

# Marine Resource Use in Kofiau and Boo Islands Marine Protected Area, Raja Ampat, West Papua. 2006—2011



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**Published by:** The Nature Conservancy, Indo-Pacific Division

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**Suggested Citation:**

Muhajir, Purwanto, Mangubhai, S., Wilson, J., and R. Ardiwijaya. 2012. Marine Resource Use in Kofiau and Boo Islands Marine Protected Area, Raja Ampat, West Papua. 2006-2011. The Nature Conservancy, Indo-Pacific Division, Indonesia. Report 3/12. 34 pp.

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All maps designed and created by Muhajir.

Available from:

Indonesia Marine Program  
The Nature Conservancy  
Jl. Pengembak 2  
Sanur 80228, Bali  
Indonesia

Asia-Pacific Resource Centre  
The Nature Conservancy  
245 Riverside Drive  
West End, QLD 4101  
Australia

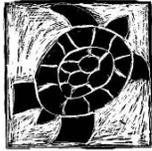
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## ACKNOWLEDGEMENTS

The authors would like to thank former monitoring staff Andreas Muljadi and Titi Nugraheni, and the staff at the TNC Kofiau Field Office in Raja Ampat, who started the resource use monitoring program in Kofiau and Boo Islands Marine Protected Area. Thanks also to Naftali Managgara, Nico Mambraku, the local communities, the local *adat*, the village government, and Kofiau district government for actively participating or supporting resource use monitoring. We would also like to thank the speedboat crew for their seamanship skills and for frequently helping with the interviews with fishers, and George Creswell for editing this report. Our gratitude also goes to all donors, in particular the Walton Family Foundation, USAID, and private donors who funded this work.



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## EXECUTIVE SUMMARY

Resource use monitoring was carried in Kofiau and Boo Islands Marine Protected Area (MPA) from 2006 to 2011, following The Nature Conservancy's resource use monitoring protocol (Wiadnya et al. 2006). The aim of this monitoring was to identify spatial and temporal patterns in the use and exploitation of marine resources within the Kofiau and Boo Islands to support the zoning of the MPA and to assess changes in use patterns over time. The surveys were carried out by speedboat and covered the entire 170,000 ha area of the MPA.

The surveys showed the dominant resource use in the MPA was fishing (99%), with largely recreational diving making up the rest (1%). Most fishers are locals from Deer, Dibalal, and Tolobi (85%), while the remaining fishers are outside/non-local fishers (15%) from Maluku and Sulawesi. Despite their numerical abundance, local fisheries took just 30% of the total annual catch, while outside fishers took 70% of the total annual catch. Many outside fishers were caught operating illegally in the MPA without a licence or with an expired licence, and were removed from the MPA by the floating ranger station Imbekwan (period 2007-2010) and by local community patrols and accompanying police (period 2011-now). Most local fishers used small vessels, such as canoes and vessels with small outboard motors, while outside fishers used larger vessels with large inboard or outboard motors. There was reduction in the number of fishers from 2006-2011, caused by a decline in the number of non-local vessels frequenting the MPA. A continued reduction in outside fishers through strong enforcement efforts would reduce the fishing pressure on the MPA and would allow for depleted fish populations to recover.

Local fishers tend to fish the waters in Kofiau that are close to human settlement, while outside fishers tend to fish the waters around the Boo Islands and reefs on the southern side of Kofiau Island, which are relatively far from human settlement. The highest number of boats was recorded in the months October to December, when communities are farming or working on their coconut plantations away from their village and are fishing to meet their daily subsistence needs. The lowest number were recorded in the month July to September, which coincides with the southeast monsoon season when sea conditions are rough and reefs in the south and at Boo Islands are fairly inaccessible.

Local fishers used traditional gears, especially hook and line (80%), while outside fishers used more destructive gear types (e.g. large nets) or destructive fishing methods (compressor, cyanide, bomb fishing). About 8% of gear used each year in the MPA falls in the category of destructive fishing gears or methods. Bomb, cyanide and compressor fishing has now largely been removed from the MPA as a result of enforcement and outreach efforts. Large nets, however, are still as of 2011, used by outside fishers frequenting the area (comprising 5% of gear types used), and is likely responsible for the declines in fish stocks recorded in reef health surveys from 2009-2011 (Purwanto et al. 2012).

Dead fish accounted for the largest proportion (40%) of the total annual catch. Live fish comprising mainly groupers and Napoleon wrasse (*Cheilinus undulatus*) caught largely for the live reef fish trade, made up 11% of the total annual catch in 2011. This fishery is of greatest concern in the MPA because there are currently no functioning spawning aggregations and reef health surveys have shown these populations to be very low (Purwanto et al. 2012). If continued, it is likely that some species will be extirpated from the MPA or will become so low that recovery may take a very long time.

The results from resource use monitoring were used to support the zoning and management planning process for the Kofiau and Boo Islands MPA, and measure temporal changes in patterns of use in the MPA. By sharing the results of this monitoring with local communities it is hoped they will have a better understanding of marine resource use in their MPA, and be more encouraged to work with Raja Ampat regency government to more proactively protect and manage their marine resources.



# INTRODUCTION

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## BACKGROUND

The Raja Ampat Islands lie at the heart of the Coral Triangle, the world centre of tropical marine biodiversity. These islands are in the western-most region of Papua, Indonesia, covering an area of approximately 4.6 million hectares. Raja Ampat has a wealth of species, including 1,437 species of fish (Allen and Erdmann, 2009, 2012), 699 species of mollusc, and 553 species of hard (scleractinian) coral (Donnelly, et al. 2003, Veron et al. 2009). Raja Ampat also has rich seagrass meadows, mangrove forests, as well as unique karst islands and marine lakes.

Traditional subsistence fishing – predominantly using handlines from small canoes – was the only form of fishing in the region prior to the 1960s and is still practiced today. The introduction of commercial fisheries – both legal and illegal – in the 1960s heralded a rapid decline in fishery resources due to over-exploitation (Palomares et al. 2007). Although the impact of human activity is relatively small compared with other areas in Indonesia or wider Southeast Asia (Burke et al. 2011, 2012), marine resources in Raja Ampat are also under threat from decades of overfishing and ecosystem damage caused by destructive fishing gears and practices (Ainsworth et al. 2008, Varkey et al. 2010, Mangubhai et al. 2012).

Despite the high reliance of local communities on marine resources (Larsen et al. 2011), there is very little quantitative data available on fish stocks, or fisheries in general, in Raja Ampat to support management decisions (Mangubhai et al. 2012). Information and data about types of marine resource use are crucial for managing fisheries, including those in marine protected areas (MPAs). Resource use data are also valuable for marine spatial planning, and in the case of Raja Ampat, for the zoning of the Kofiau and Boo Islands MPA as well as the other six MPAs in the network (Agostini et al. 2012, Grantham et al. 2012). In response to this need, The Nature Conservancy, along with the district government and local communities, started monitoring Kofiau and Boo Islands MPA in 2006 to collect data on spatial and temporal patterns of marine resource use in the MPA.

## OBJECTIVES

The overall aim of monitoring marine resource use is to provide spatial and temporal data of resource use to policy makers and stakeholders for the purposes of planning, management, evaluating management effectiveness and adaptive management. The resource use monitoring program at Kofiau and Boo Islands MPA was implemented to achieve the following objectives:

1. Obtain data about and identify trends in marine resource use, particularly fisheries (extractive use) and tourism (non-extractive use);
2. Identify types and spatial and temporal patterns of use of marine resources and provide this information to resource users, regency and district governments, and local communities; and
3. Provide managers with data to inform decisions about the zoning and management of the Raja Ampat MPA network, and in Kofiau MPA in particular.

## SURVEY METHODS

---

Kofiau and Boo Islands MPA lies off the western tip of Papua, and is one of seven MPAs in the Raja Ampat MPA network (Figure 1). Kofiau and Boo Islands MPA, hereinafter Kofiau MPA, has 44 small islands and consists of two major island groups – Kofiau Islands in the east and Boo Islands in the west. Coral reefs cover an area of 13,800 ha, while mangrove forests cover 3413 ha in the MPA. There are currently four villages – Deer, Dibalal, Tolobi, Mikiran – located in the northern section of the MPA, where they are sheltered from strong winds and waves during the southeast monsoon (May to October).

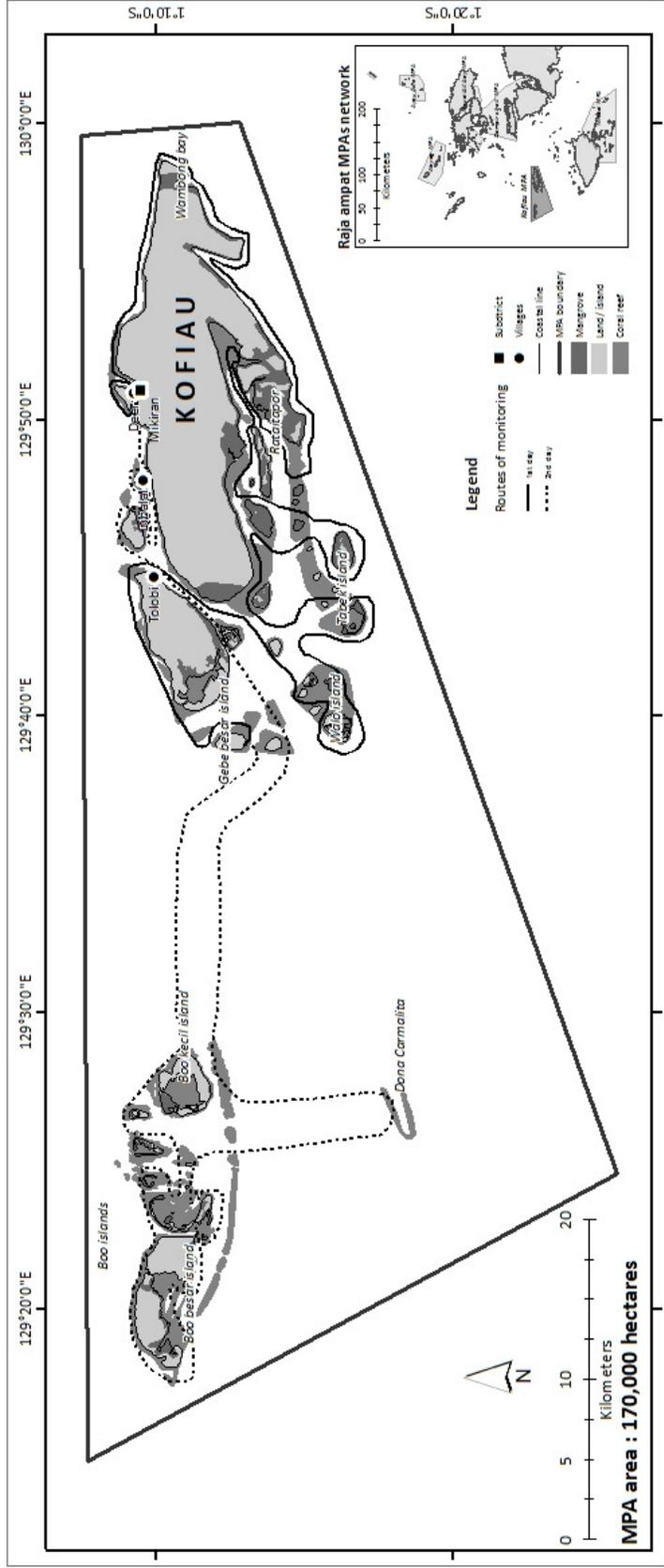
Monitoring the use of marine resources involves carrying out field surveys to identify the types of resource uses there are in a specific area. These surveys are carried out according to a marine resource use monitoring protocol developed by The Nature Conservancy (Wiadnya et al. 2005). In the protocol and this report, ‘resource use’ refers to the use of renewable marine resources (biota), including extractive uses (for example, fishing and taking coral rock) and non-extractive uses (for example, tourism and education). Resource uses can also be categorised as ‘mobile’ (such as hook and line, nets and other gear types) or ‘non-mobile’ (such as seaweed farming, floating houses).

### FREQUENCY OF SURVEYS

Resource use monitoring was carried out between March 2006 and March 2011. The surveys typically took place in the daytime, between 9am and 5pm, and were carried out by TNC staff with the involvement of district government and local villagers from Kofiau MPA. Surveys were carried out in speedboat, following the same pre-determined route around the MPA, covering the area from the coastline to 500 m offshore (Figure 1). The speedboat stopped whenever it encountered fishers or other resource users in the MPA. The plan was to have one (1-2 day) trip every month, but due to operational difficulties, such as bad weather and engine problems, or restrictions in funding, this schedule was not strictly adhered to. A total of 46 survey days (or 28 trips), with the number of months surveyed annually, varying from 2-5 months.

### DATA COLLECTION

Data about all types of uses of marine resources were collected from interviews of mobile resource users (i.e. those on boats), and by observing and recording non-mobile resource uses (i.e. fixed gears or structures) in Kofiau MPA. Non-mobile use includes all fixed gear found in the MPA for 2-3 months or more, and excludes any permanent structures such as harbours, beach resorts, etc.. Examples of non-mobile gear include fish traps, floating cages (*karamba*) for storing live fish, seaweed farming, pearl farms, floating houses, and moorings for dive liveaboard boats. The data recorded for mobile resource uses includes: type of use, origin of fishers, type of vessel, types of fishing gear, estimated catch, species caught, and the geographical position (latitude, longitude) of the resource use, outlined in the resource use monitoring protocol (Wiadnya et al. 2005).



**Figure 1.** Route of marine resource use surveys in Kofiau and Boo Islands Marine Protected Area. The black route is the first sortie, and the dotted line represents the second sortie. Once sortie per day is conducted, and with each pair of sorties comprising a trip.

## RESULTS AND DISCUSSION

### NUMBER OF USERS OF MARINE RESOURCES

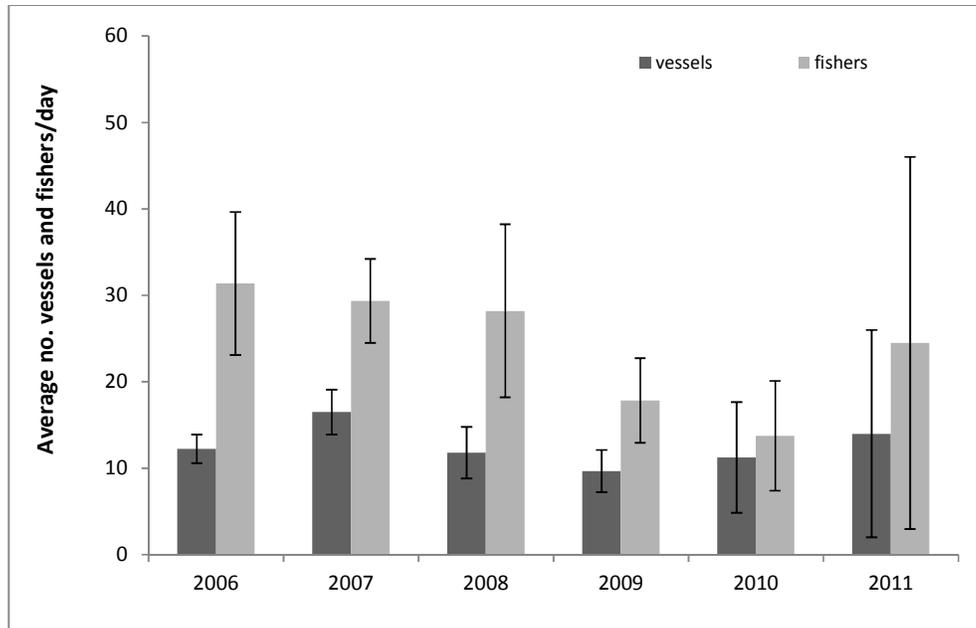
A total of 28 trips (or 46 survey days) carried out between 2006 and 2011. Over this survey period 578 marine resource users were interviewed or encountered in Kofiau MPA, including local and non-local fishing fishers, and liveboard operators (Table 1). The majority of boats (573 or 99% of boats) were engaged in fishing activities, while the remaining boats were engaged in recreational diving (and in one case, recreational fishing). During the survey period, an average of 12 boats were interviewed per day, with the number of vessels recorded ranging from 2 to 109. The average number of people on each vessel was two.

The low number of dive liveboards in Kofiau suggests that it is not a preferred dive destination for operators. Currently there are fewer dive locations identified in Kofiau compared to other MPAs (Jones and Shimlock 2009). As fish and shark populations improve, there may be more interest by liveboard operators to visit the MPA, if there were opportunities to dive to well-protected and functioning no take zones.

**Table 1.** Resource uses in Kofiau and Boo Islands Marine Protected Area from 2006-2011.

Year	Month	No. of trips	No. of days	Marine resource users			Total users/month
				Fishing boats	Recreational fishers	Dive liveboards	
2006	March	1	2	26	0	0	26
	July	2	4	45	0	0	45
	October	1	2	24	3	0	27
2007	June	2	3	42	1	0	43
	September	1	2	19	0	0	19
	October	4	7	109	0	1	110
	November	2	3	59	0	0	59
2008	January	2	4	28	0	0	28
	February	2	3	49	0	0	49
	September	1	2	6	0	0	6
	October	1	1	9	0	0	9
	November	1	1	26	0	0	26
2009	January	1	2	24	0	0	24
	May	1	2	15	0	0	15
	October	1	2	19	0	0	19
2010	January	1	2	30	0	0	30
	May	1	1	12	0	0	12
	November	1	1	3	0	0	3
2011	January	1	1	26	0	0	26
	March	1	1	2	0	0	2
<b>Total</b>		<b>28</b>	<b>46</b>	<b>573</b>	<b>4</b>	<b>1</b>	<b>578</b>

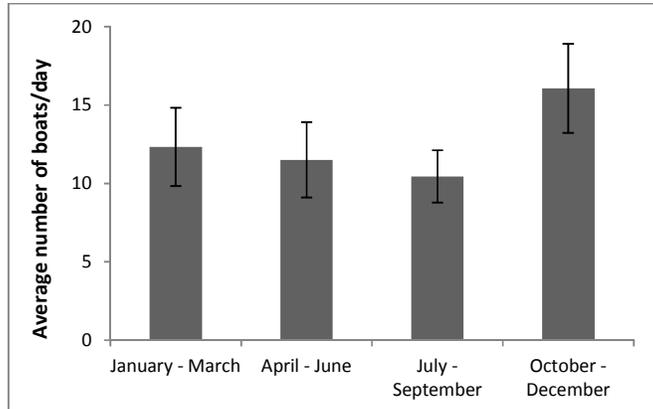
There was a decrease in the average number of fishers interviewed per day from 2006 and 2011 (Figure 2). This decrease is thought to be due to the routine patrols on the floating ranger station *Inbekwan*, which targeted illegal fishers, the majority of whom originated from outside the MPA. Outside fishers<sup>1</sup> generally used larger boats with more fishers on board. A reduction in the number of large vessels visiting Kofiau therefore resulted in the overall reduction in the number of fishers harvesting in the MPA. It is vital that this downward trend be maintained by increasing the number of patrols in Kofiau MPA. A decline in the number of fishers will mean a reduction in the fishing pressure in the MPA and will allow fish and invertebrate populations in depleted areas to recover.



**Figure 2.** Average number of fishers and vessels encountered per day during resource use surveys in Kofiau and Boo Islands Marine Protected Area each year. Total number of vessels = 573. Total number of fishers = 1,157. Error bars = standard error.

The highest number of boats recorded in Kofiau MPA was during the period October to December (averaging 16 vessels/day), which coincides with the northwest monsoon (Figure 3). The lowest average number of vessels (averaging 10 vessels/day), was recorded in the period July to September, which coincides with the southeast monsoon (Figure 3). During the October to December period, there are many fishing vessels fishing on coral reefs in the MPA. This is because during this period the local people are busy doing land- or island-based activities such as copra farming around Kofiau and Boo Islands, and to meet their daily food needs they fish the waters adjacent to their coconut plantations. Fishing boats were found throughout Kofiau MPA on all coral reefs (Figure 4), suggesting fishers – both local and outside fishers – are targeting reef fish rather than pelagic species.

<sup>1</sup> The term ‘non-local’ fishers refers to ‘outside’ fishers that do not come from Kofiau and Boo Islands MPA, and therefore do not hold traditional rights to fish in the MPA. The terms are used interchangeably in this report.

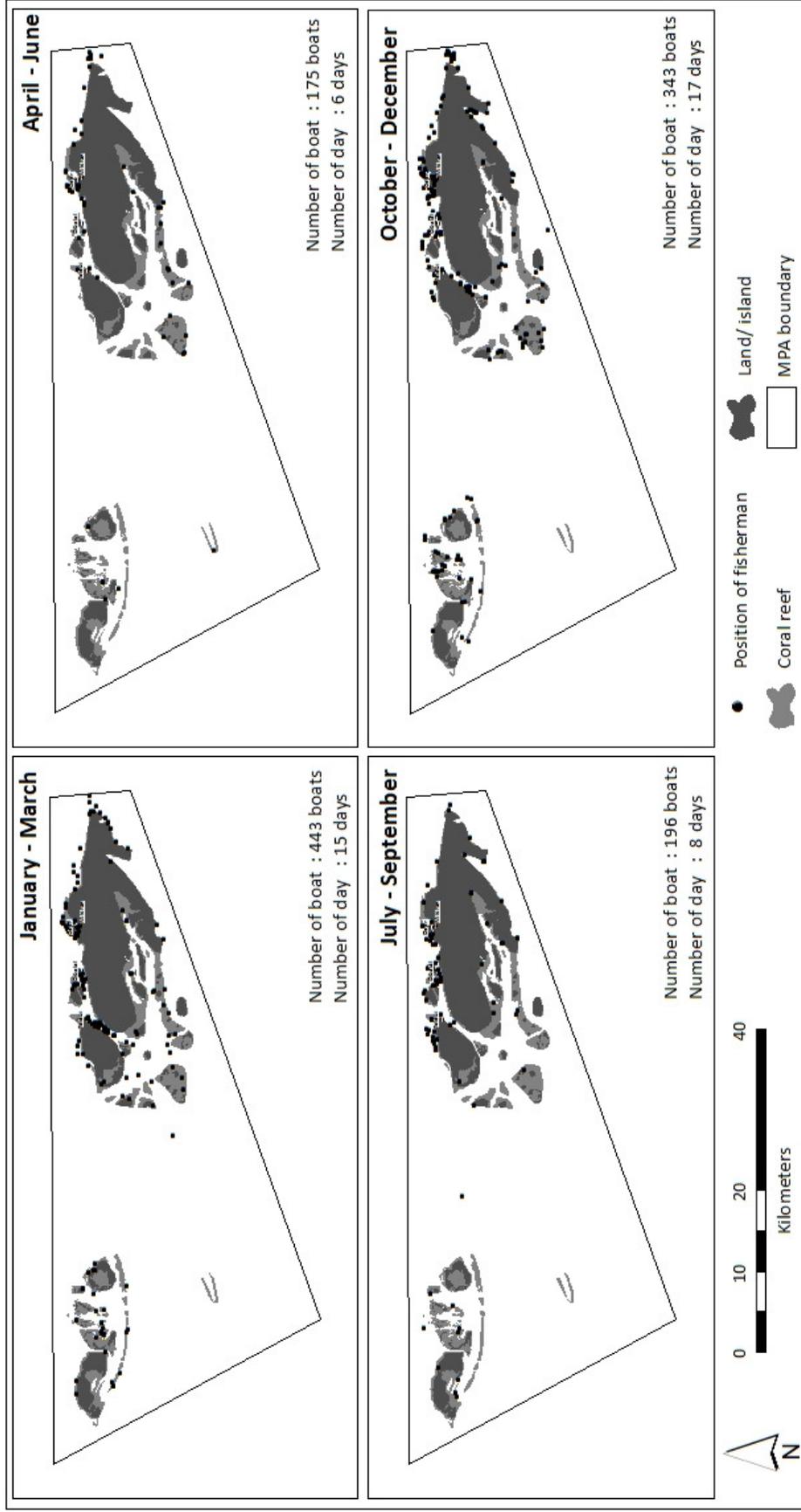


**Figure 3.** Average number of vessels per day (+SE) using resources in Kofiau and Boo Islands Marine Protected Area, by 3-month periods (quarters).

In July to September, the number of vessels operating is at a low and is concentrated in the area close to human settlements in north Kofiau (Figure 4). There is very little activity in south Boo and Kofiau because of the strong winds and ocean swell associated with the southeast monsoon season (Mangubhai et al. 2012). In the period January to March, an average of 12 vessels/day was recorded, with fishers covering the entire Kofiau MPA (Figure 3). Between April and June, an average of 11 vessels/day were recorded (Figure 3), but users concentrated their fishing close to their villages settlements (Figure 4), especially as weather becomes less predictable and the southeast monsoon begins (around May/June).



Resource user in Kofiau and Boo Islands Marine Protected Area. Photographs by Muhajir/TNC (top), D.A. Handono/TNC (bottom left), Purwanto/TNC (bottom right).



**Figure 4.** Maps of the distribution of fishing vessels operating in Kofiau and Boo Islands Marine Protected Area during the four quarters of the year. Data is shown for all years pooled (2006 – 2011). Note there are differences in sampling efforts over the years, and so these maps only represent distribution patterns and not intensity of use.

## ORIGIN OF FISHERS

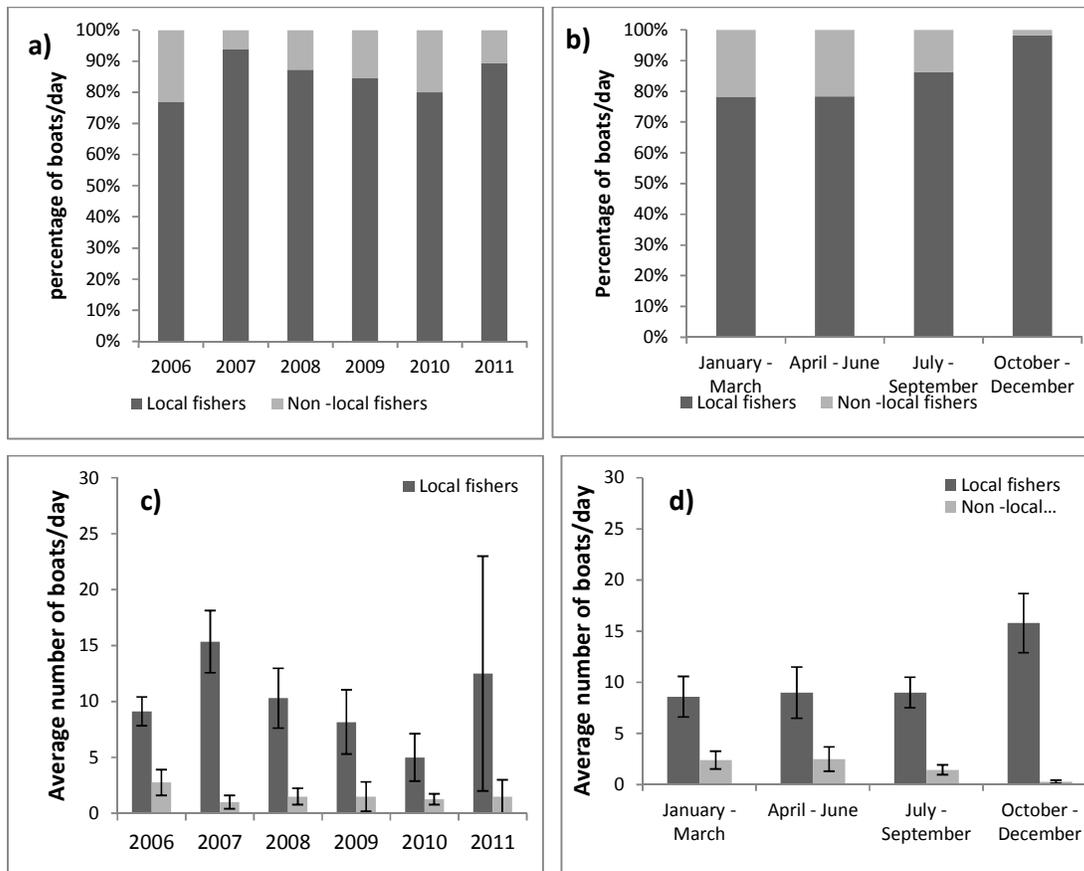
Of the 573 fishing vessels recorded in Kofiau MPA, 485 vessels (85%) were local and 88 vessels (15%) were non-locals (from outside the MPA). Most of the local fishers operating in the area were from the local villages of Deer (39%), Tolobi (24%) and Dibalal (22%), who have traditional/tenurial rights to Kofiau MPA. The non-local vessels were mainly from Maluku (12%), Sulawesi (2%), Papua (<1%), and other areas of Indonesia (<1%) (Table 2). These figures indicate that while fishery resources in Kofiau MPA are important to locals, they are also exploited by outside fishers. Enforcement conducted since 2007 in the MPA has shown that the majority of outside fishers are operating illegally in the MPA, either without a permit or with expired permits. Illegal fishing, if uncontrolled, could result in continued declines to marine resources, particularly reef fish (Purwanto et al. 2012).

**Table 2.** Number and origin of vessels and fishers in Kofiau and Boo Islands Marine Protected Area (MPA), recorded in resource use surveys from 2006-2011. Local fishers from the MPA are indicated by an asterisk.

Origin	No. of vessels	% of total vessels	No. of fishers	% of total fishers	Average no. fishers/vessel
Deer*	222	38.7	320	27.7	1.4
Tolobi*	136	23.7	222	19.2	1.6
Dibalal*	127	22.2	225	19.4	1.8
Maluku	68	11.9	257	22.2	3.8
Sulawesi	13	2.3	87	7.5	6.7
Papua	4	0.7	18	1.6	4.5
Other parts of Indonesia	3	0.5	28	2.4	9.3
<b>Total</b>	<b>573</b>	<b>100</b>	<b>1057</b>	<b>100</b>	

Figure 5 shows the percentage of local versus non-local fishing vessels recorded in Kofiau MPA from 2006 to 2011. The majority of vessels were local, ranging from 77-94% composition (averaging 85%), while non-local vessels ranged from 6-23% (averaging 15%), over the 6 years of surveys (Figure 5a). Spatially, vessels using marine resources in Kofiau MPA fish all coral reef areas in Kofiau and Boo. In Boo, the only local resource users are people from Deer and Dibalal. Figure 6 clearly shows local fishers concentrate their fishing effort around reefs closest to their village, suggesting that there are still relatively healthy fish populations to meet their subsistence needs. In contrast, non-local vessels concentrate their fishing efforts in Boo Islands and on the southside of Kofiau Island, clearly avoiding potential conflict with local resource owners from the MPA.

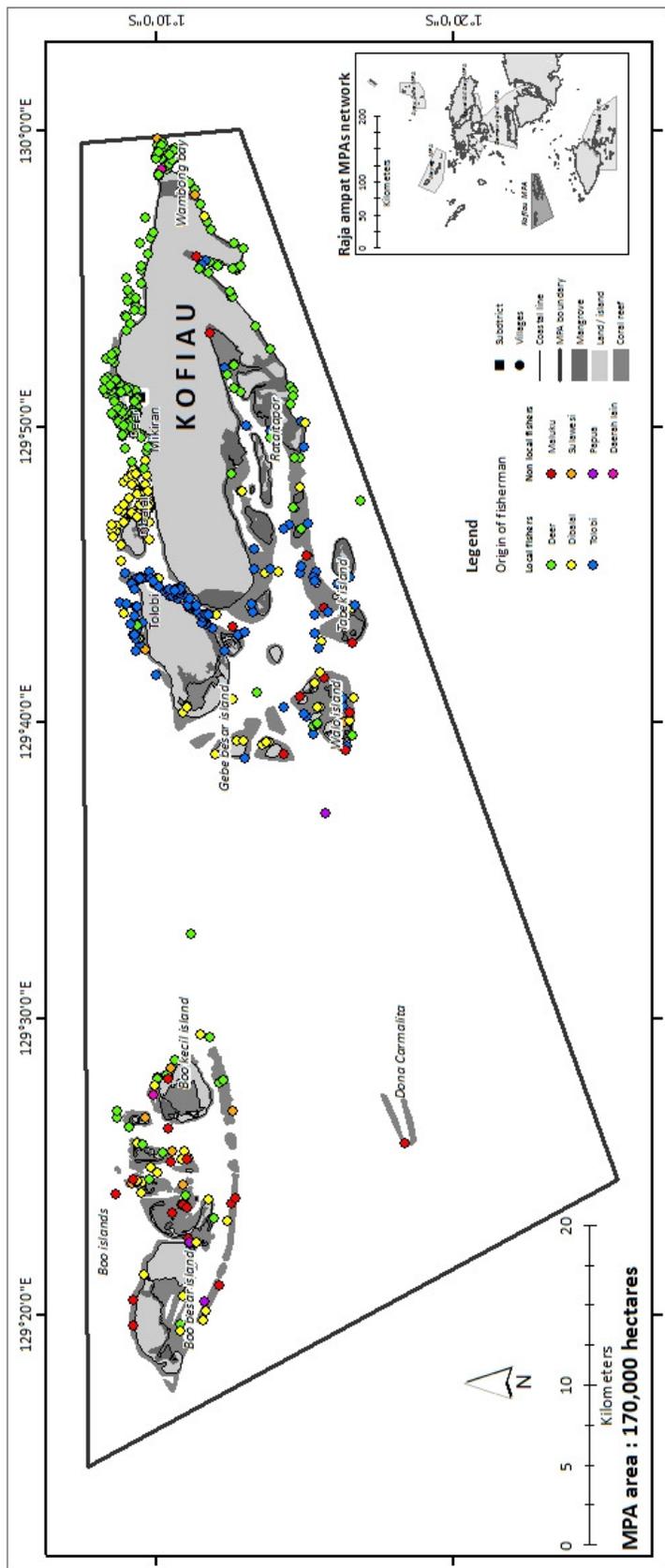
The seasonal patterns shown in Figure 5b and 5d suggests that non-local vessels prefer to fish in Kofiau MPA in the periods January to June, when they make up 22% of the total. In the period July to September non-local vessels comprise 14% of the total number of boats in the MPA, and are as low as 2% in the months October to December (Figure 5b), suggesting outside fishers avoid the MPA when local fishers are most active and most prevalent throughout the MPA. These results suggest that local patrols need to be particularly vigilant during the period January to June, to check the permits of outside fishers frequenting the MPA.



**Figure 5.** Composition of vessels operating in Kofiau and Boo Islands Marine Protected Area by origin of vessel by year (a, c), and by b) 3-month period (b, d). The top graphs show percentages, and the bottom graphs show average number of boats/day.



Examples of fishing vessels recorded in Kofiau and Boo Islands Marine Protected Area. Photographs by Muhajir/TNC.



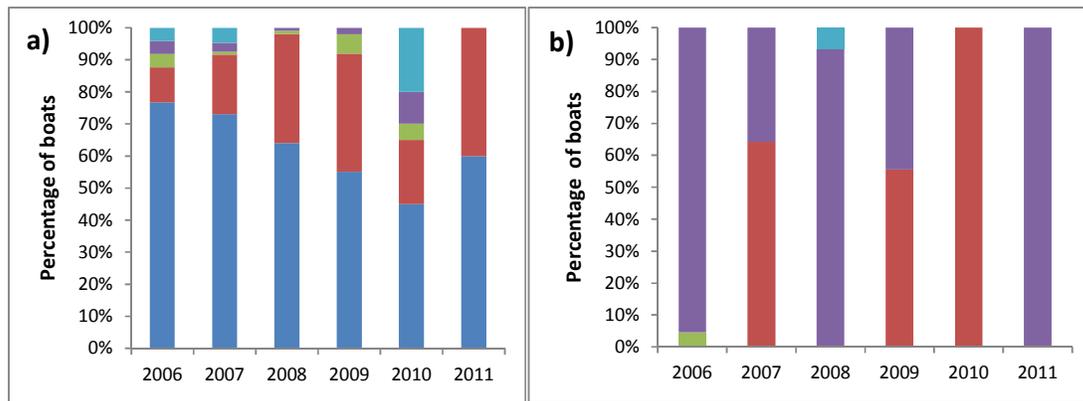
**Figure 6.** Map of resource users in Kofiau and Boo Islands Marine Protected Area by origin of fisher, recorded during resource use surveys from 2006–2011.

## TYPES OF VESSELS OPERATING IN THE MPA

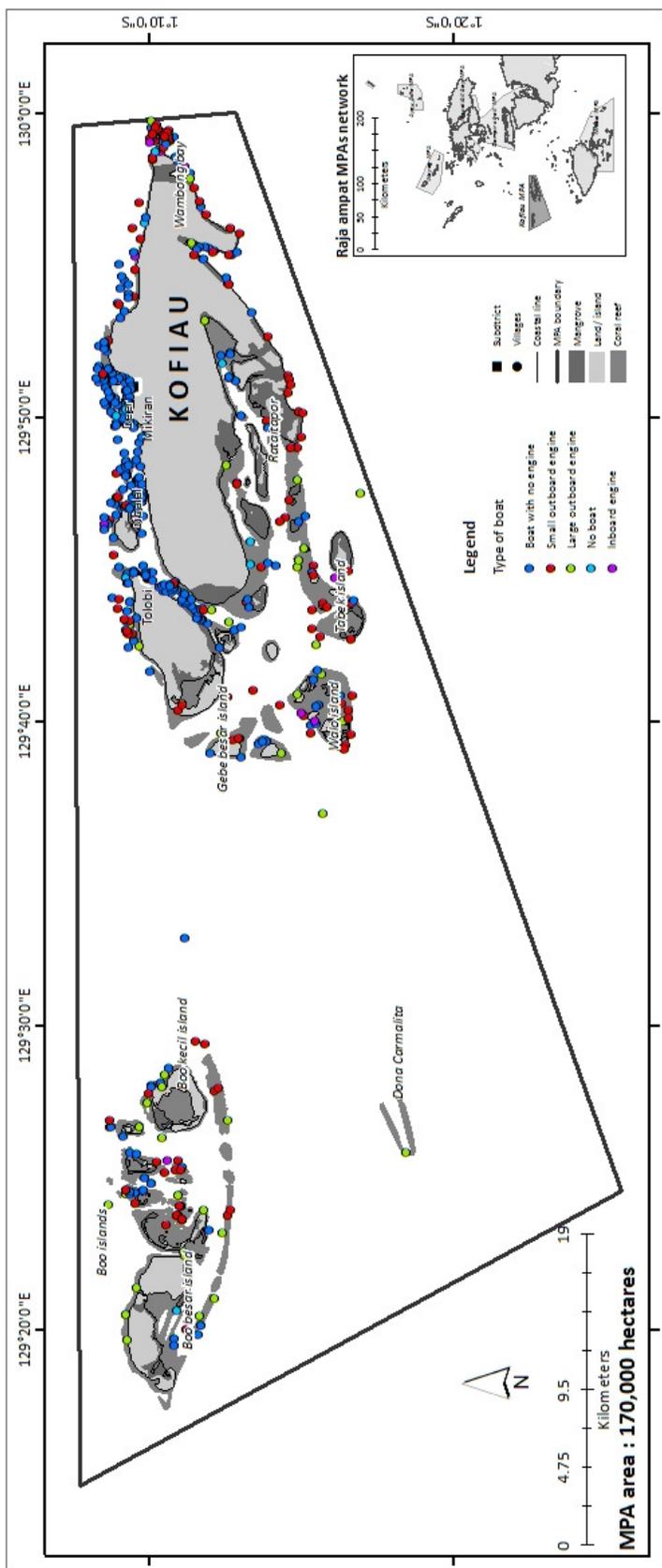
The types of vessels operating in Kofiau MPA include vessels with inboard motors, vessels with large or small outboard motors and motor-less vessels (local canoes). Generally local boats have on average 2 fishers/vessel, while non-local vessels have an average 6 fishers/vessel (Table 2). This difference between local and non-local vessels reflects the differences in size in boats used. Outside fishers travel extensive distances across Indonesia to get to Papua and stockpile catch, and therefore require larger more motorised vessels.

In contrast local fishers use motor-less vessels or vessels with small outboard motors that can carry only one or two people (Figure 7). These small vessels are used to fish from because they are agile and easily manoeuvred in areas of shallow reef, and are more affordable for local community members. Given these differences, regulating vessel size may be one way of reducing illegal outside fishers targeting marine resources in the MPA.

In 2006, motor-less vessels made up 77% of the total, decreasing to 45% by 2010. In 2006, vessels with small outboard motors made up 11% of the total, rising annually to 40% by 2011. This indicates that local fishers are switching from using canoes to vessels with small outboard motors. This increase in wealth in Kofiau MPA was also documented during perception monitoring surveys in 2005, 2006 and 2010 (see Figures 5 and 6 in Hess et al. 2011).



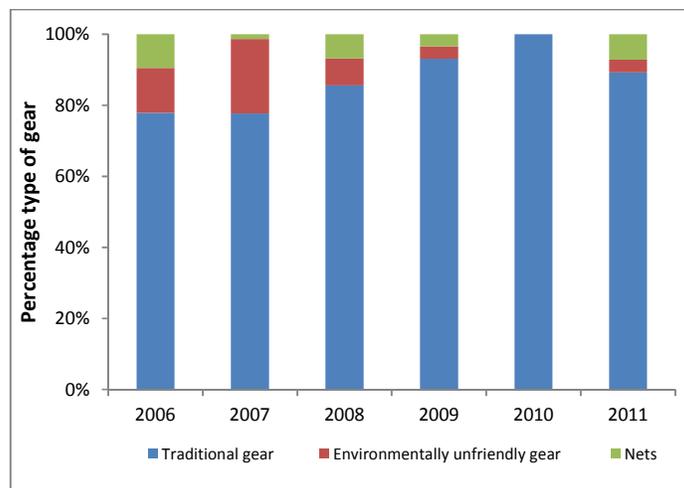
**Figure 7.** Composition of vessels used in Kofiau and Boo Islands Marine Protected Area from 2006-2011 by a) local vessels, and b) non-local vessels.



**Figure 8.** Map of the distribution and composition of vessels operating in Kofiau and Boo Islands Marine Protected Area by origin, from 2006–2011.

## TYPES OF GEAR USED IN THE MPA

The types of fishing gear used in Kofiau MPA are divided into three categories: (1) traditional gear, (2) environmentally unfriendly gear (such as compressors, cyanide, explosives, portable traps and *bameti*<sup>2</sup>), and (3) nets. Traditional gear are the most commonly used type used in the MPA, comprising 70% in 2006–2007, and increasing to around 90% in 2010 to 2011. There was a downward trend in the percentage use of environmentally unfriendly gear, from around 10% in 2007 to around 4% in 2009.



**Figure 9.** Fishing gear used in Kofiau and Boo Islands Marine Protected Area from 2006–2011. Traditional gear included hook and line, drag line. Environmentally unfriendly gear included compressor, cyanide, explosives, *meting bameti*<sup>2</sup>. Nets included gill nets, drag nets/purse seine nets.

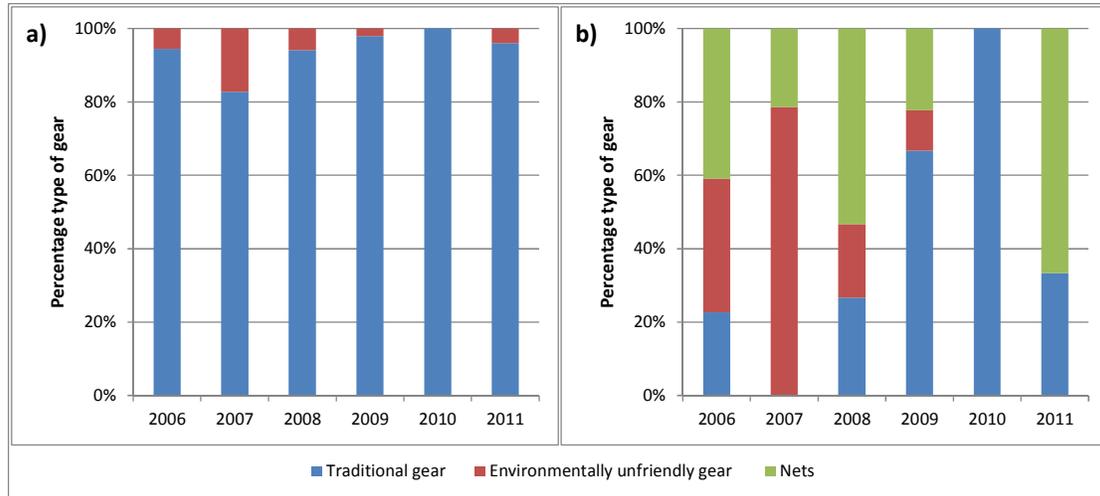
Use of environmentally unfriendly gear was recorded during the monitoring period, averaging 8% of gear used each year. These gear cause damage to coral reef ecosystems, which in turn impacts on the fish population in Kofiau MPA. Some of the gear types are illegal under Indonesian law such as compressors, cyanide and explosives. Nets are still being used in Kofiau, and on average makes up 5% of the gear types used in the MPA each year. These nets have the potential to remove large volumes of marine resources, and if uncontrolled could contribute further to the declines in fish populations, and therefore community fisheries resources (Purwanto et al. 2012).

The composition of gear by origin of fishers operating in Kofiau MPA is shown in Figure 10a. The main difference in gear preferences is that local fishers prefer to use traditional gear such as hook and line, while outside fishers prefer to use more destructive gear types, including those banned under Indonesian law. The most recent surveys show 92% of local users selecting traditional gears to fish.

It is important to note that there are still some local fishers who use more destructive gear types, and they comprise 5% of users across Kofiau MPA. The type of gear these local fishers use includes compressors and *meting bameti*, and these activities are carried out in locations far from human settlements. Figure 10a shows that compressors were used in 2007 and comprised 17% of all gear types, but then decreased in subsequent years, following the implementation of a ‘Rare Pride Campaign’ focused on the impact of destructive methods and gear types on habitats and fisheries. In

<sup>2</sup> *Bameti* is using spears to fish and crowbars to collect shellfish at low tide, which sometimes also involves turning coral over.

2010, there were no compressors used in Kofiau MPA, attributable to a community awareness program (conducted through religious activities), about the dangers of using this kind of gear. Another contributing factor was the enactment of Law 5/2009 (an amendment to Law 31/2004 on fisheries), which prohibited the use of compressors across Indonesia. However, in 2011, compressors appeared again in the MPA and accounted for 4% of gear used by local fishers thought to be collecting sea cucumbers in deeper waters. The use of compressors by these individuals has caused internal conflict in the communities. To stop local fishers from using these damaging gear types, it is clear that peer pressure is needed to change the habits of this 4% of fishers (2 individuals).



**Figure 10.** Composition of gear used in Kofiau and Boo Islands marine protected area by origin of fisher. a) local fishers, b) non-local fishers.

In contrast, 56% of outside fishers used traditional gear, while 15% used destructive gear types. The use of destructive gear types is a large contributing factor to the decline in fisheries resources documented in Kofiau MPA between 2009 and 2011 (Purwanto et al. 2012). Destructive gear is used mainly in areas south of Kofiau and Boo, which are far from human settlements. Nets are used only by outside fishers (29%) that target reef fish around Boo; these fishers are likely responsible for fish biomass declines documented at Boo Islands (Purwanto et al. 2012). Therefore, it is vital that the intensity of monitoring in Boo and the southern side of Kofiau be increased, targeting outside fishers using nets and other destructive gears that are rapidly depleting the resources in the MPA.

Following a workshop in April 2011, the heads of district, adat and village agreed to conduct local patrols throughout the MPA in collaboration with local police. With the recent traditional *adat* declaration of the zoning plan for the Kofiau MPA by local communities, and the increased frequency of local patrols, a further reduction is expected. The recent success in the prosecution of bomb fishers in Kofiau will send a strong message to illegal fishers to avoid fishing in the MPA and has inspired the local community to remain vigilant with their patrols.

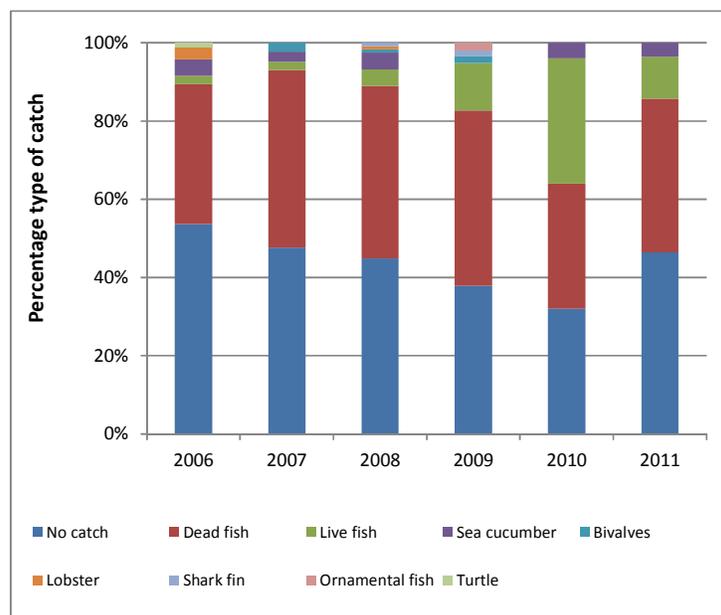


## ORIGINS OF FISHERS AND TYPES OF CATCH

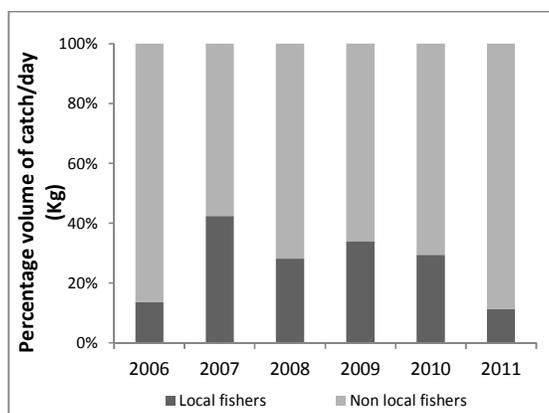
Marine catch in Kofiau MPA is divided into nine categories: (a) dead fish, (b) live fish (grouper and Napoleon wrasse – *Cheilinus undulatus*), (c) sea cucumber, (d) lobster, (e) *Trochus*, (f) shark fin, (g) ornamental fish, (h) turtles, and (i) no catch. Figure 12 shows that an average of 44% of fishers operating in Kofiau MPA had no catch when interviewed by the monitoring team. However, in general, dead fish make up the largest proportion of total catch, averaging 40% annually.

Live reef fish made up 11% of the total catch in Kofiau MPA in 2011. In 2010, catches of live fish were as high as 16% of the total catch; this was because a small number of local villagers did business with an illegal live fish trader backed by a corrupt enforcement officer. This business closed down because there was community pressure to stop because outside fishers did not have the necessary permits, and the majority of locals were opposed to the operation.

Sea cucumbers are also a target for fishers, making up an average of 3% of the total catch each year. Other types of catch, such as shellfish, lobster, shark fin and ornamental fish (and on one occasion turtles), were targeted by fishers operating in Kofiau MPA. Most of these categories of catch are fish or invertebrates that live in on or around coral reefs, which means that fishing pressure is focused on this ecosystem, and there is very little pelagic fishing in the MPA. This indicates just how important it is to have a zoning plan in place to manage coral reef fisheries, using a combination of no-take and traditional use or ‘sasi’ (seasonal closures) zones to ensure long term sustainability and food security for local people. Community involvement and buy in for the Kofiau MPA will hopefully lead to greater compliance of local fishers with the zoning plan and their continued commitment to conduct local patrols in the MPA.

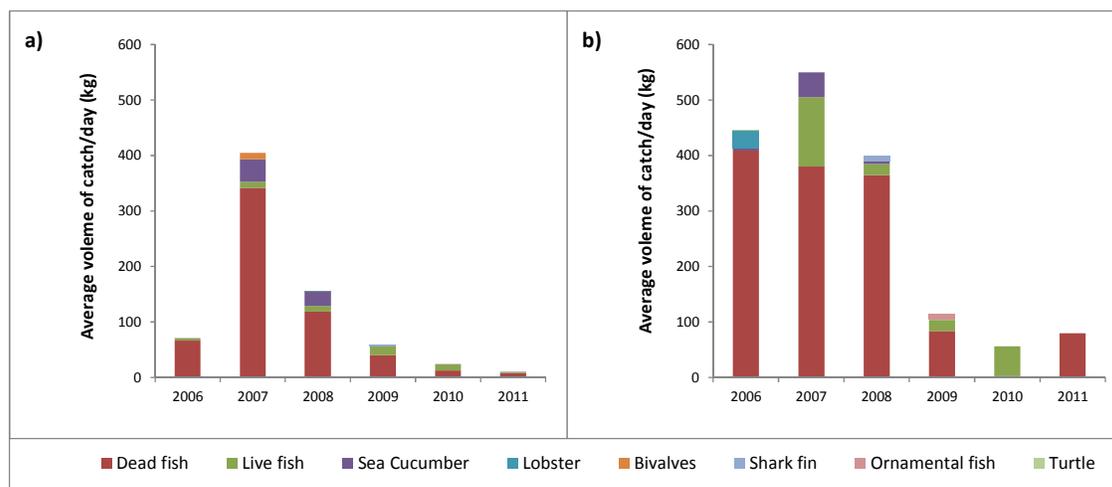


**Figure 12.** Composition of catch taken from Kofiau and Boo Islands Marine Protected Area from 2006-2011.



**Figure 13.** Composition of catches by local and non-local fishers (kg/day).

Average daily catch during the period 2006-2011 was 297 kg/day. The average catch of local fishers was 91 kg/day or 31% of the total catch, while the average catch of outside fishers was 206 kg/day or around 70% of the total catch. In general, the catch of outside fishers made up a larger percentage than that of local fishers. This is thought to be due to the type of gear used by outside fishers, who make more use of nets, which can catch larger volumes of fish.



**Figure 14.** Average daily catch (kg) by origin of fisher using resources in Kofiau marine protected area. a) Local fishers, b) non-local fishers.

In general, local fishers caught fish to meet their subsistence needs, and targeted sea cucumber, live fish, shellfish and shark fin for sale to the various collection agents in the villages (Figure 14a). Sea cucumber catches by local fishers peaked in 2007 and 2008, because some local fishers used compressors in those years. Between 2009 and 2011, sea cucumber catches decreased thanks to continuous socialisation of the government law banning the use of compressors. Since 2007, local fishers' targeted live fish for the live reef fish trade, with the largest average catch in that first year. This is because there were live fish dealers in each village. The decline afterwards, likely reflects declines in grouper numbers in the MPA and growing opposition to collecting groupers as communities had greater awareness of their status of their marine resources.

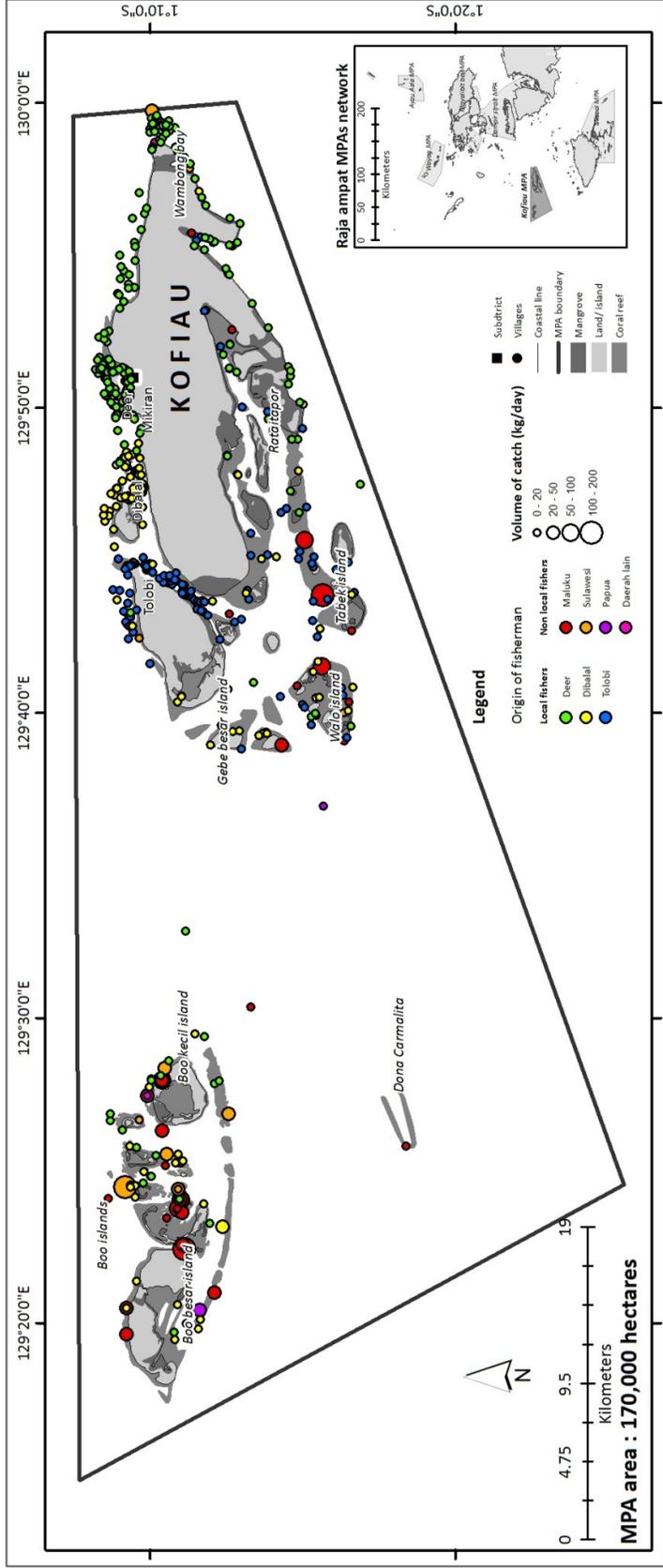
The average catches of outside fishers are shown in Figure 14b. Dead fish and live fish are the main targets for outside fishers. The primary dead fish targeted by outside fishers is needlefish (family Belontiidae). The same method is used to catch needlefish as well as fish for live fish (grouper and Napoleon wrasse): non-local operators transport their gear into the area and then build bamboo cages (*karamba*) to store the fish they catch. None of the vessels operating to catch live fish recorded during the surveys had permits from Raja Ampat Fisheries and Marine Agency (Dinas Kelautan dan Perikanan), but they did have written permission by a village head. This capture of live fish began in 2007 and continues today and requires more focused effort to manage grouper and Napoleon wrasse populations in the MPA. Sea cucumber and lobster are also targets for outside fishers, and they typically catch these species using compressors, which is now illegal in Indonesia.

The large volume catches of outside fishers using fishery resources in Kofiau MPA has made a significant contribution to the overfishing issue faced by local communities, and is a threat to the sustainability of fisheries in this MPA. The large numbers of outside fishers fishing in Kofiau MPA is a result of the absence of zoning plan (until recently), as well as absence of a clear regulating mechanism to control the number of commercial licences that are given out for Kofiau MPA. The general perception or paradigm that the sea is open access is also thought to be a reason why so many outside fishers operate in Kofiau MPA. In addition, the local belief that fish resources are endless or will replenish continuously promotes the permissive attitude towards or acceptance of outside fishers using resources in the MPA.

Figure 15 shows that there is pressure from overfishing in all areas of Kofiau MPA, but that the areas under most pressure are the Boo Islands and the waters around Walo Island. These areas are far from human settlement, so it is important that they be targeted by local patrols. In general, it is fishers from Maluku and Sulawesi that catch large volumes (100-200 kg/day). The recent zoning of Kofiau MPA in October 2011, now provides a unique opportunity to better manage resource use in the MPA, and if enforced should result in increases in fish and invertebrate populations, and therefore improved fisheries for local communities. It will be important that fisheries regulations be clearly articulated in the management plan currently being developed for the Raja Ampat MPA network, with clear lines of authority between capture fisheries and protected area management within the Raja Ampat Fisheries and Marine Affairs Agency.



Photographs showing illegal catches in the Kofiau and Boo Islands Marine Protected Area. From left to right, and top to bottom: illegal harvesting of coconut crabs, a species protected in Indonesia, and shark finning in Kofiau MPA.



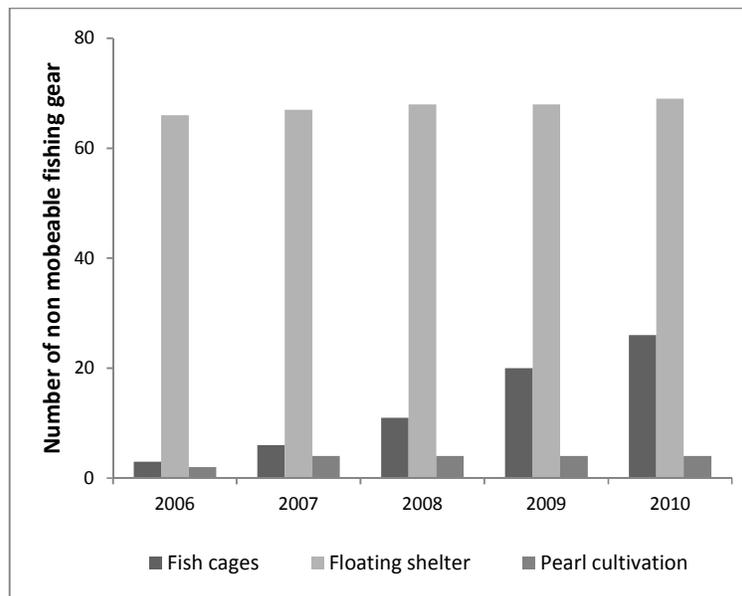
**Figure 15.** Map of the fishing in Kofiau and Boo Islands Marine Protected Area, by origin of fishers. Note size of circles denotes the volume of fish caught (kg/day)

## TYPES OF NON-MOBILE USES

The types of non-mobile resource use recorded in Kofiau MPA are floating houses, fish cages, and pearl farming. There is an upward trend each year in these non-mobile resource uses in the MPA (Figure 13). Floating houses are the most common non-mobile use recorded and the increase in this use is relatively small – these are used by local fishers as resting places when they are fishing far from where they live and also as places to store produce from their gardens, such as copra.

Other non-mobile resource uses are fish cages and pearl farms. In 2006, only 3 fish cages were recorded, but in 2009, there was a significant increase to 20 cages. This indicates that capture of live fish in 2009 and 2010 was very high, because these cages are used to store captured live fish before they are sold, and are routinely collected by live fish dealers using collection vessels.

Another non-mobile resource use is pearl farming, which is done by a non-local business man. In 2006, pearl farms were operating in only two areas, but by 2007, they had expanded and were operating in four areas. The local people and local government accept the presence of pearl farms in Kofiau MPA because they assume that this activity will benefit the local economy, and is considered non-extractive and has low impact to the environment (Mangubhai et al. 2012). However, the locations of these pearl farms should be designated or regulated to avoid conflict with other resource uses, such as fishing, and to avoid disruption of the passage of local vessels.



**Figure 16.** Non-mobile resource uses in Kofiau and Boo Islands Marine Protected Area from 2006-2011.

## CONCLUSIONS

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In summary, the resource use data from the surveys conducted in Kofiau MPA from 2006 to 2011 showed the following:

- Fishers make up the largest proportion of users (99%), and there has been no growth in recreation diving or recreational fishing, which make up only 1% of the total resource use in Kofiau MPA.
- There has been a decline in the number of fishers from 2006 to 2011, caused by a decline in the number of non-local vessels frequenting the MPA.
- Outside fishers were mainly from Maluku and Sulawesi and accounted for 15% of fishers using Kofiau MPA. This relatively small proportion of fishers, however, remove 70% of the total annual catch from the MPA, and often operate with a valid permit.
- Local fishers tend to fish the waters in Kofiau that are close to human settlement, while outside fishers tend to fish the waters around the Boo Islands and reefs on the south side of Kofiau Island, which are relatively far from human settlement.
- The highest number of boats was recorded in the months October to December, when communities are farming or working on their coconut plantations away from their village and are fishing to meet their daily subsistence needs. The lowest number were recorded in the month July to September, which coincides with the southeast monsoon season when sea conditions are rough and reefs in the south and in Boo Islands are less accessible.
- Local fishers use traditional gears, especially hook and line, while outside fishers use more destructive gear types (e.g. large nets) or destructive fishing methods (compressor, bomb fishing, cyanide). About 8% of gear used each year in the MPA falls in the category of environmentally unfriendly types.
- Bomb and cyanide fishing has now largely been removed from the MPA, and compressor fishing has been reduced. Large nets, however, are still used by outside fishers frequenting the area and is likely responsible for the declines in fish stocks recorded in reef health surveys (Purwanto et al. 2012).
- Live reef fish (comprising mainly groupers and Napoleon wrasse) made up 11% of the catch in 2009. This fishery is of greatest concern in the MPA because there are currently no functioning spawning aggregations and reef health surveys have shown these populations to be very low (Purwanto et al. 2012). If continued, it is likely that some species will be extirpated from the MPA or will become so low that recovery may take a very long time.

## RECOMMENDATIONS

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From 6 years of resource use monitoring we make the following recommendations:

1. Given the high costs of running surveys in remote MPAs, resource use monitoring should be undertaken as part of the local community patrol program that now operates in Kofiau MPA. This will enable local communities and the government to monitor changes in resource use in Kofiau MPA as part of their efforts to measure how effectively the MPA is being managed and levels of compliance with the recently declared zoning plan.
2. To ensure the sustainability of fisheries in Kofiau MPA, zoning regulations, licensing mechanisms, and regulations on the use of gear need to be explicitly stated in the management plan for the Raja Ampat MPA network, to manage fishing pressure on the MPA, particularly from outside fishers who use larger boats and more destructive gear types.
3. Local patrols need to become more routine and consistent, and should initially focus heavily on areas being targeted by outside fishers such as Boo Islands and the southern side of Kofiau Island, to enforce community declared zoning plan and existing fisheries regulations.
4. The data from resource use monitoring and reef health monitoring in Kofiau suggests that the live reef fishery requires urgent management as grouper and Napolean wrasse populations are very low with some species likely to go extinct without intervention. Given there are no longer any functional spawning aggregations sites in the MPA, recovery of this fishery will take a long period of time.
5. Implement local education programs that will build the knowledge and awareness of local people about sustainable fisheries, allowing locals them to participate more in initiatives that promote sustainable fisheries in Kofiau MPA.

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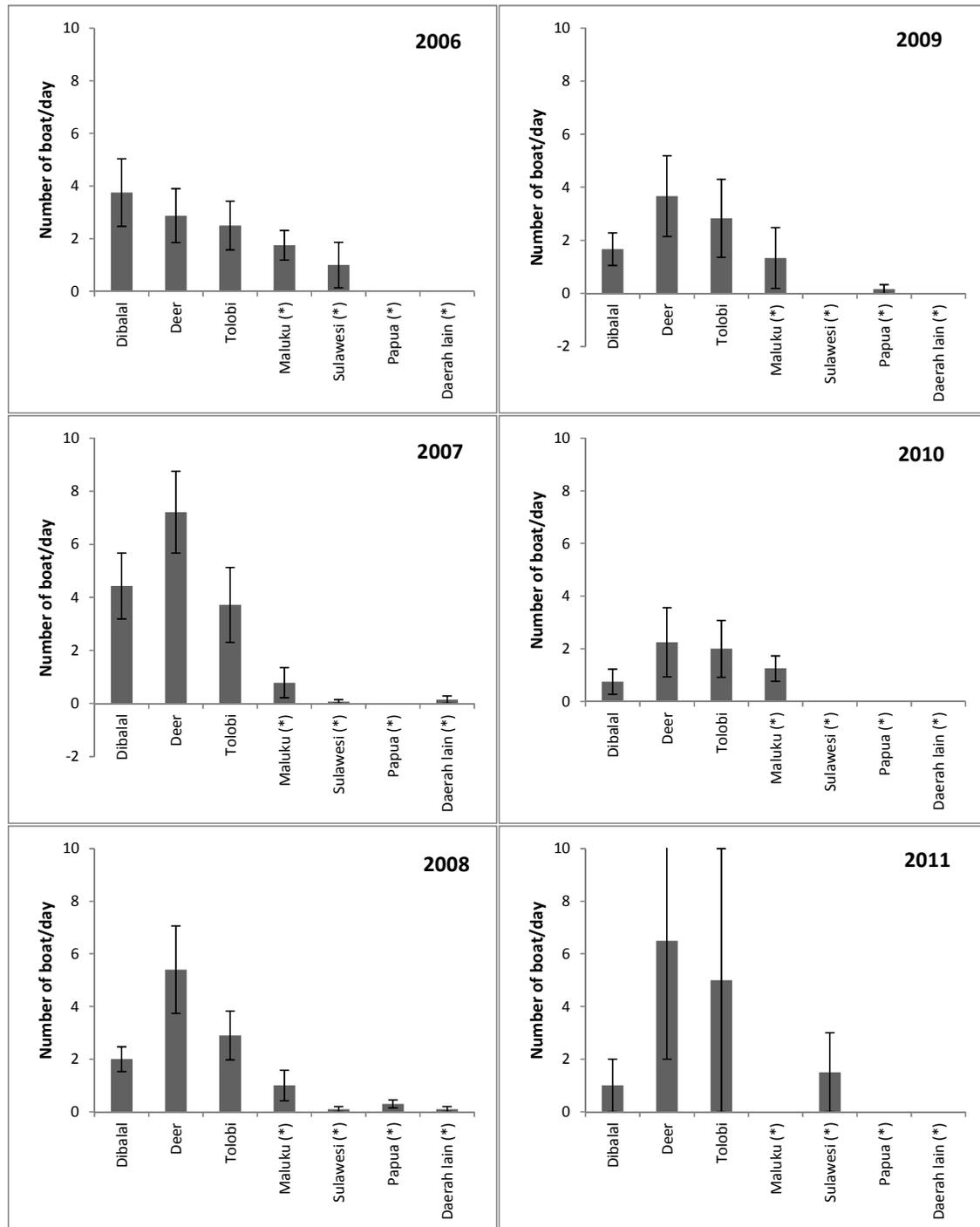
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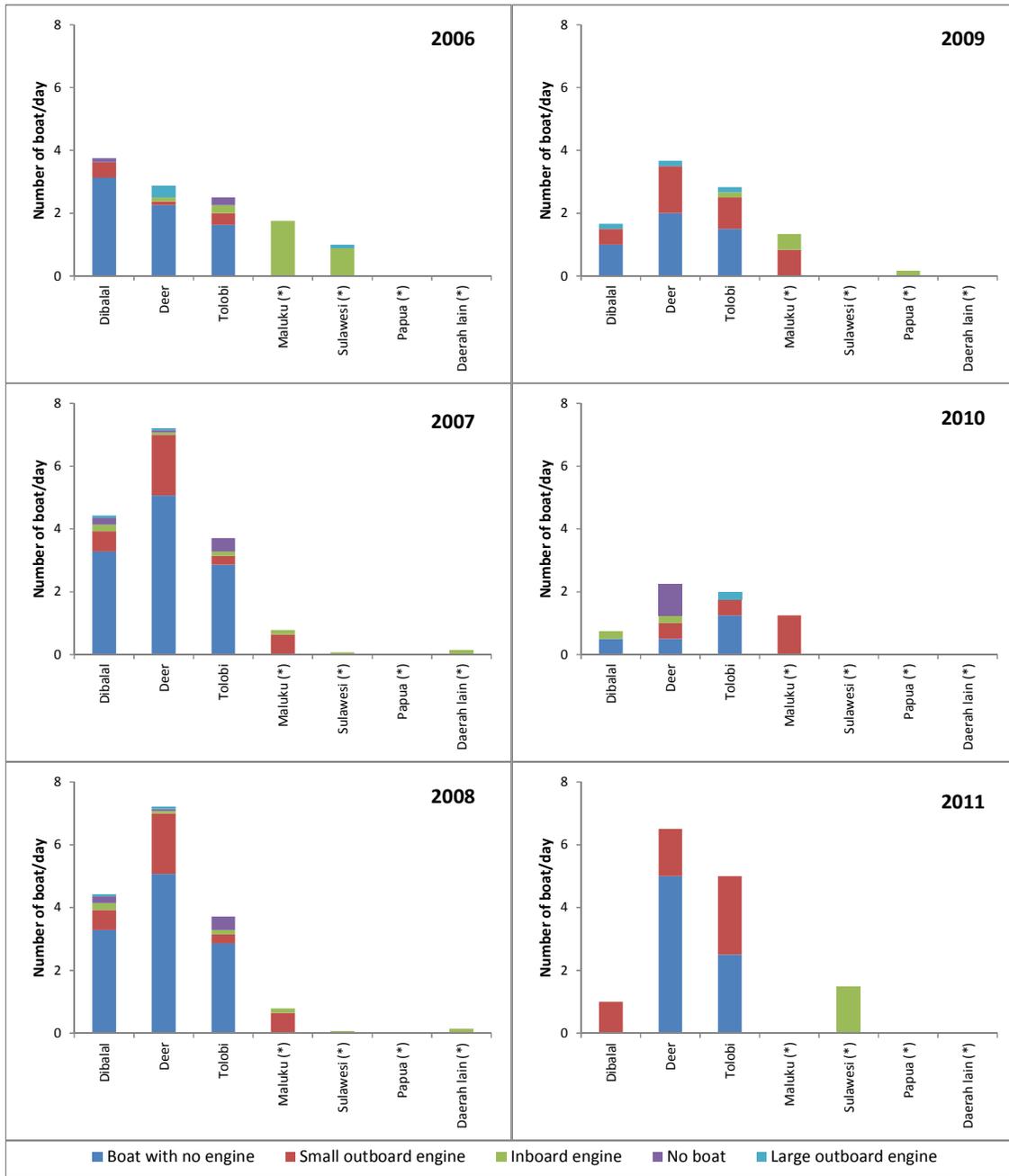
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# APPENDICES

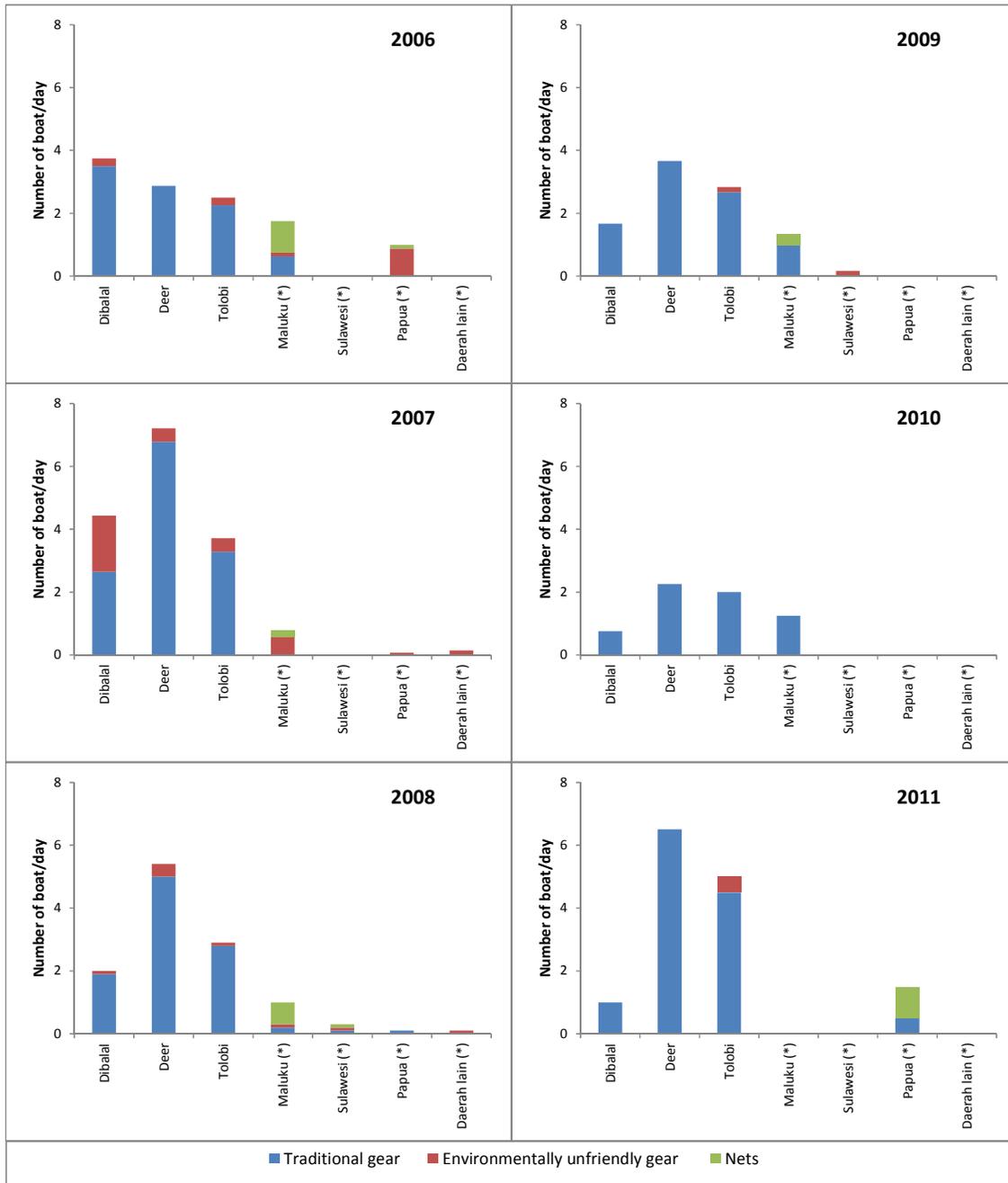
**Appendix 1.** Number of vessels operating in Kofiau and Boo Islands marine protected area by origin, 2006 – 2011.



**Appendix 2.** Composition of vessels recorded using marine resources in Kofiau and Boo Islands marine protected area, by origin, 2006 - 2011.



**Appendix 3.** Composition of gear used by vessels recorded using marine resources in Kofiau and Boo Islands marine protected area, by origin of vessel, 2006 - 2011.





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