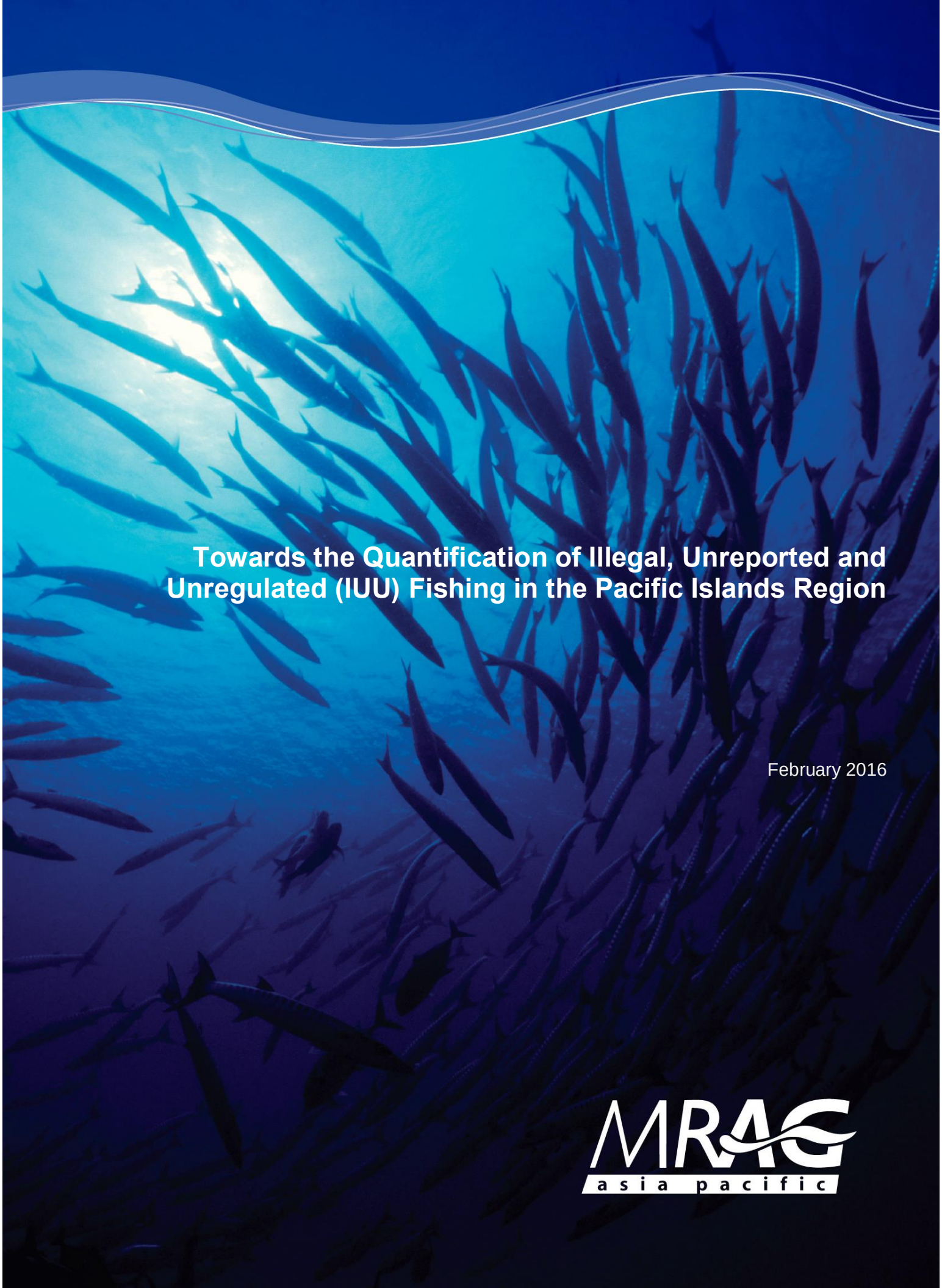

Towards the Quantification of Illegal, Unreported and Unregulated (IUU) Fishing in the Pacific Islands Region

February 2016

MRAG asia pacific

About MRAG Asia Pacific

MRAG Asia Pacific is an independent fisheries and aquatic resource consulting company dedicated to the sustainable use of natural resources through sound, integrated management practices and policies. We are part of the global MRAG group with sister companies in Europe, North America and the Asia Pacific.

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Acronyms and abbreviations

AIS	Automatic identification system
ALB	Albacore tuna
ALC	Automatic location communicator
BET	Bigeye tuna
BIL	Billfish
CCM	Members and Cooperating Non-members (of the WCPFC)
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CI	Compliance index
CMM	Conservation and management measure
EEZ	Exclusive economic zone
EM	Electronic monitoring
EPO	Eastern Pacific Ocean
FAO	UN Food and Agriculture Organisation
FAD	Fish aggregation device
FFA	Forum Fisheries Agency
FFA RR	FFA Regional Register of Fishing Vessels
FSMA	Federated States of Micronesia Arrangement
HMTCs	Harmonised Minimum Terms and Conditions for Foreign Fishing Vessel Access
HSP	High seas pocket
IATTC	Inter-American Tropical Tuna Commission
IPOA-IUU	International Plan of Action for IUU
IUU	Illegal, unreported and unregulated fishing
MARPOL	Marine pollution
MCS	Monitoring, control and surveillance
NFD	Non-fishing days
NPM	Net profit margin
NPOA-IUU	National Plan of Action for IUU
OTH	Other species
PIRFO	Pacific Islands Regional Fisheries Observer
PNA	Parties to the Nauru Agreement
PS	Purse seine
RFMO	Regional Fisheries Management Organization
RIMF	Regional Information Management Facility
ROP	WCPFC Regional Observer Program
SIDS	Small Island Developing State
SKJ	Skipjack tuna
SLL	Southern longline fishery
SPC	Secretariat of the Pacific Community
TLL	Tropical longline fishery
USMLT	US Multilateral Treaty
VDS	Vessel Days Scheme
VMS	Vessel monitoring system
WCPFC	Western and Central Pacific Fisheries Commission
WCPFC RFV	WCPFC Record of Fishing Vessels
WCPF-CA	Western and Central Pacific Fisheries Convention Area
WCPO	Western and central Pacific Ocean
YFT	Yellowfin tuna

Executive Summary

APPROACH AND MODEL DEVELOPED

This is the first attempt made to quantify the volume, species composition and value of IUU fishing in Pacific tuna fisheries specifically. We used a 'bottom up' approach which aimed to quantify the level of IUU fishing associated with 11 main risks across four risk categories: (i) unlicensed/unauthorised fishing, (ii) misreporting, (iii) non-compliance with other license conditions (e.g. FAD fishing during the purse seine closure period) and (iv) post-harvest risks (e.g. illegal transhipping). Estimates of IUU volume and value were developed for each of the three main fishing sectors - purse seine (PS), tropical longline (TLL) and southern longline (SLL) – and then aggregated to produce an overall estimate for Pacific Islands region tuna fisheries. Data was used for the period 2010 to 2015.

The approach took account of all of the available information to generate 'best estimate' values of IUU activity for each risk in each sector, as well as minimum and maximum range values. We then used Monte Carlo simulation to account for uncertainty in the underlying information and produce probabilistic estimates of IUU activity. The level of information available to support estimates of different IUU risks varied considerably between sectors and between risks. For a small number of risks good quantitative information was available. However, for the majority of risks the level of information available was very limited, reflecting the secretive nature of IUU fishing.

A key output of the project has been the development of a framework for the quantification of IUU fishing in Pacific tuna fisheries and the design of a basic model that can be refined and updated over time as IUU risks change and better information becomes available. Given the limitations in the information available to quantify many of the risks, the outputs of this work should be seen as a 'first cut'. Recommendations to strengthen the availability of information have been made and we would encourage the exercise to be repeated on a regular basis to track trends in IUU fishing activity and help target MCS efforts.

QUANTIFYING THE NATURE, VOLUME AND VALUE OF IUU FISHING

Our simulations suggest the best estimate **total volume of product either harvested or transhipped involving IUU activity in Pacific tuna fisheries is 306,440t, with 90% confidence that the actual figure lies within a range of 276,546t to 338,475t. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $616.11m. The 90% confidence range is between $517.91m and $740.17m.** That is, there is a 95% chance the figure is greater than $517.91m and a 5% chance the figure is greater than $740.17m.

Of the three main sectors assessed, estimated volume of IUU product was highest in the purse seine fishery, accounting for 70% of overall volume. Estimated IUU volumes in this sector were largely driven by reporting violations and illegal FAD fishing during the closure period. The TLL and SLL sectors accounted for 19% and 11% of the overall volume respectively. In the TLL sector, IUU volumes were largely driven by misreporting (49% of total TLL volume) and post-harvest risks (39%), principally illegal transhipping. Estimates of both misreporting and illegal transhipping were, in turn, influenced by high levels of uncertainty. Similar results were achieved in the SLL sector, with misreporting and post-harvest risks accounting for 57% and 36% of overall estimated IUU volume respectively.

By contrast, the TLL sector accounted for the highest ex-vessel value of IUU product ($272.55m) given the higher market value of its target species. This sector accounted for around 44% of overall estimated IUU value, while the purse seine sector accounted for 37%. The SLL sector had the lowest overall estimates of IUU product value (19%).

Of the four main IUU risk categories assessed, reporting violations and non-compliance with other license conditions (e.g. illegal FAD fishing; use of non-prescribed gear) accounted for 54% and 29% of the total estimated IUU volume respectively. Post-harvest risks (mainly illegal transhipping) accounted for 13% of the estimated volume but 27% of the estimated value. This was driven by higher estimates of illegal transhipping in the longline sectors which receive proportionally higher prices for product. Unlicensed fishing accounted for only 4% of the estimated overall volume.

Amongst the main target species, skipjack accounted for the largest proportion of total estimated IUU volume (33%), but a lesser proportion of the total estimated ex-vessel value (18%). The total estimated IUU volume of SKJ (100,730t) equated to around 5.1% of estimated total SKJ catch in the WCP-CA in 2014. Yellowfin accounted for the next highest volume (96,126t), making up 31% of the total estimated IUU volume, and 27% of the ex-vessel value. The total estimated IUU volume of YFT equated to around 15.8% of the estimated total catch of YFT in the WCP-CA during 2014. Much of this is driven by estimates of misreporting in the purse seine fishery which is subject to 100% observer coverage, and therefore may result in little unaccounted for catch. Bigeye also accounted for 19% of the overall estimated IUU volume, but 28% of the ex-vessel value. The total estimated IUU volume of BET equates to around 35% of the estimated total catch of BET in the WCP-CA in 2014. Importantly, this does not necessarily mean that 35% of additional BET have been taken in addition to reported figures. For example, a substantial proportion of the overall IUU BET estimates come from estimates of illegal transhipping, the product for which may still be reported in logsheets. ALB accounted for 4% of the overall estimated IUU volume and 6% of the total ex-vessel IUU value. The total estimated ALB IUU volume equates to around 9.4% of the estimated total ALB catch in the WCP-CA in 2014, although a substantial proportion of this related to post-harvest offences for which information was uncertain.

Analysis and Main messages

Apart from the headline volume and value figures, there are a number of key messages arising from the analysis:

- **The estimates of IUU volume and value generated here are lower than most commonly quoted estimate of IUU fishing in the WCPO region ($707m – $1.557b), although these studies are not 'apples Vs apples' comparisons.** The previous study (Agnew et al, 2009) used a 'top down' approach that looked at IUU fishing across a suite of species wider than tuna (e.g. demersal fish, shrimp) as well as including parts of Indonesia and the Philippines (across FAO Area 71). Relatively high levels of IUU fishing in coastal states on the western Pacific seaboard influenced the overall results;
- **Estimates of IUU are dominated by the licensed fleet -** assuming catch transhipped illegally is taken by licensed vessels, IUU fishing by the licensed fleet accounts for over 95% of the total volume and value of IUU activity estimated here. This proportion rises to 97% if unlicensed fishing by vessels that are otherwise authorised to fish in the Pacific Islands region (i.e. they

are on the FFA RR or WCPFC RFV) are considered part of the 'licensed' fleet. This is consistent with previous studies and has important implications for MCS planning and investment;

- **Ex-vessel value is not a good indicator of actual loss to FFA members** – this is because the full value of the catch is not returned to coastal states under normal circumstances (only a proportion of total revenue is, typically through access fees) and because of their nature, some risks may not necessarily result in direct losses. In general, a better measure of the actual impact on coastal states is likely to be the economic rent lost as a result of IUU activity. Based on the most recent estimates of profitability in the WCPO purse seine and longline sectors, we estimate the rent associated with IUU product estimated here is around $152.67m. Nevertheless, because of the nature of access arrangements in Pacific tuna fisheries, it is possible that much of the rent associated with IUU activity is captured anyway, and this estimate either overstates, or is at least at the upper end of, actual impacts on the real economy. For example, in the purse seine fishery, there is a good argument that the competitive nature of the bidding process under the VDS means that rents generated through IUU activity would be captured in the prices that fishing companies are prepared to pay for fishing days and are therefore not lost to Pacific Island countries. This is perhaps less the case for the longline sectors where current access arrangements are probably less efficient at capturing rent;
- **Stronger catch monitoring arrangements are required in the longline sector** – mechanisms to independently verify catch in the longline sectors are limited for many fleets. Additional measures are required to strengthen confidence in catch reporting and compliance with catch-based CMMs and generate better estimates of IUU activity;
- **'IUU' is not straightforward** – while the IPOA-IUU definition of IUU is clear in theory, applying it for the purposes of quantification is not always straightforward. Interpretations on what is, and is not, considered IUU for the purposes of quantification can substantially influence results;
- **More accurate estimates of IUU activity require stronger monitoring and coordination of relevant statistics** – the information available to support quantification of many risks was relatively limited and largely confined to expert judgement. Achieving more accurate estimates of IUU activity will require stronger monitoring and analysis, and the coordination of relevant statistics. While in some cases, this may require 'new' initiatives, in many cases it will simply require more effective use of existing facilities;
- **Strong in zone MCS arrangements must be mirrored on the high seas** – the outcomes of this study argue for stronger monitoring of catch and transhipment activity across all sectors, and in particular the longline sectors. Given the shared nature of stocks in the region, stronger MCS arrangements in zone should be mirrored on the high seas;
- **Future IUU risks –** the nature of IUU fishing is dynamic and influenced by the mix of incentives and disincentives, as well as changes in the regulatory environment. Future iterations of the IUU model developed here will need to take changes in the nature of IUU fishing into account.

WHAT ADDITIONAL MEASURES CAN

Considerable efforts have been taken at the national, sub-regional (FFA/SPC/PNA) and regional levels (WCPFC) to mitigate IUU fishing in Pacific tuna fisheries. Many of these are likely to have been highly effective at achieving their intended purpose

BE TAKEN TO ELIMINATE IUU FISHING?

(e.g. the FFA and WCPFC VMS, the FFA Regional Register, the FFA Harmonised Minimum Terms and Conditions for Foreign Fishing Access, the Pacific Patrol Boat Program, Niue Treaty, 100% observer coverage on the PS fleet) and will have contributed to the relatively low estimates of IUU fishing across a number of sector/categories. Nevertheless, the results of this study indicate that substantial uncertainty still exists in relation to IUU activity across a range of key risks, and additional measures are required to strengthen incentives for voluntary compliance, reinforce deterrents to non-compliance and improve monitoring throughout the supply chain.

Ultimately the most practical mix of MCS arrangements to deal with IUU fishing will be a function of the balance between the likely effectiveness of the measure in treating priority risks, practicality of implementation and overall costs. An outline and discussion of possible additional MCS measures that can be taken to further mitigate IUU fishing in WCPO tuna fisheries is provided, taking into account risks targeted, costs and practicality. Key priorities identified in the longline sectors are to:

- Strengthen mechanisms for independent monitoring of catch through the supply chain;
- Strengthen transhipment monitoring and control;
- Strengthen on-board monitoring of fishing activity through improved observer coverage and the introduction of electronic monitoring technology.

In the purse seine sector, MCS arrangements are generally stronger than the longline sector, though based on the current management of the fishery priorities include:

- Strengthening mechanisms to verify fishing activity (e.g. to assess non-fishing day claims; FAD fishing during the closure);
- Catch verification through the use of cannery data;
- Better monitoring and management of FAD usage.

1 Introduction

Illegal, unreported and unregulated (IUU) fishing is a recognised global problem which undermines the integrity of responsible fisheries management arrangements and results in lost value to coastal states (e.g. Agnew et al, 2009). Previous studies have shown that the effects of IUU fishing are often hardest felt in developing coastal states heavily reliant on fishing for income (e.g. MRAG, 2005).

Quantifying the nature and extent of IUU fishing is important in gauging potential losses suffered by coastal states, addressing uncertainties in stock assessments and planning effective monitoring control and surveillance (MCS) responses. However, by its very nature IUU fishing is secretive and difficult to estimate with accuracy (FAO, 2002; Le Gallic and Cox, 2006). Previous attempts to estimate IUU fishing in the Western Pacific Ocean (including non-tuna fisheries in the Philippines and Indonesia) have put the likely value at between US$707m and $1,557m (Agnew et al, 2009), however this estimate included both non-tuna fisheries (e.g. shrimp, demersal fish) as well as areas outside the 'Pacific Islands region' as defined in this study (e.g. Indonesia, Philippines).

As part of the European Union-funded Devfish II project, this study was commissioned to produce estimates of the volume and value of IUU fishing in the tuna fisheries of the Pacific Islands region[1]. The Terms of Reference for the study are included at Annex 1. For the purposes of this study we have adopted the definition of IUU fishing set out in the FAO International Plan of Action (IPOA) – IUU (Box 1).

BOX 1: WHAT IS IUU FISHING?

Illegal fishing refers to fishing activities:

(1) conducted by national or foreign vessels in waters under the jurisdiction of a State, without the permission of that State, or in contravention of its laws and regulations;

(2) conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or

(3) in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.

Unreported fishing refers to fishing activities:

(1) which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or

(2) undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization.

Unregulated fishing refers to fishing activities:

(1) in the area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; or

[1] The Pacific Islands Region is considered to comprise the EEZs of FFA's 15 Pacific Island member countries and adjacent high seas areas in the tropics.

(2) in areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law.

1.1 Approaches to estimating IUU fishing

Approaches to quantifying IUU fishing can generally be grouped into two categories – 'top down' and 'bottom up' (see for example, MRAG, 2005). Top down approaches typically use a fixed proportion (or range) of the catch which is estimated to be IUU to arrive at an overall estimate of IUU catch volume and value. For example, Pauly & McLean (2003) provide estimates of unreported catch as a proportion of the total global reported catch in the range of 25-30%. Top down approaches are convenient in that they can be applied to produce direct global or regional estimates of IUU catch, but should be applied with caution given the nature and extent of IUU fishing may vary substantially from country to country, region to region and fishery to fishery.

As the name implies, the bottom-up approach involves analysis of more detailed information at a local scale in an effort to build a more accurate picture of IUU fishing activity and particularly the variation in vulnerability to such activity from state to state, or fishery to fishery. Estimates obtained in this way are added together to develop an overall estimate of IUU catch. The challenge with this approach is that it is time consuming and information is often very patchy and hard to collect. There are therefore many gaps to fill that require analytical methodologies of varying degrees of complexity. Even when these are used, it is still possible that some types of IUU catches will be missed, and also that some may be 'double-counted'. Nevertheless, whereas the top-down approaches might be considered to result in maximum overall estimates of IUU catch, depending on the nature and level of information available, bottom-up approaches arguably have the potential to provide more accurate estimates of IUU activity.

2 Approach used in this study

2.1 Overall approach

For this study, we used a bottom up approach which aimed to arrive at regional-scale estimates of the volume and value of IUU fishing by first breaking down the 'IUU problem' into discrete quantifiable units, and then aggregating these up to produce a regional scale estimate. The approach we used in this study was similar in part to the 'anchor points' approach described in Ainsworth and Pitcher (2005) (and later used by Agnew et al, 2009, for their global IUU study) in that we assigned 'best estimates' and minimum and maximum ranges of known IUU activities and then used Monte Carlo simulations to determine the likelihood that IUU fishing would be within a certain range. However, the approach was amended for this study based on the nature of the assignment (a 'snapshot' estimate of IUU activity, rather than a historical time series) and the nature of the risks and available information (for example, the availability of data for some risks allowed for more direct estimation of 'best estimates' and ranges).

Generating estimates of the volume, species composition and value of IUU fishing involved five main steps:

2.1.1 Identifying IUU risks

The first step in the analysis involved identifying the main IUU risks (e.g. unlicensed fishing, mis- and under-reporting, illegal transhipping, etc) in each of the main fishing sectors (purse seine, tropical longline, southern longline). These were identified through previous studies in the region (e.g. MRAG Asia Pacific, 2009), risk assessments undertaken for National Plans of Action for IUU (NPOA-

IUU) and through discussions with relevant regional agency staff. The list of relevant risks was discussed and agreed at the Planning Workshop to commence the project.

2.1.2 Determining 'best estimate' and minimum/maximum range

The next step involved identifying the information available to support estimates of IUU activity, and then using that information to determine a 'best estimate' level of activity and the most plausible minimum and maximum (min/max) values. In practice, the quality and nature of the information available varied considerably between risks. Relatively precise 'best estimates' could be assigned to some risks based on the nature of the available information (e.g. misreporting in the purse seine fishery which is subject to 100% observer coverage), while others were more subjective (e.g. illegal transhipment).

Given the highly variable nature of the IUU risks, a basic calculation to quantify likely IUU volume and species composition was tailored to each risk based on the information available. As a general rule, an uncertain quantity (e.g. the number of days fished by vessels on the FFA Regional Register in EEZs for which they were unlicensed) was multiplied by a known quantity (e.g. the average catch rate and species composition per day in the relevant sector) to constitute the basic calculation for each risk. 'Best estimates' and minimum and maximum ranges could then be assigned to the uncertain value based on the nature and quality of information available. Minimum and maximum ranges took into account the uncertainty in the available information base (i.e. risks with more certain information has narrower ranges, risks with limited information had larger ranges).

2.1.3 Assigning likely probability distribution

Once 'best estimate' and min/max values had been assigned, a likely probability distribution of IUU activity within this range was determined. In general, triangular distributions were used where there was a reasonable level of confidence that the actual level of IUU activity was likely to be closer to the 'best estimate' than either the minimum or maximum value (Figure 1). This is consistent with the approach used by Pitcher et al (2002), Ainsworth and Pitcher (2005) and Agnew et al (2009). Uniform distributions were used where the information base was highly uncertain, although in general we attempted to avoid these.

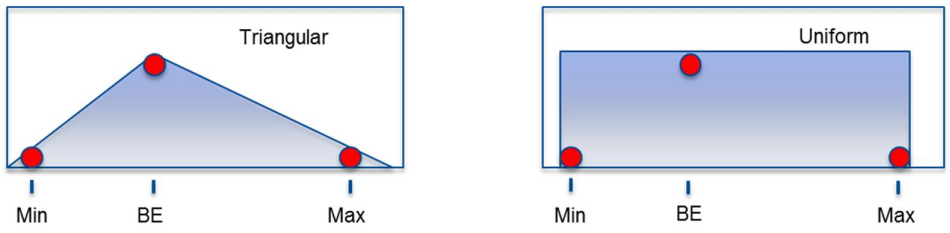


Figure 1: Example distributions of probability assigned to IUU activity. Triangular distributions were used where it was more likely the actual level of IUU activity was closer to the best estimate than either the minimum or maximum values. Uniform distributions were used where the information base was highly uncertain.

2.1.4 Monte Carlo simulations

We then used Monte Carlo simulation (using '@Risk' software) to define the relative probability that IUU volumes were within certain ranges, based on the best estimate and min/max values as well as the probability distribution assigned (Figure 2). Monte Carlo simulation is a widely-used analytical technique for calculating probability distributions of possible outcomes by performing a large number of trial runs, in which variables are substituted randomly from within a specified range. Monte Carlo simulation has previously been used by a number of authors in attempts to estimate IUU activity (e.g. Pitcher et al, 2002; Ainsworth and Pitcher, 2005; Agnew et al, 2009). The approach

has a number of benefits over 'single point' or deterministic models in that it produces probabilistic results. In the context of this study, the simulations produce a probability that IUU for a given risk will be greater than a certain value.

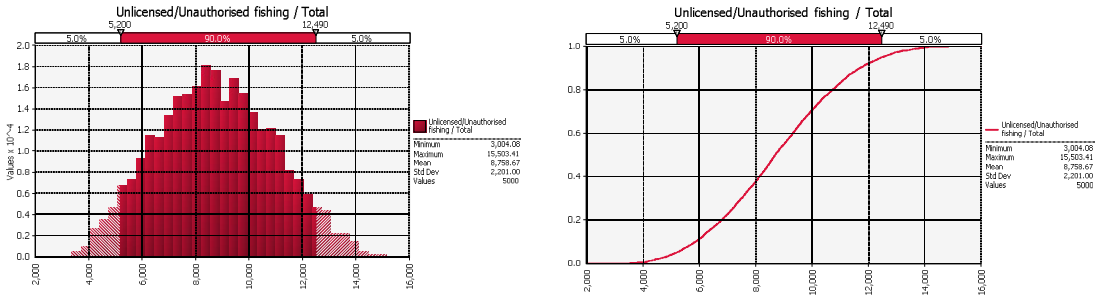


Figure 2: Example probability distribution outputs from Monte Carlo simulation.

Taking our example distributions in Figure 1, where a triangular distribution was assigned, randomly selected simulations involving values around the best estimate would be assigned a higher probability than simulations involving either the minimum or maximum values. In this way, the 'best estimate' value would be given higher weight in the ultimate probability distribution. However, where we thought there was no better chance that the actual IUU value was around the 'best estimate' than the minimum or maximum values and a uniform distribution was assigned, simulations would assign each random variable between the minimum and maximum values an equal probability (Figure 1) and give equal weight in the ultimate probability distribution.

To that end, uncertainty is factored into the estimates in three ways:

- The width of the min/max range – in most cases, the narrower the min/max range around the best estimate, the more certain the inputs;
- The probability distribution chosen for the Monte Carlo simulations – for risks in which the 'best estimate' was relatively strong, triangular distributions around the best estimate were chosen – i.e. the probability of the actual level of IUU being close to the best estimate was assumed to be higher than that it being closer to the minimum of maximum value; and
- The probability distribution produced by the Monte Carlo simulation – this gives an estimate of the likelihood that the actual IUU estimate will be above or below chosen benchmarks.

2.1.5 Quantifying ex-vessel value

Based on the likely volumes and species compositions associated with each risk, we were able to calculate the likely ex-vessel value of IUU fishing activity. For each species in the three main sectors (PS, TLL, SLL) we assumed likely markets (sashimi grade for longline yellowfin; canning grade for purse seine yellowfin) and were able to generate likely market values based on known trade and market data (Annex 2). From this we were able to calculate the likely ex-vessel value of IUU caught fish across each main sector and collectively. In the case of misidentifying species in logsheets, only the marginal difference in value between the actual species and the species reported was taken into account.

Notwithstanding that, despite being the most widely used figure to convey IUU catch values, simple ex-vessel or market values are not necessarily an accurate reflection of loss of value added to Pacific island economies. This is discussed in more detail in Section 4.

2.1.6 Study period

Importantly, the data available for each risk type varied in precision and availability over different time periods. Vessel logbooks and some observer workbooks, for example, are relatively slow to be submitted and the most recent complete three year set of WCPFC public domain catch and effort data for the longline fisheries was between 2010 and 2012. Conversely, VMS data through FFA is available in near real time and we were able to use data to 2015. Because data were not available across each of the risks for a consistent three-year timeframe we have used averages of the latest available three-year time frame to inform estimates of most risks in most cases. To that end, we have not attempted to estimate total IUU in a single snapshot year or period. Rather, our overall estimates should be considered 'typical' levels of annual IUU fishing across each category for the period encompassed by the study (2010-2015) and are sufficient to inform consideration of future MCS priorities and the like. The specific amount of IUU occurring in each year will vary according to inter-annual factors such as overall level of effort, regulatory changes, MCS coverage, etc.

2.1.7 Information collection, planning and ground-truthing

The approach and methodology described above was supplemented with a number of initiatives designed to identify, collect and ground-truth relevant information. These included:

2.1.7.1 Planning workshop

We commenced the study with a Planning Workshop involving members of the project team, FFA and SPC staff. The main purpose of the workshop was to agree the methodology to be used for the study, as well as to agree the scope. The main outcomes were that:

- the "Pacific Islands Region" will be defined as the area below 20oN, east of 130oE and north of the southern boundary of the WCPFC Convention area, and east to the eastern boundary of the WCPFC Convention boundary, including EEZs of both FFA and non-FFA member states and areas of high seas;
- the area will exclude the Indonesian and Philippines EEZs;
- IUU estimates will be made at the level of the three main fisheries – purse seine (PS), tropical longline (TLL) and southern longline (SLL);
- the boundary between the TLL and SLL will be 7.5oS (later amended to 10^{o}S to be consistent with existing regional practice);
- where possible, data to be used for estimates will be 2011-2014 for real time data and 2011-2013 for non-real time data;
- the pole and line fishery would not be included in estimates.

The workshop also examined the main MCS/IUU risks facing Pacific tuna fisheries, as well as the likely information available to quantify each risk. Risks were identified according to four main categories:

1. unlicensed and unauthorised fishing;
2. misreporting and non-reporting;
3. non-compliance with other license conditions (e.g. use of unauthorised gear);
4. post-harvest risks (e.g. illegal transhipping).

Descriptions of each risk are summarised at Annex 3.

2.1.7.2 Country visits

In addition to analysis of data available through regional agencies, we undertook site visits to Fiji, the Republic of the Marshall Islands, Papua New Guinea, Tuvalu and the Solomon Islands to gather relevant national level information. Countries were selected by the Planning Workshop on the basis that they are key port and/or flag states, and may hold valuable information available only at the

national level (e.g. outcomes of dockside compliance inspections, surface boarding and inspection reports, etc).

2.1.7.3 Ground-truthing workshop

Estimates of the volume, species composition and value of each risk prepared by the project team were 'ground-truthed' at a workshop attended by FFA staff and the project team in Honiara on 20-21st October, 2015. The equation for calculating each risk, 'best estimate' and min/max ranges, scalars and probability distributions for each risk were risk were presented and agreed or refined where necessary, based on attendees' practical experience with Pacific tuna MCS and IUU issues. This process ensured that any obvious errors or misinterpretations were picked up and added a layer of validation to the outputs.

2.1.8 Out of scope issues

There are number of other activities that are illegal under national law or license conditions, but did not directly result in 'unaccounted for' fish and were considered out of scope. These included, for example, breaches of marine pollution (MARPOL) regulations, interactions with species of special interest (SSIs) and illegal bunkering.

Breaches of MARPOL regulations, for example, appeared to be more or less habitual on most vessels from observer reports. On LL vessels, tangled main line and branch line is routinely discarded at sea, as is bait packaging and kitchen scraps. On purse seine vessels, similar MARPOL offences are routinely reported by observers.

2.2 Approach to quantifying individual risks

Broadly, we categorised the 'in scope' IUU risks into four basic types of activity:

1. Unlicensed fishing;
2. Misreporting (including under-reporting and misidentification);
3. Non-compliance with other license conditions;
4. Post-harvest risks.

Approaches to quantify each individual risk within these categories, including the information available, the basic equation to calculate the level of activity and best estimate and min/max ranges, are outlined below.

2.2.1 Unlicensed fishing

Three different classes of unlicensed/unauthorised fishing were identified:

1. Unlicensed fishing by vessels on the FFA Register;
2. Unlicensed/unauthorised fishing by vessels flagged to WCPFC CCMs, but not on the FFA Register;
3. Unregulated fishing (i.e. by vessels flagged to non-WCPFC CCMs, or vessel not authorised on the WCPFC RFV).

Classes were separated based on the information available to quantify the IUU risk. For example, vessels in the first class are all licensed in at least one FFA member EEZ and are required to have a functioning ALC reporting to the FFA VMS. Vessels in the second class are authorised to fish on the high seas within the WCP-CA, but not in FFA member EEZs. These vessels are required to have functioning ALCs reporting to the WCPFC VMS. Vessels in the third class do not report to any VMS for which FFA or WCPFC have data sharing privileges and are effectively 'dark' from that point of view (albeit they may be tracked by AIS in some cases).

2.2.1.1 Unlicensed fishing by vessels on the FFA Register

This risk relates to the possibility of a vessel licensed in one FFA member EEZ fishing in another zone for which it has no license (i.e. 'border hopping'). A number of different data sources were used to arrive at 'best estimate' and range estimates for this risk including:

- VMS data for each of the three sectors (PS, TLL, SLL), combined with 'compliance index' data for each vessel derived from FFA's Regional Surveillance Centre;
- Aerial and surface surveillance data, primarily from regional operations during the study period;
- Observer reporting;
- Information from FFA member site visits;
- Media reports.

'Best estimates' and minimum and maximum ranges were assigned by estimating a proportion of the overall number of fishing days undertaken by vessels on the FFA register in each of the three sectors likely to be fished in an EEZ for which the vessel had no license. These were then multiplied by the average daily catch rate and species composition for that sector to arrive at overall estimates of IUU volume and species composition.

'Best estimate' and min/max range figures were primarily assigned using VMS and FFA 'compliance index' (CI) data. As part of their regional surveillance function, the FFA Regional Surveillance Centre assigns each vessel for which it has VMS visibility (i.e. all vessels on the FFA Register and vessels on the WCPFC RFV operating within FFA member EEZs, as well as vessels visible using the Automatic Information System, AIS) a CI. The CI is a number between 0 to -5 and is based on the vessel's compliance status. Vessels rated 0 are deemed to be a very low risk of undertaking IUU activity; vessels rated -4 or -5 are at very high risk of undertaking IUU activity, or have been involved in confirmed IUU activity. In the context of this study, vessels rated -3 and above are deemed to be at high risk of undertaking IUU and this CI is most frequently assigned because a vessel is not licensed in the EEZ in which it is currently located. While many vessels with a -3 CI are simply making innocent passage through an EEZ (which is relatively easily visually detected by VMS), this group of vessels (together with the -4 and -5 CIs) are at higher risk of unlicensed fishing and gave us a 'starting point' to adjust based on aerial surveillance and other information.

To collect a relatively random sample of data, a snapshot of CI data for all vessels across all FFA member EEZs was taken for one day of each week during the period January 2013 to August 2015. Data from this period was used because the FFA member license lists available to FFA were thought to be current[2]. This produced between 32,758 and 37,855 individual CI vessel ratings for each of the three sectors. Of these, the proportion assigned CIs of -3 and above were identified, and from this, the proportion of these vessels likely to be engaged in unlicensed fishing activity was estimated based on expert judgement. Final best estimate and min/max ranges were also informed aerial and surface surveillance and observer information where available.

[2] Out of date license lists would produce higher rates numbers of -3 CIs because information was not available to indicate a vessel was licensed in an EEZ.

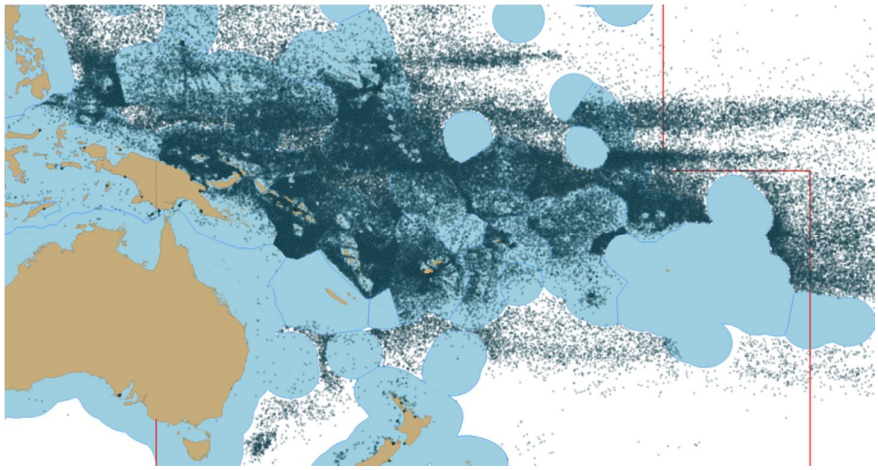


Figure 3: VMS position data sampled for vessels on the FFA Register between 2013 and 2015.

Purse seine

In the purse seine sector the ground-truthing workshop agreed that the level of unlicensed fishing activity was likely to be very low. During the study period this sector included around 280 vessels, fishing an average of 52,350 days per year. Vessels in two fleets – the US Multilateral Treaty (USMLT) and the Federated States of Micronesia Arrangement (FSMA) – are authorised to fish in each of the main EEZs and accounted for around 1/3 of the fleet during the study period (~90-100 vessels out of ~280). Given these vessels are authorised to fish in each of the main purse seine EEZs, they are unlikely to engage in unlicensed fishing in the context of this risk.

No unlicensed fishing activity has been detected by aerial surveillance assets during the study period, vessels are polled hourly by VMS under VDS arrangements and all vessels are subject to 100% observer coverage which is likely to act as a deterrent to non-compliance. While a relatively high proportion (28%) of sampled vessels had a CI score of -3 and above, the ground truthing workshop agreed that the overwhelming majority of these would have been engaged in innocent passage to transhipment ports. Notwithstanding that, some prosecutions for unlicensed fishing by purse seiners occurred during the study period. For example, in 2013 Nauru fined the owners of the *Albacora Uno* (licensed in Kiribati) $1m for illegally fishing in its waters during 2012[3].

On the basis of the above, the ground truthing workshop agreed that the minimum estimate should be set at very low levels (around 0.01% of the average total days fished), while the maximum figure should account for the possibility of slightly higher levels of unlicensed activity (0.2% of fishing days) and the best estimate should be set closer to the minimum (0.05%).

Tropical longline

In the tropical longline sector, the ground truthing workshop agreed that the inherent risks of unlicensed fishing are likely to be higher given the larger number of vessels (781 longliners on the FFA RR), higher levels of effort (average of 100,194 fishing days during 2011-2014) and the operational nature of the gear which can drift many tens of nautical miles in a set. While aerial surveillance during regional operations detected no confirmed unlicensed activity during the study period, MCS arrangements are generally weaker than the purse seine sector given very low rates of observer coverage and there are arguably fewer financial disincentives to unlicensed fishing. Moreover, several instances of automatic location communicators (ALCs) not reporting or being

[3] E.g. http://www.islandsbusiness.com/2015/item/938-eu-boat-fined-us1m-for-illegally-fishing-in-nauru

swapped were detected during FFA coordinated regional operations during the study period, which leaves open the possibility of unlicensed activity.

Compliance index information showed that around 35% of days at sea during 2013-2015 were spent in EEZs for which vessels had no license, albeit the vast majority of these days are likely to be in innocent passage. Amongst the countries in which site visits were undertaken, RMI reported a total of 8 vessels detected in their EEZ fishing without a license during the study period, while the Solomon Islands reported around 22 vessels involved in unlicensed activity although some of these may have been high seas vessels fishing without ALCs.

The ground truthing workshop agreed the proportion of likely unlicensed fishing days in the TLL sector should be set at higher levels than the PS sector, albeit still at relatively low levels. The workshop considered it plausible that as few as 0.1% of days are fished in zones for which no license exists (given the absence of widespread evidence of non-compliance detected through regional operations), while its also plausible that as many as 1.5% of days are unlicensed given the comparatively weak monitoring arrangements in the fleet. The best estimate was set slightly towards the lower end of the min/max range.

Southern longline

The information base for the SLL sector was similar to the TLL sector in that few instances of unlicensed fishing were detected during regional operations in the study period, although generally the MCS arrangements are weaker in this sector than purse seine. Observer coverage remains very low. SLL vessels fished an average of 80,692 days inside EEZs during the study period. VMS and CI data showed around 43% of longline days at sea in the SLL area were spent in zones for which the vessel had no license, although the ground truthing workshop agreed that majority of these days were likely to have been transiting to and from key SLL ports such as Suva. Amongst the FFA members visited, Fiji reported a total of 17 incidents of possible unlicensed fishing picked up through port inspections during the study period, while the Solomon Islands reported 22 incidents of possible unlicensed fishing in total detected by aerial/surface surveillance (albeit the Solomons EEZ straddles both SLL and TLL zones). The ground-truthing workshop agreed there was no obvious evidence to suggest the rate of unlicensed activity was likely to be different between the TLL and SLL sectors, and the proportions of overall days used for the min/max range and best estimate were the same as for TLL.

Table 1: Best estimate and min/max range for unlicensed fishing activity by vessels on the FFA RR by size and sector (by average number of days fishing per year). Percentages in parentheses represent the proportion of the total average fishing days by relevant vessels in that sector.

Sector	Min	BE	Max	Dist.
Purse seine	5 (0.01%)	26 (0.05%)	105 (0.2%)	Triangular
Tropical Longline	100 (0.1%)	501 (0.5%)	1503 (1.5%)	Triangular
Southern longline	81 (0.1%)	403 (0.5%)	1210 (1.5%)	Triangular

2.2.1.2 Unlicensed/unauthorised fishing by vessels on the WCPFC RFV, but not on the FFA Register

This risk broadly relates to the possibility of WCPFC high seas fishing vessels fishing in FFA EEZs for which they have no license. Vessels on the WCPFC RFV report to the WCPFC VMS and are not routinely visible to FFA members on the high seas, although members may apply to view vessels within 100nm of the EEZ boundary (with data to be destroyed within 72hrs). Members may also apply to have their zone included in the WCPFC VMS, which allows them to view WCPFC vessels while in their zone, although only 10 FFA members have reportedly taken up this option to date. At

the regional level, FFA also has access to the full suite of WCPFC VMS data during regional operations, however are required to destroy high seas VMS data within 48 hours, so the capacity to undertake analysis of high seas vessel activity in FFA member EEZs is somewhat limited.

The ground-truthing workshop agreed that the main risks in this category were likely to be incursions on the fringes of FFA member EEZs by vessels ordinarily fishing the high seas, or when transiting FFA member EEZs, and on the western fringes of the FFA area by WCPFC authorised vessels that are ordinarily fishing in their own domestic waters or high seas pockets.

The information available to quantify unlicensed fishing by high seas vessels is largely limited to some VMS information, particularly during regional operations, aerial and surface surveillance data and limited observer information. The basic calculation used to quantify activity in each sector was the number of unlicensed fishing days * the average catch volume and species composition for each sector. Small vessels in each sector were assumed to have catch rates 2/3 of 'average' vessels.

Purse seine

In the purse seine sector, estimates of IUU activity were split into 'average' and 'small' vessel categories to account for likely differences in catching capacity. The ground-truthing workshop agreed that the amount of unlicensed fishing activity by 'average' high seas vessels is likely to be very low. The overall level of high seas activity is relatively low (average of 4,211 fishing days on the high seas Vs 52,350 in zone during 2011-2014; WCPFC, 2015b), and no unlicensed fishing activity was detected by aerial surveillance during the study period. These vessels are subject to 100% observer coverage and considerable financial disincentives exist if caught illegally fishing (for example, see *Albacora Uno* case above). The workshop considered it plausible that no unlicensed fishing occurred, but that estimates should be set at levels to account for the possibility of some small level of unlicensed fishing.

In the small vessel category, the ground-truthing workshop agreed the main risk is likely to be from incursions on the western fringes of the FFA area. The main fleets on the WCPFC RFV but not licensed in FFA member EEZs are those of Indonesia and the Philippines, including vessels authorised to fish in high seas pocket 1 (HSP1) under CMM 14-01 (Figure 4). Under CMM 14-01, Philippines vessels are limited to a high seas cap of 4,659 days, while Indonesian vessels have no high seas allocation. WCPFC (2015b) indicates that actual fishing effort by Philippines flagged vessels in HSP1 was around 4,096 days in 2013 and 3,461 in 2014, while the Indonesian and Philippines fleets fished a combined average of around 1,732 days within their domestic EEZs (outside archipelagic waters) during 2011-2014.

While anecdotal reports of numerous incursions exist (e.g. in Palau's EEZ), direct evidence to quantify the level of likely activity is limited. The workshop agreed that estimates should be set to account for some level of illegal activity, with the min/max range set relatively broadly, and the 'best estimate' at the lower end of the estimates.

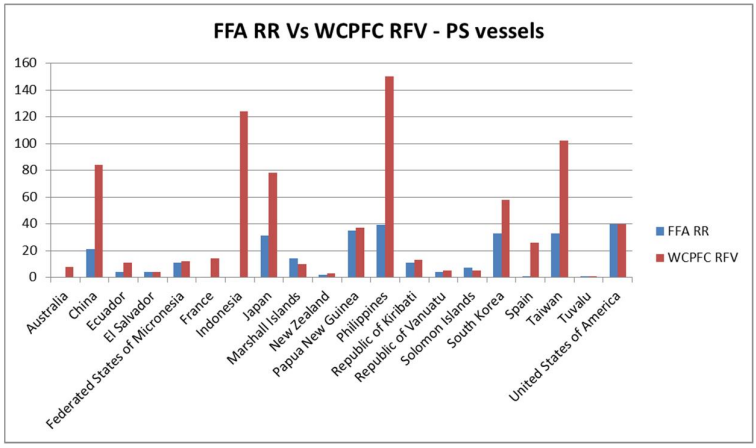


Figure 4: Comparison between number of purse seine vessels by flag on the FFA Regional Register and the WCPFC RFV (as at August, 2015).

Tropical longline

Unlike purse seine, a considerable proportion of longline fishing effort occurs on the high seas (an average of 61,652 fishing days in the TLL area between 2011 and 2014, compared to 100,194 in zone), and a large number of vessels are authorised on the WCPFC RFV but not on the FFA RR (3568 Vs 781) (Figure 5). The evidence available to support estimates of activity is both limited and mixed. While no unlicensed fishing activity was detected by high seas vessels using aerial surveillance during 2011-2014, one recent operation detected two 'dark' longline targets fishing in the WCPF-CA without an operational ALC[4] (albeit the vessels were in the high seas pocket north of the Solomon Islands). Likewise, there were incidents during the study period in which large groups of vessels on the WCPFC RFV were detected by aerial surveillance, but neither reporting to the WCPFC VMS nor manually reporting (e.g. 19 Taiwanese flagged longline vessels were detected within 100nm of RMI's EEZ by Australian aerial surveillance in 2013 but not reporting to the WCPFC VMS; WCPFC, 2013c). The Solomon Islands reported a total of 22 possible detections of unlicensed activity during the study period, with many of these suspected to be vessels fishing without ALCs adjacent to the high seas pockets.

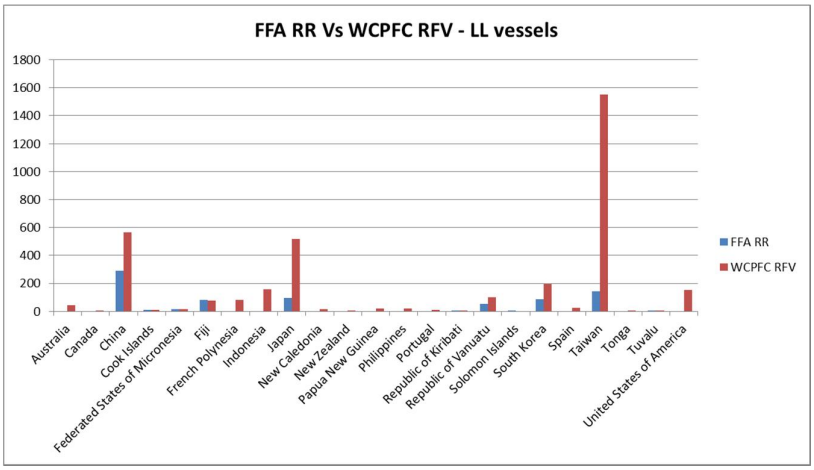


Figure 5: Comparison between number of longline vessels by flag on the FFA Regional Register and the WCPFC RFV (as at August, 2015).

[4] http://www.ffa.int/node/1594

The ground-truthing workshop considered the main opportunities for infringement in the TLL sector to be on the fringes of FFA member zones. They also noted the inherently higher risk associated with longline gear given its operational nature allows it to drift many tens of nautical miles in a set, and the relative absence (apart from VMS) of MCS coverage of large parts of the high seas longline fleet (e.g. very limited observer coverage; very limited aerial/surface surveillance coverage). Given the absence of unlicensed vessels detected through aerial surveillance, the ground-truthing workshop agreed that the minimum estimate should be set at a low level, although the min/max range should be set broadly at this stage to acknowledge the high levels of uncertainty in the information base and to account for the possibility of higher rates of unlicensed fishing. They agreed the best estimate should be set at the lower end of the min/max range. Assuming average high seas effort of 61,652 fishing days during the study period, the estimates vessels equate to 0.1% (min), 0.5% (best estimate) and 1.5% (max.) of total fishing activity.

Southern longline

Similar to the TLL sector, the ground truthing workshop considered the main risk of infringement was on the fringes of FFA member zones. However, overall effort is lower in the SLL sector (~161,846 Vs 103,367 fishing days) and unlike the TLL sector, the majority of effort is within EEZs (average of 80,692 in zone Vs 22,675 on the high seas during 2011-2014). Accordingly, the workshop agreed that estimates should account for a lower absolute level of unlicensed fishing activity. The information base for the SLL is similar in nature to the TLL in that few unlicensed vessels were detected by aerial surveillance between 2011 and 2014, although one unlicensed vessel was detected fishing inside the Tonga EEZ during Operation Kurukuru '14. Fiji reported no detections of unlicensed fishing by high seas vessels in their zones during the study period. The workshop agreed that the best estimate and min/max range figures should be set at the same proportions as those adopted for the TLL sector.

Table 2: Best estimate and min/max range for unlicensed fishing activity by vessels on the WCPFC RFV but not on the FFA RR by size and sector (by average number of days fishing per year).

Sector	Min	BE	Max	Dist.
Purse seine				
Average vessel	0	20	50	Triangular
Small vessel	20	100	400	Triangular
Tropical Longline	62 (0.1%)	308 (0.5%)	925 (1.5%)	Triangular
Southern longline	23 (0.1%)	113 (0.5%)	340 (1.5%)	Triangular

2.2.1.3 Unregulated fishing

For the purposes of this analysis, 'unregulated' fishing was defined as fishing by vessels flagged to states that are not cooperating members of the WCPFC, or by vessels flagged to cooperating parties but which are not on the WCPFC Record of Fishing Vessels (and are therefore not authorised to fishing on the high seas inside the WCPF-CA). The latter category is probably an extension of the standard IPOA-IUU definition of unregulated fishing, but these vessels were included because they have the same 'visibility' as unregulated vessels not reporting to any regional VMS.

Perhaps unsurprisingly, data availability for unregulated fishing was particularly weak. To that end, estimates for this risk were largely based on exert judgement considering the information available.

The main information available comes from aerial and surface surveillance, observer sightings, previous risk assessments and anecdotal information.

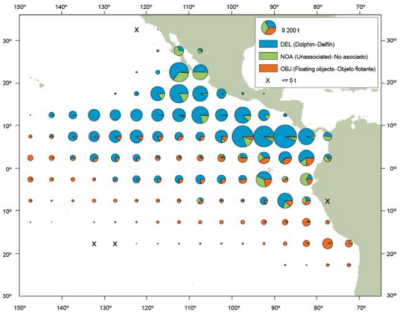
Purse seine

In the purse seine sector, no unregulated vessels have been detected by aerial surveillance in recent years, although anecdotal reports exist of incursions by Eastern Pacific Ocean (EPO) vessels on the eastern fringes of the WCPFC-CA and smaller domestic south east Asian vessels in the western fringes (e.g. small purse seiners with support vessels fishing in Palau). Aerial surveillance coverage of both areas, particularly in the east, is extremely limited. VMS evidence for EPO vessels is unavailable given the absence of any data sharing arrangement between WCPFC and IATTC (and member states), hence any incursions by EPO vessels into the WCPFC area (and vice versa) may go undetected.

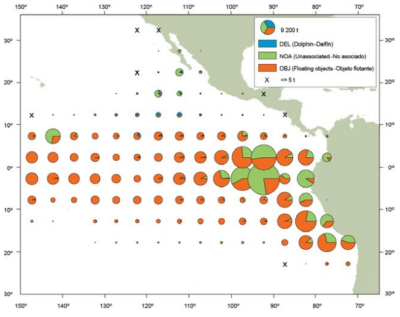
In general, the opportunity for truly unregulated purse seine vessels (i.e. those flagged to parties other than cooperating members of the WCPFC) to fish in the WCPO undetected is likely to be negligible. The main purse seine fishing countries are members of the WCPFC, and industry intelligence tracking both existing purse seine vessels and those under construction is detailed to the point that there is likely to be few, if any, 'unaccounted for' vessels.

The ground-truthing workshop agreed that the main opportunities for unregulated purse seine came through incursions by EPO licensed vessels into the WCPF-CA and by smaller, domestic purse seiners from south east Asia on the western fringes. The basic calculation used to estimate activity was number of days unlicensed fishing * average catch rates and species composition in the relevant sector. Because of the likely differences in capacity between EPO vessels and smaller SE Asian vessels, estimates were made for 'average' vessels and 'small' vessels. Catch rates for small vessels assumed to be 2/3 of the average.

The workshop agreed that estimates of illegal activity for average vessels should be set at very low levels, with higher figures for smaller vessels. The workshop considered it plausible that no unregulated fishing occurred, although it was more likely that there were a small number of incursions (best estimate 50 days; max. 200 days) from EPO vessels. The workshop noted that the main fishing ground for both YFT and SKJ were in the eastern part of the IATTC area, although some fishing did occur along the border between the convention areas (150°W) (Figure 6). On the western fringes of the study area, the workshop agreed that the level of incursions was likely to be higher based on the larger number of small south east Asian vessel and more frequent anecdotal reports of incursions in EEZs such as Palau. The workshop agreed that it was possible only a relatively small number of incursions occurred (50 days), although it was more likely the actual number was higher (200 days) and, given the absence of good information, the maximum figure should account for the possibility of a much higher level of unregulated activity (500 days).



(a)



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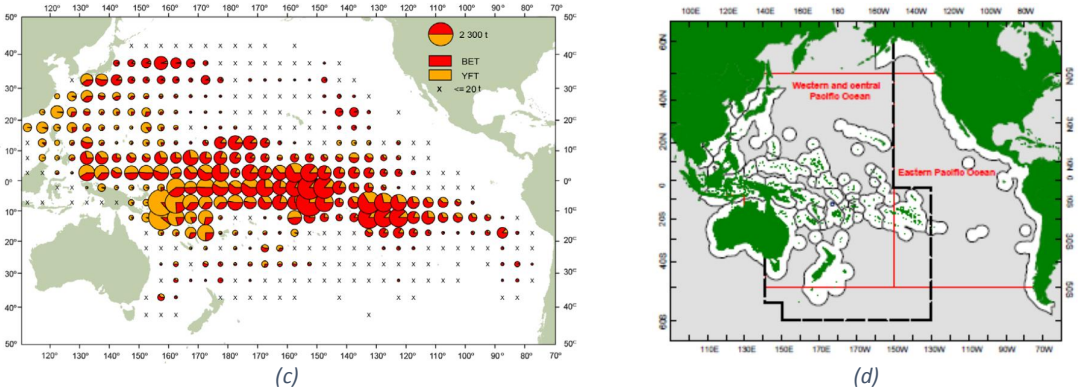


(c) *(d)*

Figure 6: Average annual distribution of (a) purse seine catches of yellowfin, (b) purse seine catches of skipjack, (c) longline catches of bigeye and yellowfin in the IATTC area between 2009 and 2013 (IATTC, 2015) and (d) the WCPFC/IATTC Convention areas.

Tropical longline

Like the purse seine fishery, the ground-truthing workshop agreed that the main opportunities for unregulated fishing in the TLL sector (as defined here) come from incursions on the eastern and western fringes of the study area, although there has historically been some level of 'traditional' unregulated fishing in the longline sector. For example, two vessels flagged to Georgia were added to the WCPFC IUU list in 2010[5]. The workshop agreed the opportunities for 'traditional' unregulated fishing are probably greater in the longline fishery given the larger number of vessels, the absence of high levels of observer coverage, and greater difficulty tracking movements between ocean basins amongst the fleet. Nevertheless, like the purse seine fishery, the information available to support quantitative estimates of unregulated fishing is weak.

The main opportunity for unregulated fishing on the eastern fringes is for vessels fishing in the IATTC area, but which are not authorised on the WCPFC RFV, to fish in the WCPFC area. While a substantial amount of fishing occurs on the boundary of the WCPFC-IATTC areas (Figure 6), a considerable proportion of the main fleets operating in the area are authorised on both the IATTC and WCPFC regional vessel registers (Table 3; Figure 7). This limits the scope for any unregulated fishing. Given the absence of strong aerial surveillance or VMS evidence for vessels not on the WCPFC RFV, the workshop agreed that estimates should account for the possibility of some level of unregulated activity, but that estimates should be set at relatively low levels (Table 5).

5 http://www.wcpfc.int/system/files/Attachment%20I%20WCPFC%20IUU%20List%20from%206%20February%202015.pdf ; one vessel, the Fu Lien No 1, was reflagged to Georgia only after the illegal incident took place, and was at the time fishing without nationality.

Table 3: Level of dual IATTC/WCPFC authorisation amongst some of the main longline fleets operating in the Pacific ((as at November, 2015).

Flag	# on IATTC RVR	# also on WCPFC RFV
EU (ES)	132	21
KR	195	176
EU (PR)	9	8
TW	155	145
JP	254	220
US	37	32
VU	44	40
CN	336	296
KI	3	0

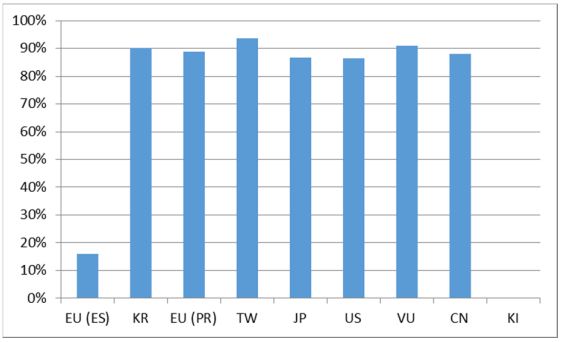


Figure 7: Proportion of longline vessels listed on the IATTC Regional Vessel Register which are also listed on the WCPFC RFV for some of the main flag states (as at November, 2015).

On the western fringes, the main opportunity for unregulated fishing is by smaller domestic vessels of south east Asian states. For the purposes of this analysis, we have included all smaller vessels that use lines to catch tuna (e.g. handliners, pumpboats, dropliners) (e.g. Figure 8). Anecdotal evidence suggests that incursions in the Palau EEZ and in the western part of the PNG EEZ are relatively frequent, and there have been a number of seizures and sightings of unlicensed vessels during the study period (by vessels targeting both tuna and demersal species). For example, illegal line vessels flagged to south east Asian states were apprehended in the Palau EEZ during both Operation Bigeye '11 and Operation Rai Balang '12. The workshop agreed that estimates should be set at levels which account for the possibility of higher levels of activity, with a 'best estimate' of 500 days unregulated fishing (essentially slightly >1 unregulated vessel fishing in the western fringes of the FFA area for each day of the year), with a minimum of 200 days and a maximum of 1500 (4-5 unregulated vessels for each days of the year).

Figure 8: South east Asian small scale fishing vessels.

Southern longline

In the southern longline sector, there is negligible scope for incursions in the west with the main opportunities in the east, and to a lesser extent in the south. Given the SLL sector has no borders with EEZs with small scale, potentially 'unregulated' fleets, the ground-truthing workshop agreed that small scale vessel incursions were likely to be negligible.

For 'average' vessels, the experience of the Georgian-flagged vessels on the WCPFC IUU List indicates some degree of unregulated fishing, although again, the ground truthing workshop agreed the numbers involved are likely to be very small. No unregulated vessels were detected by aerial

surveillance during the study period, while the majority of the major fleets operating in adjacent jurisdictions (IATTC, CCSBT) are also authorised on the WCPFC RFV (Figure 7; Table 4). Many of the CCSBT authorised vessels not on the WCPFC RFV (e.g. Indonesian, EU and South African fleets) are likely to be fishing in other areas (e.g. Indian Ocean; Atlantic Ocean).

Table 4: Level of cross-authorisation in the WCP-CA by longline vessels authorised under CCSBT (Data source: Consolidated List of Authorised Vessels[6]

Flag	CCSBT	Also WCPFC	%
AU	30	28	93%
TW	82	23	28%
ID	128	3	2%
JP	90	89	99%
NZ	23	3	13%
PN	3	0	0%
EU (PR)	27	9	33%
KR	13	11	85%
SA	19	0	0%
EU (ES)	76	22	29%
VU	1	1	100%

To that end, the ground–truthing workshop considered it plausible that no unregulated fishing occurred, although it was more likely some small degree of unregulated incursions occurred and the maximum figure should be set at levels to account for the possibility of a slightly higher level (Table 5).

Table 5: Best estimate and min/max range for unregulated fishing activity by vessel size and sector (by average number of days fishing per year).

Sector	Min	BE	Max	Dist.
Purse seine				
Average vessel	0	50	200	Triangular
Small vessel	50	200	500	Uniform
Tropical longline				
Average vessel	20	100	300	Triangular
Small vessel	200	500	1500	Triangular
Southern longline				
Average vessel	0	20	200	Triangular

2.2.2 Misreporting and non-reporting

Vessels authorised to fish in the Pacific Islands region have an obligation to report catch and effort accurately under a range of different provisions. At the WCPFC level, the Convention (Annex 3,

[6] http://clav.iotc.org/browser/search/#.Vku8sHYrLIU

Article 5) requires that fishing operators "*record and report vessel position, catch of target and non-target species, fishing effort and other relevant fisheries data in accordance with the standards for collection of such data set out in Annex I of the Agreement*." Moreover, CMM 13-05 requires each CCM to ensure that "*the master of each vessel flying its flag in the Convention Area shall complete an accurate written or electronic log of every day that it spends at sea on the high seas of the Convention Area*". The details of operational reporting requirements are set out in Annex 1.3 to 1.6 of the *Scientific Data to be Provided to the Commission* (WCPFC, 2012) and include obligations to report a range of target and non-target species as well as a range of operational details (e.g. number of hooks per set for longlines, set type for purse seine, location). At the FFA member level, the Harmonised Minimum Terms and Conditions for Foreign Fishing Access (HMTCs) require that vessel operators keep daily records of all catch and bycatch species, including all catch discarded at sea and all by-catch transhipped or unloaded offshore, and submit final versions of these reports to licensing countries within 45 days of trip completion (FFA, 2011).

For the purposes of this study we have assumed that both the WCPFC and FFA agreed reporting requirements have been translated into relevant flag state and coastal state regulation and/or license conditions.

Purse seine

The main source of information to examine misreporting in the purse seine fishery came from comparisons of observer vs logsheet reporting for the same trips/sets. Since 2009, purse seine vessels have been subject to 100% observer coverage so there is a considerable body of independent data on vessel catch. Observer data was supplied by SPC for 179,499 sets between 2011 and 2014 for which equivalent logsheet information was available. These data were grouped at the trip level to reduce estimation errors at the set level, equating to 6,918 trips once trips with obvious reporting errors were removed.

To investigate the potential for misreporting, we compared observer versus logsheet reporting for each of the 6,918 trips. Estimates of catch recorded by vessels and observers often varied in both volume and species composition and there are multiple possible 'offence types' under which inaccurate reporting may be classified. For example, where fish reported by an observer do not appear to be reported anywhere in the vessel logsheet, these may be classified as 'not reported'. Where a fish of species A appears to have been reported as species B, this may be classified as 'misidentified'. How they're classified does not affect the volume of catch misreported (the total volume of catch subject to a potential offence is captured, irrespective of how they're categorised), but it does affect the potential economic loss involved. For example, 10t of YFT not reported may result in the full 'loss' of the value of the fish. If the same 10t of YFT was reported in the vessel logsheet as SKJ, only the marginal difference between YFT and SKJ is lost (in theory). There were also a considerable number of instances in which there was no clear link between the composition of the catch reported by the vessel and that reported by the observer.

To ensure consistency in the analysis, we applied a framework of decision rules to categorise instances of misreporting in the PS fishery. These are summarised in Figure 9.

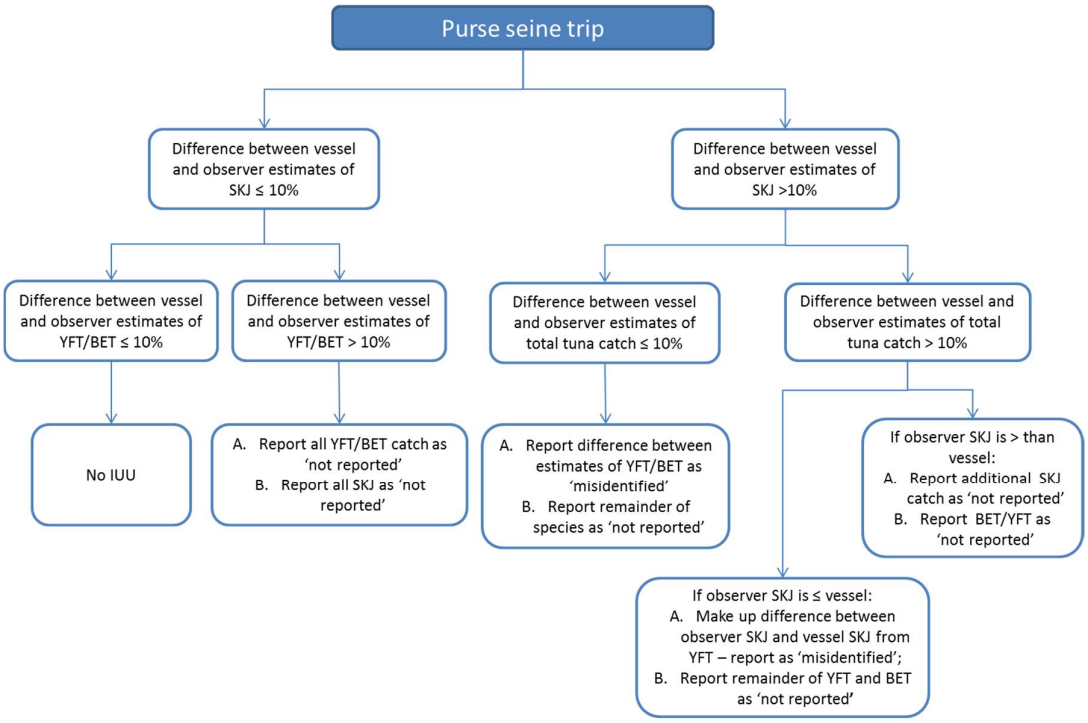


Figure 9: Decision rules used to categorise reporting offences in the purse seine fishery.

Reports entered into daily logbooks by both vessels and observers at the time of catch are estimates only. In assessing potential breaching of reporting obligations at the set level, FFA use a general 'rule of thumb' tolerance of 5%. That is, if the vessel and observer reports are within 5% of each other it is assumed the vessel has attempted to estimate catch accurately and no breach has occurred. Where the difference is >5%, there may be some basis for further investigation.

For the sake of conservatism in this study we used a tolerance of 10%. With that in mind, the first question in the set of decision rules was whether the vessel and observer estimates of SKJ were within 10% of each other. If that was the case, the same question was asked of the YFT/BET estimates. If these were within 10% of each other, no potential misreporting was recorded. If the YFT/BET estimates were >10% different (in most cases the observer report is higher), the YFT/BET catch was recorded as 'not reported' (for example, if a vessel reported 100t SKJ only for a set, whereas the observer recorded 100t SKJ, 5t YFT and 1t BET, the YFT/BET catch was recorded as 'not reported').

If the difference between the observer and vessel SKJ estimates are >10%, the next question was whether the overall catch of tunas was within 10% (i.e. in most cases, had some of the YFT/BET been reported as SKJ?). If this was the case, additional YFT/BET was categorised as 'misidentified'. If the estimates of the total tuna catch were >10% different and the observer's estimate of SKJ was >10% higher that the vessel, all additional catch was categorised as 'not reported'. If the estimates of the total tuna catch were >10% different and the observer's estimate of SKJ was equal to or lower than the vessel, the difference in SKJ was initially made up from YFT (i.e. the equivalent amount of YFT was categorised as 'misidentified'), while any remaining catch was categorised as 'not reported'.

Scatter plots showing correlations of total catch and species level reporting between observers and vessel logsheets are included at Annex 4.

The analysis made a number of important assumptions which should be tested in future iterations of this assessment. These include:

- The observer's estimate of weight is 'correct' – while observers use a standard methodology to calculate estimated catch weights (volume of brail*number and fullness of brails) there is no guarantee their estimates of weight will be better than experienced skippers' estimates. Nevertheless, observer data represents the best independent information available and our experience from the sample sets suggests there is a reasonable basis that the observer accounts are credible (e.g. they reported species the vessel didn't report; many give detailed explanations in workbook notes sections as to why their estimate differed from the vessel's, etc);
- Accuracy of observer reporting is similar across all Pacific observer programs – our experience from the samples suggests this is a reasonable assumption, particularly given they are provided with standardised training and forms according to SPC/FFA Pacific Island Regional Fisheries Observer (PIRFO) standards.

Importantly, where an instance of misreporting was >10% and triggered a decision rule, the full difference between the observer and vessel estimates was classified according to the offence type (not reported, misidentified). That is, if the difference between the observer and vessel was 11%, the full amount was recorded, not simply the excess over 10%.

Unlike other risks for which the best estimate and min/max range was interpreted from limited information, the availability of quantitative data on this risk allowed us to use a distribution for Monte Carlo simulations which best fit the available data. A 'Laplace' distribution was used in each case which recognised the very large proportion of '0' and small sum entries as well as a few larger entries, both positive and negative (i.e. catch being over-reported). The best estimate for the Monte Carlo simulations was set at the average figure for each of the risk categories.

Table 6: Average rates of misreporting for each category across sample trips (in tonnes per trip)

Category	SKJ	YFT	BET	OTH	Dist.
Not reporting (t/trip)					
Retained	0.46	15.13	6.45	-0.79	Laplace
Discarded	14.24	2.46	0.62	-0.31	Laplace
Misidentifying	0	14.47	6.39	0.21	Laplace

SPC information suggests that the typical number of trips undertaken annually in the WCPO PS fishery is between 1,900 and 2,100. For this study we assumed a value of 2,000. For the purposes of Monte Carlo simulations, the probabilities of each infringement were formulated for all possible 2,000 sets. Each trip, with its possible infringement value, was then summed to provide a total annual MT value of infringements.

Longline

There are several ways in which catches in the longline fishery could be misreported in logsheets:

- Under- or misreporting the number of each species taken – it is the number, rather than weight, of fish used in regional stock assessments, so accurate reporting of this figure is particularly important. Given fish are landed individually, there is little excuse to get the numbers wrong;
- Misreporting of catch weight – on the standard SPC/FFA Regional Longline Logsheet, vessels are required to record the number of retained and discarded fish, and an estimated weight of retained fish. Even where numbers are reported accurately, weights may be under- (or over-) reported. Incentives to under-report would be strong where access fees (or other

fees – e.g. transhipping fees) are structured around catch volumes or value. Underestimation of weights would be particularly important where compliance against catch-based limits (e.g. the WCPFC BET limits) was determined against estimated weights in the absence of independent verification;

- Misidentifying species.

Given the very limited observer coverage across much of the longline fleet, and the absence of other means of independently verifying catch and effort, the information base upon which to examine misreporting is relatively weak compared to purse seine. The main information sources available were observer Vs vessel logsheet records for a limited number of observed trips (mostly focusing on domestic and domestically-based foreign vessels) and a limited sample of vessel logsheet Vs unloadings data. For this study, three main data sources were available:

1. **Comparisons of observer versus logbook records by NUMBER for 219 trips during 2013 and 2014.** Observer data was raised according the proportion of baskets or hooks observed. Data was largely drawn from the Fiji, Vanuatu and Tonga observer programs, on vessels primarily flagged to Fiji, Vanuatu, China, Taiwan and the Cook Islands;
2. **Comparisons of observer versus logbook records by WEIGHT for the same 219 trips during 2013 and 2014.** Vessel estimated weights were taken directly from logsheets. Observer weights were derived using standard length-weight relationships used by SPC for the main tuna species and raised according to the proportion of baskets or hooks observed;

Comparisons of both number and weight for fish for each main LL species category for the sample trips are outlined in Table 7.

Table 7: Comparisons of observer reports Vs vessel logsheet reporting for 219 trips in the WCPO LL fishery (source: SPC)

Species	ALB	BET	YFT	BIL	OTH
By NUMBER					
Observer report	83,700	8,868	30,879	5,409	58,772
Vessel logsheet	84,957	6,720	25,252	3,925	42,004
% difference	-1.5%	24%	18%	27%	29%
By WEIGHT (kg)					
Observer report	1,337,240	215,200	730,294	NA	NA
Vessel logsheet	1,373,202	151,557	545,007	NA	NA
% difference	-3%	30%	25%	NA	NA

Scatterplots showing the degree of correlation between vessel logsheets and observer counts are shown in Annex 4 (Figure 39 and Figure 40).

3. **Comparisons of unloadings versus logbook records by NUMBER across 564 trips undertaken during 2013 and 2014 and unloaded in Fiji.** In total, this represented 903,202 unloaded fish. Vessels were predominantly Fiji and China flagged. Given port-based monitoring cannot check discarding reporting, these data were used to inform estimates of retained species reporting only.

Counts of total fish reported in vessel logsheets Vs unloadings for the same trips, and overall rates of under-reporting, are outlined in Table 8.

Table 8: Numbers of fish reported on vessel logsheets Vs unloadings counts for a sample of 564 trips (totalling 903,202 fish) in a key WCPO longline port. Numbers are the totals across the 564 trips.

Category	ALB	BET	YFT	OTH
Vessel logsheet	475,485	36,102	176,064	193,832
Unloading count	484,673	40,231	179,791	198,507
% under-reported	1.9%	10.3%	2.1%	2.4%

Scatterplots showing the degree of correlation between vessel logsheets and unloadings counts for the main target species are shown in Annex 4 (Figure 41). Broadly, vessel reporting of ALB and YFT has a relatively tight relationship with unloadings counts, but reporting of BET and other species is less correlated.

Each of the data sets was supplied by SPC.

Importantly, these data are likely to over-represent the domestic and domestically-based fleets at the expense of long-range distant water fleets, for which there were few available independent data for comparative purposes. In the context of this study, this means that the data being used is representative of fleets subject to more intensive MCS coverage, and arguably have greater incentives for compliance, and therefore our overall estimates of IUU volumes and value may be conservative.

Moreover, given the host observer programs and unloading location, these data are also likely to over-represent the SLL sector at the expense of the TLL sector. In our estimates, we have made the assumption that reporting behaviours are likely to be relatively consistent between sectors, although this should be tested in future iterations of the study.

The basic equation used to estimate IUU volumes was the difference between the volumes reported in vessels logsheets and the estimated actual catch, taking into account the estimated levels of misreporting. Rates of misreporting were calculated using the differences between observer and unloadings data versus logsheet reporting for the equivalent trips in the sample data. For example, if unloading monitors counted 100 fish of species X being landed, but the vessel logsheet recorded only 76 of these species, the under-reporting rate would be 24%. The estimated actual catch was then calculated according to the following formula: total reported catch in vessel logbooks/X = % reported/100, where X is the estimated total catch. Estimates were produced for each of 5 main species groups – ALB, BET, YFT, BIL and OTH – across both retained and discarded catch.

Given the limitations in the sample data, and the lack of independent comparative data for large sections of the WCPO LL fleet, substantial assumptions have had to be made in these initial estimates.

For each of the retained target and non-target species categories, the minimum figure was set at 0% under-reported to account for the possibility that all vessels are reporting catch accurately (except for ALB, where observer estimates suggested a small level of over-reporting) (Table 9). While this appears unlikely from the sample data (particularly given these are the fleets subject to most intensive MCS coverage), there is little available evidence to indicate otherwise. The best estimate figure was set at the level of under-reporting identified using the unloadings data. These data could be considered the 'best' of the available data given they represent complete trips (whereas observer data requires raising), although the fact that the data is available for one (albeit major) port only is a major limitation. The maximum figures were set at the level of under-reporting identified using the observer versus logsheet comparisons of weight to account for the possibility that both numbers and weight are under-reported. The available observer data is potentially subject to reporting and

raising biases, and is also likely to over-represent the SLL sector, but could be considered a plausible maximum value based on the data available.

Table 9: Estimated under-reporting rates of key longline species in percentage of total catch.

Species	Min	BE	Max	Dist.
Retained catch				
ALB	-3%	1.9%	5%	Triang.
BET	0%	10.3%	30%	Triang.
YFT	0%	2.1%	25%	Triang.
BIL	0%	2.4%	27%	Triang.
OTH	0%	2.4%	29%	Triang.
Discarded catch				
ALB	70%	95%	99%	Triang.
BET	70%	95%	99%	Triang.
YFT	70%	95%	99%	Triang.
BIL	70%	95%	99%	Triang.
OTH	70%	95%	99%	Triang.

For discarded fish, there was not a single trip from the sample of 219 trips for which observer and logsheet data was available in which the vessel reported discards for the main target species. This is despite space being available on standard SPC/FFA logsheets to record discards. Informal advice from SPC suggested that from the records they have available, only on around 1% of trips were discards reported. Those few vessels that did report discards appeared to report them consistently. For the purposes of this study, we set the maximum under-reporting figure at 99% to account for the few vessels that report discards. The best estimate figure was set at 95% to account for the possibility that a larger number of vessels (than those held by SPC) report discards. The minimum figure was set at 70% to account for the possibility that some fleets report discards, although based on the available data this figure may be very conservative. There was no evidence available to indicate different rates of discard reporting amongst different species categories.

Proportions of retained versus discarded catch were provided by SPC and calculated from observer data (Table 10).

Table 10: Rates of discarding for key target and non-target species in the WCPO longline sector (source: SPC)

Species	ALB	BET	YFT	BIL	OTH
Retained : discarded	97:3	95:5	95:5	92:8	24:76

2.2.3 Non-compliance with other license conditions

2.2.3.1 Fishing on a FAD when not authorised

Setting on a Fish Aggregation Device (FAD) when not authorised is principally an issue for the purse seine sector, although the license conditions of many FFA members restrict longlining around anchored FADs to restrict access to other sectors (artisanal, purse seine). In the context of this

project, the term FAD means "... *any man-made device, or natural floating object, whether anchored or not, that is capable of aggregating fish*" (WCPFC, 2009). To that end, we have not attempted to estimate the level of illegal FAD fishing in the LL sector, and there is general acknowledgement the level of IUU activity is likely to be very small.

In the purse seine sector, setting on schools associated with floating objects is prohibited under CMM 14-01 during the months of July to September, with options to extend the FAD closure or adopt a FAD management plan to limit the overall number of sets. Prior to CMM 14-01, FAD closures were implemented under the PNA 3rd Implementing Arrangement (3IA), as well as CMM 08-01 and subsequent revisions. Nevertheless, we are aware that some flag states provide exemptions for their vessels to fish on FADs during the closure and this represents a key source of uncertainty in the available data.

The main source of information on non-compliance with the FAD closure comes from observers, although other analytical tools are increasingly being developed to independently verify set type through differences in catch composition. For example, Hare et al (2015) developed an approach using observer catch sampling to retrospectively predict purse seine set type. In their analysis, they used a series of models based on tuna species composition, tuna length, bycatch species composition and non-sampling variables (e.g. temporal and spatial variables) to predict set type. Using their best performing model (CT2 with bycatch), they estimated that an average of 11.6% of sets identified as 'unassociated' during the FAD closure periods between 2009 and 2012 were likely to be associated, with a minimum rate of 7.1% in 2010 and a maximum rate of 15.9% in 2012 (Table 11).

Table 11: Comparison of set type misclassification error rates analysed by Hare et al (2015), using their preferred model (CT2). 'Type 1' sets are those reported by the vessel or observer as 'unassociated' which are actually likely to be associated.

	Tuna-only			With bycatch		
	Type I	Type II	Overall	Type I	Type II	Overall
2009	34.3%	9.3%	25.7%	13.9%	11.5%	13.1%
2010	14.0%	35.0%	16.0%	7.1%	40.7%	10.3%
2011	19.2%	21.5%	19.9%	11.8%	23.1%	14.9%
2012	42.6%	16.8%	35.7%	15.9%	19.6%	16.9%
All years	25.9%	19.2%	24.4%	11.6%	21.8%	13.9%

The basic equation used to estimate IUU catch for this risk was the proportion of sets during the FAD closure period likely to be set on associated schools * average catch rates and species composition for associated sets. The average number of sets undertaken during the FAD closures in the study period (17,673) was provided by SPC.

The ground-truthing workshop agreed that considerable incentives exist to fish on FADs during the closure period (i.e. higher average catch rates; higher proportion of successful sets) and some degree of illegal setting on FADs almost certainly occurs. A number of previous prosecutions have occurred including the US Government fining a number of vessels a total of over $6m for setting or fishing on FADs during the FAD closure period [7], or setting FADs without authorisation in US waters[8]. Moreover, one Chinese flagged vessel was detected illegally fishing on FADs during Operation Bigeye '11, and numerous anecdotal reports of FAD fishing fines exist.

In the absence of better data, the best estimate was set at the average level of misclassified 'unassociated' sets identified by Hare et al (2015) between 2009 and 2012, with the minimum and maximum figures set at the upper and lower bounds. Although there is some uncertainty

[7] http://www.nmfs.noaa.gov/ole/newsroom/stories/13/04_090413_purse_seine_fad_case.html

[8] http://www.nmfs.noaa.gov/msa2007/docs/biennia_report_to_congress.pdf (p. 106)

associated with vessels receiving exemptions to the FAD closure, Hare et al's (2015) estimates relate only to sets identified as 'unassociated' and therefore exclude sets reported as associated and made under an exemption. This will serve to reduce the uncertainty associated with exemptions.

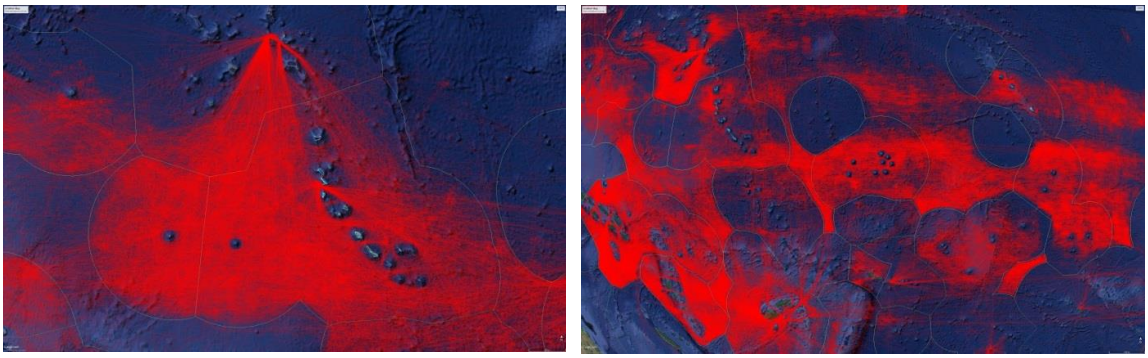
Table 12: Best estimate and min/max range for illegal FAD fishing in the purse seine sector (by proportion of sets during the FAD closure period likely to be sets on floating objects).

Sector	Min	BE	Max	Dist.
Purse seine	7.1%	11.6%	15.9%	Triangular

2.2.3.2 Fishing inside closed waters

The majority of FFA members have a number of closed waters provisions, particularly for foreign licensed vessels. Most commonly these take the form of closures around islands (and or reefs) (e.g. 12nm) to reserve these areas for customary and artisanal fishing, or closures to foreign fishing in archipelagic waters (e.g. Solomon Islands, Fiji). Some FFA members also have closures for other purposes (e.g. Palau enforces a 50nm closure to foreign fishing around Malakal Harbour to reserve the area for sportfishing).

The information available to support estimates of the extent of fishing inside closed waters was largely limited to VMS data and anecdotal reports. Participants at the ground-truthing workshop considered the issue to be relatively minor in the overall scheme of IUU activity. VMS track information, albeit not definitive (in that detects only the presence of a vessel, not whether fishing occurred) appears to show high levels of compliance with closed waters provisions (Figure 10).



(a) *(b)*

Figure 10: VMS tracks showing (a) purse seine and (b) longline vessel activity adjacent to closed areas in 2014.

The basic calculation used to estimate the level of IUU activity in closed areas within FFA member waters was the estimated number of days fishing * average catch rate and species composition for the sector. Catch composition and catch rates inside closed waters were assumed to be the same as the broader fishery.

Purse seine

For the purse seine sector, the available evidence suggests the level of illegal fishing is likely to be very limited. No instances of illegal fishing inside closed waters have been detected by aerial surveillance during regional operations in recent years, VMS data appears to show high levels of compliance with closed waters, 100% observer coverage is likely to act as a deterrent to non-compliance, and anecdotal reports suggest there have been few, if any, prosecutions for purse seiners contravening closed waters provisions during the study period. Nevertheless, one successful prosecution of a vessel for fishing inside the newly designated Phoenix Islands Protected Area was

recorded in late 2015.The ground-truthing workshop agreed that it was possible that some minor level of illegal activity was occurring though the best estimate and min/max ranges should be set at low levels.

Tropical longline

For the tropical longline sector, the ground-truthing workshop agreed the level of illegal activity is likely to be higher, largely as a result of higher numbers of vessels and fishing days, as well as the operational nature of the gear which can drift tens of nautical miles in a set. Moreover, the absence of observer coverage means the disincentives are likely to be lower than purse seine. Nevertheless, as with purse seine, the available evidence for high levels of illegal activity appears to be limited. VMS data appears to show high levels of avoidance of closed areas, and anecdotal evidence suggests the number of detections and prosecutions have been low.

Site visits to FFA member countries indicated very low levels of fishing inside closed waters. In RMI, no confirmed breaches of closed waters were detected during 2011 to 2014 either by VMS or aerial/surface surveillance, although occasional unconfirmed anecdotal reports were received from island communities.

Southern longline

In the southern longline sector, the ground-truthing workshop agreed the evidence suggested the level of illegal activity is likely to be low. VMS information appears to show a high degree of avoidance of closed waters, and FFA staff receive very few requests for support with prosecutions against breaches of closed waters. No vessels have been detected by aerial surveillance during regional operations fishing inside closed waters between 2011 and 2014. Likewise, in country visits indicated very few breaches. In Fiji for example, which has an archipelagic zone and numerous closures around islands, there were no incidents of breaching closed water conditions detected either by VMS or observer trip reports between 2001 and 2014. In the Solomon Islands, one suspected closed water infringement was detected by VMS in 2014, and none in the preceding three years.

Based on the available evidence, the ground-truthing workshop agreed that estimates should account for the possibility that some level of illegal activity occurs, but that overall estimates should be set at low levels.

Table 13: Best estimate and min/max range for illegal fishing activity within closed waters inside FFA member zones (by number of days fishing per year).

Sector	Min	BE	Max	Dist.
Purse seine	0	10	50	Triangular
TLL	20	50	200	Triangular
SLL	15	40	160	Triangular

2.2.3.3 Shark finning

Shark finning is defined here as the practice of removal and retention of the fins while discarding the carcass at sea. Under WCPFC CMM 10-07, CCMs are required to ensure their vessels "*have on board fins that total no more than 5% of the weight of sharks on board up to the first point of landing*", or alternatively require that their vessels land sharks with fins attached to the carcass. Although most FFA members reportedly prohibit the practice of shark finning, and some (e.g. Palau, RMI) prohibit the retention of shark products altogether, there is some uncertainty over the extent to which the WCPFC shark finning CMM has been translated into in zone arrangements. For the purposes of this

assessment, we have assumed that the CMM has been adopted by all FFA members, and to that extent the estimates presented here may be an overestimate.

Quantitative information on shark finning is largely limited to analysis of regional observer information, with only limited information currently available from national level compliance programs (e.g. from boarding and inspection reports). The best information appears to come from Rice et al (2015) who used observer information to analyse the fate of captured sharks. In the purse seine sector, the proportion of sharks reported finned has decreased over time, with only a very small proportion finned in 2014 (Figure 11) (albeit one purse seine vessel was detected with shark fin and skins on board during Operation Rai Balang '13 in contravention of RMI legislation). In the longline sector, which takes a higher volume of sharks overall, the proportion of finned sharks decreased from 2009 to 2012-3, but rose again in 2014 (Figure 11).

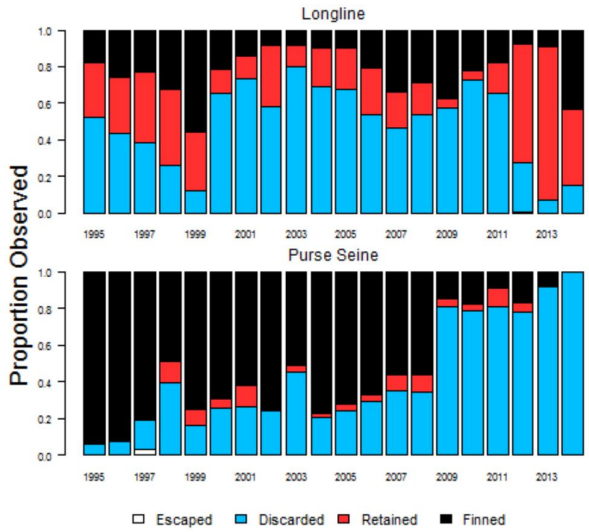


Figure 11: Fate of observed sharks caught by purse seine (top) and longline (bottom) in the WCPO (proportion by number for all species combined). (Rice et al, 2015)

For the purposes of our analysis, we have assumed that the finning reported below post-2011 was undertaken illegally. The basic calculation used to estimate the weight of illegal shark fin in each sector was the proportion of finned sharks*the total average volume of sharks caught (2011-2014)*a nominal dry weight fin:carcass ratio of 2%. We acknowledge this fin:carcass ratio will not hold for all sharks (see for example, Francis, 2014), although is reportedly a commonly used rough rule of thumb. Estimated dry weight of fins taken was multiplied by a nominal ex-vessel price of $40/kg for dry fins (although this value may be conservative). Total shark catch in each sector was derived from WCPFC public domain data for the relevant area.

Our 'best estimate' value was set at the average proportion of finning during the period 2011 to 2014, while the minimum and maximum proportions were set at the minimum and maximum proportions over the same period. We assumed similar levels of finning occurred in the tropical and southern longline sectors, although additional analysis may reveal whether this assumption holds true. For the longline sector, the level of shark finning on vessels without observers is unknown and may be higher than observed vessels given the presence of an observer may act as a disincentive to non-compliance. To that end, the maximum proportion may be an under-estimate.

Table 14: Best estimate and min/max proportion of sharks finned by sector (between 2011-14).

Sector	Min	BE	Max	Dist.
Purse seine	1%	9%	17%	Triangular
Longline	9%	17%	32%	Triangular

2.2.3.4 Use of non-prescribed gear

Non-compliance with gear use provisions is largely an issue for the longline sectors rather than purse seine, although the PNA members have agreed to introduce minimum mesh size regulations to limit bycatch of juvenile tuna. In the longline sectors, the main issue relates to the use of wire trace which is prohibited under most FFA member license conditions. Wire trace is predominantly used to target sharks.

The information available to quantify the use of wire traces is relatively weak and largely limited to isolated boarding and inspection reports, dockside monitoring reports and observer reports. In RMI, one instance of illegal use of wire trace was detected through surface surveillance in 2013, while none were detected in 2011, 2012 or 2014. Nevertheless, there was a suspicion amongst some officials interviewed that some fleets continued to use wire trace. In the Solomon Islands, there have been no prosecutions during the study period although officials interviewed suspected the practice occurs. In Fiji, no use of non-prescribed gear has been detected through dockside inspections or reported by observers during the study period, although prosecutions have been reported elsewhere[9].

Given sharks are the main target species where wire trace is used, the basic equation used to calculate the level of illegal take is the proportion of the overall shark catch taken while using illegal wire traces. In light of the economic incentives to catch sharks, the ground-truthing workshop agreed that it was at least likely that some use of wire trace occurs and the min/max range should be set broadly to take into account the uncertainty in the information base. No evidence was available to suggest that illegal use of wire trace is higher in either the TLL or SLL sector.

Table 15: Best estimate and min/max proportion of sharks finned by sector (between 2011 and 2014).

Sector	Min	BE	Max	Dist.
TLL	5%	10%	20%	Triangular
SLL	5%	10%	20%	Triangular

2.2.4 Post-harvest risks

2.2.4.1 Illegal transhipping

There is considerable uncertainty around the extent to which illegal transhipping occurs in the Pacific. Under the FFA HMTCs, transhipment at sea is prohibited for foreign vessels (except for authorised group seiners in PNG), although implementation of requirements at the national level is reportedly patchy. Fiji and PNG allow transhipping by domestic-based longliners to carriers to allow for the consolidation and transport of fresh catch to market and to reprovision with bait and

[9] E.g. http://pidp.eastwestcenter.org/pireport/2010/March/03-05-05.htm

supplies (McCoy, 2012). In Fiji, three domestic companies are allowed to undertake the practice with vessels authorized to fish in the Fiji EEZ. In contrast, FSM and the Marshall Islands have specifically prohibited transhipment at sea or catch consolidation and transhipment by locally-based longliners (McCoy, 2012).

Under WCPFC CMM 09-06, transhipment at sea by purse seine vessels is prohibited (except for authorised PNG and PH flagged group seiners and NZ flagged domestic vessels), while transhipment at sea is allowed for other vessels (including longline) which have received approval from their CCM (after meeting requirements set out in the CMM). All transhipments at sea require an observer from the WCPFC ROP on the receiving vessel[10], and the submission of a WCPFC Transhipment Declaration by both the offloading and receiving vessel for each transhipment. At sea transhipment is also prohibited for all foreign fishing vessels under the PNA's 2nd Implementing Arrangement (PNA, 1990), although McCoy (2012) advises "it would be incorrect to assume that the PNA ban on transhipping at sea is universally followed by all Parties". He notes that transhipment at sea is allowed by at least two PNA countries for locally-based longliners, while one PNA country allows longline transhipment in its EEZ to domestic-flagged carriers.

Historically there have been challenges in tracking transhipping behaviour with WCPFC (2013a) noting "*the limitations of the WCPFC VMS to the high seas make it impossible for the Commission to track carriers throughout the Convention Area. Therefore transhipping maybe occurring at sea inside national waters with no reports being received, or if received by the individual member countries no regional analysis of this data is presently available*" and moreover that "*there continues to be a problem in knowing what carriers coming into the Convention area are intending to do, it is not known if all carrier vessels transhipping at sea are carrying an observer, as it is impossible for the Commission Secretariat to know how many carriers intend to tranship at sea. VMS checks on carriers show that many do not have observers when they are viewed on the high seas however it is not known if these carriers are transiting to ports to tranship therefore not requiring an observer, or whether they intend to tranship at sea either in a EEZ or on the high seas*."

The information available to support estimates of illegal transhipping was relatively limited, and was ultimately determined by expert judgement. Average volumes of tuna per transhipment in the purse seine fishery was provided by SPC, while volumes in the longline fishery were calculated from high seas transhipment figures reported to WCPFC (WCPFC, 2015a). There is some possibility that this approach would over-estimate the average volume per transhipment across the full longline fleet, given high seas vessels are likely to have a larger capacity on average and some vessels may simply consolidate catch of time-limited products (e.g. high grade sashimi), however it is also true that larger high seas longliners are more likely to tranship than offload catch in port. We assumed that there was no substantial difference in average transhipment volumes between tropical and southern longline vessels, although better information on this may be generated in future iterations of the model. Species compositions for each fishery were assumed to be proportionate to those in the overall catch for each sector.

The basic calculation used to estimate illegal transhipment activity was the estimated number of illegal transhipments * the average volume per transhipment. Minimum, best estimate and maximum values were determined based on the information available.

Purse seine

For purse seine vessels, quantitative data was limited although the opportunities for illegal transhipment were assumed to be relatively low. Transhipment at sea is almost universally

[10] With the exception of transhipments to receiving vessels <33m, and not involving purse seine or frozen longline caught fish. In this case, the observer can be either on the catching or receiving vessel.

prohibited, vessels are subject to 100% observer coverage, considerable financial disincentives exist to non-compliance (for example by tying up vessels caught transhipping at sea) and vessels are subject to 100% VMS coverage, with frequent polling associated with the VDS. In addition, no instances of illegal transhipping by purse seiners have been detected by aerial surveillance in recent years, and no illegal transhipments were reported by observers on GEN-3 forms examined.

To that end, the ground truthing workshop considered it plausible that as few as zero illegal transhipments occurred in the purse seine fishery in any given year, but it was more likely that a very small number occurred. Accordingly, the best estimate was set at 10 with a maximum at 20. A triangular distribution was used for Monte Carlo simulations.

Tropical Longline

Quantitative data was equally limited for tropical longline vessels, although the opportunities and incentives for illegal transhipment were considered to be substantially greater than for purse seine. Longline vessels make up around 86% of all vessels authorised to tranship at sea through the WCPFC, and over 90% when only catching sector vessels are considered (WCPFC, 2015a). Moreover, there is only very limited observer coverage of many fleets. Of the 555 high seas transhipments reported to WCPFC in 2014, the vast majority were longline vessels in the tropical eastern WCPO with fewer transhipments in the SLL area (Figure 12).

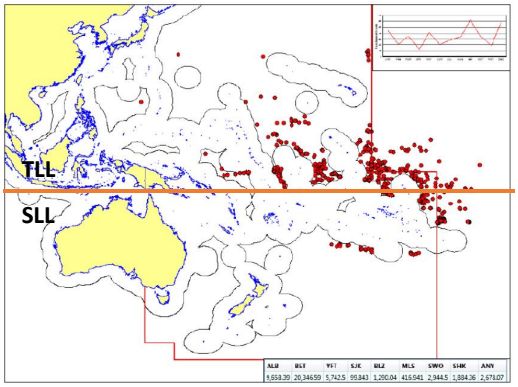


Figure 12: Positions of high sea transhipment activity in 2014 reported to the WCPFC according to CMM 09-06. (WCPFC, 2015a)

Aside from the high seas transhipment information provided to the WCPFC according to CMM 09-06, centralised information on transhipments and unloadings in the WCPO area is limited. No routine reporting of unloadings in Pacific island ports occurs (McCoy, 2012), and as a result there is only limited capacity to reconcile reported catches against reported unloadings/transhipments. In the most recent assessment of transhipping in the WCPO, McCoy (2012) estimated that around 35% of the total longline target catch in 2010, or around 63,000t, was transhipped (including offloaded) in Pacific Island nation ports. Using 2014 data, if the same proportion of the longline catch in the study area (~184,860t[11], target tuna only) was landed in Pacific island ports, the amount transhipped would be around 64,701t. The amount reported to the WCPFC as being transhipped on the high seas during 2014 was 57,746t (including blue marlin, striped marlin and swordfish) (WCPFC, 2015a), leaving around 62,413t to be transported to market through other means.

[11] http://www.ffa.int/node/425

Figure 13: Illegal transhipment detected through VMS and followed up by aerial surveillance in the high seas pocket north of the Solomon Islands in 2011. (Photo courtesy FFA)

While there is uncertainty in the information base, the ground truthing workshop agreed that some degree of illegal transhipment certainly occurs. Tropical longline vessels were detected illegally transhipping during both Operation Kurukuru '11 and Kurukuru '12, and with more recent use of new analytical tools over 60 *potential* cases of transhipment were detected and passed on to members for further assessment. Of the FFA members for which site visits were undertaken, the Solomon Islands provided anecdotal evidence of illegal transhipment in the high seas pocket north of their EEZ, including vessels fishing under charter in the Solomons EEZ.

The ground-truthing workshop agreed that estimates should be set to acknowledge that some level of illegal transhipping occurs, but kept broad to account for the uncertainties in the information base. The minimum figure was set low to account for the possibility that virtually all of the transhipments occurring on the high seas were being reported to the WCPFC, while the maximum figure was set at roughly double the current level of reported transhipments to account for the possibility that reporting is weaker than expected. The workshop agreed that the best estimate figure should be set at the lower end of the min/max range at this stage.

Southern Longline

In the southern longline sector, the ground-truthing workshop agreed that illegal transhipment was also likely to be occurring although estimates should be set at lower levels given both overall levels of fishing effort and numbers of transhipments reported to the WCPFC were lower than the tropical longline sector (Figure 12). At this stage, estimates have been set nominally at half those of the TLL sector, although these estimates should be refined if better analytical information becomes available in future versions of the model.

Table 16: Best estimate and min/max range for illegal transhipping (by average annual number of illegal transhipments).

Sector	Min	BE	Max	Dist.
PS	0	5	10	Triangular
TLL	10	100	500	Triangular
SLL	5	50	250	Triangular

2.2.4.2 Unauthorised offloading in foreign ports

Although not required by all members, a number of FFA members have provisions in license conditions that require catch landed within their zone to be landed in a nominated domestic port.

For example, Palau requires that all catch taken in Palau's EEZ by foreign flagged longline vessels be landed at Malakal Harbour. Fiji and FSM both have similar provisions for their licensed fleets.

In the case of Palau, there has long been anecdotal concern that some vessels are offloading in neighbouring Philippines ports to circumvent Palau's (US$0.35/kg) export tax on fisheries products and shark protection measures, as well as take advantage of cheaper reprovisioning. The information base to assess the concerns is weak however, with few reported prosecutions. Palau has no information sharing or compliance cooperation arrangements with Philippines, and until recently did not require port-to-port monitoring of its licensed vessels. As a result, vessels potentially landing catch outside Palau's waters were unable to be effectively tracked.

The ground-truthing workshop agreed that the issue of landing in unauthorised ports was more likely to be an issue for (selected) longline fleets than for purse seine which, on the basis of the available information, had few restrictions on ports of landing. The possible exception was Papua New Guinea which reportedly has conditions in all foreign access agreements that require at least 10% of catch to be landed for processing onshore (and against which '*not one fish has ever been landed for processing*') (PNG NFA, 2015). Nevertheless, given the uncertainty around enforcement of this provision we have not attempted to quantify the level of activity (albeit 10% of all catch landed by foreign purse seine vessels in PNG waters during the study period would add up to a very substantial figure).

The information base to quantify unauthorised longline unloadings in foreign ports was very weak, and largely limited to anecdotal reports from EEZs for which unauthorised landings were a potential problem. The basic equation used was the estimated number of unauthorised offloadings * the average volume and species composition/offloading. The latter figure was assumed to be the same as an average transhipment.

The ground truthing workshop agreed that the min/max range should be set at broad levels to account for the high level of uncertainty. They also agreed that the number of unauthorised landings is likely to be higher in the tropical sector than the southern sector.

Table 17: Best estimate and min/max range for offloading catch in unauthorised foreign ports (by average annual number of unauthorised offloads).

Sector	Min	BE	Max	Dist.
TLL	10	100	300	Triangular
SLL	5	50	150	Triangular

3 Estimates of the volume and value of IUU fishing

This section sets out the main outcomes of simulation modelling based on the 'best estimate', likely min/max ranges and likely probability distribution for each risk described above. Volume and ex-vessel value figures are generally discussed in terms of the 'best estimate' value and the 90% confidence range value. The 'best estimate' value in reality is the 'expected value' generated from simulation modelling. The expected value is a weighted average of the different potential values each risk could have and the values' associated probabilities[12]. The 90% confidence range is the range within which, based on the inputs to the model, simulation modelling suggests there is a 90% chance the actual IUU figure is within the range specified. Another way of looking at it is that there is a 95% chance the actual IUU figure is above the lower end in the range, and a 5% chance it is higher than the higher end. The ex-vessel values are based on the figures outlined for each product in Annex 2.

3.1 Overall estimates

Our simulations suggest the best estimate **total volume of product either harvested or transhipped involving IUU activity in Pacific tuna fisheries is 306,440t, with 90% confidence that the actual figure lies within a range of 276,546t to 338,475t. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $616.11m. The 90% confidence range is between $517.91m and $740.17m.** That is, there is a 95% chance the figure is greater than $517.91m and a 5% chance the figure is greater than $740.17m.

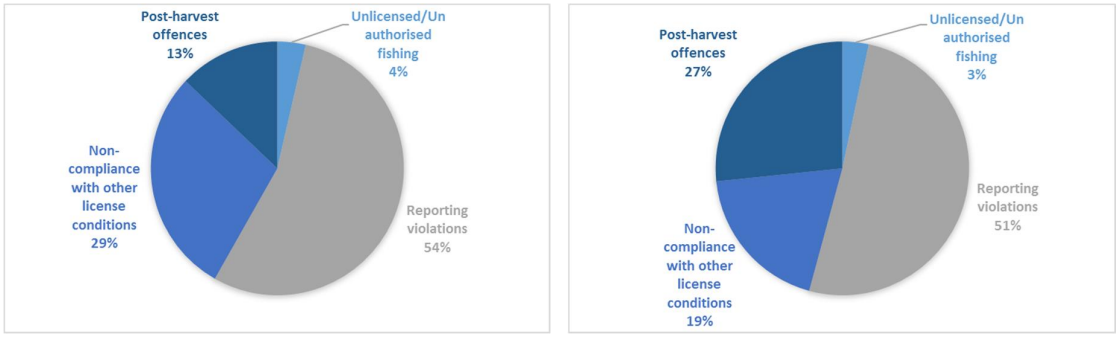
3.1.1 By risk type

Amongst the four categories of risk identified here, the largest contributions to the overall IUU volume were made by reporting violations and post-harvest risks, accounting for 54% and 29% of the total volume respectively (Table 18; Figure 14). Much of the volume associated with reporting violations was driven by under-reporting and misidentifying target species in the purse seine fishery, while post-harvest risk estimates were influenced largely by the estimates of illegal transhipping in the longline sectors. In turn, the higher ex-vessel prices received for longline product meant a higher effective price per tonnage value for post-harvest risk than other risks. Non-compliance with license conditions was the third highest contributor to overall volume, primarily driven by FAD fishing during the closure period in the purse seine fishery. The various types of unlicensed fishing accounted for only around 4% of total estimated IUU volume.

Table 18: Estimated total IUU volumes and ex-vessel value in Pacific Islands region tuna fisheries, by risk category.

Risk	BE (t)	90% range (t)	BE ($)	90% range ($)
Unlicensed fishing	11,078	7,351 – 14,945	$20.65m	$15.28m – $26.22m
Reporting violations	167,341	157,387 – 179,848	$313.42m	$270.60m – $377.01m
Other license conditions	88,440	66,957 – 109,557	$117.93m	$92.06m – $143.49m
Post-harvest risks	39,580	21,429 – 61,151	$164.12m	$81.69m – $266.49m

[12] For example, an identified risk resulting in 10MT of catch with 20% probability, 50MT with 60% probability, and 120MT with 20% probability would result in an expected value of 56MT ([10*0.2]+[50*0.6]+[120*0.2]). This expected value is important because whilst 50MT might have seemed a logical value to discuss because of its 60% probability, 56MT takes into account the other possible values of that risk.



(a) *(b)*

Figure 14: Contribution of each risk category to total estimated IUU (a) volume and (b) value in in Pacific Islands region tuna fisheries.

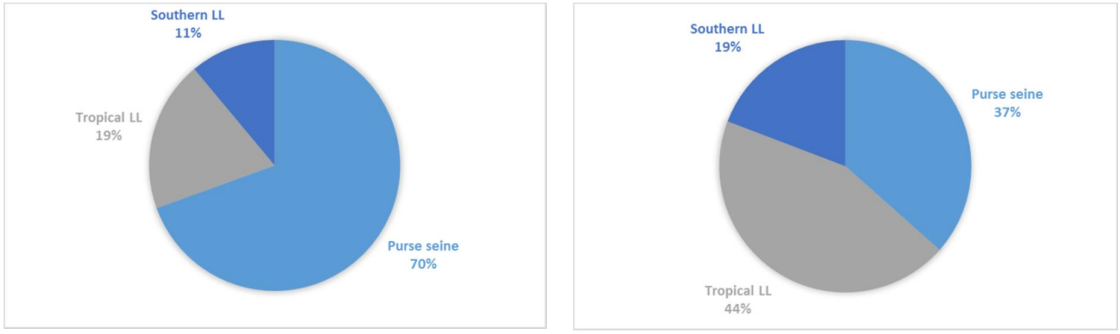
3.1.2 By sector

Of the three main sectors assessed, estimated volume of IUU product was highest in the purse seine fishery, accounting for 70% of overall volume (Table 19; Figure 15). Estimated IUU volumes in this sector were largely driven by reporting violations and illegal FAD fishing. The tropical longline and southern longline sectors accounted for 19% and 11% of the overall volume respectively.

By contrast, the tropical longline sector accounted for the highest ex-vessel value of IUU product ($272.55m) given the higher market value of its target species. This sector accounted for around 44% of overall estimated IUU value, while the purse seine sector accounted for 37%. The southern longline fishery had the lowest overall estimates of IUU product value.

Table 19: Estimated total IUU volume and value in each of the main sectors.

Sector	BE (t)	90% range (t)	BE ($)	90% range ($)
Purse seine	212,895	190,853 – 235,115	$225.20m	$200.35m – $251.56m
TLL	59,637	42,435 – 82,308	$272.55m	$184.90m - $385.62m
SLL	33,907	25,108 – 45,177	$118.36m	$87.67m - $158.54m



a) *(b)*

Figure 15: Contribution of IUU (a) volume and (b) value in Pacific Islands region tuna fisheries by main sector.

3.1.3 By species

Of the main target species, skipjack accounted for the highest volume of IUU product, accounting for around 33% of overall estimated volume, but only 18% of the overall ex-vessel value given its lower market price relative to other species (Table 20; Figure 16). The total estimated volume of IUU SKJ equated to around 5.1% of the estimated total catch of SKJ in the WCP-CA area in 2014. Much of the SKJ volume was driven by misreporting and non-compliance with license conditions (e.g. FAD fishing during the closure) in the purse seine fishery.

Yellowfin accounted for the equal next highest volume, accounting for 31% of the total estimated IUU volume, and 27% of the ex-vessel value. The total estimated IUU volume of YFT equated to around 15.8% of the estimated total catch of YFT in the WCP-CA area during 2014. However, because much of the YFT volume is driven by under-reporting and misidentification on logsheets (e.g. YFT misidentified as SKJ) in the purse seine fishery and this sector is subject to 100% observer coverage (and catch sampling) which is used to adjust regional catch figures, this does not necessarily result in 'unaccounted for' catch. The ex-vessel value of YFT was roughly proportional to its volume, with lower ex-vessel prices achieved for canned product in the purse seine balancing out higher prices achieved in the longline sectors.

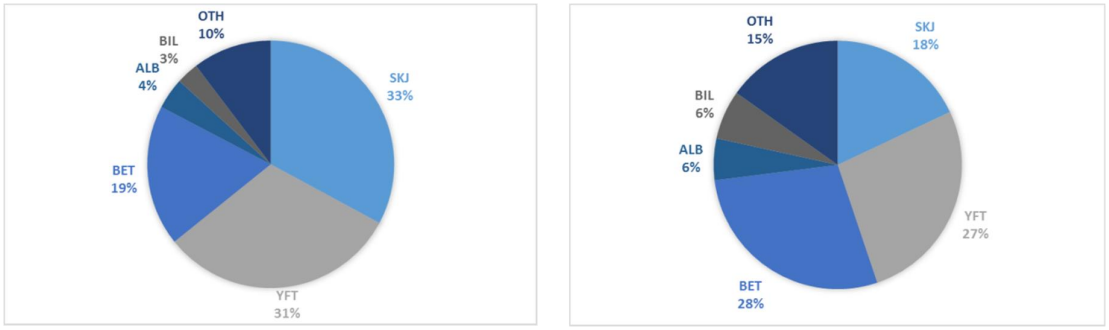
Bigeye also accounted for 19% of the overall estimated IUU volume, but 28% of the ex-vessel value. The proportionally higher contribution to the ex-vessel value total reflects the fact that much of the estimated IUU volume came from the longline sector which achieves relatively high market prices. The total estimated IUU volume of BET equates to around 35% of the estimated total catch of BET in the WCP-CA area during 2014. Importantly, this does not necessarily mean that 35% of additional BET have been taken in addition to reported figures. For example, a substantial proportion of the overall IUU BET estimates come from estimates of illegal transhipping, the product for which may still be reported in logsheets.

ALB accounted for 4% of the overall estimated IUU volume and 6% of the total ex-vessel IUU value. The total estimated ALB IUU volume equates to around 9.4% of the estimated total ALB catch in the WCP-CA area in 2014. Much of the estimated volume of IUU ALB comes from estimates of illegal transhipping for which information is uncertain.

Billfish and other species accounted for 3% and 6% of the estimated IUU volume and 10% and 15% of the estimated ex-vessel IUU value respectively. Much of the value of the other species category was driven by estimates of shark finning and misreporting.

Table 20: Estimated total IUU volumes and ex-vessel value of each main species in Pacific Islands region tuna fisheries.

Species	BE (t)	90% range (t)	BE ($)	90% range ($)
SKJ	100,730	83,946 – 117,706	$110.80m	$93.08m – $129.88m
YFT	96,126	88,886 – 104,437	$165.47m	$135.75m – $202.53m
BET	56,473	47,251 – 67,872	$173.61m	$118.26m - $243.90m
ALB	12,480	7,602 – 18,509	$33.42m	$20.96m – $49.72m
BIL	8,928	5,778 – 12,878	$39.46m	$25.54m – $56.91m
OTH	31,703	26,400 – 38,312	$93.35m	$79.15m – $111.01m



(a) *(b)*

Figure 16: Proportion of each main species in the overall estimates of IUU (a) volume and (b) value in Pacific Islands region tuna fisheries.

3.2 Purse seine fishery

3.2.1 Overall

The best estimate volume of IUU product in the purse seine sector is 212,895t, with a 90% confidence range of 190,853t to 235,115t. This represents around 10.5% of the estimated total purse seine catch in the WCP-CA area in 2014. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $225.20m. The 90% confidence range is between $200.35m and $251.56m.

Table 21: Estimated total IUU volumes in the purse seine sector, by risk category.

Risk	BE (t)	90% range (t)
Unlicensed fishing	8,759	5,154 – 12,482
Reporting violations	118,678	113,138 – 124,391
Other license conditions	81,733	60,431 – 102,859
Post-harvest risks	3,725	1,176 – 6,272

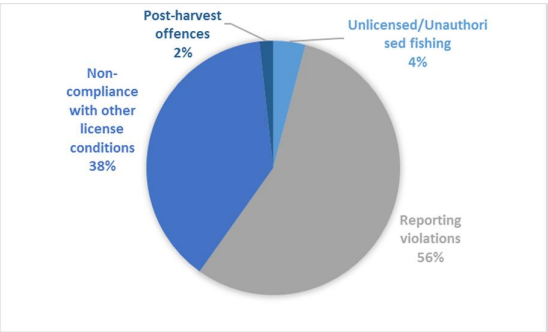


Figure 17: Contribution of each risk category to total estimated IUU volumes in the purse seine sector.

Table 22: Estimated total IUU volumes in the purse seine sector, by species.

Species	BE (t)	90% range (t)
SKJ	100,730	83,946 – 117,706
YFT	80,626	76,024 – 85,284
BET	33,283	31,400 – 35,131
OTH	-1,744	-2,336 – -1,147

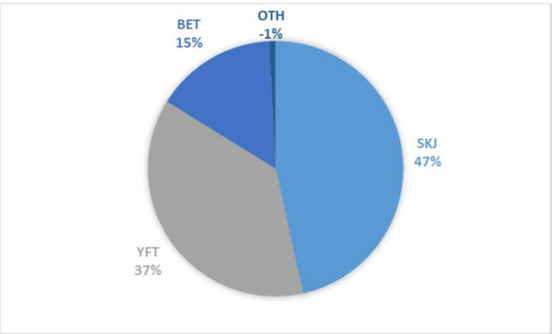


Figure 18: Total estimated volume of each species involved in IUU activity in the purse seine sector.

The largest contributor to the total estimated IUU volume and value are reporting violations, accounting for 56% the estimated IUU volume (Table 21; Figure 17). This was largely driven by estimates of under-reporting and misidentifying of YFT and BET. The next highest contributor was the 'non-compliance with other license conditions' group of risks, accounting for around 43% of total estimated IUU volume. The vast majority of this total is driven by estimates of FAD-fishing during the closure period.

By contrast, both unlicensed fishing (4%) and post-harvest risks (2%) accounted for a very small proportion of overall estimated IUU volume.

The estimated IUU species composition is broadly reflective of the catch composition in the PS sector, although higher rates of BET are evident due to under-reporting and misidentification of this species in logsheets (Table 22; Figure 18).

3.2.2 Unlicensed/unauthorised fishing

The best estimate value of unlicensed and unauthorised fishing in the purse seine sector is 8,759t (90% confidence range of 5,154t – 12,482t). For context, this value represents around 0.4% of the estimated total purse seine catch in the WCP-CA area in 2014.

Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $10.32m.

Table 23: Estimated IUU volumes associated with unlicensed/unauthorised fishing in the PS sector, by risk type.

Risk	BE (t)	90% range (t)
Unlicensed fishing – FFA RR	851	228 – 1,650
Unlicensed fishing – WCPFC RFV - average	455	138 - 806
Unlicensed fishing – WCPFC RFV - small	2,253	767 – 4,216
Unreg. – 'average'	1,625	436 – 3,143
Unreg. - small	3,575	942 – 6,206

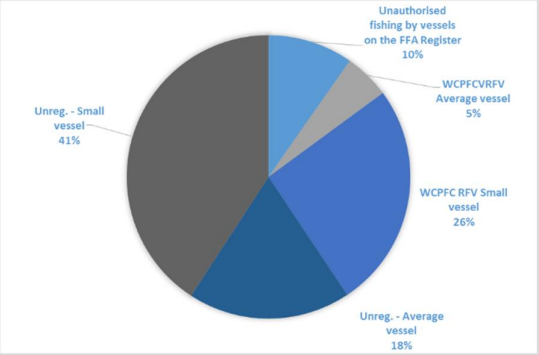


Figure 19: Contribution of each risk to total estimated IUU unlicensed/unauthorised fishing volumes in the PS sector

Unregulated fishing by small vessels (principally domestic south east Asian fleets) was the main contributor, accounting for 41% of the expected volume (Table 23; Figure 19). This was based on an assumption of relatively frequent incursions in the western fringes of the FFA area. Nevertheless, there is considerable uncertainty about the actual level of activity, which should be refined in future versions of the model. Unlicensed fishing in FFA EEZs by vessels on the WCPFC RFV but not on the FFA RR was the next main contributor, accounting for 26% of total expected IUU volume. Unlicensed fishing by FFA RR vessels and WCPFC RFV average sized vessels, each of which is subject to 100% observer coverage, is expected to account for relatively small volumes of IUU product.

3.2.3 Misreporting

The overall volume of misreported product according to the decision rules used in this study was 118,678t (113,138t to 124,391t). The main contributors were not reporting of retained YFT and misidentification of YFT, accounting for 25% and 24% respectively (Figure 20). This result is broadly consistent with previous analyses which have shown relative under-reporting of YFT in the fishery

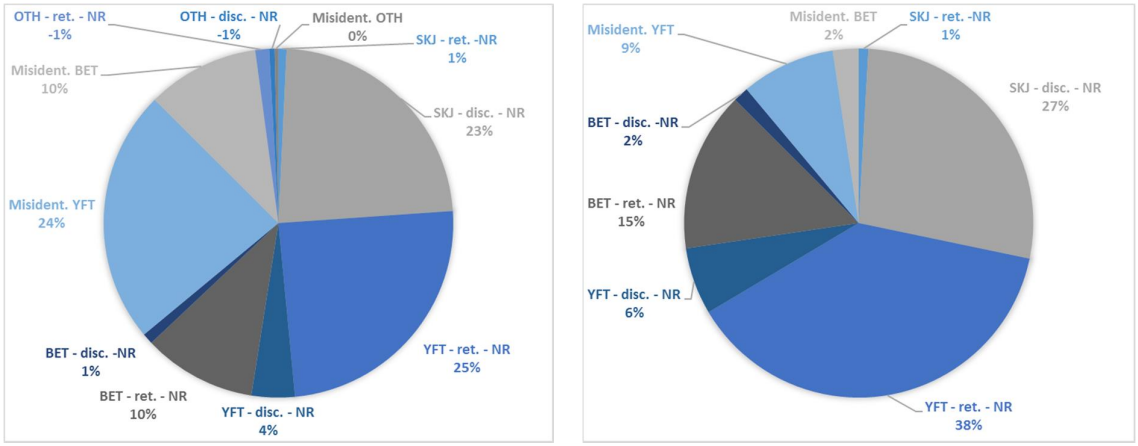
(e.g. Hampton and Williams, 2011), and is perhaps not surprising given the looseness of the correlation between observer and vessel logsheet reporting for these species in sample sets (Figure 38). Not reporting of discarded SKJ was the next main contributor, accounting for 23% of overall volume, while not reporting of retained BET and misidentifying BET each accounted for 10% of overall volume. In the case of purse seine caught YFT, the amounts defined as 'IUU' according to the decision rules adopted for this study is not insignificant, representing around 8.4% and 1.4% of the estimated total 2014 purse seine YFT catch for 'not reported retained' and 'misidentified' catch respectively. Similarly for BET, the amounts defined as 'IUU' according to the decision rules adopted for this study, represent around 19.1% and 1.8% of the estimated total 2014 purse seine BET catch for 'not reported retained' and 'misidentified' catch respectively

Not reporting of retained and discarded SKJ equated to less than 2% of the total 2014 purse seine catch.

Table 24: Estimated total under-reporting in the purse seine sector, by species and fate.

Species	BE (t)	90% range (t)	BE % 2014 PS catch	BE Value ($)
Not reported				
SKJ				
Retained	928	-3,478 – 5,223	0.06%	$1.02m
Discarded	28,480	26,910 – 30,029	1.8%	$31.33m
YFT				
Retained	30,260	28,239 – 32,346	8.4%	$43.70m
Discarded	4,920	4,648 – 5,195	1.4%	$7.1m
BET				
Retained	12,900	12,070 – 13,730	19.1%	$7.21m
Discarded	1,234	1,165 – 1,304	1.8%	$1.62m
OTH				
Retained	-1,572	-1,773 - -1,371		
Discarded	620	-1,175 – -71		
Misidentified				
YFT	28,940	27,095 – 30,747	1.6%	$9.96m
BET	12,780	12,055 – 13,503	23.8%	$2.73m
OTH	428	383 - 472		

In value terms, the main contributor to ex-vessel value was not reporting of YFT, accounting for 38% of overall value, and not reporting of SKJ discards which accounted for 27%. Misidentifying YFT and BET contributed to proportionally less than their volume because only the marginal difference in ex-vessel value between SKJ and YFT/BET was taken into account (given YFT/BET were almost always misidentified as SKJ). The overall ex-vessel value of misreported product was $114.41m.



(a) *(b)*

Figure 20: Proportion of each risk type/species category to total (a) volume and (b) value of misreporting in the purse seine fishery. (NR = not reported; misident. = misidentified)

3.2.1 Non-compliance with other license conditions

The group of risks categorised as non-compliance with other license conditions accounted for around $96.08m ($71.03m - $120.91m) in estimated ex-vessel value.

Table 25: Estimated total volumes of IUU product associated with non-compliance with other license conditions in the PS sector, by risk category.

Risk	BE (t)	90% range (t)
Unauthorised FAD fishing	81,338	59,987 – 102,431
Closed waters	390	97 – 780
Shark finning (dry fin weight)	5.9	2.3 – 9.5

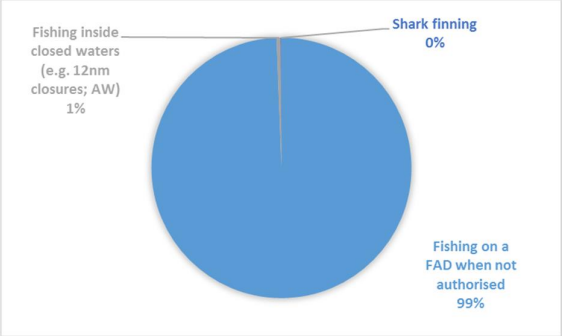


Figure 21: Contribution of each risk to total estimated IUU value ($) associated with the 'non-compliance with license conditions' risks in the PS sector

Of these, unauthorised fishing on FADs during the closure period accounted for over 99% of the estimated value and volume (Table 25; Figure 21). By comparison, both fishing inside closed waters and shark finning accounted for negligible estimated IUU activity. In the case of shark finning, this is not surprising given the relatively small amount of sharks taken in the fishery and the very low rates of finning, particularly in recent years. In the case of fishing inside closed waters, this is also not particularly surprising given the apparent avoidance of closed areas by vessels and 100% observer coverage.

3.2.2 Post-harvest risks

Our simulations suggest that IUU activity in the post-harvest sector involves product with a likely ex-vessel value of around $4.39m ($1.39m – $7.39m). This was solely related to estimates of illegal transhipping given there are few known restrictions on landing catch in foreign ports in the PS sector (notwithstanding the PNG case discussed previously). The best estimate volume of product involved was around 3,725t, or around 0.2% of the overall reported PS catch in the WCP-CA area in 2014.

3.3 Tropical Longline Fishery

3.3.1 Overall

The best estimate volume of IUU fishing in the tropical longline fishery is 59,637t, with a 90% confidence range of 42,435t to 82,308t. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $272.55m. The 90% confidence range is between $184.90m and $385.62m. That is, there is a 95% chance the figure is greater than $184.90m and a 5% chance the figure is greater than $385.62m.

Table 26: Estimated total IUU volumes in the TLL sector, by risk category.

Risk	BE (t)	90% range (t)
Unlicensed fishing	1,521	952 – 2,133
Reporting violations	29,327	21,680 – 39,763
Other license conditions	5,223	3,197 – 7,604
Post-harvest risks	23,567	8,687 – 43,637

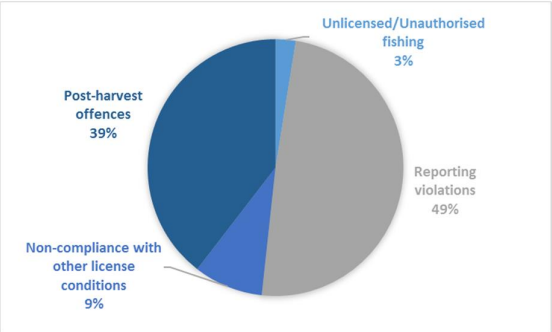


Figure 22: Contribution of each risk category to total estimated IUU volumes in the TLL sector.

Table 27: Estimated total IUU volumes in the TLL sector, by species.

Species	BE (t)	90% range (t)
ALB	2,928	1,440 – 4,890
BET	19,961	11,179 – 31,109
YFT	10,969	5,872 – 17,463
BIL	6,707	3,738 – 10,427
OTH	19,071	15,032 – 24,140

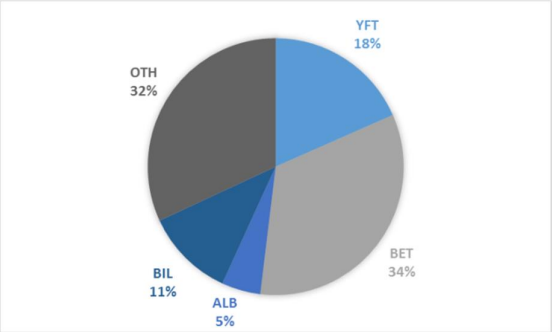


Figure 23: Total estimated volume of each species involved in IUU activity in the TLL sector.

The largest contributor to the total estimated IUU volume and value is misreporting, which accounts for 49% of estimated total IUU volume (Table 26; Figure 22). Estimates of misreporting are heavily influenced by the uncertainty in the underlying data and the resulting broad min/max ranges used. The next largest contributor was the post-harvest group of risks, accounting for 39% of total volume. Much of this is driven by the uncertain and broad range of values assigned to illegal transhipping. Getting better information on both misreporting and illegal transhipping this risk would assist future versions of the model and the extent to which both contribute to IUU activity in the TLL sector.

Non-compliance with other license conditions accounted for around 9% of overall volume, while unlicensed fishing accounted for only 3%.

In the absence of better information, the approach used in this study assumes average species composition associated with most risks, so the estimates species composition is broadly reflective of the catch composition in the TLL sector (Table 27; Figure 23).

3.3.2 Unlicensed/unauthorised fishing

The best estimate value of unlicensed and unauthorised fishing in the tropical longline fishery is 1,521t (90% confidence range of 952t – 2,133t). Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $7.52m (90% confidence range is between $4.71m - $10.55m).

Table 28: Estimated total IUU volumes in the TLL sector, by risk category.

Risk	BE (t)	90% range (t)
Unlicensed fishing – FFA RR	621	237 – 1,095
Unlicensed fishing – WCPFC RFV	382	146 - 674
Unreg. – 'average'	142	30 - 253
Unreg. - small	376	117 - 635

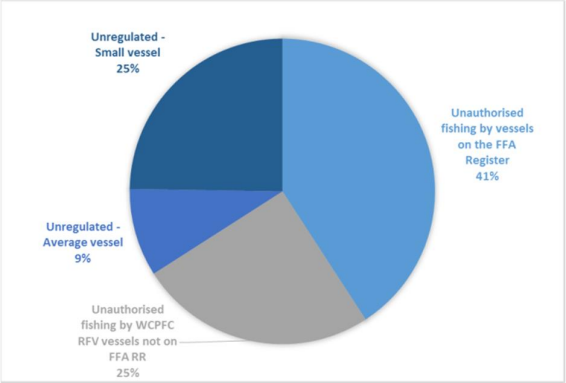


Figure 24: Contribution of each risk to total estimated IUU volumes in the TLL sector

Unauthorised fishing by vessels on the FFA register was the main contributor to the overall volume of IUU product, accounting for 41% of the likely IUU volume (Table 28; Figure 24). Unregulated fishing by small vessels (as defined here which includes the domestic fleets of south east Asian countries) and unauthorised fishing by vessels on the WCPFC RFV accounted for around 25% of the overall volume each. Unregulated fishing by 'average' vessels (in essence, vessels flagged to states other than CCMs to the WCPFC) is expected to account for very little IUU activity.

3.3.3 Misreporting

Reporting in the longline fishery is characterised by high levels of uncertainty. There are few, if any, independent means of verifying catch and effort for many vessels, and even where independent means exist (e.g. observers), there are uncertainties in the data which need to be explored to identify true trends. Logsheet and observer coverage is lower than that in the purse seine sector and there are few opportunities for dockside inspection for some fleets. As a result, the final min/max ranges used here were broad to take into account uncertainty.

The overall volume of misreported product (both retained and discarded) estimated through our simulations was 29,327t (21,680t to 39,763t).

Of the retained product, the main contributor to overall volume was BET, which accounted for 52% of under-reported, retained product (Table 29). The next highest contributor was YFT at 21%, followed by BIL and OTH on 13% and 12% respectively. ALB accounted for only around 1% of estimated misreporting in the TLL sector. Of the discarded product, OTH accounted for 61% of the estimated unreported discards. BET and YFT were the next highest contributors on 17% and 10% respectively, followed by BIL on 9%. ALB accounted for only 2% of estimated discarded unreported catch.

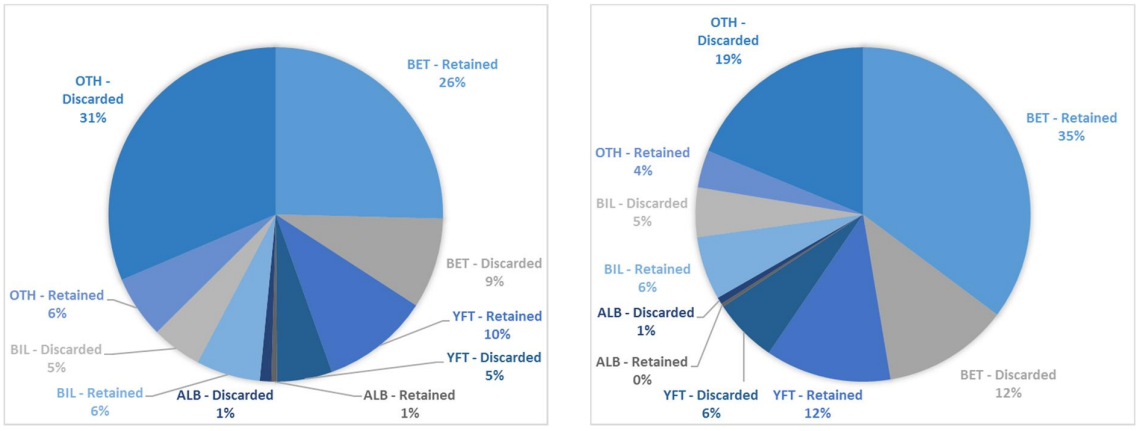
Collectively, the volumes estimated as unreported by this study are not insignificant. The total volume of retained and discarded BET represents around 21% of the average BET catch in the TLL area between 2010 and 2012, and 15.5% of the CMM14-01 BET catch limits by flag (noting that SIDS flagged vessels do not have limits) for 2014. These results have important implications for the integrity of the CMM if ultimately validated. Of the remaining species, the combined retained and

discarded unreported catch represents 15%, 19% and 75% of the average longline catch in the TLL area between 2010 and 2012 for YFT, BIL and OTH respectively.

Table 29: Estimated total under-reporting in the TLL sector, by species and fate.

Species	BE (t)	90% range (t)	BE % 2010-12 TLL av. catch
Retained			
ALB	156	-187 – 480	1.3%
BET	7,473	1,968 – 15,681	15.5%
YFT	3,060	507 – 7,534	9.9%
BIL	1,825	308 – 4,528	10.9%
OTH	1,711	278 – 4,320	11.7%
Discarded			
ALB	328	282 - 361	2.8%
BET	2,577	2,157 – 3,065	5.4%
YFT	1,569	1,326 – 1,844	5.1%
BIL	1,425	1,193 – 1,690	8.5%
OTH	9,202	7,700 – 10,993	62.8%

In value terms, the main contributor to ex-vessel value was not reporting of retained BET, accounting for 35% of overall value, and not reporting of discarded OTH which accounted for 19% (Figure 25). The overall ex-vessel value of misreported product was $131.42m.



(a) *(b)*

Figure 25: Contribution of each species/fate combination to total (a) volume and (b) value of misreporting in the TLL sector.

Importantly, as discussed above, there are substantial limitations in the data available for the LL sectors. Until a more comprehensive audit of the full LL dataset is undertaken and better systems of independent verification are put in place, it is possible that rates of misreporting in the LL sectors are either higher or lower than those reported here. Given the absence of effective MCS coverage on many fleets and the substantial incentives for under-reporting, our best guess is there is more scope for higher, rather than lower, rates of under-reporting although there is an absence of definitive evidence at this stage.

3.3.4 Non-compliance with other license conditions

The group of risks categorised as non-compliance with other license conditions accounted for around $17.02m in ex-vessel value.

Table 30: Estimated total volumes of IUU product associated with non-compliance with other license conditions in the TLL sector, by risk category.

Risk	BE (t)	90% range (t)
Non-prescribed gear (sharks)	4,978	2,960 – 7,363
Closed waters	80	32 – 145
Shark finning (dry fin weight)	165	103 - 238

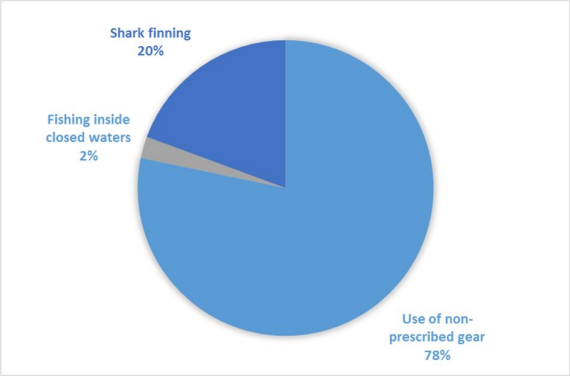


Figure 26: Contribution of each risk to total estimated IUU value ($) associated with the 'non-compliance with license conditions' risks in the TLL sector

Of these, the use of non-prescribed gear contributed the largest volume of estimated IUU product (all sharks) and around 78% of the total predicted best estimate value ($13.3m) (Table 30; Figure 26). Shark finning accounted for the next highest volume, with a best estimate value of 165t of dried fin weight (assuming 2% of total weight), although this figure would be the highest volume if the full wet weight of the shark body is taken into account (~8,250t). Overall the best estimate ex-vessel value of shark fins taken from finned sharks was $3.3m, accounting for around 20% of the total value of this group of risks.

Fishing inside closed waters accounted for only a very minor contribution to the total IUU volume and value.

3.3.5 Post-harvest risks

Our simulations suggest that IUU activity in the post-harvest sector involves product with a likely ex-vessel value of around $116.58m ($42.98m - $215.87m). The largest portion of this result (87%) is driven by the estimates for illegal transhipping which, in turn, are heavily influenced by the uncertainty in the information base. As a result, the min/max range has been kept deliberately broad. Efforts should be made in future to generate a better quantitative understanding of the risks around illegal transhipping (number of illegal transhipments, likely volumes, species composition) in order to more confidently assign best estimate and narrow the min/max range. For context, the current best estimate of the volume of illegal transhipping (20,537t) is around 33% of the high seas transhipments reported to WCPFC for 2014 (62,876t), much of which occurs in the TLL area (WCPFC, 2015a).

Table 31: Estimated total volumes of IUU product involved in post-harvest IUU activity in the TLL sector.

Risk	BE (t)	90% range (t)
Illegal transhipping	20,537	5,751 – 40,491
Landing in unauthorised ports	3,030	1,648 – 4,410

Table 32: Estimated value of IUU product involved in post-harvest IUU activity in the TLL sector.

Risk	BE ($)	90% range ($)
Illegal transhipping	$101.59m	$28.45 - $200.31m
Landing in unauthorised ports	$14.99m	$8.15 - $21.82m

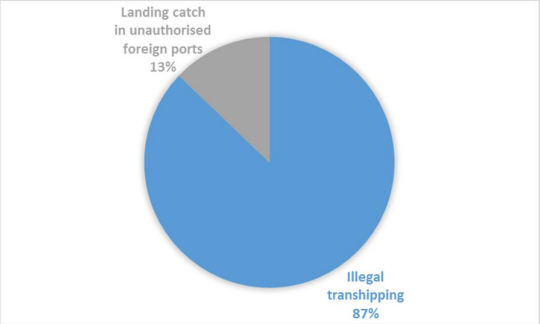


Figure 27: Contribution of each risk to total estimated IUU volume in the post-harvest sector associated with the TLL fishery.

The landing of catch in unauthorised foreign ports accounted for product valued at around $14.99m, and was ultimately not an insignificant risk in the overall scheme of TLL risks. Like illegal transhipping however, the estimates are driven by the weak information base and the broad min/max range and should be revised where possible after generating addition information.

The total volume of product involved in post-harvest risks was estimated at 23,567t, and the species composition assumed to be consistent with the 'typical' catch composition of the TLL sector based on logsheet reporting (i.e. YFT – 25%; BET – 39%; ALB – 10%; BIL – 14%; OTH – 12%). Nevertheless, if illegal transhipment typically involves preferential transhipment of some species over others (e.g. bycatch, shark fins, sashimi grade target species) this should be investigated and factored into future versions of the model.

Unlike some of the other risks, there is a reasonable chance of 'double counting' if, for example, underreported catch is also illegally transhipped. This is obviously very difficult to quantify without better information on both risk areas, but should be considered further in future versions of the model.

3.4 Southern Longline Fishery

3.4.1 Overall

In the southern longline fishery, the best estimate volume of IUU product is 33,907t, with a 90% confidence range of 25,108t to 45,177t. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $118.36m. The 90% confidence range is between $87.67m and $158.54m. That is, there is a 95% chance the figure is greater than $87.67m and a 5% chance the figure is greater than $158.54m, based on the input values used in the model.

Table 33: Estimated total IUU volumes in the SLL sector, by risk category.

Risk	BE (t)	90% range (t)
Unlicensed fishing	799	423 – 1,240
Reporting violations	19,336	15,364 – 24,634
Other license conditions	1,484	925 – 2,146
Post-harvest risks	12,288	4,712 – 22,249

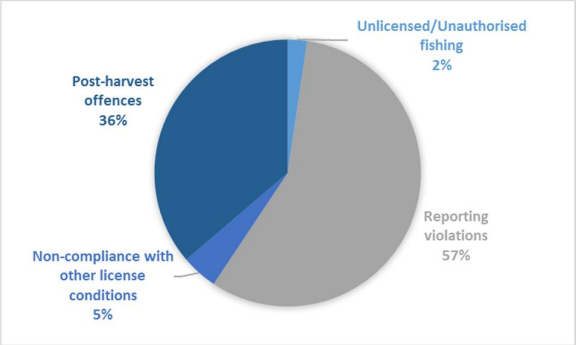


Figure 28: Contribution of each risk category to total estimated IUU volumes in the SLL sector.

Table 34: Estimated total IUU volumes in the SLL sector, by species.

Species	BE (t)	90% range (t)
ALB	9,551	5,052 – 15,280
BET	3,228	1,813 – 5,141
YFT	4,531	2,438 – 7,241
BIL	2,221	1,267 – 3,570
OTH	14,376	11,257 – 18,835

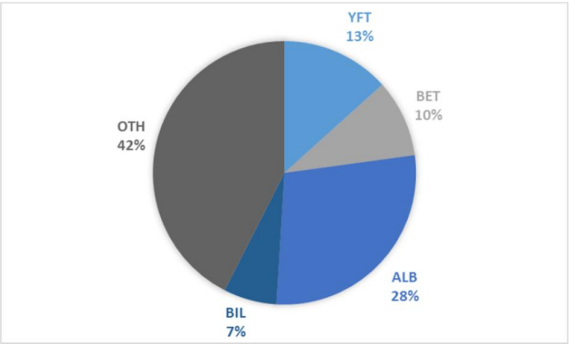


Figure 29: Total estimated volume of each species involved in IUU activity in the SLL sector.

Like the TLL, the largest contributor to the total estimated IUU volume and value are the reporting violations accounting for over half of the total best estimate value (Table 33; Figure 28). Again, much of this is driven by the uncertain and broad range of values assigned to misreporting. The next largest contributor was the post-harvest group of risks, accounting for 36% of total volume, which was also influenced by uncertainty in the information base. Non-compliance with other license conditions accounted for around 5% of overall volume (lower than TLL, largely as a result of lower shark catch), while unlicensed fishing accounted for only 2%.

In the absence of better information, the approach used in this study assumes average species composition associated with most risks, so the estimates species composition is broadly reflective of the catch composition in the SLL sector (Table 34; Figure 29).

3.4.2 Unlicensed/unauthorised fishing

The best estimate value of unlicensed and unauthorised fishing in the SLL sector is 799t, with a 90% confidence range of 423t to 1,240t. Based on the expected species composition and markets, the ex-vessel value of the best estimate figure is $2.8m.

Table 35: Estimated total IUU volumes in the SLL sector, by risk category.

Risk	BE (t)	90% range (t)
Unlicensed fishing – FFA RR	566	216 - 999
Unlicensed fishing – WCPFC RFV	159	61 - 281
Unregulated	74	14 - 158

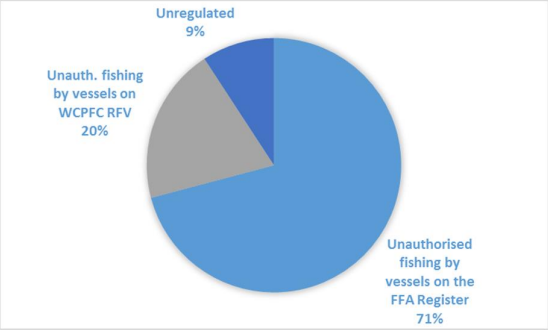


Figure 30: Contribution of each risk to total estimated IUU volumes in the SLL sector

Unauthorised fishing by vessels on the FFA register was the main contributor to the overall volume of IUU product, accounting for 71% of the estimated IUU volume. This number was higher than in the TLL sector (41%) given the larger proportion of fishing done within FFA member zones. Unauthorised fishing by vessels on the WCPFC RFV but not the FFA RR accounted for the next highest volume with a best estimate of 159t. Unregulated fishing was predicted to account for only a very small amount of illegal activity. The estimates for unregulated fishing were considerably lower than the TLL sector (518t), driven largely by the absence of exposure to large south east Asian fleets on the western fringe.

3.4.3 Misreporting

The overall volume of misreported product (both retained and discarded) estimated through our simulations was 19,336 (15,364t to 24,634t).

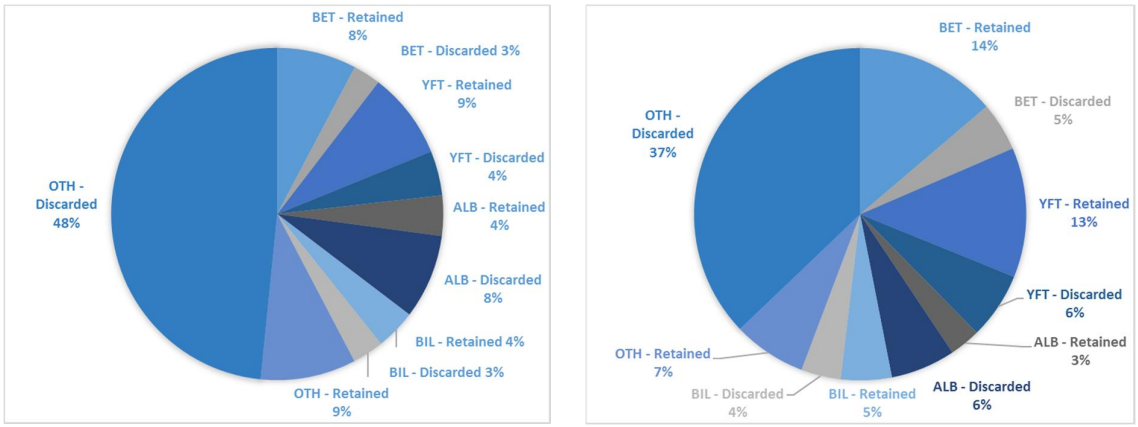
Of the retained product, the main contributors to overall estimated IUU volume were OTH, YFT and BET accounting for 28%, 25% and 23% of the unreported retained product respectively (Table 36). ALB and BIL both accounted for around 12% of estimated unreported product. Of the discarded product, OTH accounted for 73% of the estimated unreported discards. ALB was the next highest on 12%, followed by YFT, BIL and BET accounting for between 4-6% of unreported discarded product each. Overall, discarded OTH species accounted for around half the estimated unreported catch (Figure 31).

Table 36: Estimated total under-reporting in the SLL sector, by species and fate.

Species	BE (t)	90% range (t)	BE % 2010-12 SLL av. catch
Retained			
ALB	764	-913 – 2,343	1%
BET	1,506	396 – 3,159	16%
YFT	1,641	272 – 4,039	10%
BIL	760	128 – 1,886	11%
OTH	1,743	283 – 4,401	12%
Discarded			
ALB	1,598	1,378 – 1,765	2.8%

BET	519	432 – 615	5.4%
YFT	841	708 – 985	5.1%
BIL	593	497 – 703	8.5%
OTH	9,370	7,843 – 11,190	62.8%

In value terms, the main contributor to ex-vessel value was discarding of OTH species, accounting for 37% of overall value, and not reporting of retained BET and YFT which accounted for 14% and 13% respectively (Figure 31). The overall ex-vessel value of misreported product was $67.59m ($53.29m - $87.88m).



(a) *(b)*

Figure 31: Contribution of each species/fate combination to total (a) volume and (b) value of misreporting in the SLL sector.

Importantly, the limitations in misreporting estimates discussed above for the TLL sector also hold for the SLL sector.

3.4.4 Non-compliance with other license conditions

The group of risks categorised as non-compliance with other license conditions accounted for around $4.8m ($3.28m - $6.63m) in ex-vessel value.

Of these, the use of non-prescribed gear (wire traces) contributed the largest volume of estimated IUU product (all sharks), and around 76% of the total predicted best estimate value ($3.7m). Shark finning accounted for the next highest value, with a best estimate dried fin weight value of $0.9m (assuming 2% of total weight). If the total weight of sharks finned is taken into account, the likely volume of catch is around 2,265t. Fishing inside closed waters accounted for only a very minor contribution to the total IUU volume and value.

Table 37: Estimated total volumes of IUU product associated with non-compliance with other license conditions in the SLL sector, by risk category.

Risk	BE (t)	90% range (t)
Non-prescribed gear (sharks)	1,367	813 – 2,022
Closed waters	72	29 – 131
Shark finning (dry fin weight)	45	28 - 65

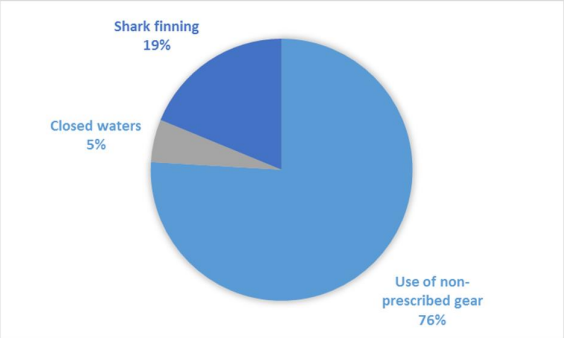


Figure 32: Contribution of each risk to total estimated IUU value ($) associated with the 'non-compliance with license conditions' risks in the SLL sector

3.4.5 Post-harvest risks

Our simulations suggest that IUU activity in the post-harvest sector involves product with a likely ex-vessel value of around $43.14m ($16.54m - $78.12m). The largest portion of this result (84%) is driven by the estimates for illegal transhipping which, in turn, are heavily influenced by the uncertainty in the information base. As with the TLL sector, efforts should be made to generate a better quantitative understanding of the risks around illegal transhipping (number of illegal transhipments, likely volumes, species composition) in order to more confidently assign best estimate and narrow the min/max range. For context, the current best estimate of the volume of illegal transhipping in the SLL sector (10,268t) is around 16% of the high seas transhipments reported to WCPFC for 2014 (62,876t) (WCPFC, 2015a). Collectively the best estimate estimates for illegal transhipment in both the TLL and SLL sectors (30,805t) is around 49% of the high seas transhipment reported to WCPFC for 2014.

Table 38: Estimated total volumes of IUU product involved in post-harvest IUU activity in the SLL sector.

Risk	BE (t)	90% range (t)
Illegal transhipping	10,268	2,875 – 20,250
Landing in unauthorised ports	2,020	638 – 3,401

Table 39: Estimated value of IUU product involved in post-harvest IUU activity in the SLL sector.

Risk	BE ($)	90% range ($)
Illegal transhipping	$36.05m	$10.09 - $71.10m
Landing in unauthorised ports	$7.09m	$2.24 - $11.94m

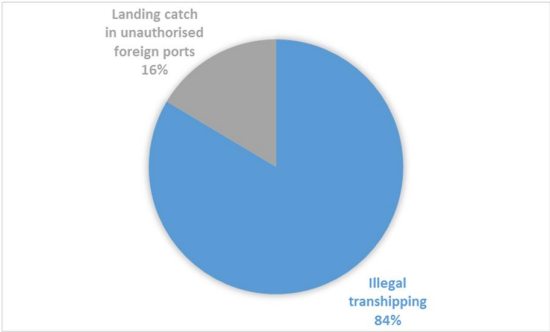


Figure 33: Contribution of each risk to total estimated IUU volume in the post-harvest sector associated with the SLL fishery.

The landing of catch in unauthorised foreign ports accounted for product valued at around $7.09m, and was ultimately not an insignificant risk in the overall scheme of SLL risks. Like illegal transhipping however, the estimates are driven by the weak information base and the broad min/max range and should be revised where possible after generating addition information.

The total volume of product involved in post-harvest risks was estimated at 12,288t (4,712t – 22,249t), and the species composition assumed to be consistent with the 'typical' catch composition of the SLL sector based on logsheet reporting (i.e. YFT – 16%; BET – 9%; ALB – 55%; BIL – 7%; OTH – 14%). Nevertheless, if illegal transhipment typically involves preferential transhipment of some species over others (e.g. bycatch, shark fins, sashimi grade target species) this should be investigated and factored into future versions of the model.

Unlike some of the other risks, there is a reasonable chance of 'double counting' if, for example, underreported catch is also illegally transhipped. This is obviously very difficult to quantify without better information on both risk areas, but should be considered further in future versions of the model.

3.5 Double counting

In any 'bottom up' approach such as this where IUU risks are quantified at a fine scale, there is potential for some 'double counting' to occur. For example, if 10t of fish were harvested illegally in an EEZ for which the vessel wasn't licensed, those same fish were then not reported in vessel logbooks, and also illegally transhipped, there is potential for those same fish to be picked up in estimates three times. To that extent, the estimates produced here could be considered an overestimate.

Nevertheless, there is a reasonable basis to suggest that the extent of double counting is likely to be relatively small in the context of the overall estimates. In the main, double counting is likely to be confined to overlaps across the four risk categories – e.g. unlicensed fishing and misreporting, or misreporting and illegal transhipping – rather than within risk categories. Because overall unlicensed fishing and post-harvest risks produced relatively small IUU estimates the potential for double counting across categories is reduced (albeit this may not be the case for the longline sectors). Moreover, for many of the unlicensed fishing and 'breaching license condition' risks (unlicensed fishing by vessels on the FFA Register, fishing in closed waters), there is a reasonable prospect that the catch would have been recorded in logbooks, at least to the extent that normal reporting occurs. This would also serve to reduce the potential for double counting.

On that basis we have not attempted to analytically reduce our estimates to account for double counting, but readers should bear the potential for this to occur in mind.

4 What are the 'real' costs and benefits of IUU fishing?

4.1 What is the real impact on Pacific Island economies?

As discussed above, ex-vessel values or market values are the most commonly used metrics by which the economic size of the IUU problem is measured, but neither is a particularly good indicator of the real impact of IUU fishing on Pacific Islands. This is primarily for two reasons:

- Firstly, the full value of the fish taken illegally would not be returned to Pacific Island countries under normal circumstances. For example, a single longline vessel may turn over $1m in revenue during a year, but the costs of production mean that only a relatively small percentage of turnover is retained as profit. License fees are typically calculated either directly or indirectly on vessels' economic profit[13] (or capacity to pay), and therefore from the original $1m in turnover the license fees returned to the Pacific Island country may be in the order of $50,000 or less (putting aside any indirect benefits gained from transhipment, provisioning, etc). Put another way, if an amount of IUU activity with an ex-vessel value of $1m was eliminated such that an additional vessel could be sustainably licensed in a fishery, the additional amount of revenue expected by the Pacific Island country would be $50,000 in license fees. The implications of these 'real' impacts on Pacific Island countries should be taken into account in future MCS planning; and
- Second, while some activities are illegal, they may not necessarily result in direct losses to Pacific Islands. Misreporting in the purse seine fishery managed under the VDS is arguably a good case in point. Under the VDS, fishing companies compete in a (relatively) open market for a limited number of VDS days. The vessel's capacity to pay, and therefore the price received by the Pacific Island country, is influenced by the catch and profitability of the catching vessel. This, in turn, will be driven by actual catches made by the vessel, rather than those reported on the logsheet (if in fact these are different). To that end, economic profits from actual catches (including any component not included in logsheets) could be expected to be incorporated into prices paid for VDS days in a competitive marketplace and is an important benefit of the VDS as currently structured. Moreover, in the purse seine fishery 100% observer coverage allows for accurate estimation of actual catches independent of logsheet reporting. This means that logsheet reported catches can be adjusted and the full economic value of the catch factored into the setting of benchmark VDS prices.

Taking these issues into account, this section provides an initial indication of a more likely 'real' impact on Pacific Island economies associated with the estimated volumes of IUU activity reported here.

Rather than ex-vessel values, a better benchmark of revenue forgone by Pacific Island countries is likely to be the rent generated by vessels from IUU activity. In general terms, 'rent' is the residual left over after production costs, capital provisions and normal profits are deducted from the revenue generated from the sale of the fish, and could be expected to be returned to coastal states under efficient access fee arrangements.

For this analysis, the forgone rent or 'economic profit' can be estimated using the Net Profit Margin (NPM) of the vessels involved in the fishery. NPM is simply a measure of the proportion of revenue

[13] Super profits take into consideration the cost of capital and are those above and beyond what an industry's normal profit should be based on its level of risk.

which can be considered actual profit[14] and is expressed as a percentage. Once the NPM has been estimated, increases in revenue from IUU activity can then be converted into foregone rent.

In the purse seine sector, the most recent economic modelling estimates that NPM ranges from -36% to 59%, with a weighted average (taking into account the numbers of vessels operating at different profit margins) of 43% (Banks, 2015; Figure 34).

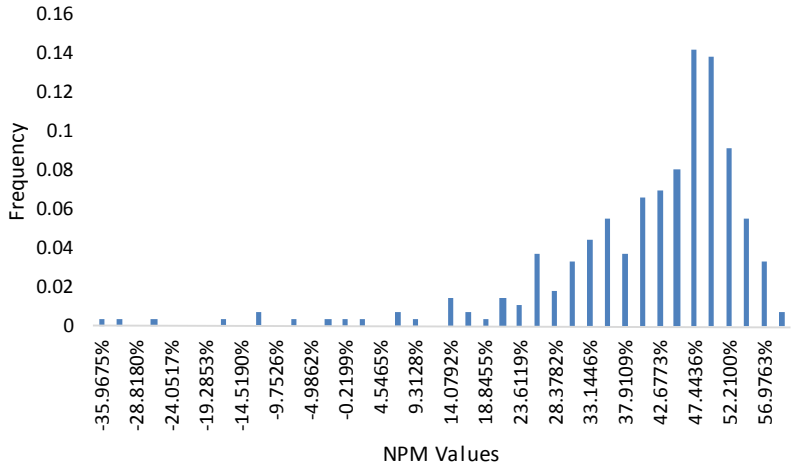


Figure 34: Net Profit Margin values in the purse seine fleet by the frequency of occurrences

In the longline sector, there was less detailed information available on specific vessel's economic performance. However, the longline fleet in general could be categorised into four main groups: Japanese longline vessels >40m, other flagged vessels >40m, Taiwanese and Chinese flagged vessels <40m, and smaller Japanese flagged vessels with gross registered tonnages of 20-120. Using FFA's vessels of good standing registry, it was estimated the proportion of vessels in each group were 4%, 35%, 54%, and 7% respectively. Taking into account each category's estimated NPM, the weighted average for the fleet's NPM was 14.54%.

Based on the ex-vessel values calculated in this study, Table 40 sets out the potential revenue forgone by Pacific Island countries in the form of lost rent or economic profit from each sector. Given the lower NPM in the longline sectors, despite having a higher ex-vessel value of 'IUU' product, the rent lost from the TLL sector is only around half that expected from the PS sector.

Table 40: Estimated IUU ex-vessel values compared with potential 'real' revenue forgone by Pacific Island countries in the form of rent, or economic profit, by fleet sector.

Sector	Revenue (ex-vessel)		Potential losses to Pacific Island countries (Economic profit)	
	BE ($)	90% range ($)	BE ($)	90% range ($)
Purse seine	$225.20m	$200.35m – $251.56m	$95.82m	$85.25m – $107.04m
TLL	$272.55m	$184.90m - $385.62m	$39.63m	$26.89m – $56.08m
SLL	$118.36m	$87.67m - $158.54m	$17.21m	$12.75 – $23.05m
Total	$616.11m	$517.91m - $740.17m	$152.67m	$135.47m - $173.23m

[14] □□□ = □□□□□□□□□□□□/□□□□□□□□□□□□□

Importantly, these estimates are not intended to be definitive and are presented mainly to highlight the point that ex-vessel values are not an effective way of measuring the 'real' impact on Pacific Island countries. **Because of the nature of access arrangements in Pacific tuna fisheries, it is possible that much of the rent associated with IUU fishing is captured anyway, and the estimates above either overstate, or are at least at the upper end of, actual impacts on the real economy.** For example, in the case of the WCPO purse seine fishery, there is a good argument that the competitive nature of the bidding process under the VDS means that rents generated through any IUU products would be captured in the prices that fishing companies are prepared to pay for fishing days and are therefore not lost to Pacific Island countries. This is probably less the case for the longline sectors where a higher proportion of fishing is undertaken on the high seas, and current access arrangements are arguably less efficient in capturing rent.

There are obviously other negative impacts associated with IUU that need to be considered in any detailed analysis of real economy-level impacts (e.g. undermining of data sets, additional MCS costs associated with deterring IUU, etc), but these would require more detailed analysis of the unique circumstances of each fishery to arrive at a more precise figure (e.g. is the revenue solely through access fees, or is revenue also lost to onshore processing?).

4.2 What is the benefit of IUU fishing to vessels?

The other important consideration in the economics of IUU fishing is the benefit to the vessel, which is different to the rent forgone by Pacific Island countries. This is because both the vessel owner's profit and the crew wages need to be taken into account.

Estimates of economic profit consider catch revenue and the cost of that catch. The cost of that catch includes the cost of labour. However, for many crew, wages are paid based on a share of catch revenue. Therefore, an incentive exists for the crew to maximise revenue because increased revenue equates to increased crew pay. On this basis, the vessel's IUU benefit is the economic profit *plus* the crew's wage.

The difference between forgone economic profit to coastal states and overall benefits to the vessel is important when considering the level of fines to set for an infringement. For example, if fines were set based on economic profit alone, a residual incentive still exists for the crew to infringe. Accordingly, fines need to be set at a level that sufficiently outweighs the full benefit of IUU activity received by the vessel.

Assuming crew wages are a share of vessel revenue and using the same weighting approach above, the WCPO purse seine fleet is estimated to have a weighted average crew share of 12.36% of vessel revenue (Figure 35). The longline sector was estimated to pay a weighted average crew share of 15.82%.

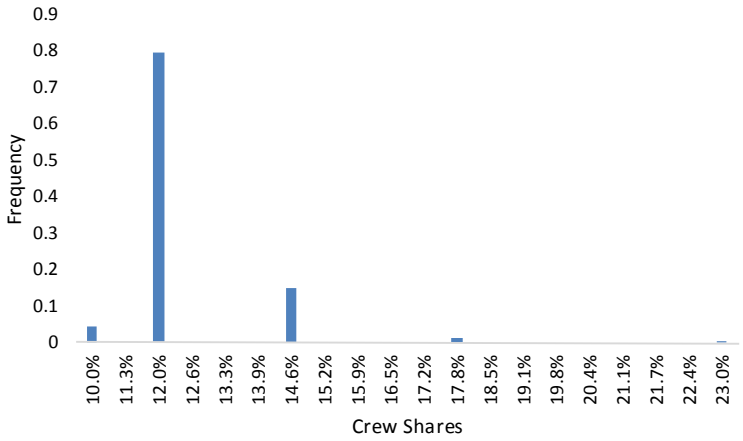


Figure 35: Crew share values in the purse seine fleet by the frequency of occurrences

Given both crew share and NPM are assumed to be directly proportionate to revenue, estimating the crew benefit of revenue gained from IUU can be added to those values in Table 40 to estimate the vessel's total benefit from IUU. These are shown in Table 41.

Table 41: Estimated IUU benefits for vessels, by fleet sector

Sector	BE ($)	90% range ($)
Purse seine	$123.65m	$110.01m – $138.13m
TLL	$82.75m	$56.14m – $112.81m
SLL	$35.93m	$26.62m – $48.13m
Total	$242.34m	$210.09m - $282.35m

Relative to the economic profit, the IUU benefit to the vessel in the purse seine sector is not substantially different. However, in the LL sectors the benefit to the vessel is double the economic profit. This is due to the relatively high crew share with respect to vessel economic profits in the longline fleets. This suggests a high incentive to infringe and has important implications for MCS planning and the settings for sanctions.

5 Main messages

Apart from the headline volume and value figures, there are a number of key messages arising from the analysis. These include:

The most commonly quoted estimate of IUU fishing in the Western and Central Pacific is between $707m and $1.5b – is this study an 'apples Vs apples' comparison?

No. The previous study (Agnew et al, 2009) used a 'top down' approach that looked at IUU fishing across a suite of species wider than tuna (e.g. demersal fish, shrimp) as well as including all areas within FAO Statistical Area 71. This meant that many areas outside of the Pacific islands region, including parts of Indonesia and the Philippines, were included in the estimates. Relatively high levels of IUU fishing in coastal states on the western seaboard of FAO Area 71 influenced the overall results. Interestingly, no SIDS FFA member EEZs were included in the countries selected to inform the time series data to underpin the regional estimates. In addition, both the timeframes and economic values (we used 'ex-vessel' price factoring in differences in markets between species/sectors, they used FAO data with a single price point per species) used are different and preclude direct comparisons.

It's still the licensed fleet

A key conclusion of analytical studies undertaken to support the development of the FFA Regional Monitoring, Control and Surveillance Strategy (MRAG AP, 2009) study was that, on the balance of probabilities, illegal and unreported fishing by licensed vessels (i.e. vessels on either the FFA RR or WCPFC RFV) is likely to be a more significant problem than illegal fishing by vessels unlicensed anywhere in the region. This study provides a more empirical basis to support that conclusion (albeit there may be areas, particularly on the fringes of the Pacific Islands region which are exposed to poaching by vessels based outside the region [e.g. Palau], where the conclusion may not hold).

Assuming catch transhipped illegally is taken by licensed vessels, IUU fishing by the licensed fleet accounts for over 95% of the total volume and value of IUU activity estimated here. This proportion rises to 97% if unlicensed fishing by vessels on the FFA RR or WCPFC RFV are considered 'licensed'. This is perhaps not surprising given entry onto the WCPFC RFV comes at very little cost, and licensing within many FFA member countries comes with few constraints, particularly in the LL sector.

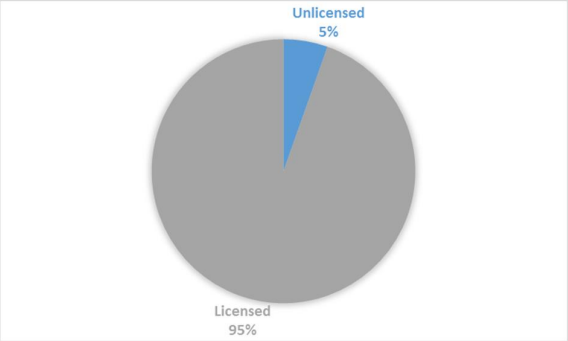


Figure 36: Estimated contribution to the overall volume of 'IUU' product in Pacific Islands region tuna fisheries by licensed and unlicensed fleets.

Nevertheless, the finding has important implications for MCS planning and investment priorities given 'we know about' the licensed fleet (i.e. they are tracked through VMS, in the case of the PS sector have observers on board, etc) and are not having to spend large amounts of money attempting to find unregulated or unlicensed vessels we don't know about.

Stronger catch monitoring arrangements are required in the longline sector

An important weakness in the existing MCS regime in Pacific tuna fisheries is the absence of effective independent catch monitoring and verification in the longline sector. Very few fleets are subject to the required WCPFC benchmark of 5% observer coverage, large portions of the fleet tranship at sea and are not subject to regular dockside compliance inspections and operational logsheet coverage for the longline sector in many coastal states is far lower than that achieved for purse seine. Moreover, delays in logsheet submission mean that there is little scope for cross-verification of vessel records against what limited independent estimates exist (e.g. observer records), or near-real time catch reconciliation. The net effect is to undermine confidence that the existing arrangements would be capable of detecting and accounting for 'leakage' from the system, and has important implications for the integrity of catch-based CMMs.

Collectively, the reporting and post-harvest offences in the longline sectors accounted for around 58% of the total ex-vessel value of IUU activity estimated here. While there is uncertainty around these figures, there is little doubt that additional arrangements to independently verify catch and effort throughout the supply chain.

Considerable uncertainty exists on the extent of illegal transhipment

The estimates of IUU activity generated here suggest that illegal transhipment, particularly in the longline sectors, is potentially a significant contributor to IUU activity, accounting for around 26% of overall predicted ex-vessel value. Anecdotal information received from some industry sources suggests that transhipment on the high seas, including consolidation of catch amongst vessels, is not uncommon and initial analysis using novel VMS/AIS tracking technology suggests the possibility that more transhipments are occurring than are otherwise being reported to authorities.

Nevertheless, the information available to support quantification is currently weak and there is uncertainty in the outcomes which are largely based on expert judgement. WCPFC (2013a) acknowledged the challenges associated with tracking high seas carriers and transhipment activity during the study period. Moreover, the absence of other forms of independent monitoring (electronic monitoring, observers) on the majority of longline vessels and the lack of any obligation to report non-high seas transhipment/unloading (e.g. fish transhipped in FFA ember ports) means that it is not possible to undertake a catch reconciliation exercise at all stages of the supply chain (to detect 'leakage'), and otherwise to disprove the possibility that illegal transhipping is occurring.

With that in mind, and with a view to both strengthening the integrity of catch monitoring arrangements and improving estimates of illegal transhipping activity in future iterations of the model, consideration should be given to additional measures to better monitor, control and estimate the extent of transhipping activity in the region. These are discussed in more detail in Section 6 and Annex 7.

Unlicensed fishing appears to be an issue at the margins

Unlicensed fishing appears to be an issue at the margin in Pacific tuna fisheries, both geographically and metaphorically. Unlike some areas where unlicensed fishing is thought to account for a large component of IUU activity (e.g. West Africa), of the risks quantified here, the three forms of unlicensed fishing collectively accounted for only around 3.4% of total ex-vessel IUU value. Moreover, of the areas where it is thought to occur, the highest risk areas appear to be the western and (to a lesser extent) eastern fringes of the Pacific Islands region, and on the boundaries of EEZs, particularly in the longline fishery. The apparent absence of frequent, large scale unlicensed fishing is consistent with the observation made above that accessing legitimate licenses in the Pacific is not particularly difficult.

The relative risk associated with unlicensed fishing compared to other risks has important implications for MCS planning and investment. Notwithstanding tracking through VMS on 'licensed'

vessels, the most effective way to detect and collect evidence of unlicensed vessels is through aerial surveillance which is typically extremely expensive (one estimate reviewed suggested ~ $19,000/hr on average). Clearly some level of aerial surveillance coverage is required to act as a deterrent to increases in unlicensed activity, however in an environment where funding for MCS is limited, these costs need to be considered in the context of other risks and alternative investments that might achieve better 'bang for buck'.

All IUU activities are not equal – some 'cost' more than others

To allow cost comparisons between risks and to achieve consistency with previous studies, we used 'ex-vessel' values to highlight the economic extent of IUU activity in each sector. However, on its own ex-vessel price is not a particularly good measure of *actual* losses to FFA members.

For example, because there are few independent mechanisms to verify catch in the longline sector, unreported catch in vessel logbook is likely to result in unaccounted for catch. This is obviously a problem for management and stock assessments, but if there is a link (however indirect) between catches reported and license fees, license fees are likely to be under-valued, resulting in actual losses to FFA members. By contrast, in the purse seine sector 100% observer coverage means that misreported catches are likely to be picked up, resulting in no unaccounted for catch[15]. Moreover, because of the structure of the VDS where vessels compete for limited days in a relatively competitive market, the value of the catch taken by the vessel will indirectly be factored into VDS fees. This is because the vessel will be well aware of their own catches and factor those into the price they're willing to pay for days. To that extent, there is a strong argument that there are few actual losses from purse seine misreporting. This is an important benefit of the current VDS structure.

By contrast, if a vessel falsely claimed a non-fishing day for a day they actually fished, this would result in an actual loss, of the price of a fishing day, to the FFA member.

In general, those IUU activities that result in catch which is ultimately unaccounted for, or unauthorised/illegitimate access to fishing opportunities that would otherwise need payment (e.g. falsely claiming a non-fishing day; unlicensed fishing) will result in actual losses to FFA members.

More accurate estimates of IUU activity require stronger monitoring and better coordination of relevant statistics

The information base to support quantification of many of the risks identified in this study was limited, and as a result, many estimates were characterised by high levels of uncertainty. While the estimates produced by this study form an important 'first cut' quantification and establish a framework by which IUU activity can be estimated, an important aim of future iterations of the model should be to have the capacity to more confidently assign best estimates to each risk (and in particular the key ones identified here) and to narrow the min/max ranges based on credible empirical information.

Achieving this will require stronger monitoring, particularly of the licensed sector (which if integrated effectively will also meet both compliance and scientific monitoring objectives), as well as a greater emphasis on the collection of relevant, quantifiable statistics associated with each risk. While in some cases this will require 'new' initiatives (e.g. electronic monitoring, increased observer and dockside inspection coverage in the LL sector, catch documentation schemes), our observation is that in many cases it will simply require using existing monitoring, surveillance and information management architecture to its fullest potential. For example, comprehensive statistics on numbers of aircraft and surface platforms used, 'on task' aerial surveillance hours, surface platform hours

[15] The only 'cost' is in having the monitoring arrangements, which arguably should be cost recovered from industry in any event.

underway, effective surveillance coverage and other metrics are kept for each of the regional operations in the region, however only very limited, summary statistics are kept on the outcomes in the way of infringements detected and prosecutions arising. Most outcomes are reported simply as the overall number of apprehensions/infringements detected, with little detail on the type of infringement. This makes analysis of an otherwise potentially very useful dataset difficult. Considerable benefit could be gained by keeping more detailed statistics/information on offence types, which could then analysed statistically (e.g. unlicensed fishing detections/'on task' air hour/nm for surface platforms) to estimate IUU volumes and track trends over time (and open up other avenues for estimation of specific risks, for example, in the same way Agnew and Kirkwood, 2007, used fisheries patrol cruise data to estimate unreported catch in the CCAMLR toothfish fishery).

Another example is the FFA Prosecutions and Violations database (now incorporated into the Regional Information Management Facility - RIMF) which seeks to consolidate the infringement and prosecution information from all FFA members to allow for region wide analysis of compliance trends, but has not been updated since around 2009.

In order to strengthen the information base for future assessments, Annex 6 sets out measures for each of the main risks that could be taken to strengthen the underlying data in preparation for future estimates. Where resources are scarce, priority should be given first to risks that are both highly uncertain and potentially significant both in economic and sustainability terms.

Stronger MCS arrangements in zone must be mirrored on the high seas

The outcomes of this study argue for stronger catch monitoring and other arrangements across all sectors (in particular the LL sectors) to better understand and deter IUU activity. FFA members have the power to implement and enforce new arrangements within their own waters, however given the shared nature of stocks in the region similar strengthening of MCS arrangements is required also on the adjacent high seas. This is particularly critical for the effective implementation of conservation and management measures which both straddle in zone and high seas jurisdictions (e.g. BET catch limits in CMM 14-01). To this end, while FFA should rightly examine measures to strengthen in zone arrangements, both individually and cooperatively, ultimately cooperation is required with the WCPFC and its members to establish effective monitoring and enforcement systems which ensure the integrity of CMMs across the full footprint of the target stocks.

Is it OK to allow fishing in the absence of effective MCS arrangements?

The outcomes of this study argue that new monitoring and control arrangements are required to verify effective compliance with regional conservation and management measures, particularly in the longline sector. As a general principle, the costs associated with these new measures should not fall to FFA member governments, but be cost recovered from industry, either directly or indirectly through license fees[16]. Given the marginal economics of many longline vessels, the natural response is likely to be that the monitoring arrangements are unaffordable. However, if FFA members rightly take the view that funding effective MCS arrangements is non-negotiable (i.e. it is the minimum 'price of entry'), the natural implications is that some of the more marginal vessels will drop out, leaving a more streamlined longline fleet. Importantly, given less competition and the potential for higher catch rates, fewer licensed vessels should not automatically mean a drop in license fee revenue. Higher per license fees may be able to be charged to take account of improved profitability, and may make achieving the MEY objectives of many FFA members more attainable.

[16] Arguably the 'first principle' of cost recovery should apply here – i.e. would the costs (e.g. observers, VMS, EM) be required if the fishing activity wasn't taking place? If 'no', then the costs are attributable to industry.

What's in a name? - 'IUU' is not straightforward

While the formal definition of 'IUU fishing' in the IPOA-IUU is relatively clear in theory, applying it for the purposes of quantifying its nature and extent presents practical challenges and questions. For example, where a vessel licensed to fish in an EEZ fails to submit a logbook to the coastal state as required, but submits a logbook of the same catch to their flag state such that the catch is ultimately included in regional catch and effort statistics and factored into stock assessments, does the failure to submit the logbook to the coastal state mean the catch should be included in estimates of IUU fishing? Or if the vessel ultimately submits the logbook to the coastal state but does so after the required deadline for submission – should this be recorded as IUU fishing? Or for example, if a vessel allowed one of their FADs to travel through an EEZ for which the vessel is not licensed – which recent FAD tracking work suggests is a regular occurrence (Figure 37) and which could be interpreted as illegal under a broad reading of the definition of 'fishing' in the WCPFC Convention – should the catch associated with this FAD be included in overall IUU estimates?

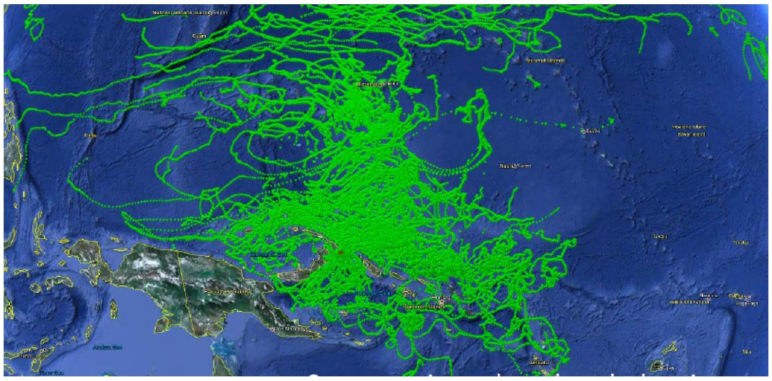


Figure 37: FAD buoy tracks from three vessels for six months. (Courtesy PNA)

The answers to these and other similar questions can have a substantial impact on the overall estimates of IUU fishing in the region. For example, previous studies have shown that the level of longline logbook reporting to many FFA member states is relatively weak, with many members reporting coverage rates of <50% (MRAG AP, 2009). The inclusion of some or all of this catch as 'IUU' would raise the estimates of IUU fishing in the region considerably. For example, if 30% of the longline catch in FFA member EEZs alone was not covered by logbooks submitted by vessels, the value of that catch alone was around $177.23m in 2014.

For the purposes of this study, we applied a general rule of thumb that all instances of unlicensed and unregulated fishing, all instances in which fish were taken in areas, at times, or by methods not authorised under license conditions, and all occasions where fish taken under a legitimate license were not reported to either the coastal or flag state (i.e. 'unaccounted for catch') should be included as IUU fishing. This rule of thumb does not hold for all potential IUU circumstances, but did serve as a useful initial guide.

Future MCS risks

The nature of illegal fishing activity is dynamic and changes over time as the mix of incentives, disincentives and the regulatory environment change. To that end, there are a number of risks that didn't feature heavily in the current analysis (given the study period) which we expect will need to be examined in future versions. In particular, there is an increasing move in the Pacific region towards the application of catch (and effort) limits, both at the national and individual vessel levels. This is perhaps most evident in the PNA purse seine VDS, but also in the BET catch limits in CMM14-01, the upcoming rollout of the PNA longline VDS, the regulation of FAD numbers and FAD sets under CMM 14-01 and the possible transition of the current purse seine VDS system to a catch-

based model. Effective MCS arrangements will be required to monitor compliance with these arrangements and estimates of any illegal activity will need to be factored into future models.

6 What additional measures can be taken to better understand and reduce IUU fishing?

Considerable efforts have been taken at the national, sub-regional (FFA/SPC/PNA) and regional levels (WCPFC) to mitigate IUU fishing in Pacific tuna fisheries. Many of these are likely to have been highly effective at achieving their intended purpose (e.g. the FFA and WCPFC VMS, the FFA Regional Register, the FFA HMTCs, the Pacific Patrol Boat Program, Niue Treaty and subsidiary agreements, 100% observer coverage in the purse seine fishery, etc) and will have contributed to the relatively low estimates of IUU fishing across a number of sector/categories. Nevertheless, it is clear from the results of this study that considerable uncertainty still exists in relation to IUU activity across a range of key risks, and additional measures are required to strengthen incentives for voluntary compliance, reinforce deterrents to non-compliance and improve monitoring throughout the supply chain.

Ultimately the most practical mix of MCS arrangements to deal with IUU fishing will be a function of the balance between the likely effectiveness of the measure in treating priority risks, practicality of implementation and overall costs. An outline and discussion of possible additional MCS measures that can be taken to further mitigate IUU fishing in WCPO tuna fisheries is provided in Annex 7. The main features and benefits of each MCS activity are described, together with the relative costs and risk categories that they're likely to address. A suggested level of priority is also given taking into account the main IUU issues identified in this report as well as issues such as likely effectiveness and implementation costs.

A discussion of the main needs and relative priorities in each fishery is included below. For convenience both longline sectors are discussed together given future needs are likely to be similar.

6.1 Longline

6.1.1 Strengthening catch monitoring

The undoubted priority in the longline sector is to strengthen catch (and effort) monitoring of licensed vessels throughout the supply chain. Current monitoring arrangements are weak or largely absent for many fleets (very limited observer coverage, poor rates of logsheet submission, limited dockside monitoring coverage), meaning that opportunities for independent verification of catches is limited. The net result is that considerable uncertainty exists in current estimates of IUU activity in the sector and little confidence that current monitoring mechanisms could detect all instances of possible 'leakage'. This is particularly critical for both stock assessment purposes and for compliance with CMMs based on catch (e.g. WCPFC BET catch limits).

There are a number of measures that could be taken to strengthen monitoring throughout the supply chain. Many of these are integrated to the extent that they serve both scientific and compliance purposes. While the costs and benefits of each measure should considered, we note that many can be implemented relatively cost effectively, or at neutral cost to FFA members if cost recovered. Key measures include:

- Strengthening observer coverage, consistent with the required 5% WCPFC benchmark;
- More active debriefing of LL observers to detect and correct potential errors in reporting, as well as investigating instances of likely misreporting;
- Electronic reporting and monitoring;
- Development and implementation of a catch documentation scheme (CDS) for key species;
- Stronger monitoring and control of transhipment;
- More frequent compliance dockside inspections;
- Stronger sanctions for catch reporting violations, including inaccurate reporting and failure to submit logsheets;

- More active cross-verification of independent data sources to identify discrepancies (e.g. logsheet Vs observer Vs unloading, etc). This is most likely to be achieved through enhanced use of through information management systems, supported by stronger analytical capacity in national and regional agencies.

6.1.2 Transhipment regulation and monitoring

A key uncertainty in the estimates of IUU activity in the longline sectors is the extent to which unauthorised transhipment at sea takes place. The absence of any centralised regional accounting of unloads means that it is difficult to reconcile reported catches with transhipments/unloads, and the absence of other effective MCS measures (e.g. capacity to undertake dockside monitoring, observer coverage) leaves open the possibility that considerably more transhipment at sea takes place than is otherwise reported.

The outcomes of this analysis suggest that additional monitoring and control of transhipment is required both to better verify longline catches and to strengthen our understanding on the extent to which transhipment takes place. Key measures that might be taken include:

- Prohibition of at sea transhipment – this is likely to meet with resistance from the longline fleet, although WCPFC analysis indicates that most high seas transhipment occurs within 200nm of port, many longline fleets have already adapted to in port transhipment and the purse seine fleet has already adapted operationally and financially to a prohibition on at sea transhipment (WCPFC, 2013b). Even where transhipment at sea is prohibited, exceptions could be made for very limited circumstances – e.g. at sea consolidation of catch where 100% observer coverage exists and prior notice;
- Greater use of analytical techniques to detect potential unreported at sea transhipments (e.g. through analysis of VMS/AIS track information, use of e-monitoring sensors);
- Requirement for reporting of in port unloads for product taken within the WCP-CA – this would potentially allow for reconciliation of catch reported in logsheets against that entering the next stage of the supply chain. A similar recommendation was made by McCoy (2012);
- Electronic monitoring on all longline, carrier, mothership and bunker vessels;
- Strong sanctions for illegal transhipment.

6.1.3 Non-compliance with other license conditions

Collectively the 'non-compliance with other license condition risks' accounted for around 7.2% of the total longline IUU activity, and slightly higher in value terms when shark finning is included. The main contributors in both the TLL and SLL sectors were the use of non-prescribed gear and shark finning. While some analytical data existed on shark finning, very little exited on the use of non-prescribed gear. Importantly, many of the possible measures suggested to better monitor catch in the longline fishery would also assist in addressing this risk. These include:

- Strengthening observer coverage;
- Electronic monitoring;
- Increased dockside compliance inspections.

6.1.4 Unlicensed fishing

The three forms of unlicensed fishing assessed here collectively accounted for only around 2.5% of total estimated IUU activity by volume in the longline sectors. Of these, the main contributor was unlicensed fishing by vessels on the FFA Regional Register, which accounted for around 51% of overall volume for both sectors combined. While the results of this study suggest that other forms of IUU activity deserve greater attention, maintaining an effective level of deterrent is important to guard against higher levels of unlicensed fishing in future. This is particularly the case if access to

longline licenses becomes increasingly restricted under new initiatives such as the PNA longline VDS. Additional measures that might be taken include:

- Electronic monitoring (which, matched with VMS, could detect fishing activity and position);
- Additional analysis of VMS/AIS tracks to identify potential illegal fishing activity (this could be built on the existing 'compliance index' system to identify vessels of interest);
- Stronger monitoring of ALC activity (e.g. active intervention where an ALC appears to be non-responsive and a real time public list of ALCs manually reporting);
- Use of synthetic aperture radar (satellite imagery).

For areas where unregulated fishing is a particular problem (e.g. the western fringes of the study area), the use of novel aerial surveillance tools such as drones and satellite imagery may assist in supplementing more conventional aerial and surface surveillance.

6.2 Purse seine

As a general rule the MCS arrangements in place for the purse seine fishery are considerably stronger than those for longline. Vessels are subject to 100% observer coverage, are required to tranship in port, generally demonstrate higher levels of logsheet coverage, and are subject to higher levels of dockside inspection. Moreover, the fact that there are fewer vessels makes them logistically easier to monitor. Nevertheless, this study has highlighted a number of areas in which stronger MCS arrangements could lead to improved economic, scientific and safety outcomes.

6.2.1 Independent verification of fishing activity

Under the current structure of the purse seine fishery management, a number of key risks relate to whether or not fishing is occurring, and if so, what type. These risks include the potential for falsely claiming of non-fishing days (NFDs), as well as illegal FAD fishing during the closure period, and have the potential to result in substantial economic losses to FFA members (as well as sustainability consequences). With that in mind, an important need is for FFA members to have the capacity to independently verify fishing activity.

Verification of non-fishing days

A key issue for integrity of the VDS as currently structured is the extent to which days spent searching for fish, or otherwise actively in support of fishing, are claimed as 'non-fishing days' (NFDs) (e.g. Arnason, 2014). While this study has assumed that days accepted as NFDs by the relevant flag or coastal state are authorised, and therefore not illegal or unreported, fraudulently claiming non-fishing days on the part of the vessel has the potential to undermine the economic and sustainability benefits of the VDS (as well as undermining the scientific basis for calculating the TAE).

The key need for PNA parties is to have the capacity to verify with a high degree of certainty the legitimacy or otherwise of NFDs applied for by vessels. Given the potential economic losses associated with falsely accepting a legitimate fishing day as an NFD (for example, 1000 'false' NFDs at $12,000/day equates to $12m in directly lost revenue), there is a strong case to be made to ensure MCS arrangements are in place to ensure no 'leakage'.

While improvements in the treatment of NFDs have undoubtedly been made (e.g. through collection of better real time observer data and more stringent evaluation of claims facilitated through the PNA FIMS), there are a number of additional measures that could be taken to strengthen the capacity of PNA parties to determine whether 'fishing' occurred. In particular, the use of EM technology may offer an additional layer of independent evidence to assess NFD claims. Given the presence of an observer on board each vessel to collect other data (catch volume, composition), EM tapes may only need to be reviewed to verify NFD applications (or other incidents requiring verification of fishing activity). This could be structured to keep ongoing operational costs low, and be undertaken on a user-pays basis (i.e. only those vessels applying for NFDs would pay costs

associated with reviewing tapes). Equally, given the current reliance on the observer to verify, or otherwise, NFD claims and the considerable sums of money involved, the use of EM technology would add an additional degree of safety to the observer's position, as well as providing some form of 'insurance policy' for both parties.

Illegal FAD fishing/catch discarding

Another main uncertainty highlighted in this study is the extent to which associated sets occur during the FAD closure, and to a lesser extent the degree to which catch discarding occurs. The verification of compliance with these measures is almost entirely reliant on observer reporting at present. Given the potential economic advantages of FAD fishing over free school sets (higher average catches; fewer 'skunk' sets), this places observers in a very difficult position to the extent that they may be offered inducements to misreport set type, and if they refuse, it may compromise their safety. As with the verification of NFDs, EM technology offers considerable potential to independently verify whether illegal FAD fishing has occurred, and similarly provides a deterrent to bribery if both vessel and observer know they are being watched. To that end, the presence of an on board camera should serve to improve the capacity to independently verify fishing activity, as well as improve the safety environment for the observer. We note that anecdotal evidence suggests that some vessels complying with commercial 'FAD-free' schemes have voluntarily installed cameras to verify set type.

6.2.2 Catch verification through cannery data

A key uncertainty in the purse seine fishery is the extent to which catch reported on vessel logsheets and observer estimates reflect the actual catch. Both sets of data reflect estimates made at sea and are subject to their own inherent biases (e.g. Lawson, 2010; Hampton and Williams, 2011). In most cases, the first time purse seine catches are weighed is during sorting at canneries, where catches are graded accurately into species and size class. The results of the catch weighing and sorting process is reflected in 'outturn reports', which set out the catch weights and size classes in the catch by species. Our experience in auditing tuna canneries to verify traceability arrangements suggests that separation of catches into species and size grades is undertaken with good precision and out-turn reports (which form the basis of payment for vessels) are considered to be accurate and appear to be accepted as such by the supply chain.

Provided adequate traceability exists and with cooperation from canneries, the use of outturn reports is potentially a valuable independent estimate of catch at the trip level (at least for retained target species). These could be compared to both vessel and observer estimates to identify discrepancies at the trip and overall level (given the mixing of sets and wells on carrier vessels, verification on a set by set basis is unlikely). Our experience suggests it would not be difficult to link the outturn report to the relevant vessel logbook and observer report based on the trip details available to the cannery (e.g. vessel name, trip dates, transhipment vessel name, port of transhipment, etc).

Importantly, generating value from this approach may not require all trips to be validated (which may be impractical in any event if not all canneries participate in a program). An appropriately sized statistical sample of trips may be sufficient to calibrate catches across the fleet (or fleets) which may be valuable for both stock assessment and detecting IUU activity. We note that this idea is not new and has been the subject of a WCPFC CMM (09-10), which still on the books. We also note that funding has been secured by SPC, ISSF and WCPFC to investigate the potential of this approach and we encourage its evaluation.

6.2.3 FAD tracking and management

Although not as clear cut as the act of setting a net around a school of fish, there is a case to be made that the setting of FADs in waters for which no fishing license exists (or more likely allowing

them to drift into these zones) may constitute illegal 'fishing' under the broad definition of fishing in most FFA member legislation, and under the WCPFC Convention[17]. Equally, there is an argument that leaving FADs in the water during the FAD closure period, when they continue to attract fish, and which may be caught on the day of opening, also constitutes 'illegal' fishing. Irrespective of the legal interpretation however, there is an argument that stronger control and management of FAD usage is required if such usage undermines the intent and effectiveness of the FAD closure. Moreover, improved registration and tracking of FADs would assist in monitoring compliance with the FAD sets during the closure period, as well as compliance with FAD management plans under CMM 14-01.

6.2.4 Unlicensed fishing

As in the longline sector, unlicensed fishing in its various forms contributed only very minor amounts to the overall estimated volume of IUU product in the purse seine fishery. To that end, there appears to be little call for additional investment in MCS arrangements specifically targeting these types of risk in the purse seine fishery, however we note that some of the initiatives discussed above (e.g. EM technology) would have indirect benefits in detecting unlicensed fishing.

[17] Part I, Article I - "fishing" means: (iv) placing, searching for or recovering fish aggregating devices or associated electronic equipment such as radio beacons; (v) any operations at sea directly in support of, or in preparation for, any activity described in subparagraphs (i) to (iv), including transhipment.

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Annex 1: Terms of Reference

Title

THE QUANTIFICATION OF IUU FISHING IN THE PACIFIC ISLANDS REGION[18]

Background

Illegal, unreported and unregulated (IUU) fishing is a major contributor to declining fish stocks and marine habitat destruction. Globally, IUU fishing takes many forms both within nationally-controlled waters and on the high seas. While it is not known for sure how much IUU fishing is taking place, some estimates indicate that IUU fishing accounts for about 30 per cent of all fishing activity worldwide.

Strong governance of the high seas through regional fisheries management organizations (RFMOs) is integral to reducing illegal fishing activities. An increasing number of RFMOs are using port and trade measures to discourage IUU fishing activity. Measures include not allowing vessels suspected of fishing illegally to dock or unload in a country's port and developing IUU lists of vessels taking part in illegal fishing activities.

In 2009, a global study[19] stressed the contribution of illegal and unreported fishing to overexploitation of fish stocks and is a hindrance to the recovery of fish populations and ecosystems. This study provided a world-wide analysis of illegal and unreported fishing. Reviewing the situation in 54 countries and on the high seas, the study estimated that lower and upper estimates of the total value of current illegal and unreported fishing losses worldwide are between $10 bn and $23.5 bn annually, representing between 11 and 26 million tonnes. The study noted significant regional differences in the level and trend of illegal fishing over the last 20 years and reported a significant correlation between governance and the level of illegal fishing. Developing countries are most at risk from illegal fishing, with total estimated catches in West Africa being 40% higher than reported catches. Such levels of exploitation severely hamper the sustainable management of marine ecosystems. However, estimates from the same study of IUU catch by species group indicate tuna fisheries to have some of the lowest levels of illegal and unreported catches (around 4%). Although there have been some successes in reducing the level of illegal fishing in some areas, these developments are relatively recent and follow growing international focus on the problem.

Previously published IUU loss estimates for the WCPFC region are somewhere in the region of 750,000 million to 1.5 Billion US dollars a year. However, there have been limited attempts to further quantify this figure in the context of contemporary Monitoring, Control and Surveillance (MCS) applications and advances in Information Management.

As part of the EU funded DEVFISH II project, FFA is tasked to provide an updated quantification of IUU in the tuna fisheries of the Pacific Islands region. FFA and SPC have a team of personnel associated with aspects of this work (including information management, data streaming and comparative analysis, VMS, Observers and catch certification). The current study proposes the recruitment of an IUU quantification specialist team to work with the designated FFA and SPC personnel on an agreed methodology to provide a detailed and up to date report on the improved quantification of IUU fishing. This would examine both the volume and landed value of IUU catches,

[18] The Pacific Islands Region is considered to comprise the EEZs of FFA's 15 Pacific Island member countries and adjacent high seas areas in the tropics, noting that data limitations may preclude some analyses for these high seas areas.

[19] Agnew DJ, Pearce J, Pramod G, Peatman T, Watson R, et al. (2009) Estimating the Worldwide Extent of Illegal Fishing. PLoS ONE 4(2): e4570. doi:10.1371/journal.pone.0004570

as well as general estimates of the impact on Pacific Island countries, and the economic costs to them, of different components of the IUU catch.

FFA and SPC will provide all available data, and assist with extractions, but consultants should be aware that there are limitations and gaps in data holdings. In particular landings data and licensing information is incomplete for some countries.

Consultants should note that FFA uses the following definition of IUU fishing, derived from the FAO international plan of action:

Illegal Fishing referring to activities:

- Conducted by national or foreign vessels in waters under the jurisdiction of a State, without permission of that State, or in contravention of its laws and regulations;
- Conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or
- In violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.

Unreported Fishing referring to fishing activities:

- Which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or
- Undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization.

Unregulated Fishing referring to fishing activities:

- In the area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; or
- In areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law (FAO, 2001).

Terms of Reference

1. Provide a summary of previous IUU quantification work undertaken in the region's fisheries, particularly tuna fisheries, and review the methodology applied to this work.
2. Review the information available through SPC and FFA to support comparative data analysis (including log sheets, observer reports, VMS, AIS, landing inspections, catch certification, MCS operations, Regional Information Management Systems(RIMF) and national Information Management Systems (IMS); and develop a robust and statistically sound methodology that makes best use of this information to quantify the volume and landed value of IUU catches, identifying clearly the different components of illegal, unreported and unregulated fishing catches.
3. Use all available information to provide a model for the nature and extent of IUU fishing in Pacific Island tuna fisheries and estimate the volume and gross landed value of catches involved.

4. Examine the impacts of IUU fishing in the tuna fisheries on Pacific Island countries, and develop estimates of the economic losses that they incur as a result of this level of IUU fishing (for example potential access fee revenue lost, impacts on the profitability of domestic fishing operations, etc.)
5. Give consideration to the current status of implementation of the Regional Monitoring, Control and Surveillance strategy (RMCSS) and the regional capacity to effectively manage IUU fishing.
6. Give consideration to the costs and benefits of further improvements to IUU monitoring, detection and elimination.
7. Work in close consultation with a nominated team of FFA/SPC staff and advisers so as to ensure all available relevant information is utilised in the preparation of the study findings and report.

Anticipated Outputs

The principal output from the study will be a detailed technical report and associated appendices that comprehensively address the terms of reference and provide a solid methodology for the estimation of IUU quantification.

The report should also provide recommendations to the Secretariat as to what additional activities or actions could be taken for ongoing estimates of IUU quantification and the increased eradication of IUU activity in Pacific Islands region.

The consultants will be required to submit a draft report for comment and review, and take account of comments before compiling the final report.

Annex 2: Ex-vessel values

Table 42: Ex-vessel market value by species (US$/MT) (Kirchner et al., 2014; Banks, 2015; author's calculations)

	SKJ	YFT	BET	ALB	BIL	OTH	SHK Fin
Purse Seine	$1,100	$1,444	$1,314			$1,100	$20,000
Tropical Longline		$5,218	$6,207	$2,678	$4,892	$2,678	$20,000
Southern Longline		$5,218	$6,207	$2,678	$4,892	$2,678	$20,000

Annex 3: IUU Activity descriptions

Table 43: IUU activity descriptions

Risk/Activity	IUU	
Unlicensed/unauthorised fishing		
Unauthorised fishing by vessels on the FFA Regional Register	I	This activity involves fishing by vessels on the FFA Regional Register (i.e. licensed in at least one FFA member EEZ and therefore reporting via VMS to FFA) in an EEZ for which they have no valid license or authority to operate. This could colloquially be referred to as 'border hopping'.
Unauthorised fishing by vessels on the WCPFC RFV but not on the FFA Regional Register	I	This activity involves fishing by vessels flagged to WCPFC CCMs but not licensed in any FFA member EEZ (both authorised and not authorised to fish on the high seas in the WCPF Convention Area) in jurisdictions for which they have no valid license or authority to operate. This could involve, for example, a CCM vessel authorised to fish on the high seas who fishes in an FFA member EEZ, or a domestic vessel of a WCPFC CCM not authorised to fish on the high seas who fishes in an FFA member EEZ.
Unregulated fishing	URG	In the context of this study, unregulated fishing occurs when (i) a vessel flagged to a state who is not a member of the WCPFC fishes inside the Convention area. For convenience (although it would probably more accurately be termed 'illegal fishing' in the context of the FAO IUU definition) we have included in this category vessels flagged to WCPFC CMMs but who are not on the WCPFC RFV. This includes domestic vessels of WCPFC CMMs authorised only to fish in their own EEZ. From a 'visibility' point of view these vessels are the same as unregulated vessels because they are not reporting to either FFA or WCPFC VMS.
Misreporting		
Misreporting of target species	URP	Misreporting of target species can include both non-reporting (or under-reporting) and mis-identifying (reporting one species as another species). In the purse seine sector, this could include reporting yellowfin as skipjack for convenience, or under-reporting the amount of skipjack taken. In the longline sector, this may include failing to report discarded target

Risk/Activity	IUU	
		species, or under-reporting both number and weight of target species. All catch, both retained and discarded, is required to be reported under the FFA Harmonised Minimum Terms and Conditions for Foreign Fishing Vessel Access (HMTCs)[20].
Misreporting of byproduct species	URP	This is the same as above but for non-tuna species.
Non-compliance with license conditions		
Use of non-prescribed gear	I	This occurs when a vessel uses fishing gear other than that allowed for under their relevant license or authority to operate. In the longline sector, for example, this may include using wire traces where such apparatus is prohibited.
Fishing on FAD when not authorised (PS only)	I	This occurs when a vessel fishes on a FAD or floating object in contravention of agreed FAD-closure measures, or in contravention of an agreed FAD management plan.
Fishing inside closed waters within EEZs	I	This occurs when a vessel fishes within areas to which they are prohibited under license conditions or other arrangements. This would include, for example, fishing within areas around islands closed under license conditions in most FFA member EEZs.
Shark finning	I	This occurs when a vessel removes and retains the fins of a shark while discarding the carcass at sea in contravention of regional CMMs.
Post-harvest IUU		
Illegal transhipping	I	This occurs when a vessel tranships catch in contravention of relevant license conditions or other regional agreements.
Landing of catch in unauthorised foreign ports	I	This occurs when a vessel lands catch in a foreign port in contravention on licensing or other agreements. For example, Palau requires that all catch taken in Palau's EEZ is landed at Malakal Harbour. Catch landed at ports other than Malakal could be considered IUU.

[20] http://www.ffa.int/system/files/HMTC%20FFC77%20Approved_0.pdf

Annex 4: Reporting comparisons

PURSE SEINE

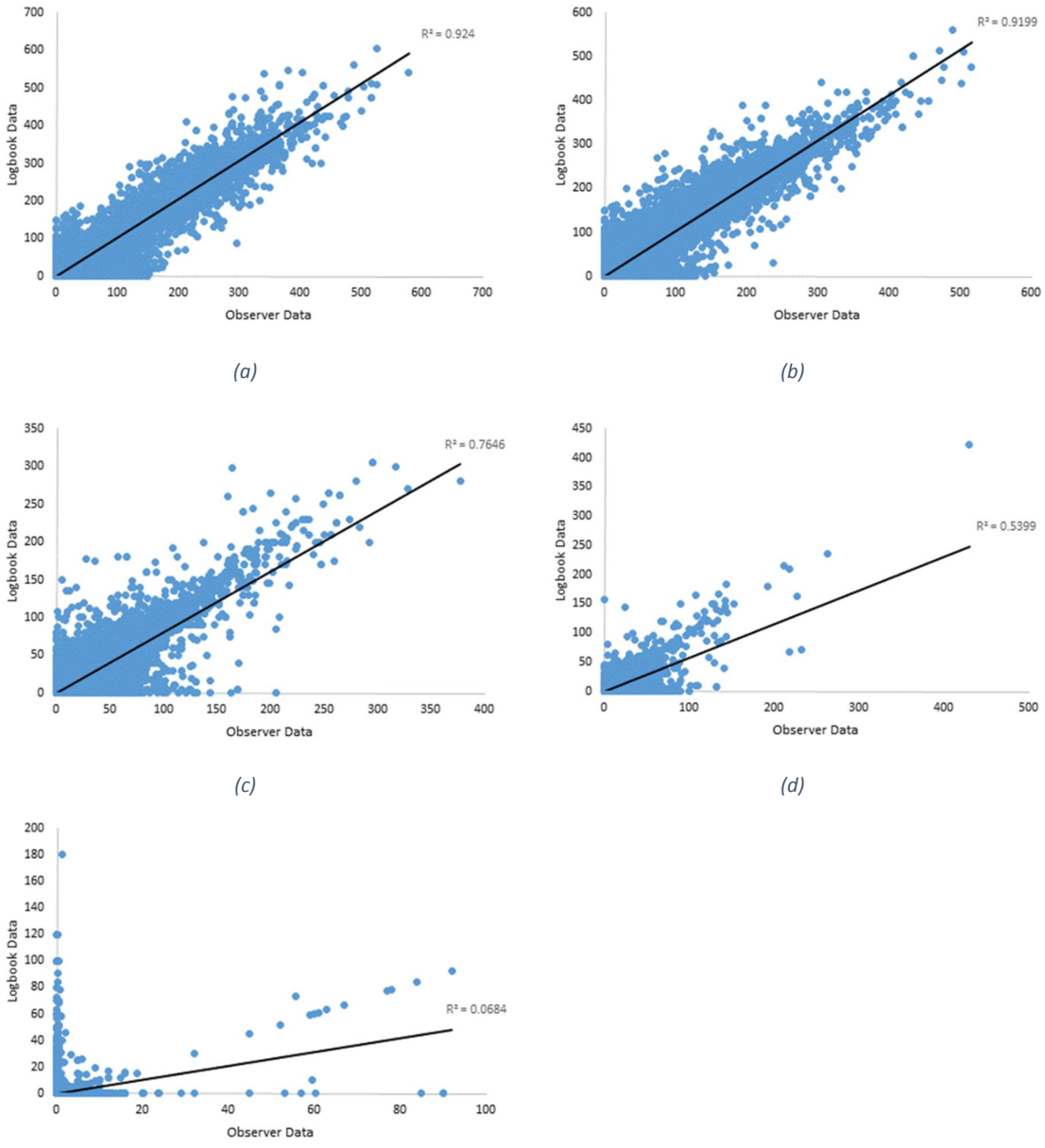
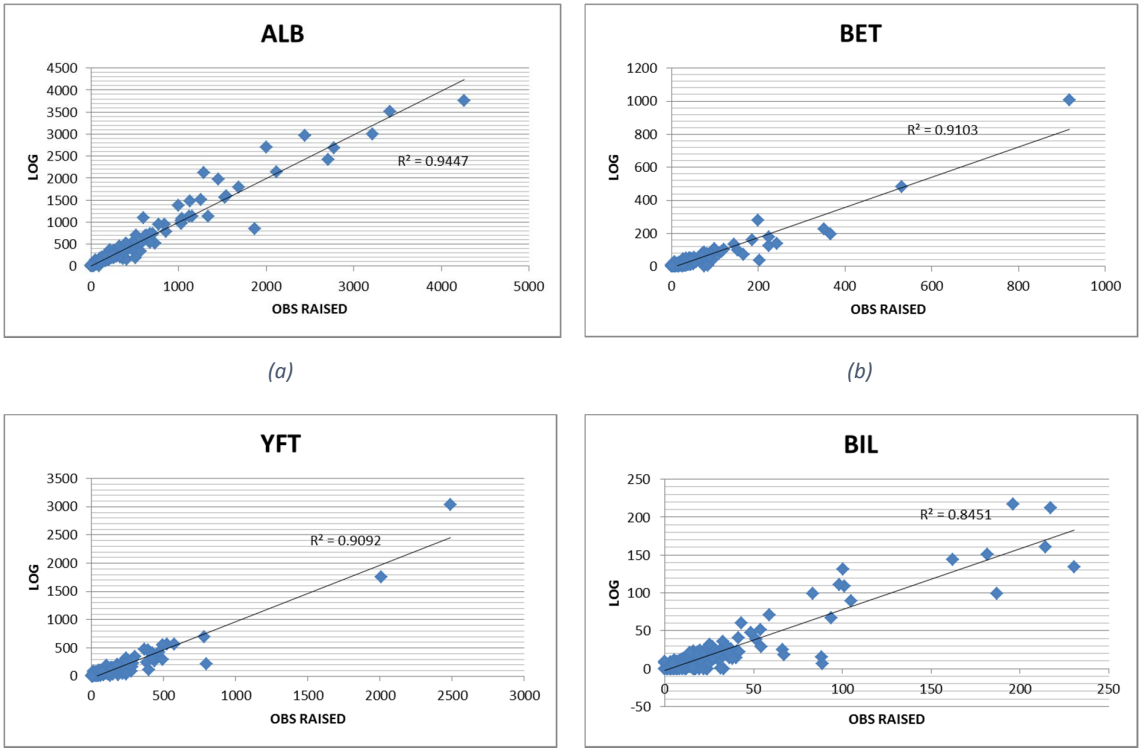


Figure 38: Scatter plots showing correlation of reporting by WEIGHT at the set level between vessel logsheets and observer reports during 2011 to 2014 (n=~170,000). (a) shows total tonnages of all species reported, both retained and discarded, (b) shows retained SKJ only, (c) shows retained YFT only, (d) shows retained BET only (e) shows retained OTH species only.

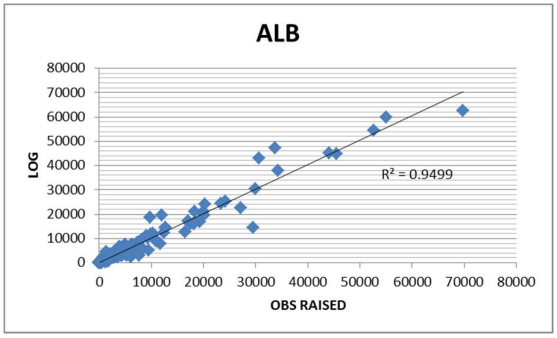
LONGLINE



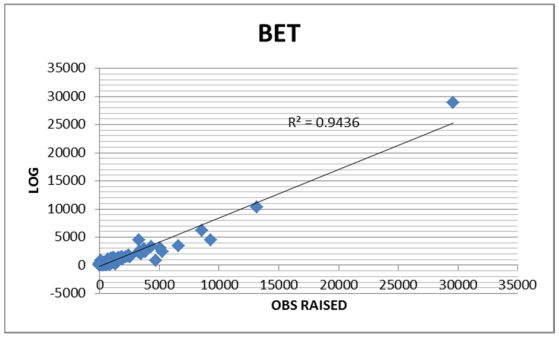
(a) *(b)*

(c) *(d)*

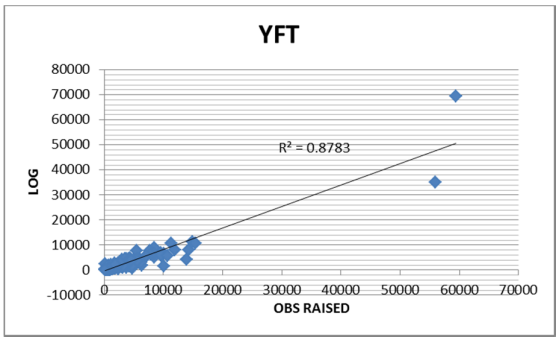
Figure 39: Scatter plots showing correlation of reporting by NUMBER between vessel logsheets and observer reports for sample of 219 trips during 2013 and 2014.



(a)

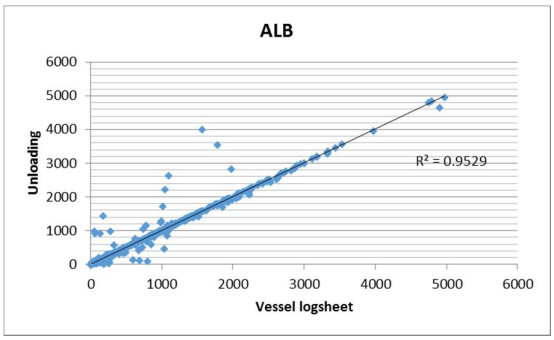


(b)

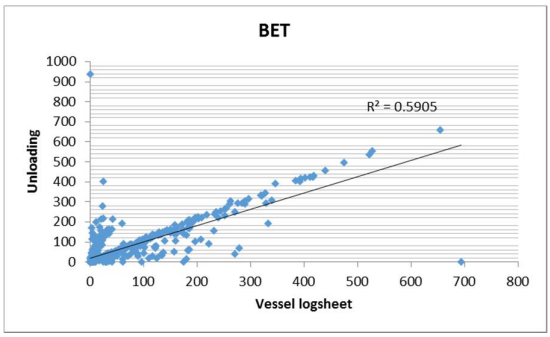


(c)

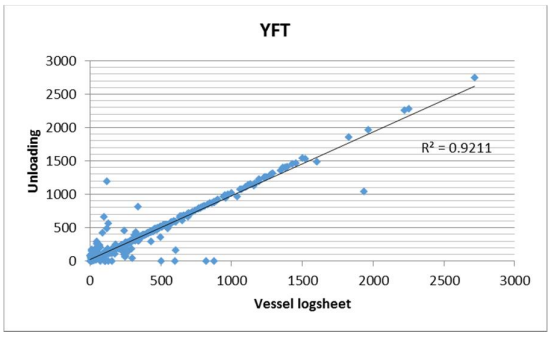
Figure 40: Scatter plots showing correlation of reporting by WEIGHT between vessel logsheets and observer reports for sample of 219 trips during 2013 and 2014.



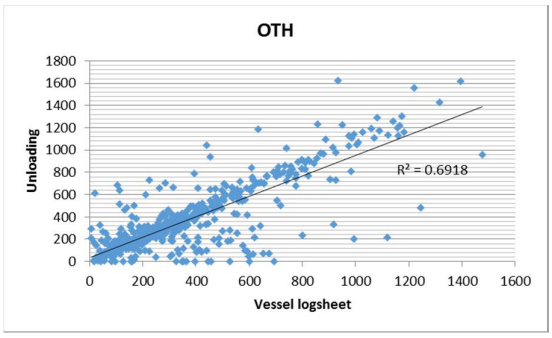
(a)



(b)



(c)



(d)

Figure 41: Scatter plots showing correlation of reporting between vessel logsheets and unloadings for the main target longline species at a key unloading port.

Annex 5: Case study: the challenges of reporting – longline

This case study has been included to highlight some of the reporting challenges faced in the longline fishery. The boat and trip involved were selected more or less at random and the circumstances are not particularly unusual in any way, other than that complete data sets were available from both the vessel and an observer. Boat X is a Chinese-flagged longliner which was operating in the Solomon Is EEZ (south of 10°S), with a Solomon Islands observer on board, during 2013. The trip in question lasted 56 days, involved 37 sets, each of around 3,800-4,000 hooks. The observer was on deck to observe hauling for 27 of 37 sets, recording catch for around 84% of baskets in observed sets. His data was raised proportionally to allow for comparisons with the vessel's reported catch for each set and the trip overall for observed sets.

Overall

Overall, the observer reported 1,521 fish retained by the vessel on observed sets, whereas the vessel reported 1,273 in the logbook – a difference of 248 fish or 16% of the retained catch by number.

No discarded fish were reported by the vessel.

Target tuna

Figure 42 and Table 44 provide a summary of the target tuna species reported by the observer and vessel respectively. Numbers of fish reported by the vessel were consistently lower than those reported by the observer across each target tuna species although given the potential variation introduced by raising the observer's data, albacore (the primary target for this trip) may be within the bounds of error. Nevertheless, vessel reporting of other key tuna species – yellowfin and bigeye – was significantly below the observer's report, with only 52% and 62% of fish reported respectively.

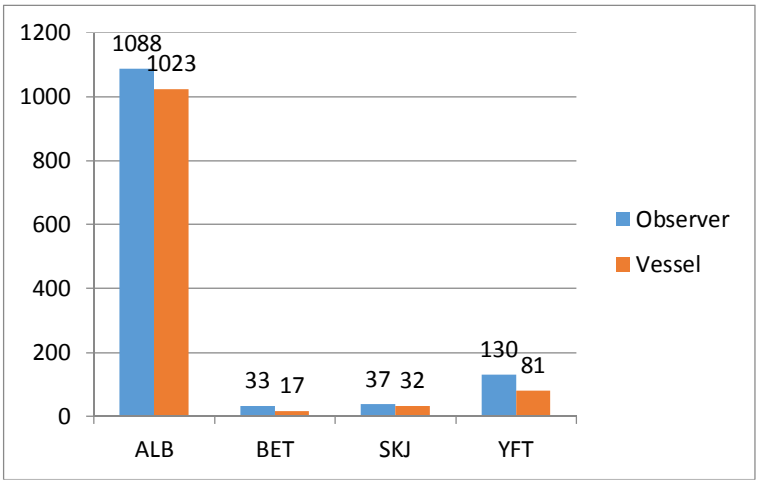


Figure 42: Comparison of target tuna species reported by the vessel and observer for the same trip.

Table 44: Percentage of each target tuna species reported by the vessel, by number

Species	% Reported
Albacore	94%
Bigeye	52%
Skipjack	87%
Yellowfin	62%

Billfish

Figure 43 and Table 45 provide a summary of the billfish species reported by the observer and vessel respectively. Overall the observer reported 43 billfish retained by the vessel to the vessel's 27 (62% reporting). Species composition of reporting was substantially different, with the observer reporting six species of billfish retained, while the vessel reported only two. While the vessel failed to report any black, blue or striped marlin nor any short-billed spearfish, they vastly over-reported the amount of swordfish retained. In essence, it appears as if all billfish were simply reported by the vessels as

'swordfish'. Given the relative ease with which billfish can be identified, this was probably for convenience.

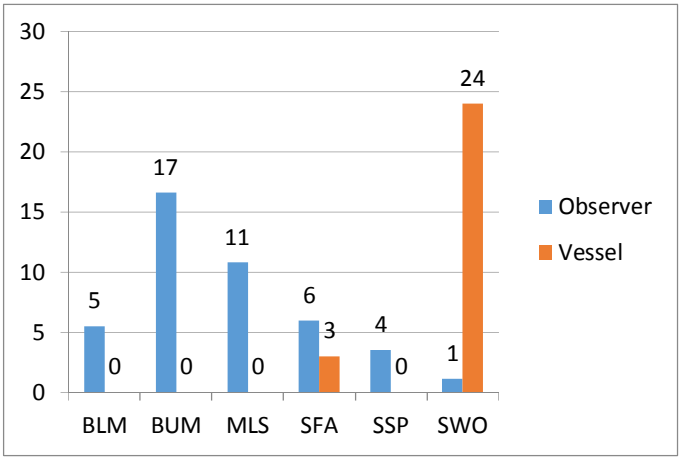


Figure 43: Comparison of billfish species reported by the vessel and observer for the same trip.

Table 45: Percentage of each billfish species reported by the vessel, by number

Species	% Rep
Black marlin (BLM)	0%
Blue marlin (BUM)	0%
Striped marlin (MLS)	0%
Sailfish (SFA)	50%
Short-billed spearfish (SSP)	0%
Swordfish (SWO)	2165%

Bycatch

Apart from oilfish, reporting of bycatch species by the vessel appeared to bear little resemblance to the numbers reported by the observer. Some species were never reported (e.g. mahi mahi, great barracuda, sickle pomfret), while others were over-reported (e.g. sunfish; F73). Some species targeted by Pacific island coastal fleets (e.g. wahoo) were reported only infrequently. Overall, the numbers of retained bycatch reported by the vessel were less than half (49%) that reported by the observer.

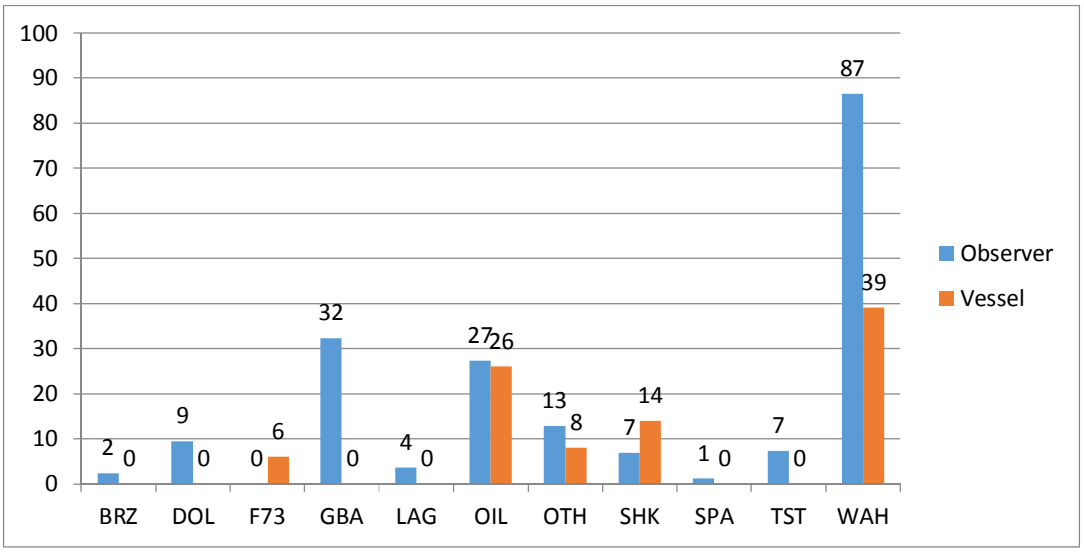


Figure 44: Comparison of bycatch species reported by the vessel and observer for the same trip.

Discussion

While little can be concluded from an individual trip, the trends in this case study were not dissimilar to those observed in other trips and highlight some of the important challenges faced by Pacific island fisheries managers. Given the importance of accurate data for stock assessments, resource

rent calculations and ecological risk assessments, these findings highlight the importance of having strong, well-resourced and independent monitoring programs on licensed vessels. The nature and scale of these are discussed elsewhere in this report.

Annex 6: Possible measures to strengthen information to support future estimates of IUU activity

A key outcome of the current study is to establish a framework and methodology for the estimation of IUU activity in Pacific tuna fisheries that can be updated and refined over time as information improves and the nature of IUU activity changes. This annex sets out possible measures to strengthen the information base to support future estimates.

Table 46: Possible measures to strengthen information to support future estimates of IUU activity

Risk/Activity	IUU	
Unlicensed/unauthorised fishing		
Unauthorised fishing by vessels on the FFA Regional Register	I	• Greater use of analytical approaches to detect fishing activity from VMS tracks • Collection of statistics on the proportion of fishing days (or other measure of activity – e.g. sets, hundred hooks, etc) suspected of being unlicensed as a proportion of the total effort
Unauthorised fishing by vessels on the WCPFC RFV but not on the FFA Regional Register	I	• Greater use of analytical approaches to detect fishing activity from VMS tracks • Recording of aerial/surface surveillance hours, contacts made and unlicensed fishing vessels detected
Unregulated fishing	URG	• Recording of aerial/surface surveillance hours, contacts made and unlicensed fishing vessels detected
Misreporting		
Misreporting of target species	URP	• Greater debriefing coverage of observer trips to detect errors and inconsistencies in reporting • Investigate use of cannery outturn reports to establish 'accurate' weights, species and size composition (purse seine and LL albacore) (already underway); comparisons of outturn reports Vs logsheet reports • Greater use of EM technology on LL vessels – collection of statistics comparing EM observed Vs logsheets returns • Greater use of information management systems (ideally coupled with electronic reporting) to compare and detect differences between independent sources of data
Misreporting of byproduct species	URP	• As above

Risk/Activity	IUU	
Non-compliance with license conditions		
Use of non-prescribed gear	I	• Greater use of EM technology; collection of statistics on rates of non-compliance by set/catch where practical • Collection of compliance statistics at the national level based on numbers of compliance events (e.g. at sea boardings; dockside inspections) Vs number of offences detected; collation/analysis of data at regional level • Where non-compliance is detected, collection of data on target species; test assumption in current model that bulk of non-compliance in the LL sector is wire traces to target sharks.
Fishing on FAD when not authorised (PS only)	I	• Updated estimates of set misclassification using Hare et al's (2015) observer sampling model • Auditing sets identified as 'misclassified' using EM technology where available.
Fishing inside closed waters within EEZs	I	• Greater use of analytical approaches to detect fishing activity from VMS tracks • Collection of statistics on the proportion of fishing days (or other measure of activity – e.g. sets, hundred hooks, etc) suspected of being unlicensed
Shark finning	I	• Collection of compliance statistics at the national level based on numbers of compliance events (e.g. at sea boardings; dockside inspections) Vs number of offences detected; collation/analysis of data at regional level • Where non-compliance is detected, collection of data on target species
Post-harvest IUU		
Illegal transhipping	I	• Greater use of analytical tools to identify potential transhipment through VMS/AIS data • Development of procedures to reconcile potential transhipments detected above, with authorised transhipments • Electronic monitoring to identify transhipping activity • Strengthen catch monitoring/verification throughout the supply chain (particularly for LL) (e.g. through a CDS/eCDS, or other independent means of verification) to identify any potential leakage through illegal transhipping
Landing of catch in unauthorised foreign ports	I	• Analysis of port-to-port VMS monitoring data; geo-fencing of key ports • Information sharing/compliance cooperation agreements with key foreign ports, where practical • Reconciliation of catches Vs unloadings where all catch is required to be unloaded domestically (e.g. Palau)

Annex 7: Possible additional measures to strengthen MCS arrangements

Table 47: Possible measures to strengthen MCS arrangements

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
Monitoring								
Strengthening observer coverage	This measure is particularly relevant to the LL sectors. Current coverage rates are very low across almost all fleets, and largely non-existent for some key sectors (e.g. DWFN high seas fleets). Very few fleets or WCPFC CCMs meet the 5% LL coverage required in CMM 2007-01. Observer data provides essential information to calibrate vessel reporting, as well as monitoring compliance with other key license conditions (e.g. reporting SSI interactions, use of non-prescribed gear, etc). Indirectly, the presence of an observer on board is also likely to act as a deterrent to non-compliance.	High, but cost-neutral to FFA members if cost recovered						
Dockside monitoring	Dockside monitoring for compliance purposes is potentially a very cost effective method of monitoring catch reporting, as well as compliance with other license conditions (e.g. shark finning, non-prescribed gear, etc). Port sampling for scientific purposes is relatively common in FFA member countries, but dockside compliance monitoring is less common. If undertaken by authorised compliance officers with powers to issue administrative sanctions, dockside monitoring is potentially an effective process to address common 'minor' offences (e.g. misreporting). The relatively concentrated nature of unloading and transhipping opportunities in Pacific Island countries lends itself to efficient dockside monitoring. Dockside monitoring programs would work best in tandem with a requirement to tranship catch in port. While strengthened dockside monitoring is likely to be valuable for the PS fleet, the main benefit will be in the LL fleet which has few alternative independent sources of catch verification.	Moderate, but cost-neutral to FFA members if cost recovered						

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
Electronic monitoring	Electronic monitoring (EM) has significant potential as a cost effective complement to human observers, particularly on the longline fleet which struggles to accommodate additional crew. EM is likely to be particularly beneficial in monitoring long-range DWFN LL vessels which rarely call into to Pacific Island ports, meaning that it is both difficult to place an observer and opportunities for dockside inspections are limited. While the highest priority for EM is the LL fleet, the technology also has important application in PS fleets in providing independent verification of fishing activity and in monitoring observer safety, as well as compliance with license conditions (e.g. pollution). The presence of an on board camera is likely to act as a deterrent to non-compliance. EM technology has already been successfully applied in a range of analogous fisheries worldwide (e.g. the Australian Eastern Tuna and Billfish Fishery).	High, but cost-neutral to FFA members if cost recovered						
Catch Documentation Scheme (CDS)	Catch documentation schemes (CDS) have been used by a number of RFMOs in an effort to better monitor catches through the supply chain and mitigate against the infiltration of IUU product (see for example, MRAG Asia Pacific, 2010, for a discussion of the main schemes). Work is currently underway on the design of a WCPFC CDS, and some parties are well-advanced on introducing domestic systems (e.g. PNG). A WCPFC CDS would assist in addressing some of the main risks highlighted in this study (e.g. misreporting, illegal transhipment), as well as contribute to conservation efforts around some of the main stocks (e.g. BET).	Moderate						
Optimising use of VMS	The two VMS systems operating in the Pacific (FFA and WCPFC) are a central tool to monitor the location and activity of licensed fishing vessels, although arguably are not yet being used to their full potential. Information sharing arrangements are yet to be agreed between many neighbouring FFA members (meaning that vessels in neighbouring waters are not seen by FFA members until they enter their own waters), while a number have yet to 'flick the switch' to allow monitoring of WCPFC vessels within 100nm of their own EEZ. Optimising the use of the existing VMS systems is an extremely cost effective way of enhancing visibility of licensed vessels, and assisting with MCS planning and prioritisation. Other improvements include	Low						

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
	optimising the use of alerts and geofencing at the national level.							
FAD registration and tracking	While there is some opacity about whether allowing FADs to travel through EEZs for which the setting vessel has no license, strengthened processes for registering and regulating the use of FADs appears to have benefits across a range of areas. Apart from getting a better handle on the number of FADs in the WCPO and their 'fishing capacity', knowing the position of FADs would help in detecting offences such as FAD fishing during the FAD closure. Registration and regulation of FAD numbers may come with an obligation to install FAD buoys which allow for satellite tracking (which is already widespread amongst industry).							
Catch verification through trade/cannery data	'Outturn' reports generated by canneries provide an accurate catch weight and species composition, broken down by size, and are potentially one of the best avenues to accurately verify catch composition. This is perhaps particularly the case in the purse seine fishery, where both current estimates of catch weight and composition (i.e. the vessels and the observer's) are estimates only. The use of cannery data to verify logsheet estimates has long been discussed (e.g. it was envisaged in WCPFC CMM09-10, which is still in force), and is currently being investigated in detail through SPC. Provided accurate traceability can be demonstrated (which should be possible) and other technical issues can be satisfactorily addressed (e.g. calibration for weight loss in transit, etc), the use of outturn reports appears to be a potentially valuable tool in establishing accurate catch records of sectors ultimately delivering to canneries (e.g. purse seine, ALB LL).	Low						
Analytical tracking of potential transhipments	A number of analytical tools currently exist, or are in development, to assist in identifying potential unauthorised transhipments based on VMS and/or AIS data. NOAA-OLE (Honolulu Office) has reportedly developed a "Transshipment Analysis Tool" TAT tool, while FFA is currently trialling similar technology. If transhipment continues to be allowed outside of authorised ports, greater use of such analytical would assist in asset tasking and investigations. WCPFC has commenced efforts to strengthen capacity to monitor high seas transhipments (WCPFC, 2015a).	Low (given VMS/AIS systems already exist)						

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
Control								
Stronger sanctions	An effective sanctions regime is an essential component of any effective MCS regime. Ultimately the cost of the sanction needs to outweigh the benefits of the offence to a sufficient extent that it acts as a significant deterrent to non-compliance. Sanctions are largely applied at the national level and require reviews at the national level. The value-added data presented in 4.2 can be singled out by fleet segment and risk, and expanded upon to assess the appropriateness of existing sanctions.	Low						
Administrative penalties for 'minor' offences	A key feature of this study is that the licensed fleet is likely to be the main contributor to IUU fishing, and many of the infringements committed are likely to be considered relatively 'minor' by national authorities (e.g. misreporting offences). Anecdotal information suggests that many of these offences are not actively prosecuted at the national level, in part because of the high costs involved in taking (criminal) action through the court system. Administrative penalties (e.g. on the spot fines) offer a potentially practical and cost effective alternative to sanctioning for 'minor' offences. Fines for offences such as 'minor' misreporting, or delayed logbook submission, would send an important signal to licensed operators that compliance with license conditions is required, and non-compliance is not tolerated, however minor. While effective governance and oversight systems are required to ensure the power to issue fines is not abused, administrative sanctions could potentially be applied cost effectively with considerable effect.	Low						
Prohibition of transhipment at sea	A requirement to tranship catch in port has been an important plank in the MCS regime underpinning the purse seine fishery in the WCPO. Transhipment in port allows for dockside compliance monitoring, independent verification of catches and catch and effort reporting, limits opportunities for illegal transhipments and allows for the placement of observers. In the longline fishery transhipment on the high seas is allowed under certain conditions. If FFA members are resolved to strengthen catch monitoring arrangements in the longline sector, prohibiting transhipment at sea would undoubtedly be a strong initiative which would likely deliver real benefits in better monitoring catches, as well as reducing uncertainty around the							

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
	actual level of illegal transhipping currently occurring. WCPFC (2013b) notes that there appear to be very few circumstances in which in port transhipment is likely to be 'impractical', and that the majority of transhipments occur within 0-200nm of port. They also note that at the time of writing there was only limited compliance with CMM 09-06[21], and that "if the Commission decides to prohibit the practice of allowing the transshipment of frozen longline caught product at sea there would be grounds to support this approach as follows: • FAO and others have expressed strong concerns about the link between this practice and IUU fishing; • The international purse seine industry has proven that it is possible to change business practices to tranship in port; • In port transshipment of product allows for far stronger monitoring and surveillance activity and greater accountability for monitoring the catch. McCoy (2012) recommends consideration be given to the impacts on domestic vessels who tranship catch at sea in any discussion of banning at sea transhipment.							
'No-go' areas in closed waters	While fishing inside closed waters (e.g. 12nm closures around islands) was estimated to be relatively limited by this study, the offence itself can be socially and politically important at the local level (particularly if vulnerable, isolated communities are affected). One option which has been used effectively elsewhere (e.g. to protect 'scallop replenishment areas' in Queensland, Australia) is to make closed areas around islands/communities 'no-go' areas for large scale licensed vessels. This may work in areas for which vessels otherwise have no reason to be in (e.g. small areas around communities that are not otherwise anchoring sites for vessels, etc). Under this option, the presence of the vessel in the closed area detected by VMS would constitute an offence. It would not be necessary to visually detect the vessel fishing, which	Low						

[21] "*while CMMs are providing documentation to support known transshipments there appears to be little or no compliance with any of the other provisions of the interim guidelines. No compliance has occurred in respect of the provision of paragraph 35 (a 1 and v*)"

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
	saves surface and aerial surveillance costs. Prosecutions based on VMS evidence alone have been generated in other jurisdictions who have similar provisions.							
Surveillance								
Increased aerial surveillance capacity	Aerial surveillance is a valuable tool to target a number of risks identified in this report (e.g. illegal transhipping, unlicensed fishing), and arguably the only effective way to target some risks such as unregulated fishing. The capacity to undertake aerial surveillance also likely acts as an (unquantified) deterrent to some forms of illegal activity (e.g. unlicensed fishing, illegal transhipment, fishing inside closed waters). Nevertheless, aerial surveillance is typically extremely expensive (~$15,000 – $25,000/air hour) and the costs and benefits should be weighed carefully before investing in this over other MCS measures. Aerial surveillance generally addresses a relatively narrow range of risks (mainly unlicensed fishing and illegal transhipping), many of which were identified as relatively minor contributors to the overall IUU picture in the Pacific (e.g. unlicensed fishing, unregulated fishing). The key question for MCS decision makers in the Pacific is if there is a limited pool of MCS resources available, is it best directed at expensive aerial surveillance, or could the same money achieve greater benefits being targeted at higher priority issues using more cost effective approaches? The other key question obviously is whether some of those risks identified as relatively minor at present would increase in the absence of the deterrent effect provided by aerial surveillance. Ultimately, some level of ongoing aerial surveillance will be important to continue to act as a deterrent to unlicensed and unregulated fishing, however the outcomes of this study do not argue for a substantial investment in new capability (with the exception perhaps of reducing uncertainty around illegal transhipping). Rather, the best use of aerial surveillance appears to be in continuing to either generate or respond to specific intelligence or risks in a very targeted way.	Very high						

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
Increased surface surveillance	Surface surveillance has benefits over aerial surveillance in that it addresses a wider range of risks (including non-compliance with a number of license conditions), although is likewise very expensive and covers less area.							
Satellite monitoring	Satellite monitoring potentially has utility for areas that are unable to be cost-effectively accessed by conventional aerial and surface surveillance (e.g. the far eastern part of the Pacific islands region), although large numbers of high resolution images may be cost prohibitive and may not be sufficiently definitive to support successful prosecutions on their own. Satellite images may be best used to support existing intelligence (e.g. where there is analytical evidence of illegal transhipping and satellite images would assist prosecution). The pros and cons of satellite information in the Pacific islands region is discussed in MRAG Asia Pacific (2009). In the context of this study, satellite images are likely to have most utility for unlicensed fishing in the eastern part of the Pacific islands region and illegal transhipping.	Varies according to number and resolution of images						
Drones and UAVs	Drones and unmanned aerial vehicles (UAVs) have had limited application in the Pacific to date, though trials have been undertaken in some countries (e.g. Palau[22]). A more detailed study on the costs and benefits of aerial surveillance in the Pacific is currently underway, though on the face of it UAVs may be a cost effective aerial surveillance solution in 'hot spot' areas (e.g. south western Palau; high seas pockets) to verify intelligence reports of illegal activity. The utility will be dependent on the costs involved, range of the UAV and capacity to take images and video able to be used in prosecutions.	High (depends on UAV, usage, image/video resolution)						
Support measures								

[22] http://www.micronesiaforum.org/index.php?p=/discussion/11472/aerial-unmanned-vehicles-drones-to-monitor-palau-s-eez

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
Strengthening the use of information management technology	Existing MCS arrangements in the Pacific (e.g. logsheets, observers, unloadings monitoring, VMS, at sea boarding and inspection, dockside inspection, etc) generate multiple data sources that can be cross-verified for compliance discrepancies (e.g. observer Vs logsheet) and analysed for national and regional trends. Considerable investment has been made in strengthening information capability across the region through programs such as TUFMAN, TUBS, FIMS and RIMF. While more could probably be done, many of the necessary tools to strengthen national and regional MCS effectiveness appear to be in place. The main need appears to be to ensure officers at the national level are adequately trained in their use and that follow up action is taken at the national level on the outcomes.							
Strengthening analytical capacity, national and regional	FFA members are almost universally characterised by having very large EEZs, with limited resources to undertake MCS. In that context it is essential that limited MCS resources are deployed in the most cost effective manner. Strengthening capacity at the national level to analyse relevant MCS information to determine and direct resources to the highest priority areas both strengthens targeting and avoids wasting resources on low priority issues. The capacity for effective analysis is strongest where there are robust information management platforms (see above) and strong national/regional coordination (see below). The case for analysis of MCS at the regional level is clear given the shared nature of stocks and the multi-licensed nature of many fleets. The increasing use of e-reporting/monitoring should facilitate more effective analysis of MCS data in the Pacific and both national and regional agencies should be gearing up to capitalise on it.							
Strengthening MCS coordination, national and regional	In most FFA member countries, responsibility for MCS activity is distributed across multiple agencies (fisheries, marine law enforcement/navy/police, attorney general, etc). Ensuring effective coordination (joint risk assessment and tasking, sharing VMS data, sharing license lists, pre-and post-patrol briefings, etc) across these entities is essential to supporting an efficient MCS regime in country. A key observation of the most recent comprehensive assessment of MCS arrangements in FFA member countries (MRAG Asia Pacific, 2009) was that both formal							

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
	(e.g. National MCS Coordination Committees) and informal arrangements for country level coordination could be strengthened in many cases. While this study has not been able to analyse progress on these recommendations in depth across all FFA members, site visits suggested progress appears to be limited in some cases. Regional agencies have an important role to play in encouraging and facilitating the development of cooperative arrangements at the national level. At the bilateral, multi-lateral and regional level, the benefits associated with stronger coordination were outlined by MRAG Asia Pacific (2009).							
Prosecutions and violations information	Centralised storage and analysis of prosecution and violation information across the FFA member states would assist in MCS planning, would facilitate information sharing and learning (particularly given many vessels are licensed across multiple FFA EEZs) as well as better estimating IUU activity. FFA has previously coordinated a 'Prosecutions and Violations' (P&V) database which was used for this purpose. The database has now been incorporated into the Regional Information Management Facility (RIMF), but entry of P&V records is voluntary and the most recent records are from around 2009. FFA members should be more actively encouraged to contribute P&V records to the database, with analysed information on trends and issues fed back via the MCSWG and other forums.							
Strengthening national protocols for responding to potential violations	An issue raised at the ground-truthing workshop was the need to ensure formal protocols existed at the national level to investigate and progress possible offences to sanction. Of the large number of possible reporting and other offences discussed in this report, it appears a relatively small proportion are progressed to sanction. While some of this may be a lack of resources, the development of formal protocols which set out steps to be taken where a suspected offence is detected might help facilitate compliance action at the national level.							
Cost recovery	Although not specifically an MCS skill, the capacity to design and implement effective cost recovery regimes to fund effective MCS arrangements is an essential component of an overall MCS regime. There is little doubt that additional MCS arrangements are required on a range of							

MCS Measure	Description/analysis	Relative cost	Risk addressed				Priority	
			Unlicensed fishing	Misreporting	Non-compliance with license conditions	Post-harvest risks	PS	LL
	fleets and the burden for funding improved MCS should not fall to FFA members. Training and mentoring on the theory and practice of cost recovery should be an essential component of MCS/administrative training in the region.							

Keys:

Risks addressed:

	Highly effective at addressing risk
	Partially effective at addressing risk
	Not effective at addressing risk

Priority:

	High priority taking into account risks/costs/practicality
	Medium priority taking into account risks/costs/practicality
	Low/Nil priority taking into account risks/costs/practicality