g times the well capacity in litres²⁷ gives the weight of salt required for one well.

Therefore, an imaginary vessel with a well capacity of 1,000 cubic meters (1,000,000 litres) distributed along 10 wells (100,000 lt / well) will use 30,700 kg of salt (30.7 tonnes) for one well, which will result in estimating that (30,700/50) 614 salt bags are used.

However, brine is not made for every well; furthermore, the more fish the vessel brings on board, the less “space” there is for brine, which is circulated among the wells to maintain the fish frozen.

To this scenario, it also needs to be considered that while “new” brine should be stored at a temperature -15 above its freezing point (fp). This safety margin should be increased to -13.5 to 1-2.5C when storing used brine that has picked up blood, slime, soluble protein, and other "foreign" material from fish. The presence of these substances increases the density of the brine, causing the salinometer to float higher in the brine, indicating a greater salinity than is actually present.

As salt is scarce and a considerable expense, brine is retained and used for several trips. The fluids and protein picked up by brine during extended use cause the measured salinity to be overestimated by an average of two percentage points. This discrepancy must be remembered when checking the concentration of brine to be used on another trip, as sufficient salt to increase the salinity by 2 % (about 26g per lt of brine) needs to be added to previously used brine at the beginning of a trip. Since this brine must be kept cold, or the organic material it contains will decompose, extra time is needed to completely dissolve added salt.

To complicate matters further in terms of “simple” calculations, in newer vessels, once the fish is frozen the brine is drained from the tank and the fish held in a dry condition with the refrigeration system on. This avoids the fish absorbing too much salt and drying of the wells is recommended when the storage period is longer. Some vessels will move the fish to “dry lockers” on port and starboard above the wells deck to be stored in operational freezer holds as one could see in land-based premises. After drying the well, the temperature of the fish will fall slowly to achieve an equilibrium. The equilibrium depends on the vessel refrigeration system and the level of insulation of the well.

For example, the Taiwanese and Chinese fleets have a 60:40 ratio of brine to dry well capacity, whereas for other fleets, such as the US or Korean fleets, they only use brine wells and therefore the assumption is that salt consumption would be higher. The Filipino fleets with their smaller boats that fish only in the PNG Archipelagic Waters, the consumption would be a different rate, as they only sub-freeze and tranship directly to carriers at sea.

Some vessels use “re-brining” (the re-introduction of brine to the dry well) as part of the unloading procedure, to melt interstitial ice (to separate fish that become "welded" to each other) and to achieve a uniform temperature distribution.

Commonly, the brine will be at a temperature of -10.5 to -11.5°C, since lower temperatures require a stronger brine, and will not melt the ice as quickly. "Floating off" is a practice in which the uppermost fish separate from the mass and float to the top and “scooped out” to be unloaded, as it can be seen in the picture below.

This process requires adding seawater to dilute the brine and put less refrigeration in it, which in turn deteriorates quickly the brine and therefore diminishes the number of “cycles” of reuse.

²⁷ Multiplying the volume of the well in cubic meters times 1000 (the number of litres held in one cubic meter) gives the capacity of the well in litres.



Photo 9: "Floating off" type unloading in Purse Seiners. Honiara Harbour

The number of "cycles" used brine can be reused, depends on the potential impact it has on fish quality (as the more it is used the more odours it concentrates), but as well practical considerations such as older brines being more difficult to maintain at the desired temperature, and are more difficult to circulate (as their density increases). Furthermore, the amount of organic matter incorporated by the brine depends in part on whether the fish is caught in free schools (as they come on board hotter, stressed and bleeding, or whether they were FAD associated schools, which are less stressed and have lower temperatures).

Unfortunately, there is no standardisation in the Purse Seiner fleet in terms of fishing vessel type and size, that can be used to make concrete calculations. In front of all these variables, independent pure calculations-based estimates become, not only difficult but arguably meaningless.

Responses from Purse Seiner operators agreed on:

- Taiwan and Chinese fleet: each trip consumes between 30-35tonnes of salt and after catching approximate 10,000t (depending on if it is during FAD closure) they will replace all the brine in the well which will require around 90mt of salt.
- US Fleet: A typical 1,200 tonnes (70m) purse seiner uses approx. 50-60t of salt per trip (which include new brine making and reusing old brine)
- FSM/RMI: Depending on the size of the vessel, the use is 25 tonnes (vessels up to 55 m) to above 50 tonnes on vessels to 75m

Based on their remarks and data of the FFA Vessels in Good Standing (VGS) the following numbers are assessed as providing a considered estimate.

Class Size (CS) of PS from VGS	# of PS / CS	Ton / trip	total /class size / trip	trips / year	tons / year
Vessels < 55m	14	30	420	16	6720
Vessels 56-75 m	156	50	7800	10	78000
Vessels > 76	83	80	6640	8	53120
Total in tons per year					137840

Table 6: Salt consumption per PS size range

To facilitate the calculations, and mindful that this is a broad estimate, this number has been rounded up to 140000 tonnes of bagged salt used by the fleet, with the qualification that these are conservative numbers.

3.2.2.2 Weight of the plastic bags used

Based on that figure, the findings that the most common salt bag is 50kg and the weight of an empty bag is in on average. 75g, the table below provides an overall estimate of the waste generated from salt bags.

Ton/year	# of bags (50 kg bags)	Weight of bags produced /year in tons (75g per bag)	Weight of bags produced /year in kg
140000	2,800,000	210	210,000

Table 7: Number and weight of salt bags used per year

We estimate that the plastic waste production from salt bags is 210 tonnes which is equivalent to 2,800,000 individual bags.

Conservative reports from operators quote plastic dumping at 25% but also its use in FADs construction. Furthermore, and as quoted before, Richardson *et al* (2015) reports that plastics (including salt bags) are the largest portion of total pollution incidents recorded at 37%. In order to estimate the amount of waste dumped by the PS leet active in the WCPO during 2019 when have used inferred that 37% of the waste generated is dumped overboard.

Using this as 37% proxy we estimate that, potentially, the Purse Seine fleet in the FFA VGS disposes 77.7 tonnes of woven plastic salt bags (equivalent to 1036000 individual bags) a year into the ocean.

3.2.3 **Pole and Liners**

SPC (2020) reports that the pole-and-line fleet has been contracting in size continuously since 1974, when the number of vessels peaked at 798, and totalled just 103 vessels in 2019. Pole-and-line effort, measured in fishing days, has shown a similar decline, from a high of 88,567 days in 1978 to 10,805 days in 2019.

The fishing effort in fleet sizes and number of days (seen in the figure below), for the pole-and-line fishery in the WCPO shows the three fleets operating. Of interest (and scope) to this study are the Japanese fleet operating to the north of the Republic of the Marshall Islands (RMI) being 11 vessels that return to Japan, and the domestic Solomon Islands fleet of 3 operating vessels.

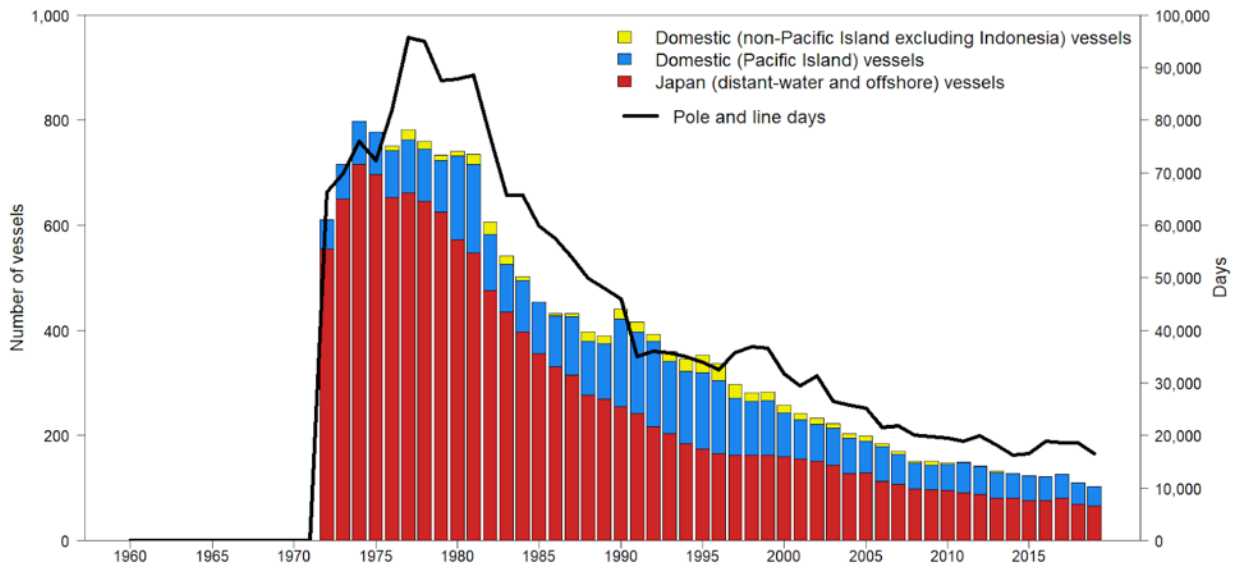


Figure 3: Fishing effort in fleet sizes and number of days for the pole-and-line fishery

The team could not establish contact with the Japanese operators and as per the three Solomon Islands vessels, considering that they fish for 4-5 days at the time and unload in port, they prepare a light brine at shore, use only live bait and they embark a maximum of 30 crew each, it is expected that their contribution to the plastic waste problem may well be insignificant in comparison to Purse Seine and Longline vessels. Therefore, an in depth analysis was not pursued for this fishery.

3.3 Operational and Maintenance Waste (O&MW)

This O&M waste stream is composed largely of 'galley wastes' which shall be used here to mean all waste generated by feeding and maintaining the crew, and 'maintenance waste', which would come largely from the engine room, and deck work associated with the bosun and his deck hands. The galley waste will comprise in large part packing materials from food and drinks consumed on board, including bulk cartons and sacks as well as individual items; it will also include waste from crew cabin and bridge rubbish bins, and toilet waste bins. The maintenance waste will, for example, include oil filters and rags, spare parts packages, broken small appliances, old paint tins and brushes, rope ends and rags from deck maintenance work. This waste stream is not generally particularly large, but it can be bulky, especially from deck and engineering work, with metal parts and old brushes that can easily break plastic rubbish sacks if these are used as bin liners. Broken plastic waste bags spill their contents, and as a result can easily end up excused by going to the 'Blue Bin'.

Food packaging should really be rinsed by the cook before putting into the rubbish bin to keep smells down. Scrap metal and old paint tins are ideally better set aside into the scrap metal pile. Where oil filters are drained first - typical good engineering practise - these can go into the scrap bin too. Such a scrap bin can either be on or below deck, depending on the vessel and space.

This O&M waste stream is largely independent of fishing effort, and is related to the size of the vessel, crew numbers, and length of time the ship is at sea more than any other metric.

3.3.1 Non-Fishing Related Waste from Fishing Vessels

It is essential to have some estimate of the amount of waste that a fishing vessel might make aside from fishing operations. It must be clear at the outset that any such estimate is influenced by a large variety of factors, including vessel size, number of crew, time at sea, etc. It will also be greatly influenced by the general standard of living of the crew: a crew who is consuming at the same level as a person in a developed country can be expected to produce significantly more waste than a crew composed of people from a less developed nation who may be eating large quantities of bulk rice and other bulk dried foods etc, and consuming little in the way of personal products in their cabins. Consumption of

fresh foods and fruit and vegetables, for example, can expect to generate more packaging, whilst dry goods and cans are typically high density food packaging that produces less waste per serving. The level of maintenance operations conducted on board at sea will have a bearing on waste, for example whether deck maintenance works are carried out during non-fishing days.

The overall point is that such estimates can only be, at best, very broad. However, it is important to have some idea of the scale of waste generation in order to have some understanding as to whether a vessel is in fact bringing back to port an amount of waste which might generally be expected to have been created during the voyage; if not, then perhaps some waste is going over the side. Ultimately, a waste generation rate based on a crew-person per day is the baseline metric.

There are two basic ways to measure waste: by weight, or by volume, in cubic metres. Weight is easier to measure, but a typical challenge of waste on board a ship is the space it takes up, i.e. volume. However, volume is very difficult to estimate, especially in small quantities, unless the container holding the waste has a known volume. Thus, it is the density - kilograms per cubic metre - of the waste that becomes a crucial parameter, and that is even harder to estimate. It should be noted in this context that the MARPOL Garbage Record Book template uses a cubic metre - volume - approach.

Materials that have been incinerated will have greatly reduced volume, but weight will not be reduced in a commensurate manner. Given the difficulties of measurement, both metrics will be used, but the final one used here will be weight, primarily because it will be easier for a fishing vessel to estimate weight rather than volume when putting off waste at a port, or transshipping to a supply vessel at sea.

3.3.2 Previous Estimates of Ship Waste

There is little data in the literature on ship waste generation rates per person per day, as most ship waste studies look at the waste received by specific ports - often European - and the number of ships; whilst these studies help port authorities determine the waste reception facilities required at a particular port, they tell us little about rates per crew-person per day, or differentiation by type of vessel. Three studies have made some attempt to give per crew-person rates, one from Europe and one from the Pacific, and these are looked at below.

3.3.2.1 European Maritime Safety Agency (EMSA) Estimates

In 2017 the EMSA conducted a study²⁸ on this issue: the study looked at fourteen vessels with regard to plastic wastes, and estimated waste per crew-person per day to be in the range of 0.001 and 0.008m³/p/dy (cubic meters per person per day)²⁹. They assume a density of the plastic waste of 16kg/m³, which would translate to weight values of 16g to 128g, with an average of 0.006m³, which 96g. To put that in perspective, this is equivalent to a crew member using about three or four 500 ml PET plastic drink bottles per day, or a single large plastic 2l fruit juice bottle.

For overall 'domestic' waste production, the study looked at a variety of ships, including passenger vessels, and had values of 0.001m³ to 0.02m³ per day³⁰, at a density of 75kg/m³. These figures give waste generation rates of 75g to 1.5kg/p/dy. These figures are not particular to fishing vessels, and also apply generally to larger cargo vessels serving European ports, and as such probably represent a reasonable picture of O&M galley and crew waste streams. These figures are useful to compare to household waste generation figures for some Pacific Islands, noted below.

²⁸ The Management of Ship-Generated Waste On-board Ships. January 2017, <http://www.emsa.europa.eu/damage-stability-study/items.html?cid=77&id=2925>

²⁹ Ibid, 6.4 Quantity of plastics generation, pp36

³⁰ Ibid, 8.4 Quantity of domestic waste generation pp43

3.3.2.2 PACPOL Study

A more specific effort was conducted by the Pacific Ocean Pollution Prevention Program (PACPOL) study in 2002³¹ and this made estimates of waste generation from vessels in Pacific ports. This study did separate out fishing vessels and also 'Carrier' supply vessels - called 'Motherships' in the table below - and provided estimates of garbage³² of around 1.8 kg /p/dy for oceanic fishing vessels, and 2.8kg/p/dy for Carrier supply vessels. These figures should be considered as all O&M waste *plus* fishing waste and were derived from field surveys by five people in Pacific ports conducted over 15 months from 2000 to 2002.

The results of that study³³ are reproduced here in Table 8 below.

Vessel Type	Indicative No. Persons Onboard	Indicative Displacement (t)	Sludge and Waste Oil ¹ m ³ /day (at sea before arrival)	Oily Bilge Water ^{2,3} amount per ship visit (m ³)	Garbage ¹ kg/ day (at sea before arrival)	Sewage ⁴ m ³ /day (in port)
Merchantmen ³	18	3,000 – 20,000	0.18	n/a	27	1.3
Tankers ⁵	15	2,000 – 20,000	0.18	n/a	22	1.0
Cruise Liners ³	600 – 1,500	10,000 - 20,000	0.27	n/a	1,800 - 4,500	42 – 105
Inter-island Traders	15 - 20	100 - 250	0.05	5	22 - 30	0.4 – 0.6
I/Island Ferries (large)	600	1,500	0.05	10	900	n/a
Inter-island Ferries	100	250	0.05	2	150	n/a
Tourist Charter Boats	10 - 20	n/a	0.01	n/a	5 - 10	n/a
Warships (very large) ³	1,000 – 6,000	20,000 – 100,000	0.18	n/a	1,700 – 10,200	50 – 300
Warships (large) ³	200	2,500	0.18	n/a	340	10
Warships (small)	20	100 - 250	0.01	5	26	1.0
Fishing (oceanic)	18	250 – 1,000	0.02	10	32	0.7
Fishing ('mothership')	18	2,000 - 4,000	0.05	10	50	0.7
Fishing (local)	2 - 5	n/a	0.005	n/a	2 - 4	n/a
Local workboats	2 - 5	n/a	0.01	0.05	2 - 4	n/a
Yachts (itinerant)	3	n/a	n/a	n/a	1.5	0.06
Local craft (day trips)	2	n/a	n/a	n/a	1	n/a

Notes:

1. Estimates are indicative only and assume all waste is retained onboard for disposal ashore (including food waste) without any treatment (eg. incineration, compaction, shredding).
2. Does not include tank washings or non-segregated ballast water.
3. Older ships not fitted with IMO approved pollution control equipment may need to discharge to shore that oily bilge which is produced while alongside/at anchor.
4. Assumes vessels not fitted with sufficiently large holding tanks or approved sewage treatment plants.

Table 8: Estimates of waste generation from selected vessels using Pacific Island Ports

3.3.2.3 FFA Fishing Waste Management Study

In 2018 FFA commissioned a report on waste management³⁴ at the three Pacific Island ports of Noro, Suva and Majuro. These three locations are also looked at in this study regarding their ability to take waste from fishing vessels. The study also made some estimates of the amount of waste generated from

³¹ Pacific Ocean Pollution Prevention Programme: Improving Ships' Waste Management in Pacific Islands Ports; SPREP 2002

³² Assuming a MARPOL Annex V definition of Garbage

³³ ES2, p V SPREP 2002

³⁴ Fishing Vessel Waste Management at Three Pacific Island Ports: FFA 2018

fishing boats by looking at receipts for waste discharged from one company's vessels in Majuro, and provisioning information from Suva operator, and taking into account factors such as number of vessels per fleet, number of crew onboard each vessel, average nights at sea, average trips per year, fishing gear type.

Estimates were then produced³⁵ based on solid waste creation per person per night at sea (these are all fairly short voyages studied). For the Chinese longliners operating out of Majuro, the estimate was 0.4kg/p/dy; for purse seiners, the report 'assumed there is very little waste of fishing gear' and came up with an estimate of 0.15kg/p/day³⁶ (150 grams per day). It is of note that cartons from bait boxes are considered 'organic waste' by the companies interviewed, and so can be legitimately dumped over the side, but they do not classify as organic waste under MARPOL.

The estimate of 0.15kg/crewperson/day is notable and falls within the range of other estimates. Also notable is that the companies opine that if port waste reception facilities were better they would expect to have better MARPOL compliance. This supports the contention made later in this report that this is fundamentally a logistical problem that must be addressed.

3.3.2.4 Household Waste Generation Rates in Pacific Islands

To put these figures into perspective, and given that the crews on fishing vessels may be from less developed countries, it is useful to hold these numbers against waste generation rates for some Pacific Island nations. In 2017 the Japanese Project for Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries (J-PRISM) conducted waste audits of several Micronesian locations, based on household waste surveys³⁷.

These surveys give household waste generation rates of 580g to 870g/p/day across seven Micronesian locations, and so are fairly consistent. These numbers would include heavier items such as some organic wastes, disposable diapers and broken household appliances etc. that would not generally be present in crew fishing boat waste streams. The results are provided below.

Location	Household Waste (per person per day)
Palau	673g/p/dy
Chuuk State FSM	834g/p/dy
Yap State FSM	582g/p/dy
Pohnpei State FSM	743g/p/dy
Kosrae State FSM	773g/p/dy
Ebeye, Marshall Is.	868g/p/dy
Majuro, Marshall Is.	868g/p/dy

Table 9: Waste generation rates in 7 Micronesian locations

³⁵ Ibid, 1.3 Solid Waste Estimates from Companies Interviewed, p 11

³⁶ Ibid, p 12.

³⁷ J-PRISM II Inception Report to JICA, Kokusai Kogyo Co., Ltd./EX Research Institute Ltd 2017

3.3.3 Estimate O&M Waste Generation Rate Per Crew-Person Per Day

If the aim is to create a 'universal metric' of grams of waste generated per crew-person per day from day-to-day onboard living, then clearly there is a range of potential values. However, the general scale is apparent: it is unlikely to be significantly less than 100g/p/dy, and similarly unlikely to be more than a kilogram, or even perhaps 500g.

This study will use an estimate of 100g, being 0.1kg of waste per crew-person per day as a simple metric that can be said to cover the vast majority of vessels' actual production of day-to-day crew living waste, mindful that some ships crews will consume significantly less than others. This figure of 0.1kg/p/dy sets a low bar, which, it is believed, cannot seriously be contested as inflated.

3.3.4 Estimate O&M Waste Generation Rate Per fleet

For crew estimates the study used the PNA FIMS database that has a specific crew tab.

3.3.4.1 Longliners

The following table shows the total and average number of crews on the longliner fleet active during 2019 according to SPC Assessment Report 20.

Vessel Number	Average crew size	Total Estimated Crew	Low No. Crew/vessel	High No. Crew/Vessel
1669	17	28373	8	35

Table 10: Breakdown of crew size on longliners 2019

(Source FFA Database Vessels in Good Standing)

Plastic/crew/day	Fleet waste/day (t)	Avg. operational days / year	Fleet waste / year (t)
0.1kg	2.8	365	1000

Table 11: Estimate of Operational and non-metallic deck and engine room operational and maintenance waste on Longliners

Using Richardson's (2015) 60% proxy figure, then an estimated 600 tonnes are potentially disposed into the ocean every year by the Longline fleet.

3.3.4.2 Purse Seiners

The following table shows the total and average number of crews on the purse seiner fleet active during 2019 according to SPC Assessment Report 20.

Vessel Number	Average crew size	Total Estimated Crew	Low No. Crew/vessel	High No. Crew/Vessel
290	32	6080	16	48

Table 12: Breakdown of crew size on Purse seiners

Based on the conservative estimate of 0.1kg of O&M waste per crew / per day, table 14 summarises the calculations for the purse seine fleet over a hypothetical year.

Plastic/crew	Fleet waste/day (t)	Avg. operational days / year	Fleet waste / year (t)
0.1kg	0.6	365	220

Table 13: Estimate of Operational and non-metallic deck and engine room operational and maintenance waste on Purse Seiners

Using again Richardson's 37% proxy figure, an estimated 80 tons are potentially disposed into the ocean every year by the Purse Seine fleet.

3.3.5 Engineering and Deck Operations Waste

Engine rooms produce scrap metal wastes of failed mechanical components, and probably some general 'e-waste' which would be broken electrical devices; other engine room wastes are typically oily rags - which must be carefully stowed in fire-proof containers - and packaging and odd small workshop related wastes. Deck waste is typically paint brushes and tins, plastic container for deck washes and the like, rope ends etc.

Both these types of waste are going to be closely related to ship size, age, and type of operations, and as such no direct estimate will be made. But metallic items, including paint tins, can go in scrap bins on deck.

3.4 Assessment of Waste Disposal Facilities in Pacific Island Ports

Good solid waste management (SWM) is a challenge throughout the Pacific Islands, with very few exceptions. Most Pacific Island ports lack proper landfill facilities, although there are exceptions; there may be some recycling of scrap metals, and some states have Container Deposit Legislation which provides cash refunds from returned beverage containers, but in general, any waste from fishing vessels that is off-loaded in Pacific Island ports will go to local landfills.

The key issues defining the quality of local landfills are: whether the waste is contained in a clearly defined and restricted area; whether the liquid that runs out of the bottom of them - called leachate - is treated; whether there is a systematic attempt to work the site using heavy equipment; and how access is controlled to the site. The majority of sites in the Pacific Islands would be classed as some form of 'dumpsite'.

Pacific landfills can be classified into three broad types:

Dumpsite

A place where rubbish is disposed of; it probably has no fence, no staff on site, is rarely worked by any heavy machine, and access is uncontrolled. Such sites frequently catch fire, and in many cases the nominal authority in charge of them, often the local government, may actively burn the waste in order to reduce the quantity at the lowest possible cost. Such sites are frequently located in mangroves or swampy, usually coastal, areas. They are typically highly polluting to the surrounding environment, especially when they burn.

Controlled Dumpsite

A dumpsite with a fence around it, and some form of restricted access so that it is not open to the public 24/7. There may be staff on site during working hours, or even a watchman outside those hours. There will be no active leachate control system. There may be some heavy machinery used to work the waste. The term 'Controlled Dumpsite' can cover quite a wide range of management options. They are a big improvement on the simple uncontrolled dumpsite; most Pacific Island ports' landfills will fall into this category.

Sanitary Landfill

In the correct terminology this is a discrete, controlled landfill site with a fence, leachate treatment and control, has formal management of the site, with ongoing operation of heavy equipment to work the waste and ensure that it is safe and compacted regularly.

This section looks at five fishing ports in the Pacific Islands, which between them provide a good range of the landfill arrangements that will be found in the islands. Only one, Suva's Naboro Landfill, located about 20 km west of the port, would be classed as a sanitary landfill. Tarawa, Majuro and Pohnpei have controlled dumpsites of varying effectiveness, and Noro would appear to have an uncontrolled dumpsite, although information has been hard to obtain remotely. Sites other than Noro are well known to one of the authors.

All the towns attached to these ports suffer problems with solid waste management:

In the Marshall Islands, the highest point in the nation is the dumpsite's mountain of garbage, known locally as 'Mt. Trashmore'.

In Pohnpei, the dumpsite is well compacted and regularly worked with a heavy machine to spread and compact the waste, using the standard landfill technique, known as the 'cell method', but the landfill itself is unbounded into the lagoon, and has no containment wall where it slowly engulfs the adjoining mangroves.

South Tarawa has three controlled dumpsites built into the lagoon tidal flats, that do have containment walls, but the dumpsite next to the port of Betio is already overfull and the wall at this site is the weakest of the three, and suffers from periodic collapse caused largely by wave overtopping and subsequent undermining of the wall.

Only Suva has a properly constructed, fully managed landfill sit at Naboro, built with the assistance of the European Union (EU) a decade ago, complete with an active leachate management system. Ideally, only Suva would be in a position to accept waste generated from foreign sources. The cost of accessing these Pacific waste disposal facilities is minimal in the wider scheme of ship operational costs, being typically in the tens of dollars to dump a light truck load, which would be the sort of quantity of waste that a fishing vessel might off-load.

3.4.1 Majuro, Marshall Islands

Majuro Atoll is the capital of the Republic of the Marshall Islands (RMI) is perhaps the largest transshipment port in the North Pacific. The atoll has a controlled dumpsite that is operated by the Majuro Atoll Waste Company (MAWC). The dumpsite is situated ocean-side at Batkan village, about 4 km from the main port of Delap, along the south side of the atoll. The site is currently far in excess of its capacity, with a mountain of waste that is 17 metres high; but the site still must accept waste as there is no alternative. The waste mountain periodically catches fire during dry periods, and waste and leachate from the dumpsite frequently escapes to the adjacent ocean. A small extension is being constructed (as of February 2021) across the road from the main dumpsite, on the lagoon side, which will alleviate the immediate issue, but a planned site at Uliga in downtown Majuro has not been developed as the site was re-assigned to developing a sports field for the next Micronesian Games.

The Marshall Islands operates a deposit/refund system for drink cans and bottles, but if items knowingly came from ships, items that were not bought in the RMI, this may mean that refunds would not to be paid.

3.4.1.1 Waste Collections

MAWC operates waste collection compactor trucks, as well as open flatbed trucks to collect waste. MAWC operates a dumpster collection service using 2, 4 and 6 cubic yard containers which are emptied at the customers' premises by a dumpster truck. There is no conventional skip truck service as such. It would be problematic for a visiting ship to be able to arrange a dumpster in the port for a short period and get it serviced promptly. Private operators can dump waste at the site for a nominal fee based on vehicle size, six days per week.

MAWC management³⁸ reports the following:

"The ship's local agent here in Majuro contacts us to come and pick up the waste from the dock. Currently we have no dumpster on hand to give to the shipping agent for their ship. We usually collect from the dock, they usually have a waste container of some sort and we go there to pick it up. We charge the shipping agent as they do the coordination on-island. The price would depend on the hours it

³⁸ Pers. comm Mr. Halston De Brum, General Manager, Majuro Atoll Waste company, January 2021.

took to collect the waste. But we have a base price that includes the rental of the flatbed truck (collection) and a disposal fee of \$30.00. It really depends on the size of the waste."

Clearly some vessel waste does go to the dumpsite, but costs are very low. There are two local fishing operations, Marshall Islands Fishing Venture (MIFV) and Koos, MIFV operates shorter longline voyages from Mauro so their vessels' waste will be off-loaded to the Majuro dumpsite. While Koos operates Purse Seiners that only occasionally go dockside to land fish.



Photo 10: The pile of waste at Majuro Dumpsite, February 2021.

Note the broken landfill containment seawall on the beach, top left.



Photo 11: Majuro Dumpsite showing how the waste is right up to the recycling shed wall

3.4.1.2 Legislation & Regulatory Oversight

The RMI Environmental Protection Authority (EPA) is the agency responsible for solid waste management and also any issues around pollution in the lagoon during transshipment operations. The EPA regularly fines ships for pollution incidents in the lagoon, usually fuel spills resulting from re-fuelling operations. The EPA is also responsible in the case of shipwrecks and groundings. The EPA office is in Delap, close to the Port, with another office on Ebeye Island, in Kwajalein Atoll.

The National Environmental Protection Act (NEPA) of 1984 created the RMI Environmental Protection Authority. This Act largely covers the administrative structure of the EPA and its general powers, with the specifics concerning areas of responsibility provided for in various powers to regulate certain activities. One of these areas is solid waste, and The NEPA has pursuant Solid Waste Regulations from 1989. The Regulations do not contain any specific provisions relating to ships or ship waste. There are also the Marine Water Quality Regulations 1992, under the NEPA, but these are largely related to oil spills and sewage discharges in coastal waters where they reference shipping.

The RMI is a party to the IMO, and has a large number of ships registered to the nation through its flag of convenience (FOC) ship registry.

3.4.2 Suva, Fiji

Suva has a sanitary landfill at Naboro, about 20 km west of the port of Suva. Suva has both local government and private waste collection operators, and all waste is trucked direct to Naboro. The landfill site is a fully engineered and well-designed site which has a conventional landfill cell structure, daily heavy equipment operations and a leachate treatment system. Naboro landfill is a sanitary landfill that was built in 2004/5 with a FJ\$10 million grant from the European Union. The landfill is operated by a private company, H. G. Leach (Fiji) Ltd.

The landfill management obtains high density of wastes into the site, of well over 1 tonne per cubic metre: this is important, as high density means that more waste is packed into the same volume of pit, there is less air in the landfill, which reduces fire hazard, and rain finds it harder to percolate through the waste, and so leachate is reduced. The ability for ships in the port to dump waste to the landfill is readily available through local companies who haul waste. Suva's Naboro landfill is the only landfill of the five locations looked at here that has the ability to responsibly accept waste from foreign ships without adding to local landfill capacity problems.

However, the Regional Reception Facilities Plan³⁹ (RRFP) does indicate that Suva is not prepared to take quarantine waste from any international shipping⁴⁰, although the plan does show that Suva might take end-of-life fishing gear and recyclables if the local authorities do not class these as quarantine waste.

3.4.2.1 Legislation & Regulatory Oversight

The Department of Environment (DoE) is the government body that contracts with landfill operator H.G. Leach Ltd. DoE is also the environmental regulator, under the Environment Management Act of 2005, and the Environment Management (Waste Disposal and Recycling) Regulations 2007, and these regulations do require companies who collect and transport waste to have permits from DoE. This means that if a ships' agent contracts a transport company to collect the ship's waste, if the company has a permit then the agent can be confident that the waste will be taken the 20 km or so to Naboro and not dumped by the road someplace on the way.

Fiji is a Party to the IMO.

3.4.3 Pohnpei, Federated States of Micronesia

Pohnpei is the major transshipment port in the Federated States of Micronesia (FSM). The Pohnpei dumpsite is at Dekehtik, next to the airport and the dock, at the end of the causeway that leads to the dock/airport area from Kolonia Town. The dumpsite is an un-engineered facility that is effectively reclaiming a mangrove area. There are no formal containment walls.

Rehabilitation works have been conducted through assistance from Japan in the recent past that have included elements of the Fukuoka Method for landfills, and this has dramatically improved the dumpsite, with a cell compaction system in use, and the dump being reasonably free of piles of waste and well-managed given the typical Pacific Island dumpsite operation. It's major failing as a dumpsite is the lack of containment walls between the dump and the adjoining mangroves and lagoon area. Traffic into the site is controlled through a gateway off the causeway.

A recycling shed is under construction, as of early 2021, at the entrance to the site to prepare for improvements to the current recycling system, which only takes aluminium cans as of early 2021, but is expected to be expanded to handle PET plastic bottles and glass bottles. The dumpsite does accept waste oil in 200 litre drums for a \$50 disposal fee, and has a simple oil/water separation facility to process water-contaminated waste oils. There has been occasional export of waste oils, but a large stockpile currently exists on the site. However there has been recent interest from a South Korean company to take the oil in bladders fitted into 20 ft shipping containers.

Pohnpei is unusual amongst the FSM states in that operation of the dumpsite is by a private company under contract to the Pohnpei State Government: Pohnpei Waste Management Services (PWMS) is the contractor who operates the current dumpsite, and the company also runs a waste collection service around Kolonia to private paying customers. Local household waste collection is the responsibility of Kolonia Town Council.

³⁹ [2] A Regional Reception Facilities Plan for the Small Island Developing States in the Pacific Region, SPREP/ IMO 2015

⁴⁰ Ibid, p6



Photo 12: Dekehtik dumpsite by the airport at Pohnpei.

Note the lack of containment towards the adjacent mangroves and lagoon.

PWMS provides a dumpster collection service to local businesses as a separate service to the dumpsite management contract, as the dumpsite management contract does not involve any contract to pick up wastes. Most larger local business that are waste generators appear to be using this dumpster service. Each business has a separate contract with PWMS. Two sizes of dumpster are available, to suit different waste generators. Dumpsters are emptied using specialist trucks that pick up the dumpster and tip the contents into a compactor truck.

Waste from fishing vessels is handled through the respective shipping agents, but PWMS will collect waste from the port when requested⁴¹. Carolines Fishing Company is a local fisheries Purse Seine operation that reported to this study returning 75% and incinerating the rest, maintains a dumpster contract with PWMS, and the cost is \$35/month. PWMS reports that they do not go and collect waste directly from ships on the dockside.

3.4.3.1 Legislation & Regulatory Oversight

The Pohnpei State Environmental Protection Agency is the agency responsible for regulations concerning solid waste in Pohnpei State. At a national FSM level, the Office of Environment and Emergency Management is the department of the FSM National Government responsible for national environmental issues, including national waters outside the 3-mile state zones.

Title 27 of the Pohnpei State Code deals with environmental matters. Chapter 1 set up the EPA and deals largely with administrative matters. Chapter 2 deals with litter abatement and in general the management of solid wastes, but does not reference ships directly in any way. Chapter 3 concerns the deposit/refund recycling system for aluminium drink cans, and Chapter 4 'Control of Plastic Wastes' is a ban on selling plastic shopping bags in Pohnpei, although does not deal with all plastic waste *per se*.

The FSM is not a party to the IMO, or the MARPOL convention.

⁴¹ Pers Comm Ms Marmy Henry, Pohnpei Waste Management Services, January 2021

3.4.4 South Tarawa, Kiribati

South Tarawa, the capital of Kiribati, has a port at Betio island which handles a number of foreign vessels, has lagoon transshipments, and also a local fishing operation called Kiribati Fisheries Ltd. Smaller vessels can go alongside at the fisheries wharf, but larger vessels are constrained by the main wharf being down a long pier deep into the lagoon to find deeper water, and even then, draught is a limiting factor.

Betio has a loosely controlled dumpsite which is adjacent to the port area and the famous Red Beach of WWII. This site has reached capacity and is due for expansion. It is the oldest dumpsite in Tarawa, and was only enclosed 25 years ago after being largely an un-contained lagoon land-reclamation operation. The dumpsite wall consists of sandbags of sand and cement which have been piled up onto a coral sand berm on the sea side. The wall suffers from undermining, and often collapses in places, when on high tide events waves wash over the wall, and then wash out the sand behind, which reduces support to the wall from wave action (see *Photo 13*), and attempts to build a concrete barrier on the existing wall to stop this have failed. As such, it struggles to maintain the waste dumped into it from the 15,000 or so residents of Betio. The site is operated by the Betio Town Council, which is also responsible for waste collections on Betio island. There is no charge to dump waste in Betio dumpsite.



Photo 13: Betio dumpsite wall damage from wave action, July 2016

There are two other controlled dumpsites further along South Tarawa, also built into lagoon tidal flats, but ship waste would be unlikely to make it to these, unless a conscious effort was made by a ship's agent to transport waste there, which would likely cost more than to deliver to Betio dumpsite. These two sites, at Nanikai and Bikenibeu, both built around 2004-5, are generally better run, the walls are far better built, albeit using a similar method, and actually have a *de facto* leachate treatment system using

the properties of coral sand to neutralise the leachate⁴². These two actually cause little lagoon pollution, have some spare capacity in the case of Bikenibeu, and would be preferential for any ship waste. However, landfill space is at a premium on South Tarawa with its rapidly expanding population. These two sites are operated by the TUC local government, and there is no charge for dumping waste into these sites.

Waste collections are nominally the responsibility of local town councils, of which there are two on South Tarawa, TUC and BTC. But most waste is either collected using a pre-paid bag system, operated by a private company, or taken to the dump by private people and businesses with their own vehicle. TUC collects some waste, but only from government housing. Betio Town Council (BTC) nominally collects all waste on Betio, but in reality struggles greatly to do so.

3.4.4.1 Legislation & Regulatory Oversight

The Government of Kiribati department who is responsible overall for regulating solid waste is the Environment and Conservation Division, part of the Ministry of the Environment. There is an Environment Act from 1999, and this does mention waste and pollution, but nothing in relation to wastes from ships. The Kiribati Ports Authority is the entity in charge of what happens inside the Port of Betio fence.

Kiribati is a party to the IMO.

3.4.5 Noro, Western Province, Solomon Islands

Noro is primarily a tuna processing plant, with the surrounding town being largely a company town. A local joint venture, Soltuna, cans tuna caught from ships owned by NFD which operate from Noro as their home base. The workforce of the cannery and the fishing company amount to around 2,000 people. It is not a transshipment port, but whilst NFD operates around ten vessels, some seventy others may be operating at any time under charter to the company. Thus, significant waste is already generated at this site, and in a country that struggles greatly with dealing with its existing waste load.

The dumpsite is reported⁴³ to be "*at crisis point*" with uncontained waste reported to spill onto the roadway on occasion, and no heavy equipment is believed to be allocated to the site by local authorities to adequately spread and compact the waste. The responsibility for dealing with waste at Noro is with the Noro Town Council, which is under the Western Province provincial government, but it is reported that the only waste collections in Noro are conducted by Soltuna and NFD, covering their own staff quarters and the fishing vessels based at the port. The dumpsite is on Soltuna land, which indicates that the provincial government, who is ultimately responsible for waste management under the relevant legislation, does not have a designated dumpsite at Noro.

3.4.5.1 Legislation & Regulatory Oversight

The Solomon Islands does have a National Waste Management and Pollution Control Strategy. This document lays out from the beginning that the overall frameworks to improve SWM need to be put in place, and recognises the current situation of the country being "*faced with challenges, including enforcement, capacity and financial constraints to name a few.*"⁴⁴ This supports the impression that the current situation in the Solomon Islands is a challenging environment just to manage the wastes generated locally, and it would be fair to say that the Solomons is one of - and perhaps the most - challenging places for solid waste management in the Pacific Islands today.

The Solomon Islands passed an Environment Act in 1998. The Act set up the Environment and Conservation Division (ECD), which has overall responsibility for solid waste management in the Solomon Islands and Part IV deals with the control of pollution. Actual day to day collection and

⁴² Pers Comm. Ms Marmy Henry, Pohnpei Waste Management Services, January 2021

⁴³ Pers. Comm. Frank Wickham, General Manager NFD Noro, February 2021

⁴⁴ National Waste Management and Pollution Control Strategy 2017-2026: Executive Summary, p iii

management of wastes and dumpsites is the responsibility of city councils or provincial governments at the provincial headquarters. (Noro is not the seat of provincial government, Gizo is, and Gizo dumpsite is on the island of Gizo some tens of miles away).

Dumpsites in the Solomon Islands are amongst the simplest to be found in the Pacific, and only a very small part of the waste generated ever reaches a dumpsite, even in the capital, Honiara. A very large portion of waste in the Solomons is burnt at the generation source.

The Act does contain one interesting provision: the power to direct public authorities, 'public authority' being defined as⁴⁵: (a) any Ministry or Division of the Central or Provincial Governments, Area Council or Town Council, agency, authority, statutory body or administrative office. The power to direct the authorities is essentially⁴⁶ [9]: "(a) to do anything within the powers of that public authority which, in the opinion of the Director, contributes to the achievement of the objects of the Act;" which could be used as a way for central government to direct port authorities with regard to improved waste management, or even ban the acceptance of waste from foreign ships.

in 2008 the Solomon Islands promulgated regulations under the above Act and include provision for licenses to pollute, in the form of Pollution Control Licenses. It is understood that only a very small number of pollution control licenses are current. The Noro fishing company, Soltuna, does qualify as a prescribed premises under the 2008 regulation, and as such it does require a Pollution Control Licence, but one has not yet been issued⁴⁷. If there is no formally, permitted dumpsite at Noro then that might in part explain the situation.

The Solomon Islands is a Party to the IMO

3.4.6 Regional Arrangements under MARPOL

Under the MARPOL Convention, Small Island Developing States (SIDS) can have regional arrangements to deal with waste from ships⁴⁸, and the Pacific SIDS have developed a Regional Reception Facilities Plan⁴⁹[12] (RRFP) which has been adopted regionally. The general idea is that SIDS should not be taking waste from foreign ships if realistically possible.

3.4.7 Main Pacific Ports Waste Facilities Summary

Overall, only Suva has a landfill that can be really said to be fit to take foreign wastes generated from fishing boats; Suva is the only port amongst those above which is listed in the Regional Reception Facilities Plan.

All other ports noted above struggle at varying degrees, and given that the waste from the boats is commercial wastes, generated as a result of business operations, and originated outside of the countries concerned, it is very hard to make case that these small Pacific Island Countries, who are already struggling deeply with their own waste crises, should take that commercial waste. Yet the cost of dumping waste in these places is so low that it makes it attractive to do so.

⁴⁵ Ibid, Part 1 Interpretation 2

⁴⁶ Ibid, 10: power to give directions to public authorities

⁴⁷ Pers. Comm Enoch Faabas, Environment Officer, ECD January 2021

⁴⁸ MARPOL [Res.MEPC.216\(63\)](#) and 2012 Guidelines for the development of a regional reception facilities plan (res. [MEPC.221\(63\)](#)).

⁴⁹ A Regional Reception Facilities Plan for the Small Island Developing States in the Pacific Region, SPREP/ IMO 2015

4 Discussion

4.1 Understanding plastic waste disposal from fishing vessels

The estimates of the amount of the different types of wastes generated by fishing vessels are provided in section 3 of this report. Yet to understand how to deal and dispose with waste is important to understand how is generated, how could be it stored and how should it be disposed.

Fishing operations and crews, like everyone else, make waste, and thus need to manage those wastes. As seen above, the waste produced can be largely broken into two types: that resulting from fishing operations, and that resulting from the crew and normal ships' operations - such as waste from food preparation in the galley - which is independent of whether the ship is fishing or not.

The first type shall be called here 'Fishing Operations Waste' (FOW), and the second is Operation and Maintenance Waste, or O&M waste.

Dealing with waste on board is a challenge as vessels are always constrained by space; but it is useful to bear in mind that the ship either put to sea, or was provisioned at sea, with the materials on board that subsequently became waste, so the issue of improving waste management is actually a logistical challenge as much as anything, and the amount of material that a ship is provisioned with is more than the resulting waste, as a fair part of it gets eaten or used, for example bait.

There are three things that are most likely to cause ships' crews to use poor waste management practises, and dump materials over the side into the ocean 'Blue Bin':

1. Smell: the sickly smell of dirty wastes that include rotting bait and other animal remains;
2. Space: no proper stowage provision for waste containers, so that they are constantly 'in the way' or make deck work awkward and dangerous;
3. Convenience and custom: crew may come from places that themselves have very poor waste management practises at home on land, and there may be little or no inherent culture or understanding present amongst crew that makes ocean dumping taboo and unacceptable.

The IMO has published a document⁵⁰ under the MARPOL Convention that gives an excellent description of suitable waste management practices on board ships, and the following provides some degree of summary of that document, with some points included from the authors' personal experience.

4.1.1 Waste management onboard

The MARPOL convention does not allow vessels to dispose of the following wastes anywhere at sea:

All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse.

Thus, even if all the waste on a vessel was put into an incinerator, the vessel must still produce some waste which requires to be off-loaded at a port somewhere, as an incinerator does not completely incinerate everything that goes into it, and ashes cannot be dumped. Incinerators will not remove any metallic or ceramic (e.g. glass) components of the waste stream either, which will comprise a significant amount; nor will larger lumps of plastics burn well in a typical deck incinerator either. Whilst incineration will reduce waste quantities by volume⁵¹, the weight reduction will only typically be by a factor of five or so for the materials burnt, across the board, and the most reduction will occur from burning paper and cardboard.

⁵⁰ Simplified overview of the discharge provisions of the revised MARPOL Annex V which entered into force on 1 March 2018, published by IMO.

⁵¹ The Guidelines For The Implementation Of MARPOL Annex V suggest a 95% reduction factor by volume for non-metallic and non-ceramic wastes pp17, Table 4

In summary, the only wastes that can be legally disposed of at sea under MARPOL are organic wastes such as food waste, animal carcasses; deck washing residues; and bulk cargo residues⁵² that cannot be easily recovered, e.g. dust from cleaning out bulk cargo holds. All other normally generated wastes on a vessel are prohibited from being dumped into the sea.

Vessels can legally and responsibly deal with their waste in three broad scenarios:

- Incinerate burnable organic based paper and cardboard waste on board, and stow the resulting ashes and other non-burnable wastes onboard pending off-loading in the next port or transshipment;
- Stow all waste for the entire voyage, and off-load when the ship next goes to home port;
- Stow all waste and off-load to a Carrier during transshipments.

Thus all methods require some storage of wastes on board; this is unavoidable. Therefore, all ships should have a dedicated space and provision of containment to store waste. All ships should have clear operational procedures for handling and stowing their wastes, as this is an everyday part of ship-board life, and MARPOL makes provision for this with requirements for Waste Management Plans and Garbage Record Books. Where a vessel does not exhibit both physical waste handling systems and written procedures, then it can be assumed that significant quantities of waste are being dumped into the ocean. This is not only in contravention of MARPOL, but where waste is dumped in the ocean for free it is also an economic advantage that the fishing business has over other, shore-based, business operations which have to deal with their waste streams and cannot just throw it out of the door.

All potential mechanisms for disposal need to be framed under the present existing regulatory frameworks, and the present situation of waste management facilities at selected locations where the plastic would be disposed.

The sections below present the minimum understanding to be had on both constraints prior to evaluating potential mechanisms.

4.2 Regulatory frameworks regulating plastic waste disposal

4.2.1 The MARPOL Treaty

The International Convention for the Prevention of Pollution from Ships⁵³ (MARPOL) is the international convention which provides the international legal framework dealing with the prevention of pollution of the marine environment by ships, either from operational or accidental causes. The Convention comes under the auspices of the International Maritime Organisation (IMO), and was adopted initially in 1973, and MARPOL has been updated by amendments through the years. The relevant section of the Convention to the issue of garbage from shipping is Annex V, and the revised MARPOL Annex V, which entered into force in 2013, prohibits the discharge of all types of garbage into the sea unless explicitly permitted under the Annex. A useful summary produced by the IMO and used as a placard on board vessels is reproduced here at table 13

⁵² Cargo residues means only those cargo residues that cannot be recovered using commonly available methods for unloading". MARPOL Annex V

⁵³ [https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-\(MARPOL\).aspx](https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx)

Garbage type ¹	All ships except platforms ⁴		Regulation 5 Offshore platforms located more than 12 nm from nearest land and ships when alongside or within 500 metres of such platforms ⁴
	Regulation 4 Outside special areas and Arctic waters (Distances are from the nearest land)	Regulation 6 Within special areas and Arctic waters (Distances are from nearest land, nearest ice-shelf or nearest fast ice)	
Food waste comminuted or ground ²	≥3 nm, en route and as far as practicable	≥12 nm, en route and as far as practicable ³	Discharge permitted
Food waste not comminuted or ground	≥12 nm, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues ^{5, 6} not contained in washwater	≥ 12 nm, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues ^{5, 6} contained in washwater		≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)	
Cleaning agents and additives ⁵ contained in cargo hold washwater	Discharge permitted	≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)	Discharge prohibited
Cleaning agents and additives ⁶ in deck and external surfaces washwater		Discharge permitted	
Animal Carcasses (should be split or otherwise treated to ensure the carcasses will sink immediately)	Must be en route and as far from the nearest land as possible. Should be >100 nm and maximum water depth	Discharge prohibited	Discharge prohibited
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	Discharge prohibited	Discharge prohibited	Discharge prohibited

Table 14: Simplified overview of the discharge provisions of MARPOL Annex V

4.2.1.1 Regulations Concerning Plastic Wastes

Regulation 1, which carries the definitions, clearly singles out plastics as being a material that must not be dumped overboard into the sea, and also it is notable that mixed wastes that include plastics are defined as being all plastics⁵⁴. This is important, as whilst a vessel would be allowed to dump food and fish waste at sea, the excuse that plastics contaminated with food or fish waste can be dumped is thus not acceptable.

It is also of note that incinerator ashes must not be dumped overboard, and that incinerator ashes that result from burning plastics are considered to be plastics under the definition⁵⁵. Thus along with the above definition of plastics, any incinerator waste in which plastics had been burnt would mean that the incinerator ashes come under the definition of 'plastics'. Any fishing gear that contains plastic is also explicitly prohibited from being dumped.

⁵⁴ MARPOL Regulation 1 Definitions: 13; Regulation 4: 4.

⁵⁵ Ibid, Regulation 1: 10 and 13.

4.2.1.2 Pacific Island Regional Reception Facilities Plan

Regulation 8 of Annex V requires Parties to the Convention to provide facilities for ships to off load waste in port, but a special provision is made for Small Island Developing States (SIDS) who may enter into regional arrangements given their 'unique circumstances'⁵⁶. Parties can also notify the IMO where port facilities are considered 'inadequate'⁵⁷

With regard to the Pacific Islands SIDS, they have developed a Regional Reception Facilities Plan⁵⁸ (RRFP) which has been adopted regionally. This plan notes 57 ports in the Pacific, but the plan itself only looks in detail at major ports, only one of which - Suva - is included in this current study, and the plan is not specific to fishing vessels. The general idea is that SIDS should not be taking waste from foreign ships as they cannot handle what they already have to deal with locally, yet there does not appear to be a systematic and legal ban on taking ship waste, and certainly the relevant dumpsite and waste collection companies in the SIDS are not aware of one if there is. There is no specific legislation that enacts such a ban.

4.2.1.3 Garbage Management Plans and Record Keeping

Regulation 10 deals with Management Plans and record keeping: every ship of over 100 gross tonnes, and/or that carries fifteen or more crew, must have a Garbage Management Plan; in addition, every ship over 400 gross tonnes and with fifteen crew must maintain a Garbage Record Book⁵⁹; however the wording suggests the interpretation is that any vessel under 400 tonnes with 15 or more crew that is visiting off-shore ports must also have a Garbage Record Book, which would cover the vast majority of fishing vessels in the Pacific.

The Management Plan "*shall provide written procedures for minimizing, collecting, storing, processing and disposing of garbage, including the use of the equipment on board. It shall also designate the person or persons in charge of carrying out the plan.*" The Convention provides a Guideline on waste management on vessels to assist development of a the Plan⁶⁰

The Garbage Record Book should record information about what garbage was put off and where, and can be hard or softcopy. It should also note when incineration takes place, and where (long. and lat.). The amount of garbage is recommended to be measured in cubic metres, which will inevitably be a very raw estimate, especially with smaller quantities.

The Garbage Record Book should be available to be inspected by the Parties' Competent Authority⁶¹ (CA), and copies may be used for any enforcement action regarding pollution.

The Regulation also requires that "*...the accidental loss or discharge of fishing gear... shall be reported to the State whose flag the ship is entitled to fly, and, where the loss or discharge occurs within waters subject to the jurisdiction of a coastal State, also to that coastal State.*"⁶² Thus records of fishing gear that is unintentionally lost should be kept.

4.2.1.4 MARPOL Guidelines for Waste Management on Vessels

The IMO has a very detailed Guideline document for waste management on vessels⁶³, and this also includes a section on Compliance Incentive Systems⁶⁴; this section clearly recognises that improvements to the management of wastes to gain full compliance with MARPOL are unlikely to be achieved simply

⁵⁶ Ibid, Regulation 1: 6; 9; 13.

⁵⁷ Ibid, Regulation 8: 3.

⁵⁸ A Regional Reception Facilities Plan for the Small Island Developing States in the Pacific Region, SPREP/ IMO 2015

⁵⁹ MARPOL Annex V, Regulation 10: 3 : "...and every ship which is certified to carry 15 or more persons engaged in voyages to ports or offshore terminals under the jurisdiction of another Party to the Convention."

⁶⁰ Resolution MEPC.295(71) 2017: Guidelines for implementation of MARPOL Annex V

⁶¹ MARPOL Annex V, Regulation 10: 5

⁶² Ibid, Regulation 10: 6

⁶³ Resolution MEPC.295(71) 2017: Guidelines for implementation of MARPOL Annex V

⁶⁴ Ibid, 6.3.

through enforcement measures or auditing by Parties. This section recognises the value of economic incentives to encourage improved waste management, and in particular that problem ports need special measures⁶⁵. Some proposals along these lines that are consistent with this approach are suggested in *Chapter X of this Document, Economic Incentives to improve SWM*.

The Guidelines provide a very useful flow diagram at Table 2⁶⁶ in the document, to map waste management on board ship, provided here at figure 4.

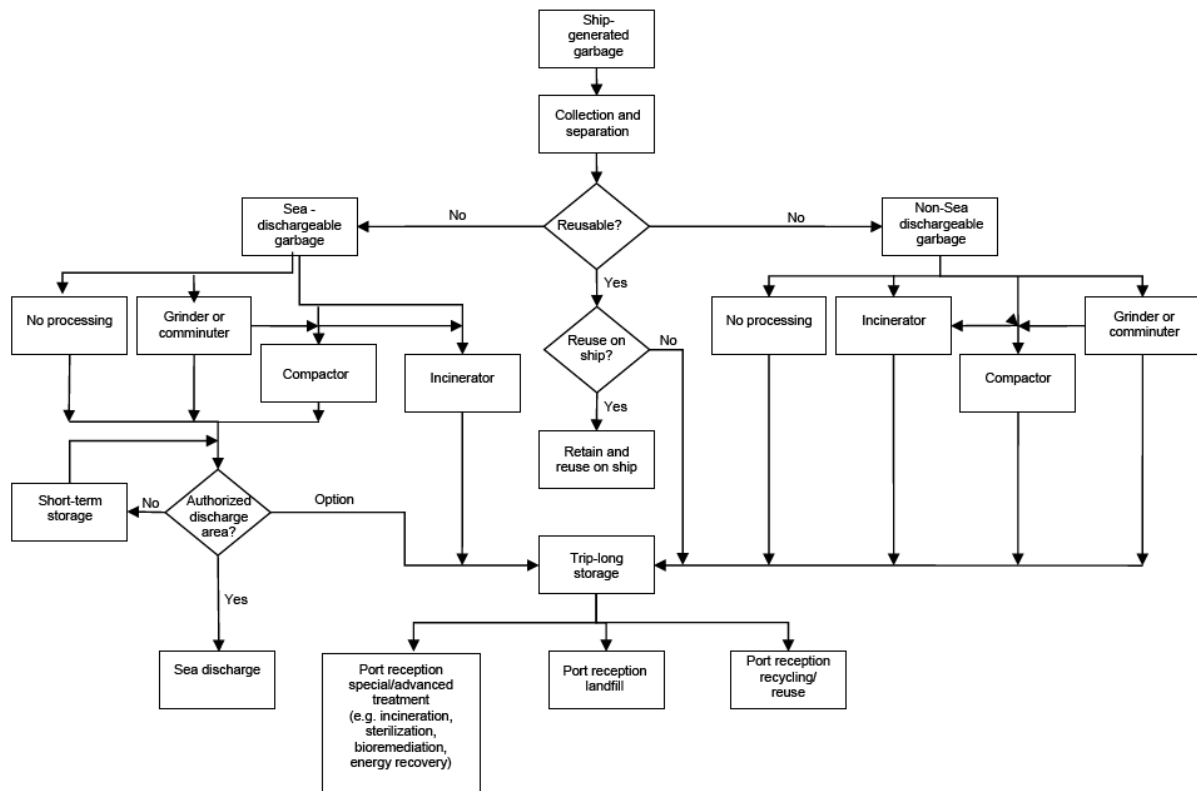


Figure 4: Options for shipboard handling and discharge of garbage

4.2.1.5 *International Crew Training and Safety Agreements*

The International Convention on Standards of Training, Certification and Watch-keeping for Fishing Vessel Personnel (STCW-F), was adopted by IMO in 1995, and came into force in 2012. The STCW-F Convention is a binding treaty that sets certification and minimum training requirements for crews of seagoing fishing vessels with the aim to promote the safety of life at sea and the protection of the marine environment, taking into account the unique nature of the fishing industry and the fishing working environment. This Convention generally applies to personnel of seagoing fishing vessels and, in particular, to skippers and officers in the deck department of fishing vessels of 24 metres in length and over.

The Cape Town Agreement deals with fishing vessel crews and safety and is expected to be ratified by October 2022⁶⁷ as a result of the Torremolinos Declaration. Along with the STCW-F and given the existing body of guidelines, standards, plans and other documentation that the IMO has produced relating to MARPOL over the last two decades and more, there is no shortage of information and training opportunities about the manner in which waste should be handled on board fishing vessels.

⁶⁵ Ibid, 6.3.1.4 "special funds to assist in problem situations such as remote ports with no land-based garbage management system in which to deliver ships' garbage;"

⁶⁶ Ibid, p 21

⁶⁷ <https://www.imo.org/en/MediaCentre/PressBriefings/Pages/25-Torremolinos-Conference.aspx>

4.2.1.6 MARPOL Summary

MARPOL has created the overall framework required such that any dumping of plastic waste into the ocean is unacceptable. The associated documentation, guidelines and standards produced by IMO over the last few years provide everything a fishing business might need to properly organise its on-board waste management systems and record keeping.

If the MARPOL Convention Annex V is being followed, and if the Garbage Record Books were electronic and uploaded to SPREP/SPC/FFA from licensed vessels, in a standard format to make search and analysis of the data easy, and all fishing gear waste lost was also recorded, it would be a relatively simple matter to determine how much fishing gear waste was being lost, as well as how much waste was generated. There is no shortage of institutional framework to cover this situation.

There is clearly no excuse for fishing businesses not to be operating a comprehensive waste management system on board their fishing vessels, which should collect all O&M waste, and waste generated by fishing activities, except that unintentionally lost.

The easiest, cleanest, and most effective way to manage the waste stream from vessels engaged in transshipment activities is to tranship waste alongside fish and return it to mainland ports with proper waste disposal facilities.

4.2.2 **WCPFC Conservation and Management Measure (CMM) 2017-04**

Conservation and Management Measure (CMM) 2017-04 was adopted by the WCPFC in Manila in December 2017, and this study has endeavoured to provide prescriptions for action that are consistent with the aims and objectives of CMM 2017-04.

The CMM was evidentially driven by a conviction that current waste disposal practises from fishing vessels were harming the marine environment⁶⁸. The CMM explicitly desires that all CCMs should be Parties to MARPOL⁶⁹, and follow MARPOL if they are parties⁷⁰.

The CMM explicitly recognises that CMMs should be following MARPOL; it explicitly recognises that SIDS are challenged through an inability to provide adequate facilities for receiving and managing waste from ships in their ports; and it explicitly states that⁷¹:

*CCMs shall cooperate, consistent with national laws and regulations, directly or through the Commission, and in accordance with their capabilities, to **actively support SIDS and Territories through the provision of adequate port facilities** for receiving and appropriately disposing of waste from fishing vessels.*
[Emphasis added.]

As the CMM is over three years old, if any CCMs have not yet joined MARPOL⁷² then clearly they may need some more active encouragement; there is, of course, nothing to stop a Flag State requiring that its vessels follow the provisions of MARPOL even if the nation is not actually a Party.

Under the Compliance Monitoring Scheme (CMS) Members report certain data and information to allow the implementation of CMMs and any trends or issues associated with implementation or the CMMs themselves to be assessed. Many of these reporting requirements are embedded in the Convention, CMMs or other WCPFC decisions. Some of the provisions specify that CCMs are to provide this

⁶⁸ CMM 17-04 Preamble: "Convinced that certain activities associated with fishing may affect the Western and Central Pacific marine environment and that these activities may play a notable role in WCPFC's efforts to minimise incidental mortality of non-target species and impacts on marine ecosystems"

⁶⁹ Ibid, adoption Point 1: "...to ratify, accept, approve or accede to the annexes of MARPOL and the London Protocol are encouraged to do so at the earliest possible opportunity if they have not already done so..." [Emphasis added.]

⁷⁰ Ibid: Preamble: "Noting that the provisions of Annex V of International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL), prohibit the disposal of all fishing gear and plastics at sea"

⁷¹WCPFC CMM 2017-04 Adoption Point 8

⁷² It is recognised that Taiwan is a special diplomatic case on this point.

information on the Implementation CMM Annual Report Part 2, and others are to be reported to the Secretariat by specific dates.

CMM 2017-04 is including in the recent CPFC Circular 2021/15: Updates on Annual Reporting and CMR-Related Preparations under Part D (Mitigating fishing impacts on species of special interest, including non-target species) of the “WCPFC Suggested Checklist of 2021 Reporting Requirements”⁷³ dated 5 March 2021 in the format presented below.

Marine Pollution reporting	CMM 2017-04 04	4. CCMs are encouraged to undertake research into marine pollution related to fisheries in the WCPFC Convention Area to further develop and refine measures to reduce marine pollution, and are encouraged to submit to SC and TCC any information derived from such efforts.	Pr-103 CMM 2017-04 03-07 (CMM 2017-04) MARINE POLLUTION {SUBMISSION TO SECRETARIAT}
	CMM 2017-04 05	5. CCMs shall encourage their fishing vessels within the WCPFC Convention Area to retrieve abandoned, lost or discarded fishing gear and retain the material on board, separate from other waste for discharge to port reception facilities. Where retrieval is not possible or does not occur, CCMs shall encourage their fishing vessels to report the latitude, longitude, type, size and age of abandoned, lost or discarded fishing gear.	
	CMM 2017-04 10	10. CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.	Pr-105 CMM 2017-04 09-11 (CMM 2017-04) MARINE POLLUTION {SUBMISSION TO SECRETARIAT}

Table 15: Part 2 reporting obligations for CMM 2017-04

Its important to remind ourselves that CMM are binding for commission members and cooperating non parties

4.3 Operational strategies for better management of plastic waste on board

Based on the findings and issues discussed in the previous sections, the potential strategies here presented are based included a mix of practical on-board measures and regulatory approaches that will involve some type of monitoring aspect yet try as far as possible create incentives for compliance, rather than fear of punishments.

4.3.1 The Reverse Logistical Approach

Elsewhere in this report - it can be seen that common Pacific Island ports visited by fishing vessels are not adequately equipped to deal with waste from foreign fishing vessels.

A clear and desirable option exists where Carrier supply vessels are equipped onboard with improved waste management regimes, and the best approach is that fishing vessels transfer their waste to the Carriers along with fish during transhipments. This approach would demand that all Carrier supply vessels were suitably equipped to handle the waste from the number of fishing vessels they were supporting.

⁷³ <https://www.wcpfc.int/doc/commission-08b/suggested-checklist-reporting-requirements-cmms-and-other-wcpfc-decisions>

These larger ships are better placed to have large holding bins for waste, and could be equipped with compactor units to compress waste for stowing and shipment back to home ports, or incinerators that are compliant with IMO MARPOL standards⁷⁴. Ensuring incinerators are to standard is a health and safety issue for shipping.

There will also need to be clarity around avoiding contamination of fish by stored waste, but as Carriers also carry hazardous materials such as oils, paints, cleaners etc. as a matter of course, this should not be a difficult issue to address.

From the food safety perspective, carriers operate as floating cool storage, and as part of that regulatory framework, the management of potential cross contamination is part of their on board programme in support of their HACCP⁷⁵ plan, therefore the boarding of compacted waste from fishing vessels while adding volume, will not add new hazards that are not already contemplated.

Whilst fishing vessels might be at sea for extended periods and operate well away from home ports, Carrier supply ships have to periodically return to home ports to off-load fish and resupply with provisions for the fishing vessels they support. These Carriers can more easily accommodate small mechanical compactors of the type commonly used in large stores and small manufacturing businesses to compact waste and so reduce the costs of waste disposal for those land-based businesses.

Figures X & Y show two sizes of typical small compactors, and use of such equipment is recommended by the MARPOL Guidelines.

Clearly, a system could be developed whereby the carriers collected the waste resulting from their provisioning activities, and fishing vessels used smaller containers - such as plastic drums - which were passed across and emptied - or swapped out - during transshipment operations.

In this scenario, waste management becomes an explicit function of the Carrier ship fleet and provides a much better possibility to compact wastes to a greater degree, and take wastes back to ports that have proper landfills and can accept the waste to a decent waste treatment facility.

The concentration of waste onto Carriers also targets any monitoring and enforcement effort on a smaller number of ships.

4.3.2 Reducing the Smell of Ship Waste

Unwholesome smells from waste come very largely from organic material that is mixed into the waste, and this organic waste degrades quickly - especially in a tropical environment - and the result smells bad and may encourage ocean dumping of waste. Organic waste in rubbish bins will be either from food residues in packaging, or from blood, scales and guts of bait and fishing related waste. The ways in which smell can be reduced are:

Food packaging waste: organic residues in food packaging waste will originate almost entirely from the galley, and as such the solution is that the cooks must rinse all relevant packaging before putting it in the bin. This is not arduous: all the plates and cutlery of the galley must be washed, and so food packaging such as plastic bags and tins should be set aside so that at the end of washing up the dishes the remaining water is used to rinse food tins and bags; this way there is no additional water demand, and dirty dishwater is quite good enough to wash out these items. As washing the dishes is an unavoidable part of galley operations, so washing food packages that need washing must be also, and requires minimal extra effort.

Fishing operations waste: that smells is largely from empty plastic Longliner bait-box liners and strapping, and these can be dumped into a drum of sea water as they are emptied of bait, so they are effectively rinsed with little effort, before being put into their rubbish receptacles, which should have adequate drainage for excess water. This should be simply a matter of being part of the procedure of

⁷⁴ Resolution Mepc.244(66) 2014 Standard Specification for Shipboard Incinerators

⁷⁵ Hazard Analysis and Critical Control Plans

baiting a line, and requires very little extra effort, and can easily be integrated into the procedure by which hooks are baited

Use of plastic chemical drums - typically 150 or 200 litre with screw on or clamp on lids - will allow potentially smelly wastes to be stowed for long periods without creating unpleasant smells on deck. Where wastes are rinsed first - as described above - this significantly reduces the problem. Drums can have small holes (3mm) drilled in the base that will allow excess water to drain off without contributing to smell.

4.3.3 **Compaction of Waste**

Crucial to good waste management in a constrained environment such as a vessel at sea is that the wastes are compacted, so that more waste is packed into the same volume, i.e. the density of the waste is increased. Typical density of waste in a household garbage bag, such as might be put out on the street for collection, is around 100 kg/m³; however, this figure can be very easily increased to around 250kg/m³ with very little effort, so reducing the space required by over a factor of two⁷⁶[5]. Garbage in a waste collection compactor truck may reach a figure of around 400 - 500kg/m³.

It is hard to increase the density of waste unless the waste is in a strong container that can withstand the compacting force: if one tries to pack garbage too tight into a plastic garbage bag, then one usually breaks the bag, with a resulting mess. So, it makes sense to have rigid containers into which the garbage is put, and then effort is made to compact the waste once it is in the container; and these containers are what will be off-loaded and emptied at some point in the future. Blue plastic drums with clamp-on lids, designed for various chemicals, are tough, easy to stow, won't break and release trash, are re-usable, and can be used in a simple fixture whereby the waste inside is hand-compressed and then the lid put on when full.

Mechanical compactors are commonly used in light industry and large stores to increase waste density and cut waste disposal costs. Whilst these may be too large to fit on smaller fishing vessels they will easily find a home on a Carrier. Two typical examples are represented here at *Photo 14*, although actual choice of unit would be dependent on exposure to the marine environment. The MAPOL guidelines document also promotes the use of compactors on board, and such an approach encourages the strategy outlined above whereby waste is transferred to Carriers during transhipments.



⁷⁶ The Impact of the Green Bag on Waste Generation in South Tarawa, Chapter 4 Waste Density: International Waters Program / SPREP 2006

Photo 14: L to R: Larger 0.5 metre³ waste baler and smaller 0.25 metre³ baler

The larger unit shown in *Photo 14 L* is suitable for baling cardboard and plastics and will give a bale density of around 200kg/m³ and a bale weight of up to 100kg; the smaller will give a slightly lower density and smaller bales that are easier to man-handle. Both use single phase electricity, and have a cycle time of around half a minute. These are provided by way of example only.

It is easier to compact a series of smaller bags than it is to compact a bigger bag, so small rubbish bins from cabins, using bin liners, are ideal for cabin waste. Any food consumed in cabins by crew is likely to be dry like biscuits or sugary like sweets, and so not a smell problem. Galley packaging waste of plastic bags and small paper/cardboard items can go into smallish bags in the galley and into the waste receptacles on a very frequent basis.

Food tins should be rinsed with the washing-up and have the bottom cut out with a can opener as well as the top, and then squashed flat by hand or foot very easy - and so reduce volume greatly. These should go into a scrap metal bin, and this can be on deck. Glass bottles should go into a drum with a lid, and with care can be broken easily so as to decrease volume: a simple method is to have a drum with a small hole in the lid, and a sledge hammer inside such that the handle sticks out through the hole in the lid, and the bottles can be smashed whilst the lid is on by lifting the hammer up and down, so avoiding any hazard to crew from flying glass fragments.

Aluminium cans can be easily crushed using a hand operated crusher fixed to a bulkhead, and these are widely commercially available; aluminium cans can also easily be crushed underfoot, or twisting and squashing by hand.

Cardboard boxes must be flattened for stowing. Large cardboard boxes can be used to hold smaller, flattened ones; It may also be suitable to use a one-tonne sack, or 'fadge', into which flattened cardboard is placed, as long as the fadge is stowed so that the cardboard is kept reasonably dry and not become sodden and so very heavy, although a woven fadge does allow water to pass through it. Cardboard can also be burnt in an incinerator easily, but burning the organic-based cardboard with any plastic or other materials that may contain chlorine and other Halogen elements, will likely produce dioxins and furans which are highly carcinogenic. (*see below*).

4.3.4 Dedicated Ship's Waste Officer

An essential part of good solid waste management on board a ship is that a crew member is assigned the responsibility to manage and keep accurate records of ship's waste offloaded. This approach is also recommended in the MAPOL guidelines. It is much better to give the job to a single person, who oversees the whole process of compaction and stowing, and can ensure that the waste is properly stowed, is compacted well to minimise space, and is off-loaded during a transshipment opportunity with a Carrier or at a suitable port. This position has been termed the 'Ship's Garbologist' in some instances.

The advantages to the Bosun and the First Officer of having a dedicated person responsible for waste management on board are significant, and it is often the case that within a crew an individual can be found who takes the issue of waste seriously and thus puts real effort into make the system work well.

This approach also provides a clear pathway to the development of operational practises and procedures for which the First Officer would be ultimately responsible, just as that position is responsible for deck operations and maintenance. Waste management should not be an engine-room responsibility under the Chief Engineer, but under the Chief Mate and deck crew.

4.3.5 Health and Safety considerations for "on deck" incineration

Fire on board a ship is a very significant hazard, and any ships' officer will be highly conversant with a number of dangers that can result from open flames. The practise of operating simple, low-temperature incinerators in old oil drums to burn waste on vessels is, at best, highly dubious, and normally ships' officers would be extremely reluctant to countenance any other open flame operations at sea. But

perceived convenience, and long-standing practise, frequently provides an exemption for such operations.

The MARPOL Incineration standards cover this issue in greater detail⁷⁷.

There is another aspect of the practise of low temperature incineration which would normally prevent it occurring, at least in a developed country workplace. This is the carcinogenic fumes generated by the burning of mixed materials in low-temperature fires, which generates chemicals that are termed Persistent Organic Pollutants (POPs); these chemicals are covered by the Stockholm Convention. When POPs are made as a by-product of activities, such as burning wastes, these are classed as unintentional POPs, or 'uPOPs'. There is a large literature covering the sources and environmental impacts of these chemicals, including the health effects⁷⁸, and burning of wastes in low-temperature fires such as ship-board incinerators is a prime source of uPOPs.

A class of chemicals called Dioxins and Furans are the highly carcinogenic products of combustion in any low temperature combustion processes where chlorine is present, which is very common. Incinerator temperatures need to exceed 850 deg. C in order to destroy dioxins and furans, and even then the products of combustion may recombine to form dioxins and furans again in the flue gases (smoke) unless there is a rapid quench process installed as part of the air pollution control system, so that the off-gases cool down very fast. There are of course many products of combustion for all combustion processes involving mixed burning, and dioxins and furans are present only in very small concentrations.

The problem, however, is that even tiny amounts of dioxins and furans can easily reach levels of concern as these chemicals are so toxic. Regular exposure of crew who are tasked with operating the incinerator can provide a significant health risk over time if they are exposed to the smoke from the fire. This is one reason why the IMO standards for incinerators onboard under MARPOL are so comprehensive.

Burning plastic woven bags that have contained salt (Chlorine) in a low temperature incinerator is a recipe for production of significant amounts of carcinogenic fumes containing dioxins and furans, and would be a significant health hazard to ships' crews, especially those who have to feed the waste into the fire. Incineration of polyvinyl chlorides (PVC)⁷⁹, and PCB chemicals with plastics is always prohibited

In summary, the use of low-temperature incinerators on board ships is a health hazard that would not normally be tolerated for shore-based businesses in developed countries, and as such provides another example of how vessel operators can gain economic advantage through poor waste management practises (*see also Section 4.5 on the Economic Advantages of Poor Waste Management*).

4.3.6 Summary of Operational strategies for better management of plastic waste on board

To summarise the above description, the following provides an outline of the procedures that should be followed on fishing vessels:

- All packaging that has directly held fresh or tinned/frozen food and residues should be washed in the galley after washing the dishes, using the same water;
- Food tins should have the bottom removed as well as the top - with a can opener - after washing, and squashed flat and put into a scrap metal bin on deck;
- Cabin and bridge/office rubbish bins should be small, use plastic bag liners, and be emptied frequently;
- Cardboard boxes should be flattened and can be stowed in fadges, or in appropriate bags

⁷⁷ 2014 Standard specification for shipboard incinerators (resolution MEPC.244(66), as amended).

⁷⁸ An excellent place to start any review is the Stockholm Convention Website: <http://chm.pops.int/>

⁷⁹ Except in a shipboard incinerator for which an IMO Type Approval Certificates has been issued in accordance with MEPC.244(66) (MEPC, 2014)

- Only cardboard and paper should be burnt in a low-temperature incinerator on deck;
- Ashes and remains from any low temperature incinerator must be put into a sealed steel container (to avoid any chance of fire) and off-loaded at a suitable location;
- All metal parts, small electrical appliances, oil filters etc. can go into a steel scrap metal bin on deck or other suitable location;
- Empty salt bags must not be burnt to avoid release of dioxins and furans;
- Plastic liners from LL bait boxes should be dumped into a bin of sea-water as soon as emptied, and thus rinsed, before disposal into suitable large containers;
- Polystyrene boxes should be broken into flat pieces to better pack into waste drums or fadges (or better still, the contents transferred to cardboard boxes at time of provisioning);
- General waste, including all plastic bags and packages, including sacks, should be placed into rigid plastic or steel drums, with lids, and ideally the waste should be initially compacted using hand methods in order to increase the density of the waste and minimise deck space. It may be that heavy duty woven fadges or one-tonne bulk bags may also be used, depending on the vessel, but there is more chance of waste escaping from these containers, especially if they are used on open decks, which is not advisable.

Once waste is collected and contained, then the best approach would be to transfer that waste to Carriers during transshipment operations, unless the fishing boat is returning to home port.

Carriers can then operate mechanical compactors and bulk holding methods to better stow and manage the wastes. Where incinerators that meet the IMO standards are used, these are much better installed on larger ships such as Carriers than on small vessels who would struggle to accommodate these larger compliant devices.

4.4 The potential role of EM on MARPOL issues

It has been a strong driver in the development of electronic monitoring (EM) policies in the Pacific that it should be a complement to the work of human observers and not a replacement. As some of the only independent data we have in terms of plastic waste management on board comes from observer data review, a logical conclusion is that EM could be also used for MARPOL issues in the same way it is used for fisheries, science, managements, compliance, and other purposes.

A EM system usually consists of wide-angle digital cameras, a GPS receiver, gear usage sensors, storage and processing devices, and a display screen. Sensors can collect data about boat locations and when fishing gear is being used. Cameras record imagery that can be analysed for determining the effort (number of sets, hooks or baskets), the total catch (species, approximate length, life status and fate) and other noticeable events (e.g. transshipments, crew behaviours, waste dumping, etc). They are “closed systems” that do not allow for manual input or changes to data that is stored.

While sensor data can be sent in real-time via satellite to national review centres, and to regional databases, normally footage from cameras is stored on a removable storage device that are provided to a review centre once the vessel returns to port. There is flexibility around whether analysis is conducted at the national level and then provided to regional agencies or vice versa. A feedback report can be sent to the captain of the vessel, to ensure that they keep the systems maintained with cameras and sensors operating effectively. A trip report is sent to the fishery manager and compliance officers to alert them of any issues.

Trials of EM systems for monitoring the activities of longline fishing vessels licenced to operate in the Pacific Island Countries and Territories began in 2014. There are now 73 longline vessels equipped with EM systems. The table below summarises the number of longline vessels per country equipped with an

E- Monitoring System, the number of EM analysts trained and working, the number of review computers available and the number of analysed sets received in the EM database at SPC.

Country	# of FV with EMS	Vessel gear	# of EM analysts trained	# of EM analysts working	# of review stations	# of Sets at SPC EM DB
FSM	7	LL	5	3	3	551
RMI	6	LL	7	7	3	1501
Fiji	50	LL	33	12	12	4920
SI	8	LL	5	3	3	99
VT	3	2 LL + 1 carrier	10	5	1	43 (from LL)

Table 16: Present status of EM trials in the FFA membership

The EM records are mainly analysed by national fisheries authorities and sometimes by EM providers. Some of the resulting EM data (vessel, catch, set, haul and location details) have been sent to SPC and are available for its member countries to query and report on using the online tool DORADO.

In the context of the WCPFC and catalysed by the COVID 19 impacts, EM is expected to grow rapidly, and the recent work developing a PNA E-Monitoring Program, a FFA EM strategy and SPC's EM standards work for the WCPFC shows the regions commitment for a methodology that is expected to build further momentum, and therefore the role of EM on MARPOL issues is one that deserves to be explored further by the region fisheries bodies, yet this is not a straight forwards process.



Photo 15: EM analysts at work

4.4.1 Issues to be considered in using EM for MARPOL issues monitoring.

The present difficulties around the general implementation of EM in the region can be categorized on issues related to policy, operation and logistics, the generalised use of EM for MARPOL issues will add the existent constrains. A non-exhaustive analysis of some of the potential implications is presented below

4.4.1.1 Policy

The importance of policy cannot be underestimated, as you need to compare apples with apples, be able to define for what purpose the data is going to be used.

The goal of EM is to provide a cost-effective monitoring solution capable of collecting data for scientific, management, and compliance purposes that complement the roles that human observers would have if they were on board.

Surveillance cameras installed on vessels have proven to be effective at recording crew and fishing activities, which can be checked for compliance with fisheries regulations. As such, camera monitoring that is integrated with Electronic fisheries information solutions (EFIS) can provide a useful means of validating vessel catch and gear reporting (hook numbers, use of wire tracers on longliners or FAD deployment and setting on FADs during the prohibition period), as well as potential overboard waste disposal, incineration of waste on deck, etc.

Yet, the EM application in the region focuses already on identifying many activities (i.e. bycatch, species of interest, etc), there is talk to be used as secondary source of data, for example, to validate catch and bycatch logsheets, furthermore they can also be an effective tool to monitor Health and Safety issues. If sensor data is added it can be useful in identifying steaming, setting and hauling. Sensors may also be inserted into winches, or added to brails to weigh the fish on transshipment.

But EM has certain limitations and cannot replace the roles of other data gathering techniques entirely. For example, current camera technology does not offer an affordable and reliable means of identifying the sex, age and species composition of a catch sample.

Some observations are difficult to make from camera footage/images, even with human input and specialist knowledge. Furthermore, camera setups (unless extremely elaborate) will generally have 'blind-spots,' where the crew could discard bycatch, hide interactions with protected species, or disposed waste, which could then go unreported.

4.4.1.1.1 Comparability of EM data vs Human

Substantial work has been done in the region by comparing the data obtained from the cameras with the data from traditional observers working in the same vessel, yet most of this work has focused on species identification, catch composition, volumes, catch coverage, etc. Yet, that type of work has not been extended to include waste disposal issues yet.

EM service providers have been researching and developing software to use Artificial Intelligence (AI) solutions to aid in the analysis of EM records. Given that it is expected that more longline vessels will be equipped with EM systems, the need for efficient analysis of a growing volume of EM records means the use of AI software will be essential. However, for EM service providers to develop AI software which meet needs, a large volume of EM records and corresponding EM data are needed. For example, for AI to be used in aiding the identification of species, at least 5000 images for each species are needed (at minimum). If this level of detail is needed in terms to identify the type of waste being disposed is necessary, remains to be defined.

The market for EM systems is currently small, which makes it difficult for an EM vendor to make a large investment in research and development on the identification of MARPOL issues when AI may only have

applicability to a small number of systems. And in cases when someone else is doing the video review (e.g., in a government centre), the vendors have a little financial incentive to invest in AI development.

4.4.1.1.2 EM minimum data field standards and training of analysts/observers

The adoption by WCPFC of EM standards to support and accommodate those CCMs that have commenced implementation of a range of EM technologies in their fisheries will ensure that the Commission's databases and systems are ready to exchange electronic data in an orderly and efficient manner.

Draft DCC Longline EM minimum data field standards (version DCC-November 2020), already incorporates a potential compliance categories and events reference codes table (for internal EM system database). As presented in the table below

CATEGORY CODE	CATEGORY	COMPLIANCE EVENT CODE	GEN-3 code	COMPLIANCE EVENT	Description	
P	POLLUTION	P1	PN-a	Waste disposal at sea	Disposal of any metals, plastics, chemicals, or fishing gear	Generated by the EM Analyst declaration during video analyses conducted over randomly selected video periods based on compliance coverage strategy
		P2	PN-b	Oil discharged	Discharge of any oil	

While the involvement of MARPOL issues is incorporated into the process, is up to the analysis its identification, analysis and login. This brings into play the issues of training and standardisation of event assessments.

4.4.1.1.3 Standards for the training, assessment and certification

Units of competencies for EM analysts and observers were presented to the PIRFO Certification Management Committee in 2018 and subsequently adopted by FFC in 2018. To build on these, Members have identified that there is a need to develop curricula to guide the training, assessment and certification of EM Analysts (staff responsible for analysing EM records). Building from the success of the Pacific Islands Regional Fisheries Observer (PIRFO) competency development programme, the impact of MARPOL training issues will need to be evaluated.

4.4.1.2 Logistics

The time it takes to analyse footage is dependent on various variables. A present estimate (with the present level; of AI/Machine Learning capabilities is 1:15 (1 hour takes 15 minutes to view/analyse), assuming the analyst is someone that knows how to operate the proprietary software and has a good understanding of the licence conditions, fish and species of special interest ID and fishing operations. At the present in the pacific, we have reviewers from third-party vendor and government fishery agencies.

The correct identification and analysis of MARPOL issues would increase on these times.

Yet, despite the challenged discussed above, there are a lot of ongoing efforts to advance AI for EM video analysis. While the hope is that it will eventually enable complete capture of species, length, and volume data, the next steps are going to advance in AI-assisted review - i.e. identifying key events, these could no doubt MARPOL issues

4.4.1.3 Costs

To date, most of the costs for EM programs in tuna fisheries have been paid by NGOs and international organizations, but this model will not continue forever. Currently, much of the enthusiasm by coastal states for EM is related to the idea that in the future, industry will be responsible for paying most, or all, of the costs.

The draft Regional Longline Fisheries Electronic Monitoring Policy formulated by FFA member countries states as a guiding principle: “User pays - full cost recovery as a default.” Many segments of the fishing industry feel that costs could be high and are also uncertain about how an EM program will affect their business. As the group that will be most impacted, they may believe that it is unfair for them to be entirely responsible for funding an EM program. This difference of opinion on who should pay for EM is seen by many as the most significant impasse for EM implementation.

Strengthening the EM role in MARPOL issues will potentially exacerbate that impasse

4.4.1.4 Operational

4.4.1.4.1 *Servicing EM Hardware Systems*

The experience from EM pilots and fully implemented programs has contributed to improved reliability of EM hardware. Nevertheless, EM hardware may break or malfunction, so it is essential to have a good servicing plan in place that clearly articulates responsibilities and minimum levels of service.

While for vessels fishing in the FFA members EEZ’s coming to port for repairs is an easy option. For High Seas vessels taking trips of several months in length and far away from port, the decision of how vessels need to respond to a malfunctioning EM system is likely to have a larger impact in the WCPO

4.4.1.4.2 *Environmental variabilities*

A further challenge is environmental variability, which can make visual recognition of MARPOL events difficult. Conditions at sea are particularly challenging – variable light, splash and spray, different vessel and background configurations.

4.4.1.5 Strengths, Challenges, and Opportunities of EM for MARPOL

EM is not a new concept, sufficient background analysis and assessments have been conducted, to which this study aligns itself⁸⁰. There have been numerous trials and fully implemented EM programs in the region. These trials have covered both longline and purse seine fisheries. From these trials, some general conclusions can be reached about the efficacy of EM as a MARPOL monitoring and compliance tool

4.4.1.5.1 *Strengths of EM*

1. Provides accurate data on the location and time of the MARPOL event.
2. Incentivizes more accurate reporting of data in logbooks.
3. Covers multiple views of the vessel at the same time, does not require breaks, and video can be reviewed multiple times.
4. Is less prone to intimidation, bribery, or interference in order to falsify reported data.
5. Review of much of the fishing activity can happen at high speed (e.g., >8x speed).
6. A space efficient solution for longline vessels with limited room for a human observer.
7. Can sometimes provide cost savings relative to human observers.

⁸⁰ Roadmap for Electronic Monitoring in RFMOs by Mark Michelin, Nicole M. Sarto and Robert Gillett. PEW. 2020

8. Helps document conformity with management measures and international obligations.
9. Scalable option to implement on various vessels with different gear types.
10. Standards for MARPOL events are already incorporated for regional databases

4.4.1.5.2 *Challenges*

1. Accurate estimates waste dumping in fishing vessels can be challenging with EM depending on waste handling techniques and camera placement
2. EM systems are not linked to fish aggregating device (FAD) buoy identification systems.
3. Hard Drive Collection logistics are very complex and will hamper the application on HS vessels.
4. Fisheries Legislation may need to be changed as to incorporate new forms of electronic evidence and even types if fisheries offences where EM evidence can be used.
5. While substantial data on MARPOL issues exist in PS fisheries from observer's work, the level of coverage is substantially less for longline
6. The observer data can be used for training AI based systems, yet the lack of images of the different types of waste being dumped may hinder its strength and efficiency

4.4.1.6 *EM Summary*

The reality is that like most new solutions, there will be opposition along the way. Industry members will likely have concerns about additional monitoring, privacy, the costs of the program, and a general fear of the unknown.

Fisheries managers may be concerned about the cost and complexity of the program and whether they will be able to effectively manage it. These concerns are legitimate and have emerged in the development of most, if not every, EM program. These issues cannot be sidestepped, and stakeholders need to be integrated into the design process so that their concerns are recognized and addressed. In particular, the industry needs to be involved as they will be the ones most impacted and their acceptance of the program will be critical to its success.

Said so, given the right support EM has the key benefit that it provides a means of reviewing footage of the video repetitively and by a number of people (*e.g. including waste identification experts n*). With more time, further review of the data compiled from footage showing disposals will strengthen the AI systems, furthermore trials could be undertaken to resolve differences between the on-board observer's record and the original E-Monitoring video analysis record to determine where the problem lies.

Furthermore, substantial advances are being made at the present regarding software tools that cannot only identify materials, opening the door for fully automated analysis of video data. In these cases, the human observer analysing the footage comes only to resolve the events that the software hasn't. This technology has the potential of speeding up the analysis massively, allowing verified to enter the databases in near real-time at some stage.

Based on these, the authors believe that including the monitoring of MARPOL events as part of the wider objectives of EM in the region is an alternative that deserves to be encouraged, independently of other waste management mechanisms and presented by this study.

4.5 **The Economics of Poor Waste Management**

The physical challenges to improved waste management on fishing vessels are primarily that waste may be smelly, and that it takes up valuable deck space. There are ways to reduce these problems, and they are the same problems that virtually every business operation faces on land. The economic challenge is quite different: there is the omnipresent option to just throw it over the side, for free. In effect, where fishing vessels use the sea for dumping their waste, they are gaining an economic advantage over other businesses who must manage their waste. This economic advantage would be quite easy to quantify for

an individual ship, as it is simply the 'avoided cost' of taking the ship's waste to a proper waste disposal facility.

But there are two additional economic advantages of poor waste management:

- 1) The ship that dumps waste into the ocean, and so pollutes the sea, will impact the well-being of the environment that provides the fish. This ship operator is in fact 'Free Riding' on the ship owner who takes waste management responsibly, and acts to preserve the health and well-being of the environment that provides their livelihood.
- 2) The littoral state that allows the waste to be dumped for free is in effect subsidising the fishing business - by saving waste disposal costs - at the cost of damaging that nation's own natural capital asset, being the fishery that generates income to the country.

These topics might seem to a degree esoteric, but in fact are in the front line of current economic thinking on managing the economic natural capital that is tied up in various business models⁸¹. The British Government has just published a major review on exactly such issues⁸², and it is worth quoting from that report:

"Low income countries, whose economies are more reliant than high income countries on Nature's goods and services from within their own borders, stand to lose the most⁸³... Nature's worth to society – the true value of the various goods and services it provides – is not reflected in market prices because much of it is open to all at no monetary charge⁸⁴... Breaking the links between damaging forms of consumption and production and Nature can be accelerated through a range of policies that change prices and behavioural norms, for example enforcing standards for re-use, recycling and sharing, and aligning environmental objectives along entire global supply chains⁸⁵."

Thus, it is perverse for any fishing vessel operator to claim that having to manage their wastes correctly is imposing an economic penalty on their business. Quite the reverse: by **not** correctly disposing of the ship's waste, the vessel owner is taking an opportunity that does not exist to the shore-based business owner, for if a typical business simply shovelled its waste out its door, soon the business would no longer operate as it would disappear behind a mountain of trash. The ship operator who allows crews to dump waste - possibly through not providing suitable waste management on board - is using the ocean for a free garbage disposal service at economic advantage to themselves.

Both the littoral states and the DWFN of the Pacific have agreed that the fish caught in the littoral states' EEZs need to be paid for to those states. If the natural services that those ocean areas provide in the form of fish can have a monetary value placed on them, then the natural services that that same ocean provides by taking garbage away can also have a monetary value put on it.

Where economic tools are used to direct behaviour, then the option is to increase the cost of the undesirable behaviour so that it is cheaper to enact the desirable behaviour. In this case, if a vessel was charged for dumping waste over the side at a higher rate than the cost of taking it ashore, then operators might find that the economic option was to manage their wastes responsibly and take them ashore, and pay less money.

How do we know when waste is dumped over the side? Hard to know, admittedly, and it could prove very expensive to try and find out. But everything that got dumped over the side - apart from fish caught in the ocean - came aboard that ship either from a port or a Carrier. Whilst actually measuring what came on board would be a huge task, it is however realistic to make some reasonable estimates of waste generation based on how big the ship is - O&M waste - and what fishing effort was conducted.

⁸¹ c.f. The Economist, February 6th 2021 Free Exchange: The Natural Question p58

⁸² The Economics of Biodiversity: The Dasgupta Review February 2021: <https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review>

⁸³ Ibid, Headline Messages, p2

⁸⁴ Ibid, p2

⁸⁵ Ibid, p3

That is what this study has attempted to do.

The analogy that springs to mind here is that of taxation, and what is owed to the taxman when there are few- or no - records. In the case of a taxpayer who cannot account properly for the tax amount paid given the size of their business, then the Inland Revenue typically makes an estimation - and a consequent demand - and the onus then becomes onto the taxpayer to prove that this demand is unjustified. This process penalises the 'free riders' who get others, who do follow national laws, to subsidise their operations.

Where fishing gear is not recovered from the ocean, and so no cost of waste disposal is incurred, there is a similar *de facto* economic subsidy occurring. Any normal business will sooner or later be confronted with the cost of removal and disposal of capital equipment, be it machinery, vehicles, building fittings etc. Where capital equipment has a residual value, then that capital equipment can be sold; but where the equipment has no re-sale value, then that equipment has a cost of disposal, even if it is simply the cost of taking it to the scrap yard or landfill.

For fishing vessel operators who simply allow capital equipment - in this case fishing gear - to be 'lost at sea' then these businesses are gaining an economic advantage over land-based operations. The littoral nations who are providing the fishing licenses are, in effect, having their income producing assets damaged by the actions of those who dump into the sea.

Given that all materials that end up dumped into the sea - whether intentionally or not - have been carried out into the ocean by the vessels themselves, then the issue is one of professionalism on the part of ships' crew and vessel operators, as to whether a vessel makes any serious attempt to ensure that, where ever possible, fishing-related equipment is recovered and returned to shore for disposal.

Whilst it is clearly understood that some fishing equipment will be unintentionally lost at sea, given the nature of the ocean and the realities of fishing, what the above demonstrates is that there is an economic incentive operating to 'loose' fishing equipment at sea at the point at which it has no longer become serviceable. Perhaps the clearest example of this is Fish Aggregation Devices (FADs): having constructed the FAD on board ship, and placed it into the ocean, it is awkward to recover it, and dismantle it on board, so that it can be carried back to the shore for disposal. Simply to record the number of FADS returned to shore would indicate the scale of this problem, and whether FADs are a *de facto* waste dumping strategy by fishing vessels, unless they are purpose built from biodegradable materials.

Thus, any argument that the cost is too high to ship operators of improving their waste management is to turn the truth on its head. Vessels and owners that allow waste to enter the ocean are taking an economic advantage over the fact that the ocean provides a free service of waste removal. To agree to dumping as a reasonable approach is to also advocate that coastal cities, towns and businesses should also dump their wastes into the sea as the sea will take it away, and so save themselves the economic cost of waste management. If the waste is not to go into the sea, it must be managed.

Responsible, professional fishing operations will in no way countenance the poor approach, and the MARPOL convention, to which most of the nations involved in fishing in the Pacific belong, is explicitly against this approach. No responsible fishing business would condone the approach that ocean dumping was acceptable, and any fishing business or nation that does is effectively supporting the Free Riders. This is a classic case where the responsible business pays the cost - just like the responsible taxpayer - whilst the Free Rider gets the benefits at no cost.

FFA do have some leverage in the Harmonised Terms and Conditions (HMTCs) that they attach to licensed fishing vessels.

The problems are:

- an economic one of incentives; a logistical one of deck management:
- and an operational one of on-board ship management of both materiel and personnel.

Identifying the underlying problems helps to determine recommendations, actions that must be as simple and practical as possible, and focused at the key points where most impact can be made for least effort.

5 Strategies and Actions proposed to minimize Plastic Waste Disposal at Sea.

The overall strategic aim must be to build a culture and practise of good waste management on board FFA licensed vessels. FFA must take actions that show that it is serious about ensuring that fishing is not also a polluting activity. The MARPOL framework provides everything needed at the higher level to do this, and the situation is effectively summed up in the MARPOL guidelines document⁸⁶:

" 6.1 Recognizing that direct enforcement of MARPOL Annex V regulations, particularly at sea, is difficult to accomplish, Governments are encouraged to consider not only restrictive and punitive measures consistent with international law, but also the removal of any disincentives, the creation of positive incentives and initiatives to facilitate more effective compliance, and the development of voluntary measures within the regulated community when developing programmes and domestic legislation to ensure compliance with the Annex."

This section describes the strategies and actions that would support those aims.

5.1 Strategic analysis and policy action points

These Strategic Points rest on two fundamental pillars: the development of incentives to reward those already doing the right thing, and to encourage change in those who need to; and simple ways to measure and monitor the wastes in order to know that that change is occurring.

Yet, it is necessary to tease out the key Strategic Points that will then inform any recommendations for action.

1. The primary issue is either that waste is dumped into the sea, or it is returned to port at some point, and in some form. MARPOL does not allow the dumping of any of the solid wastes considered in this study, and incineration ashes must be returned to port, thus:

All vessels should be returning some quantity of waste to port.

2. If something is to be managed, then usually it will need to be measured. Therefore, the questions are: *how much?* and *how do we measure that?* There are two separate waste streams to consider, Fishing Operations Waste, and O&M waste. The first is related to fishing effort; the second to crew and vessel size, and the number of days at sea:

A measure of expected waste generation by vessel is required.

3. The overall, high level framework of institutional and technical standards and guidelines already exists within the MARPOL Convention. The overall aim must be to ensure that those vessels who do not have good waste management practices, do so:

Under the FFA HMTCs all licensed fishing vessels must comply with MARPOL, whether the flag state is a Party or not.

4. As noted elsewhere in this report, there is actually an economic incentive to operate a vessel with poor waste management; therefore, one way ahead is to create an economic incentive to improve waste management:

Create an economic incentive to follow MARPOL requirements.

5. Measures must be simple to implement where possible for both FFA and fishing companies. Onerous and complex reporting systems that require significant additional manpower and cost to report, monitor and enforce are unlikely to be adopted:

Use simple metrics and focus effort on a smaller number of key locations.

⁸⁶ Enhancement of Compliance with MARPOL Annex V: Resolution Mepc.295(71), 2017. Guidelines for The Implementation of MARPOL Annex V p25

6. The issue of waste management on board a ship is fundamentally a logistical challenge; all the materials that become waste were put on the ship either in port or during a transshipment:

Use existing logistical pathways.

7. Pacific Island ports already have a domestic waste crisis and are in very large part unsuitable to take foreign wastes generated by overseas business operations, so aside from local-based fishing vessels, wastes need to be returned to originating home ports:

Wastes from DWFN should not be off-loaded at Pacific Island ports.

8. Larger vessels are much better placed to have better waste management systems, as they have more space to operate small compactors to increase waste density, can operate compliant incinerators, and can handle and stow larger waste containers:

Carrier vessels to accept wastes from fishing vessels where transshipments occur.

9. There must be a long-term element to the strategic actions which is aimed at changing the culture on board over time on those fishing vessels that do not currently have good waste management systems in place:

Start with easier measures and lift the bar over time.

10. Ship owners and operators who can show that they have MARPOL compliant systems already in place, and already take waste management seriously, must be recognised. Those who do not must be held accountable:

Reward good businesses and target poor operators.

5.1.1 Developing Economic Incentives

In the economics of waste management there is the concept of Extended Producer Responsibility (EPR), which can be easily seen at work in bottle and can deposit/refund systems, but is increasingly widely used around the world for things like end-of-life tyres, mobile phones, even vehicles. The basic principal is that money is paid at the point of first sale, and that money is either returned when the original item is sent in for recycling or disposal, or else used to fund a recovery system for that type of product. Some EPR systems have been in place for over forty years: mobile phones in Australia and recovery for recycling of cars in Germany are both good examples of modern systems.

To put a deposit and refund on all the items that a fishing vessel might create as waste is clearly unworkable. However, it is clear that there is a direct link between waste generated and fishing effort - Fishing Operations Waste (FOW) - and waste generated by days at sea -O&M waste. If nominal measures are agreed for FOW that are tied to fishing effort, then it is a simple matter to require that a fishing effort of X will generate a FOW of Y. This then leads us to the situation where when a vessel produces Y waste from effort X, it can be rewarded by an incentive of \$Z.

Where does the money come from to pay the \$Z incentive? Using the principals of EPR, this is levied at the time of paying the fishing license fee, so that the money becomes, in effect, a 'Waste Bond' held in escrow, perhaps by FFA member countries and/or PNA⁸⁷, whilst the vessel fishes, and the amount itself returned to the vessel operator, as long as it produces the expected waste amount of Y by the end of the period.

The original 'Waste Bond' amount could be rolled over each year and become a credit on subsequent fishing license fees, avoiding the transaction cost of moving actual money. Under this scenario, it would

⁸⁷ Or it would also be possible to use existing banking practise of banks holding guarantees, such as the EU requires for some project contractors. This would avoid FFA having to actually hold the money.

only be when a fishing company joins, or withdraws, from a specific fishery and terminates its licensing arrangements, that any actual transfer of funds might be required.

What happens to waste that is transferred from a vessel at sea to a Carrier?

In this case the waste has become a commodity like the fish, and is measured just as the fish are measured during a transshipment. The licensing requirements attached to the vessel would allow transfer of waste to a Carrier - in fact, they should encourage it. Transfer of waste to a Carrier should be considered as the same as taking the waste back to a DWFN port as far as the fishing vessel is concerned. This is because Carriers can be much better set up to compact, manage and stow wastes, and take them home. Essentially: Pack In and Pack Out.

This approach is using a 'reverse logistics' strategy to dealing with the waste problem: the waste materials may well have come from a Carrier in the first place. Carriers are larger vessels, tend to spend less time at sea, are much better placed to have compactors to reduce waste volumes, and may have IMO compliant incinerators rather than the simple, polluting and unsafe open drum fire-places found on the poop decks of smaller ships.

Carriers, by the nature of their operations of handling stores and receiving fish, are also much better placed to have good record keeping systems, as they have to record what supplies they take on, what they disburse, and what fish they receive. Thus recording and managing the waste flows simply becomes another logistical function of the Carrier.

This overall approach addresses the strategic points 1,3,4,5,6,7,8 & 10 enumerated above (section 4.7.1), the waste is concentrated into a smaller number of vessels, which are easier to monitor, better equipped, using the logistical pathways already in place, and waste is not put off in Pacific ports which cannot really handle it.

Where a fishing business loses its Waste Bond by being unable to show sufficient waste has been transferred, the economic incentive is in play. Ships that do not use Carriers will have to record their waste offloads to port as per usual.

Vessels and companies that can show existing waste management practises that meet MARPOL and the strategic points above, and can convince the licensee as such, may not be required to pay the Waste Bond at all, so rewarding existing good operators: this is important.

Notable in MARPOL is the requirements for Garbage Record Books and Waste Management Plans, things that good operators will already have in place, and along with a few photos of existing on-board practices and equipment, providing evidence of existing MARPOL compliance should not be an onerous task for those companies.

'Waste Bonds' that are forfeit through poor waste management by business operators could possibly be used to financially reward those who collect lost fishing gear from the ocean⁸⁸, as has been proposed by the IMO/MARPOL. This approach would best tie in with measures to tag fishing gear with the IMO Ship Identification Number⁸⁹, so that claims cannot be made for recovering one's own gear, and where there is a dispute about collecting another vessel's gear that is not lost there is some potential to adjudicate the matter (e.g. date of set and location).

5.1.2 Measurement of Waste

To measure the potential waste that might be generated in the future at the time at which the ship is provisioned is unworkable. What can be done is to make reasonable, *conservative* estimates of the waste that might be expected to be generated, and then introduce an expectation of a similar amount of waste being off-loaded from the fishing vessel.

⁸⁸ Actions: point 5: "...Facilitate incentives for fishing vessels to retrieve derelict fishing gear.." Resolution Mepc.310(73) (2018) Action Plan To Address Marine Plastic Litter From Ships

⁸⁹ Ibid, Action points 2. & 3.

It will be important to initially have a low, conservative estimate of waste production, otherwise ship operators who reduce potential waste at the time of provisioning (for example through re-packing vegetables from Styrofoam boxes to cardboard) or other low-waste strategies could be penalised, which would be perverse; also, a number of variables contribute to expected waste. 'Expected waste production' would need to be worked out by a simple formula relating to each particular ship, based on size, type of fishing, days at sea, and crew numbers. Calculations elsewhere in this report can provide some initial guidance to this approach.

Keeping the expected waste production number low is consistent with Strategic point 9: the effort to instigate, in the long term, a culture on board ship of better waste management. Over time, as systems on board improve (especially regarding the removal of simple, less-safe low temperature incinerators on small vessels) and as data collection increases, improved estimates of expected waste can be made, and an initial low bar can be lifted.

Thus, the way that the waste is measured becomes important. As seen in *Section 3* of this report on Waste generation estimates 'Measuring the Waste' MARPOL Garbage Record Book templates use volume in cubic metres as the measure, but as space is at a premium, increasing density by reducing volume is a crucial strategy on board ship, so weight becomes a better metric. Using volume would also militate against a vessel using compaction as a method to manage waste, something that should be encouraged, not discouraged.

Weight is also easier to estimate in small amounts, and reasonable estimations are going to be an essential ingredient of this entire process of recording what waste is produced.

Another very good reason to use weight is that where fish are transferred to a Carrier, they are weighed - or estimated by weight - and so using the same metric would work best for recording this additional commodity transfer.

5.2 Proposed Actions

The following actions would support the above strategic approach. An outline of what is required to take those actions is also provided.

5.2.1 Provide all licensed vessels with a simple template electronic Garbage Record Book.

A piece of work would need to be conducted to develop a suitable electronic Garbage Record Book template, aiming to minimise the quantity of information required to be recorded so that it is as *simple as possible* to fill out and check. (*For example the garbage categories used in MARPOL can be simplified significantly for the purposes of this Action: there is no need to identify so many categories*).

Weight in kilograms should be the measurement; and the book - probably a simple excel sheet - should be uploaded regularly to a shared SPREP/SPC/FFA database. Where each ship has given its own file name, then each uploaded file could replace the last for example, to avoid multiple files. This work is an IT task based on input from a waste advisor. This is consistent with Strategic Points 1, 2 & 5.

5.2.2 Set up a ER database to accept uploaded Garbage Record Books.

An electronic repository for the standardised Garbage Record Books is needed on FFA servers or the cloud that vessels can upload their data to. This is an Electronic Reporting (ER) task and compliments Action 1.

5.2.3 Require all licensed vessels to provide a Garbage Management Plan.

This plan should be as simple as possible consistent with representing the realities of waste storage on the vessel in question. A concise template plan should be drawn up to assist standardisation and encourage simplicity, to avoid recording any unnecessary information. Carriers should be expected to have provision detailed in their plans to take waste from fishing vessels during transshipments. Carriers will be expected to show compaction capacity and/or large waste holding capacity.

Standardising plans should help ensure that only the important information is in the plan: for example how waste is contained and stowed, any compaction measures, scrap metal separation, description of any incinerator used, etc. There is *no necessity* to go into recycling capacity, waste type and separation - other than scrap-metal or not. Waste oils are an engine room issue: 'garbage' is solid waste. A draft Template Plan should be drawn up and 'field tested' on a small number of suitable candidate companies/vessels who are prepared to assist, so as to develop the simplest Plan possible but one fit for the purpose. This is consistent with Strategic Points 3, 5, 6 & 8.

5.2.4 Develop a formula for Calculating Expected Waste Generation per vessel.

This could use more real-world inputs as well as the materials of this study. Ideally, identify a small number of vessels that have good waste management systems, and study them to get data. Use that data to develop a simple formula based on vessel size, number of crew, days at sea, fishing type, fishing effort. This report can provide some guidance to developing this piece of work, as a desk-top study is not ideal in this case.

This Action can be combined with Action point 3 so that the same field testing of a Management Plan can be used to collect some data. The study period need not be too long, the intention is to determine a number for reasonable floor of expected waste generation, and feed into the development of on-board systems. Good measurements will provide good data to help vessels plan their waste stowage requirements over an expected voyage length.

Vessel owners could be incentivised to participate by being given a waiver from having to post an initial Waste Bond, if that approach was subsequently taken. This is consistent with Strategic points 2, 9 & 10.

5.2.5 Require all incinerators on carrier vessels to meet IMO standards.

Poor incinerators are not only health and safety risks, but also significant sources of pollution. Ensure that any waste incineration that does take place on board ship only takes place in a decent incinerator fit for purpose, and *not* in a non-compliant device that is a potential health and safety hazard. As compliant devices will be larger and more complex and expensive, it can be expected that these will tend to be only installed on Carrier vessels, so directing any waste reduction by incineration towards Carriers. This concentrates monitoring effort on a smaller number of subjects, especially as incinerated waste is harder to measure.

This Action requires that vessels submit pictures and specifications of their *installed* incinerator, on the vessel in question, at the same time - and as part of - their Waste Management Plan. Non-compliant incinerators will cause rejection of the Plan. A lead time can be provided so that a future date by when vessels *must* comply can be set. The MARPOL standards for incinerators are extant⁹⁰; this Action requires no additional effort. This Action is consistent with Strategic Points 3, 4, 8 & 10.

5.2.6 Develop a 'Waste Bond' System that is payable at time of licensing.

The Action Points above will feed into the development of a 'Waste Bond'. With some measure of the amount of waste generated consistent with ship operations and size, a level of Waste Bond that should be posted can be determined. There are a significant number of factors that must be considered when setting the Bond level, both practical, economic and political. The Waste Bond would be held in escrow, using one of the conventional methods, and rolled over annually for each license period.

5.2.7 Communicate the new Waste Regime to FFA Stakeholders.

If the above Actions are decided and underway, then the rationale for taking them needs to be communicated to key stakeholders. This could be refined and spelt out in a written briefing papers, possibly at least two: one more detailed along the lines of an Executive Summary that might go to key

⁹⁰ Resolution Mepc.244(66) 2014 Standard Specification For Shipboard Incinerators

stakeholders, and one a Fact-sheet style of publication that can be more widely circulated to those are less interested in the detail, but need to know about the coming changes to the licensing conditions.

5.2.8 Strengthen implementation and reporting of WCPFC CMM 2017-04

The proposal in this report that FFA should require via the HTCCs that all licensed vessels fishing in FFA members waters compliance with the CMM Point 1 which is consistent with MARPOL, and could be expected to be welcomed by Flag States as it has enabled them to share the onus of compliance with MARPOL from purely the Flag State imposition to the vessels interest to operate under FFA's HMTCs and their inclusion in the list VGS, while noting this approach is consistent with both MARPOL⁹¹ and the CMM⁹².

Is also important to note that CCM are expected to report on progress, actions and alleged violations of the CMM for the following points:

- 4: CCMs are encouraged to undertake research into marine pollution related to fisheries in the WCPFC Convention Area to further develop and refine measures to reduce marine pollution, and are encouraged to submit to SC and TCC any information derived from such efforts.
- 5. CCMs shall encourage their fishing vessels within the WCPFC Convention Area to retrieve abandoned, lost or discarded fishing gear and retain the material on board, separate from other waste for discharge to port reception facilities. Where retrieval is not possible or does not occur, CCMs shall encourage their fishing vessels to report the latitude, longitude, type, size and age of abandoned, lost or discarded fishing gear.
- 10. CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.

Both in the Preamble to CMM 2017-04 and at Adoption Points 6, 7 & 8 the understanding is clearly expressed that Pacific SIDS are currently challenged by the ability to manage their own waste, and not just from ships; section 3.4 of this report details the waste crisis current in most relevant Pacific SIDS ports. In the light of this expressed recognition of the problems these SIDS ports face, it is perverse to expect them to handle the vessel waste problem where a clear alternative exists⁹³, being the option of taking the waste back to the countries where the products subsequently contributed to the waste were sold. This is a conventional understanding underpinning international solid waste management⁹⁴ conventions.

Point 8 of the CMM requires of CCMs some active support to SIDS who are struggling with solid waste management issues⁹⁵. This report clearly shows the challenges that most Pacific SIDS face in this respect - the pictures speak for themselves. The simplest way that CCMs can enact this point is to ensure that their fishing vessels dispose of their waste only at ports with adequate facilities.

Clearly this Point 8 does not expect that CCMs are going to finance the building - or improvement - of landfill facilities in SIDS. Thus, this point is much more easily addressed by CCMs acting to take waste away on CCM Carrier vessels so that it is only off-loaded in ports which have adequate waste disposal facilities.

⁹¹ Enhancement of Compliance with MARPOL Annex V: Resolution Mepc.295(71) 2017. Guidelines For The Implementation Of MARPOL Annex V p25

⁹² CMM 17-04 Adopted Point 3: "CCMs are encouraged to prohibit their fishing vessels operating within the WCPFC Convention Area from discharging..."

⁹³ recognising that local -based operations will have to use local SIDS ports' facilities.

⁹⁴ c.f. the Basel Convention on the Transboundary Movement of Hazardous Wastes <http://www.basel.int>

⁹⁵ Ibid: 8. CCMs shall cooperate, consistent with national laws and regulations, directly or through the Commission, and in accordance with their capabilities, to actively support SIDS and Territories through the provision of adequate port facilities for receiving and appropriately disposing of waste from fishing vessels. [Emphasis added.]

Through the 'Waste Bond' system proposed, which would of course also apply to Carriers and any other FFA licensed vessels, the Carrier fleet can actively participate in ensuring that waste only goes to ports that have adequate facilities. As Carriers take on the waste from fishing vessels - even if from a different Flag State to the Carrier - a secondary market will spring up whereby the Carriers will be paid by the fishing vessels to take the wastes away - just as the vessel normally would pay to have its waste disposed of in port⁹⁶.

The Garbage Record book will record transshipment to a Carrier as a transfer of ownership just as it does fish, and so fulfil the fishing vessels' obligation to dispose of their waste correctly under the Waste Bond conditions. What that might cost will be entirely up to the market, but will also be influenced by the level at which the Waste Bond is set: if it is set too low, the market will not function. Carriers will then in turn pay to dispose of the waste at a port with adequate facilities. This proposal is using market mechanisms to enact point 8, and at a far lower cost than that of actively financing waste management facilities and landfill construction in SIDS.

Points 9⁹⁷ and 10⁹⁸ of the CMM address the loss and recovery of fishing gear. MARPOL proposals are also moving in this direction with moves to mark fishing gear with the vessel number. The proposals in this study that a standardised Garbage Record Book be developed could easily incorporate a lost fishing gear log; MARPOL already provides that lost fishing gear should be notified, but to the Flag State - which action is of questionable utility - and sometimes the coastal state⁹⁹. If fishing gear were both marked and logged as lost, then the proposals in this study to potentially use forfeit Waste Bonds to incentivise those vessels that recover lost fishing gear are supporting Points 9 & 10.

It could be expected that by FFA members taking on these compliance roles through licensing conditions, CCMs can share off their responsibility to meet their obligations under CMM 2017-04 to FFA, and FFA can then get the vessels and fishing businesses themselves to take action to meet the aims of the CMM, all through the incentive provided by the Waste Bond system.

Having established MARPOL as the relevant framework for pollution control at the beginning of the list of adopted points, the CMM at Point 3 then states: "*CCMs are encouraged to prohibit their fishing vessels operating within the WCPFC Convention Area from discharging:...*" and a list of pollutants banned by MARPOL is provided¹⁰⁰. This is inconsistent. Either WCPFC wants CCMs to follow MARPOL, or it doesn't. The language '*encouraged to prohibit*' in reference to something which is expressly prohibited under MARPOL (as is the case with most of what is in the list of Point 3) could possibly be taken to be understood as encouragement to ignore MARPOL, and that the WCPTC might turn a blind eye to lack of compliance with MARPOL. Obviously, this was not the intention of Point 3. Thus, by adopting the recommendations of this report, WCPFC can avoid any misunderstanding, as the onus for compliance is shifted to the FFA HTMCs conditions; FFA in turn can shift the onus of compliance to the fishing companies, as they are the ones who must comply with MARPOL and the CMM in order to ensure that their Waste Bond is not forfeit.

5.3 Timelines for Action

The Actions 1 to 5 could be conducted over one year, so that by the end of that first year the formula for expected waste has been developed, and templates for Garbage Record Books and Management Plans have been developed and field tested. At the start of a new licensing period, vessels will be required to

⁹⁶ If a Fishing vessel is not already paying to have its waste disposed of in port than it is clear why the WCPFC is "convinced that certain activities associated with fishing..."

⁹⁷ CMM 17-04 Adoption Point 9: CCMs are encouraged to develop communication frameworks to enable the recording and sharing of information on fishing gear loss in order to reduce loss and facilitate recovery of fishing gear.

⁹⁸Ibid, Point 10: CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.

⁹⁹MARPOL Annex V Regulation 10.6: "...the accidental loss or discharge of fishing gear... shall be reported to the State whose flag the ship is entitled to fly, and, where the loss or discharge occurs within waters subject to the jurisdiction of a coastal State, also to that coastal State."

¹⁰⁰ With the exception in the list of 'food waste'.

post a Waste Bond which will be fully refundable when, at the end of the period, the expected amount of waste has been off-loaded. Vessels re-licensing can roll-over their Waste Bonds. Non-compliant vessels will lose their Bond, and be required to pay another.

Vessels that at the start can demonstrate full compliance with MARPOL and produce records and plans to support that, including pictures of the situation on the relevant vessel, may not be required, at the discretion of FFA, to post a Waste Bond. This rewards businesses who are already making the required effort. This is consistent with Strategic Points 4 & 10.

5.4 Subsidiary Actions

5.4.1 Inclusion of CMM2017-04 / MARPOL issues as part of EM role out objectives

As discussed in section 4.4, EM is aimed for substantial deployment in the region and has already a role to play on pollution monitoring, albeit the policy, logistics and operational issues discussed.

Off-loading of fish to Carrier or home port should be accompanied by off-loading of waste, and thus could be easily verified through footage

There should be no expectation of video observers that they should be actively looking through a large quantity of footage for incidents of waste going overboard during normal ships' operations. This is consistent with Strategic Points 5 & 6.

5.4.2 Strengthening the existing requirements Marking of Fishing Gear and use biodegradable FADs

The IMO Action Plan¹⁰¹ suggests that fishing gear should be marked with the deploying vessel's identifiers, in particular this should be enforced in FADs. If this measure was enacted, it would be possible to reward those who collected discarded fishing gear by using the Waste Bond money of those who lost the gear.

It could be that a system was devised so that only where gear is lost, and not recorded as lost, and another vessel finds it, that only then that some fraction of the Bond was forfeit. This way, vessels who 'loose' lots of gear to avoid taking home end-of-life equipment can be sanctioned or identified. Development of such a proposal clearly needs some effort to come up with a workable incentive system using this principle.

There is a large area of potential study and policy development to look at working out some sliding scale to sanction those who lose a large amount of fishing gear. For example, loss of a FAD built using only biodegradable materials, designed to break down over time in the ocean and not entrap by-catch of any sort might not incur penalties, but loss of FADS made of plastic components - or incorporating trash - would. The Waste Bonds could provide the source of funds. Such work would need to be conducted after the effort to develop an initial Waste Bond level. Similarly, the determination of Waste Bond levels themselves could be subject to a vessel's record at the end of each licensing period, creating a sliding scale in the similar vein to a golfing 'Handicap', and so rewarding good operators.

¹⁰¹ Resolution Mepc.310(73) Action Plan To Address Marine Plastic Litter From Ships

6 Conclusions and take away messages

6.1 Sources of non-fishing gear plastics

Our findings, based on the team's experience and our consultations, validate that finding and focussed on the assessment of volumes of the following items:

- For longliners the waste assessed consists of plastic liners and plastic straps on bait cartons and plastic bags for bagging tunas in Refrigerated Sea Water and Slurry Tanks.
- For tuna purse seines the main sources of plastic waste were salt bags used to store the salt which is used in brine tanks and also used in Fish Aggregating Devices (FADs) along other plastics.
- In addition, other plastic waste from food and beverage packaging and living on board, what we call Operational and Maintenance Waste (O&MW) is also a major source of plastic and other waste not only onboard longliners but on all vessels at sea.

6.2 Estimation of plastic waste generated and disposed by the fleet per year

6.2.1 Longline

Produced

The actual plastic waste products from bait boxes are estimated as between 402 and 935 tonnes, of which the median value would be about 670 tonnes per annum.

Cardboard waste is much larger and estimated at between 2958 and 6879 tonnes for the 1669 active vessels in the WCPO, of which the median value would be about 4,920 tonnes per annum.

Dumped

Using 60% as a proxy we estimate that between 241 and 560 tonnes of plastic waste from bait only is being dumped at sea, while the figures for cardboard is in between 334 tonnes and 776.

6.2.2 Purse seine

Produced:

We estimate that the plastic waste production from salt bags is 210 tonnes which is equivalent to 2,800,000 individual bags.

Dumped

Using this as 37% proxy we estimate that, potentially, the Purse Seine fleet in the FFA VGS disposes 77.7 tonnes of woven plastic salt bags (equivalent to 1,036,000 individual bags) a year into the ocean.

6.2.3 Operational and Maintenance Waste (O&MW)

6.2.3.1 Longliners

The actual plastic O&MW from longliners is estimated as 1,000 tonnes

Using Richardson's (2015) 60% proxy figure, then an estimated 600 tonnes are potentially disposed into the ocean every year by the Longline fleet.

6.2.3.2 Purse Seiners

The actual plastic O&MW from Purse Seiner is estimated as 220 tonnes

Using again Richardson's 37% proxy figure, an estimated 80 tons are potentially disposed into the ocean every year by the Purse Seine fleet.

6.3 Assessment of Waste Disposal Facilities in Pacific Island Ports

- Overall, only Suva has a landfill that can be really said to be fit to take foreign wastes generated from fishing boats; Suva is the only port amongst those above which is listed in the Regional Reception Facilities Plan.
- All other ports noted above struggle at varying degrees, and given that the waste from the boats is commercial wastes, generated as a result of business operations, and originated outside of the countries concerned.
- It is very hard to make case that these small Pacific Island Countries, who are already struggling deeply with their own waste crises, should take that commercial waste.

6.4 Constrains, strategies and proposed actions

6.4.1 *Regulatory frameworks regulating plastic waste disposal*

- MARPOL has created the overall framework required such that any dumping of plastic waste into the ocean is unacceptable.
- If the MARPOL Convention Annex V is being followed, and if the Garbage Record Books were electronic and uploaded to SPREP/SPC/FFA from licensed vessels, in a standard format to make search and analysis of the data easy, and all fishing gear waste lost was also recorded, it would be a relatively simple matter to determine how much fishing gear waste was being lost, as well as how much waste was generated. There is no shortage of institutional framework to cover this situation.
- There is clearly no excuse for fishing businesses not to be operating a comprehensive waste management system on board their fishing vessels, which should collect all O&M waste, and waste generated by fishing activities, except that unintentionally lost.
- The easiest, cleanest, and most effective way to manage the waste stream from vessels engaged in transshipment activities is to transship waste alongside fish and return it to mainland ports with proper waste disposal facilities.

6.4.2 *Operational strategies for better management of plastic waste on board*

Operational procedures that should be followed on fishing vessels:

- All packaging that has directly held fresh or tinned/frozen food and residues should be washed in the galley after washing the dishes, using the same water;
- Food tins should have the bottom removed as well as the top - with a can opener - after washing, and squashed flat and put into a scrap metal bin on deck;
- Cabin and bridge/office rubbish bins should be small, use plastic bag liners, and be emptied frequently;
- Cardboard boxes should be flattened and can be stowed in fadges, or in appropriate bags
- Only cardboard and paper should be burnt in a low-temperature incinerator on deck;
- Ashes and remains from any low temperature incinerator must be put into a sealed steel container (to avoid any chance of fire) and off-loaded at a suitable location;
- All metal parts, small electrical appliances, oil filters etc. can go into a steel scrap metal bin on deck or other suitable location;
- Empty salt bags must not be burnt to avoid release of dioxins and furans;
- Plastic liners from LL bait boxes should be dumped into a bin of sea-water as soon as emptied, and thus rinsed, before disposal into suitable large containers;

- Polystyrene boxes should be broken into flat pieces to better pack into waste drums or fadges (or better still, the contents transferred to cardboard boxes at time of provisioning);
- General waste, including all plastic bags and packages, including sacks, should be placed into rigid plastic or steel drums, with lids, and ideally the waste should be initially compacted using hand methods in order to increase the density of the waste and minimise deck space.
- Once waste is collected and contained, then the best approach would be to transfer that waste to Carriers during transshipment operations, unless the fishing boat is returning to home port.
- Carriers can then operate mechanical compactors and bulk holding methods to better stow and manage the wastes.
- Where incinerators that meet the IMO standards are used, these are much better installed on larger ships such as Carriers than on small vessels who would struggle to accommodate these larger compliant devices.

6.4.3 Role of EM on MARPOL issues

- The reality is that like most new solutions, there will be opposition along the way.
 - Industry members will likely have concerns about additional monitoring, privacy, the costs of the program, and a general fear of the unknown.
 - Fisheries managers may be concerned about the cost and complexity of the program and whether they will be able to effectively manage it. These concerns are legitimate and have emerged in the development of most, if not every, EM program.
- These issues cannot be sidestepped, and stakeholders need to be integrated into the design process so that their concerns are recognized and addressed. In particular, the industry needs to be involved as they will be the ones most impacted and their acceptance of the program will be critical to its success.
- Taking in consideration all issues discussed, the authors believe that including the monitoring of MARPOL events as part of the wider objectives of EM in the region is an alternative that deserves to be encouraged, independently of other waste management mechanisms and presented by this study.

6.4.4 Strengthen implementation and reporting of WCPFC CMM 2017-04

The proposal in this report that FFA should require via the HTCCs that all licensed vessels fishing in FFA members waters compliance with the CMM Point 1 which is consistent with MARPOL, and could be expected to be welcomed by Flag States as it has enabled them to share the onus of compliance with MARPOL from purely the Flag State imposition to the vessels interest to operate under FFA's HMTCs and their inclusion in the list VGS, while noting this approach is consistent with both MARPOL¹⁰² and the CMM¹⁰³.

Is also important to note that CCM are expected to report on progress, actions and alleged violations of the CMM for the following points:

¹⁰² Enhancement of Compliance with MARPOL Annex V: Resolution Mepc.295(71) 2017. Guidelines For The Implementation Of MARPOL Annex V p25

¹⁰³ CMM 17-04 Adopted Point 3: "CCMs are encouraged to prohibit their fishing vessels operating within the WCPFC Convention Area from discharging... "

- 4: CCMs are encouraged to undertake research into marine pollution related to fisheries in the WCPFC Convention Area to further develop and refine measures to reduce marine pollution, and are encouraged to submit to SC and TCC any information derived from such efforts.
- 5. CCMs shall encourage their fishing vessels within the WCPFC Convention Area to retrieve abandoned, lost or discarded fishing gear and retain the material on board, separate from other waste for discharge to port reception facilities. Where retrieval is not possible or does not occur, CCMs shall encourage their fishing vessels to report the latitude, longitude, type, size and age of abandoned, lost or discarded fishing gear.
- 10. CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.

Points 9¹⁰⁴ and 10¹⁰⁵ of the CMM address the loss and recovery of fishing gear. MARPOL proposals are also moving in this direction with moves to mark fishing gear with the vessel number. The proposals in this study that a standardised Garbage Record Book be developed could easily incorporate a lost fishing gear log; MARPOL already provides that lost fishing gear should be notified, but to the Flag State - which action is of questionable utility - and sometimes the coastal state¹⁰⁶.

If fishing gear were both marked and logged as lost, then the proposals in this study to potentially use forfeit Waste Bonds to incentivise those vessels that recover lost fishing gear are supporting Points 9 & 10.

6.4.5 Strategies proposed to minimize Plastic Waste Disposal at Sea

- All vessels should be returning some quantity of waste to port
- Under the FFA HMTCs all licensed fishing vessels must comply with MARPOL, whether the flag state is a Party or not.
- Create an economic incentive to follow MARPOL requirements
- Use simple metrics and focus effort on a smaller number of key locations.
- Use existing logistical pathways.
- Wastes from DWFN should not be off-loaded at Pacific Island ports.
- Carrier vessels to accept wastes from fishing vessels where transhipments occur
- Start with easier measures and lift the bar over time.
- Reward good businesses and target poor operators

6.4.6 Proposed policy actions

- Provide all licensed vessels with a simple template electronic Garbage Record Book.
- Set up a ER database to accept uploaded Garbage Record Books.
- Require all licensed vessels to provide a Garbage Management Plan.
- Develop a formula for Calculating Expected Waste Generation per vessel

¹⁰⁴ CMM 17-04 Adoption Point 9: CCMs are encouraged to develop communication frameworks to enable the recording and sharing of information on fishing gear loss in order to reduce loss and facilitate recovery of fishing gear.

¹⁰⁵ Ibid, Point 10: CCMs are further encouraged to develop frameworks or systems to assist fishing vessels to report the loss of gear to their flag State, relevant coastal States, and the Commission.

¹⁰⁶ MARPOL Annex V Regulation 10.6: "...the accidental loss or discharge of fishing gear... shall be reported to the State whose flag the ship is entitled to fly, and, where the loss or discharge occurs within waters subject to the jurisdiction of a coastal State, also to that coastal State."

- Require all incinerators on carrier vessels to meet IMO standards.
- Develop a 'Waste Bond' System that is payable at time of licensing
- Communicate the new Waste Regime to FFA Stakeholders

6.4.7 *Subsidiary Actions*

- Inclusion of MARPOL issues as part of EM role out objectives
- Strengthening the existing requirements Marking of Fishing Gear and use of biodegradable FADs

7 Annexes

7.1 Stakeholders consulted

Name	Position	Organization	Country
Berry Muller	Deputy Director	MIMRA	Marshall Islands
Fong Lee	Sustainability Manager	FCF	Taiwan
Marko Kammer	General Manager	Carolines Fishing Company	Federated States of Micronesia
Frank Wickham	General Manager	NFD	Solomons Islands
John De Beer	Operations Manager (retired)	Bumble Bee, Thai Union	USA
Chris Lord	Operations Manager	Santa Isabel	Ecuador
Jun Liang	General Manager	MIFV	Marshall Islands
Radhika Kumar	General Manager	Solander Fisheries	Fiji
Malo Hosken	EM/ER Officer	SPC	New Caledonia
Eugene Muller	General Manager	Koss Fisheries	Marshall Islands
Gan Jun	2 nd Mate	FV Xian Fa 8 (PS)	China
Chen Zhiyi	Fleet Manager	KFL	Kiribati
Anthony Talouli	Marine Pollution Advisor	SPREP	Samoa
Mike Donoghue	Consultant Biologist	Te Tiaki Moana Ass.	New Zealand
Halston De Brum	General Manager	Majuro Atoll Waste Co	Marshall Islands
Moriana Phillip	General Manager	RMI EPA	Marshall Islands
Marmy Henry	General Manager	Pohnpei Waste Management Services	FSM
Patti Pedrus	Pollution Control Officer	OEEM	FSM

7.2 Questionnaire prepared

AN ASSESSMENT OF FV PLASTIC WASTE DISPOSAL PRACTICES IN THE WCPO REGION

This is a study for FFA, with the overall aim is to provide workable proposals to help improve management of the waste generated by fishing vessels, where they are required.

Needless to say, we are totally aware how annoying these questionnaires can be, so we are very thankful in advance if you would assist us, as it will be in the industry's best interest to get some hard data on this subject.

Please answer as best you can and those parts which are relevant to your operations:

1) In which country is your fleet based:

PART ONE: Single-Use Plastic Waste from Fishing Activities

2. FOR LONGLINERS ONLY

- - i) Not including fishing gear, which of the following single-use plastics are used during fishing:
 - (1) Bait boxes (strapping and plastic liner bags);
 - (2) plastic bags used to keep tuna in Refrigerated Seawater;
 - (3) other (please add):
 - ii) From your experience which is the most used size of bait carton in the longline fleet?
 - (1) 10kg,
 - (2) 15kg,
 - (3) 20kg
 - (4) 25 Kg
 - (5) other (please add):
 - iii) On average, how many hooks do you bait with a carton of your usual size (as above).
 - iv) Does the amount of bait per carton vary much depending on the fish you are targeting?

Yes No

 - (1) If YES, could you give a rough range of typical hooks per box covering the different fish targeted please.
 - v) From your experience, on average, what portion of ship waste is dealt with as follows (please circle/note/highlight one option):

	none	25%	50%	75%	100%
Incinerated on board					
Stowed and returned to port					
Offloaded at Pacific Is. ports					
Passed to carriers at transhipments					
Dumped at sea					

(vi) Does your operation use other plastic containers during fishing that are reused, e.g. plastic fish bins or re-usable sacks/bags? Please note briefly.

• **3. FOR PURSE SEINERS ONLY**

- vi) Not including fishing gear, which of the following single-use plastics are used during fishing:
 - (1) Salt Bags:
 - (2) Other Plastic bags:
 - (3) PVC Pipes off-cuts (for FAD making):
 - (4) other (please add):
- i) From your experience which is the most commonly used size of salt bag on your fleet?
 - (1) 25 Kg
 - (2) 50lb
 - (3) 50kg
 - (4) 100lb
 - (5) 100kg
 - (6) 1 tonne
 - (7) Other (please write):
- ii) From your experience, on average, what portion of ship waste is dealt with as follows (please circle/note/highlight one option):

	none	25%	50%	75%	100%
Incinerated on board					
Stowed and returned to port					
Offloaded at Pacific Is. ports					
Passed to carriers at transhipments					
Used in making FADs					
Dumped at sea					

Part 2: Weight of Plastics

4. LONGLINERS

PLEASE could open 1 carton of bait as per your answers to questions 2 (longliners section) above and weight separately (in grams) the carton, the strapping and the **dry** liner bag? And write the resulting weights below

5. PURSE SEINERS

PLEASE could you weight (in grams) a **dry** salt bag of the most commonly used in your fleet? And write the resulting weight below:

Part 3: Practical Suggestions for Management of Single-Use Plastics on Board

If the MARPOL prohibition on dumping plastic at sea was to be universally followed, we seek your ideas to help improve waste management for fishing vessels, such as improved port facilities for waste.

1) Longliners

- a) What recommendations/ideas would you like to make to reduce plastics brought on board ship before fishing starts?
- b) What recommendations/ideas would you like to make to help you deal with waste in ports you visit?

2) Purse Seiners

- a) What recommendations/ideas would you like to make to reduce plastics brought on board ship before fishing starts?
- b) What recommendations/ideas would you like to make to help you deal with waste in ports you visit?

Finally! Thank you very much for your help

If you are more comfortable with call, or what to know anything about the study, please let us know:

Robert Lee ecolomarine@gmail.com

Francisco Blaha Franciscoblaha@mac.com

Based on you time zone we can arrange a call