IMPROVED TURTLE CONSERVATION IN SEBATIK ISLAND, NORTH KALIMANTAN, INDONESIA

10 November 2017

FINAL REPORT[1]

PACIFIC RIM INNOVATION AND MANAGEMENT EXPONENTS, INC., PHILIPPINES

Faculty of Marine Science and Fisheries
Hasanuddin University

[1] Prepared by the Faculty of Marine Science and Fisheries, Hasanuddin University (UNHAS).

TABLE OF CONTENTS

LIST OF TABLES

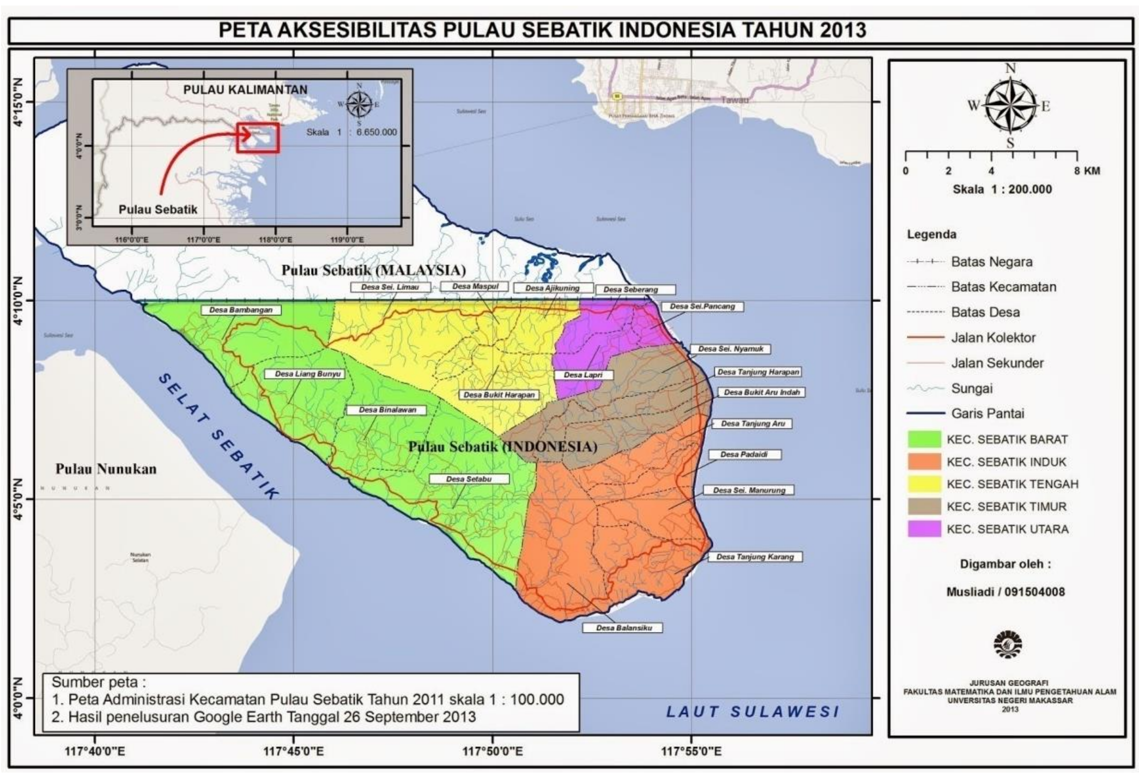
LIST OF FIGURES

I. INTRODUCTION

Sebatik Island, in Nunukan District, North Kalimantan Province, is one of the outermost islands of Indonesia. The border between Indonesia and Malaysia bisects the Island, with the northern half in Malaysia and the southern half in Indonesia. Two currencies are used in trade on Sebatik Island, the Indonesian Rupiah (Rp.) and the Malaysian Ringgit. Many goods are imported from Tawau City in Malaysia, just across the narrow strait separating Sebatik Island from the mainland of Sabah, Malaysia to the north. The current state and development of Sebatik Island has been, is, and will continue to be strongly influenced by conditions and activities in the nearby economic centres within the two neighbouring countries, i.e. Nunukan (Indonesia) and Tawau (Malaysia).

The Indonesian part of Sebatik Island is divided into 5 Sub-Districts (**Figure 1**). The sub-districts and their administrative capitals are: Sebatik Sub-District, capital Tanjung Karang; Sebatik Timur Sub-District, capital Sei Nyamuk; Sebatik Utara Sub-District, capital Sei Pancang; Sebatik Tengah Sub-District, capital Aji Kuning; and Sebatik Barat Sub-District, capital Binalawan.

Figure 1. Map of Sebatik Island



The majority of the people living on Sebatik Island are involved in trade, fisheries or palm-oil plantations. Because of their ethnic origins, many Sebatik islanders trade with people in South Sulawesi. Many goods imported from Malaysia are shipped across the Makassar Straits to be sold in Pare-Pare and Makassar. Goods shipped to Sebatik from South Sulawesi include livestock products, especially eggs, and other agricultural produce such as rice, herbs and spices and other basic foodstuffs. The bulk of this inter-island trade is freighted via the Nunukan-Pare-Pare shipping route.

Sebatik Island is situated within the Sulu-Sulawesi Sea Marine Ecoregion (SSME), comprising parts of the Philippines, Malaysia and Indonesia. According to Trono and Cantos (2002), seven of the known species of sea turtles are found in this region: the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive Ridley turtle (*Lepidochelys olivacea*), leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*). Furthermore, important habitats for green and hawksbill turtles within this region include Sipadan Island in Malaysia, to the north of Sebatik, and the Derawan Islands in Indonesia, to the south of Sebatik. Turtles are known to migrate between these habitats; thus, migrating sea turtles could be expected to pass through waters close to Sebatik Island.

The expansion in fishing activities in coastal areas is believed to be a significant factor contributing to the decline of several sea turtle populations, including mortality due to turtle by-catch, i.e. incidental capture in fisheries targeting other species (FAO, 2004, 2005; Gilman et al, 2009). As pointed out by Gilman et al. (2009), in order to mitigate turtle by-catch it is necessary to understand the specific situation, including the fishing gear used, the way in which the gear is set and retrieved, the mechanisms through which turtles become entrapped, and other relevant technical information. In addition, data on environmental conditions and the wider socio-economic and cultural context are likely to be needed when formulating plans to reduce sea turtle by-catch. This report presents data and information relevant to the mitigation of sea turtle by-catch, specifically for turtles caught by fishermen from Sebatik Island in the waters off North Kalimantan District, up to (and in some cases crossing) the Indonesian-Malaysian border.

II. THE ECONOMIC ROLE OF MARINE FISHERIES IN COASTAL COMMUNITIES

A. Demographic data

As stated above, Sebatik Island is an outermost island divided between two countries. The southern part of the island is within the territory of the Republic of Indonesia, while the northern part is Malaysian territory. The most recent demographic data for the Indonesian part of Sebatik Island are shown in **Table 1**. These data show that in 2015 there were nearly 38,000 inhabitants, comprising over 9,200 households. The conditions on Sebatik Island and its development are influenced by the proximity of Sebatik Island to two major economic hubs, i.e. Nunukan (Indonesia) and Tawau (Malaysia).

Table 1. Demographic Data for Sebatik Island, Nunukan District, in 2015

No	Sub-District	Population (number)	Percentage (%)	Population Density (per km^2)	House-holds	Average people/ household
1	Sebatik	4,646	12.23	90.97	1,208	4
2	Sebatik Timur	12,524	32.96	319.73	3,170	4
3	Sebatik Utara	5,648	14.87	366.99	1,637	4
4	Sebatik Tengah	7,337	19.31	153.78	1,637	4
5	Sebatik Barat	7,837	20.63	84.02	1,571	4
	Sebatik Island	37,992	100		9,223	4

Source: Nunukan District Statistics Bureau, 2016.

The data in Table 1 show that Sebatik Timur Sub-District was the most populous sub-district, with 12,524 inhabitants living in 3,170 households, and the second highest population density (≈320/km^2). Sebatik Sub-District had the smallest population, with 4,646 inhabitants living in 1,208 households, but the second lowest population density (≈91/km^2). The remaining 3 sub-districts (Sebatik Utara, Sebatik Tengah and Sebatik Barat) had similar numbers of households, but very different population densities. Sebatik Utara Sub-District, with the second smallest population, had the highest population density among the five sub-districts, nearly 367/km^2.

B. Marine Fisheries Production Data

Official fisheries production data (in metric tons), comprising the recorded catch of Sebatik Island fishermen over the period 2011–2015, are shown in **Table 2**. These data show an overall slightly increasing trend in catch volume; although catch volume was less in 2012 than 2011, this was not a sharp drop, and annual catch volume rose steadily thereafter. In 2011, there are no figures for two of the sub-districts, as they were still part of Sebatik Sub-District which produced over 95% of the total catch volume. As might be expected, there were no marine fisheries catch data for Sebatik Tengah, which does not have a coastline.

Table 2. Marine Fisheries Production Data for Sebatik Island, Nunukan District, 2011 - 2015

No	Sub-District	Recorded Catch (Metric tons)				
		2011	2012	2013	2014	2015
1	Sebatik	3,142.67	1,277.92	1,282.91	1,292.00	1,305.69
2	Sebatik Timur	0.00	1,254.20	1,273.26	1,298.40	1,323.76
3	Sebatik Utara	0.00	565.76	564.45	570.02	581.22
4	Sebatik Barat	124.68	136.78	140.45	147.73	145.48
	TOTAL	3,267.35	3,234.66	3,261.07	3,308.15	3,356.15

Source: Nunukan Marine and Fisheries Service, 2016.

The data in Table 2 present a strong contrast with the sub-district demographic data (Table 1) as well as the length of coastline in each sub-district (Figure 1). From 2012 to 2015, Sebatik and Sebatik Timur, the least and most populous districts, had similar production figures of around 1250-1320 metric tons. Between them, these two sub-districts produced around 78% of the total catch volume. In 2015, Sebatik Timur Sub-District produced slightly more than Sebatik, both producing over 1,300 metric tons of fish.

While Sebatik District has a relatively long shoreline, Sebatik Timur has a short coast, not much longer than Sebatik Utara, which was consistently third in terms of marine fisheries catch volume data, producing around 565-580 metric tons. Despite having the longest coastline, running almost the full length of the Indonesian part of Sebatik Island facing southwest towards Nunukan Island, Sebatik Barat Sub-District consistently had the lowest catch volume, ranging from around 125-148 metric tons. The Sebatik Island fishermen target both demersal and pelagic species. The most recent catch data per species or species group are shown in **Table 3** (third quarter of 2015) and **Table 4** (2016). These data show considerable variation in both catch volume and catch composition between the months. However with such a short time-frame (15 months) they cannot be used to identify seasonal trends with any certainty. Several commodities stand out in terms of catch volume. High value/high volume commodities include large shrimp and Spanish mackerel.

Commodities which appear to be very seasonal include anchovies, skip-jack tuna, jacks and trevallies, squid, crabs, milkfish, flatfish and small shrimps. On the other hand, commodities with relatively stable catch volumes include silver pomfret, seabream, snappers, grunters, catfishes, herrings, threadfins, conger eels, and queenfish. Several commodities had a sharp drop in July 2016, possibly related to the timing of the fasting month of Ramadan, e.g. lobster and shellfish.

Table 1. Sebatik Island monthly marine fisheries catch data, October – December 2015

No.	Commodity	2015 Catch Volume (Kg)		
		October	November	December
1	Silver Pomfret	1985	4228	3677
2	Seabream	2066	3867	3501
3	Snappers	2315	3158	5781
4	Grunters	1210	3670	1715
5	Rays	2100	4501	3646
6	Catfishes	2010	2858	4538
7	Large shrimp	7286	11960	9625
8	Small shrimp	150		
9	Spanish mackerel	4895	6548	7565
10	Anchovies	280	260	195
11	Skipjack tuna		257	400
12	Lobster	317	306	471
13	Herring	1468	2319	2777
14	Threadfin	1468	3693	2975
15	Groupers	1301	1225	2095
16	Seaweed	43100	9700	7150
17	Jacks/trevallies	135	749	635
18	Conger eels	3538	3857	5412
19	Queenfish	1370	2205	2966
20	Wolf herring	303	1430	1910
21	Milkfish	150	2900	7500
22	Squid		774	1440
23	Shellfish (bivalves)		650	1755
	Total	**77,447**	**71,115**	**77,729**

Source: Sebatik Fish Landing Site (PPI), 2017.

Table 2. Sebatik Island marine fisheries monthly catch data for January – December 2016

No.	Commodity	Monthly catch volume - 2016 (Kg)											
		January	February	March	April	May	June	July	August	September	October	November	December
1	Silver pomfret	2910	2269	1936	1462	1986	1727	1224	1583	2096	3380	1754	2367
2	Seabream	3610	3347	3088	3278	3685	4155	2530	3794	5602	4385	2840	3836
3	Snappers	2535	2245	2396	2164	3323	2403	1786	3121	3045	3340	2602	2751
4	Grunters	2279	2315	2485	2570	3405	2196	1830	4695	2791	3356	2562	3882
5	Rays	3995	3195	3368	3000	3590	4266	3938	5276	4602	5847	4749	5300
6	Catfishes	3936	5296	5493	4459	5117	3946	2724	4805	3722	5021	4561	6307
7	Large shrimp	14420	11140	14350	17390	21920	20962	11995	16090	15253	17827	11620	19385
8	Small shrimp	382		350	3461	6906	20963	2511	7384	7374	2294	10494	2915
9	Spanish mackerel	6410	4480	5174	5262	8101	4500	4836	6066	6763	6183	4944	5653
10	Anchovies	530	120	40	2105	14792	213	6688	2401	9892	18566	10034	16995
11	Skipjack tuna	1600	300			556							
12	Lobster	416	393	313	213	358	202	79	296	341	238	281	202
13	Herring	2612	2665	2347	2960	3654	1641	1461	2538	2212	2244	1763	3057
14	Threadfin	3457	3085	2834	2657	3210	2579	2197	3349	3915	4490	2635	3770
15	Groupers	1549	1005	607	965	1840	1327	988	1954	1662	2016	2024	2694
16	Seaweed	13400		26150	13400	22276				29126			
17	Jacks/trevallies	620	510	203	200	380	80	95	129	180	520	115	170
18	Conger eels	5485	5277	8085	10833	10291	9457	5759	5569	7567	7155	6796	9268
19	Queenfish	3170	2455	1926	2895	3100	2917	2020	2440	3692	3506	3003	4685
20	Wolf herring	655	320	480	450	554	438	486	610	554	1251	852	1421
21	Milkfish	5300	5200	6510	9045	13668	4881	14027	14808	27208	3008		1635
22	Flatfish	1570	778	654	200	147		248	124	412	346		
23	Crabs	170	1110	130	180	216		2579	10786	256	196	216	
24	Shellfish (bivalves)	3850	4600	2650	2200	3725	1340	277	1620	6500	7120	4270	7400
25	Other	650	915	616	396	1298	2420	2917	6658	599	2186	1548	3550
	Total	85,511	63,020	92,185	91,745	138,098	92,613	73,195	106,096	145,364	104,475	79,663	107,243

Source: Sebatik Fish Landing Site (PPI), 2017.

C. Coastal community fisheries-related economic activities

The economic activities of coastal communities around Sebatik Island include the processing of fisheries commodities and aquaculture as well as marine capture fisheries. These include the following four livelihoods activities.

1. Dried Fish Production

Two kinds of dried fish produced by the Sebatik Islanders are particularly important to the local economy, in terms of income as well as food security. These are anchovies (*Stolephorus* sp., local name *ikan teri*) and croakers (*Johnius* sp., local name ikan gulama), often referred to as "cracker fish" (ikan kerupuk) because when dried the fishes becomes very thin (see photos below). The dried croakers not only look like crisps or uncooked crackers (e.g. prawn crackers), but are also prepared for eating (deep fried) in a similar way. These species are especially abundant in Sebatik, Sebatik Timur, and Sebatik Barat Sub-Districts, and can often be seen laid out to dry.

Dried croakers sell for around Rp. 65,000/kg, while dried anchovies fetch around Rp. 45,000/kg. Most of the dried fish production is sold locally, within Nunukan District. Dried fish processing in Sebatik Island is largely small-scale, using simple, traditional methods. After landing, the fish are cleaned and sun-dried, usually with no cover or protection from insects, dirt, or other sources of contamination. Packaging of the dried fish is also usually very basic, with the fish being sold loose (by weight) and put in plastic bags, or weighed and put into tied or sealed plastic bags (generally cheap and not food grade standard), as shown below.

Photo 1. Dried croakers

Photo 2. Dried anchovies

Photo 3. Drying process

Photo 4. Packaged dried croakers

2. Production of dried ebi (small shrimp)

Small shrimp, locally called *ebi*, are also caught and dried, mostly in Sebatik Barat Sub-District. The shrimp are mostly caught in the waters around Nunukan Island, using a kind of mini-trawl called a *cantrang*. The production of dried *ebi* is a much more complicated process than that used for the dried fish above. The first step is to boil the shrimps until thoroughly cooked; the second stage is to sun-dry the shrimp, as for dried fish. The third stage loosens the shells from the meat by putting the dried shrimp in a sack which is then vigorously beaten. Finally, the shrimp are cleaned, separating the shells through repeated winnowing. The meat is sold as *ebi*, mostly in Sebatik and Nunukan Islands, fetching around 80,000/kg. The shells are not wasted; they are also collected and sold for Rp. 2000/kg for use in animal feed and agricultural fertilizer.

Photo 5. Shell removal

Photo 6. Cleaning

Photo 7. Dried shrimp ready for sale

3. Salt Production

Salt production is one of the seasonal livelihood activities in the Tanjung Karang area of Sebatik Sub-District. Salt production is generally limited to the dry season, when seawater turbidity is greatly reduced due to the low rainfall frequency and intensity, while the higher insolation increases the evaporation rate. Although these activities are still small-scale, using simple equipment and methods, the technology used is different from the widely used, traditional saltpans. The seawater/brine evaporation takes place in shallow racks or drying tables lined with tarpaulins (*terpal*), so that the salt produced is whiter (has less impurities) than that produced in traditional earthen saltpans. The salt produced is quite well packaged and sold locally, however production volume is still quite low.

Photo 8 and 9. Evaporation and crystal formation

Photo 10. Packaging

4. Seaweed Farming

Seaweed, mostly *Gracilaria* sp., is farmed in the coastal waters around Sebatik Island, especially in Sebatik and Sebatik Barat Sub-Districts. The seaweed is harvested after around 2 months, sun-dried, and sold to traders who come to the seaweed farming villages. The average price is Rp. 6,500/kg.

Photo 11 and 12. Seaweed drying process

D. Fishing Household Income

The income groups of fishing households in each of the five Sebatik Island Sub-Districts of can be seen in **Table 5**. Overall, the majority were in the three middle income groups; however there were noticeable differences between sub-districts. These data indicate that, on average, fishing household income was highest in Sebatik Sub-District and lowest in Sebatik Barat Sub-District

Table 1. Sebatik Island fishing household income by Sub-District in 2017

Income range (Rp.)	Sebatik Tengah		Sebatik Utara		Sebatik Timur		Sebatik		Sebatik Barat	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
≤1,000,000	0	0	2	10	11	25	7	21	8	24
1,100,000 - 2,000,000	4	25	5	25	13	30	4	12	17	52
2,100,000 - 3,000,000	6	37.5	6	30	12	27	9	27	7	21
3,100,000 - 4,000,000	6	37.5	5	25	4	9	4	12	1	3
> 4,000,000	0	0	2	10	4	9	9	27	0	0
Total	**16**	**100**	**20**	**100**	**44**	**100**	**33**	**100**	**33**	**100**

Source: Analysis of primary (survey) data, 2017.

In Sebatik Tengah, the same percentage (37.5%) were in the Rp. 2,100,000 – 3,000,000 and 3,100,000 - 4,000,000 groups, while in Sebatik Utara Sub-District 30% were in the Rp. 2,100,000 - 3,000,000, with 25% each in the group above and below. In Sebatik Timur, the majority (82%) were in the lowest 3 groups, with the highest percentage (30%) in the Rp. 1,100,000 - 2,000,000 ranges. Sebatik had the most even spread across all five income groups, with equally high percentages (27%) in the middle and top groups, and nearly as many (21%) in the lowest income group. In Sebatik Barat, the distribution was concentrated in the lowest three income groups (97%), with over half in the Rp. 1,100,000 - 2,000,000 range (52%) and similar percentages (24% and 21%) in the very lowest (≤ Rp. 1,000,000) and middle (Rp. 2,100,000-3,000,000) income groups.

E. Dependency of The Sebatik Community on Marine Resources

Employment data for Sebatik Island are shown in **Table 6** and **Figure 2**. By 2015, the plantations sector had become the dominant economic sector in Sebatik Island, employing almost 44% of the active workforce. Oil palm plantations are the most extensive (as can be seen from satellite data through Google Maps), while other plantation commodities include coconuts, pepper and coffee. Fisheries were the second largest sector, followed by arable agriculture, small-scale service industries, trade and transportation. In 2015, over a fifth (≈ 21%) of the workforce was employed in the fisheries sector, indicating a relatively high level of economic dependency on marine resources. In addition, fisheries produce is a major source of dietary protein.

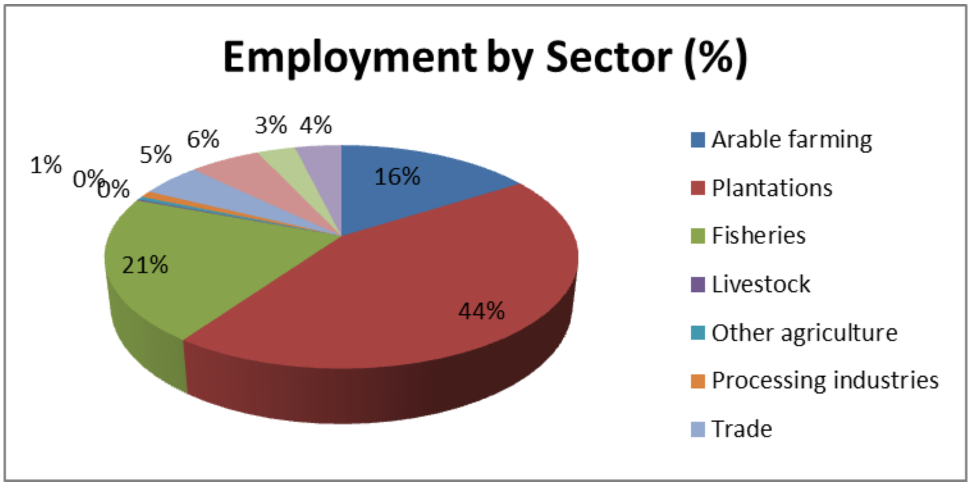
Table 2. Sebatik Island Employment data in 2011

No	Livelihood Sector	Employment	
		People	Percent
1	Arable farming	1,559	15.99%
2	Plantations	4,271	43.79%
3	Fisheries	2,044	20.96%
4	Livestock	17	0.17%
5	Other agriculture	47	0.48%
6	Processing industries	94	0.97%

7	Trade	478	4.90%
8	Service industries	566	5.80%
9	Transportation	306	3.14%
10	Other	371	3.80%
	Total	**9,763**	**100%**

Source: Sebatik Islad Detailed Zonation Plan, 2012.

Figure 1. The livelihood activities of Sebatik Islanders by sector in 2011



F. Fishing fleet and fishing gear

Many of the people living in the coastal communities around Sebatik Island are employed in fisheries. In Sei Taiwan sub-village, Tanjung Karang Village, Sebatik Sub-District, many of the men fish with a kind of trammel net which is referred to as "*pukat kantong*" (**Figure 3**), which means literally pocket or bag net, because it is set in such a way that a fold is formed, into which the target species enter and become entangled in the triple layers of the net.

Figure 2. Trammel net in Tanjung Karang Village, Sebatik Sub-district

These nets are usually set during daylight hours, in fishing grounds extending from the coastal waters around Sebatik Island to the waters of Ambalat. Shrimp are the main target. The fishermen usually haul the nets during the afternoon and then return to shore, usually before dark. Some Sei Taiwan fishing community members also farm seaweed. The main commodity caught in these trammel nets, at least by volume (**Fig. 4**), is croakers (*Johnius* sp.), although they are often many other demersal species contained in the catch, including the much rarer but more valuable lobsters (*Panulirus* sp.). Just one lobster can be worth as much as a netfull of croakers.

Figure 3. Croakers (*Johnius* sp), the main trammel net catch (by volume)

Figure 4. Typical fishing boats used by trammel net fishermen

At Sei Nyamuk, in Sebatik Timur Sub-District, most fishermen operate nets designed to catch Spanish mackerel (*tenggiri*) or silver pomfret (*bawal*), therefore the two main net types are called *pukat tenggiri* and *pukat bawal*. A typical *pukat bawal* fishing boat and a silver pomfret caught in such a net are shown in **Figures 6** and **7.**

Figure 5. Typical *pukat bawal* fishing boat preparing to go to sea in Sei Nyamuk Village, Sebatik Timur Sub-District (the net can be seen in the front of the boat)

Figure 6. A silver pomfret, the main species (by volume) caught with *pukat bawal* nets

The *pukat tenggiri* gillnets are generally operated quiet a long way from Sebatik Island, with fishing trips typically lasting 5-7 days. The fishing grounds include Bunyu, Tarakan and Nunukan Islands, and the catch is dominated by pelagic species. The *pukat bawal* gillnets have a mesh size of 6.75-7 cm. When set, the gear is comprised of up to 40 nets joined together, each of which is 31.5 m in length x 6.75 m high. Fishing grounds extend from the coastal waters of Sebatik Island to Ambalat. The catch is largely comprised of demersal species, including the fish which give the net its name, the silver pomfret *bawal putih* (*Pampus argenteus*), as well as rays (*Dasyatis* sp.), jacks and trevallies (*Caranx* spp.), lobsters (*Panulirus* spp.) and other demersal species.

G. Fisheries-turtle interactions and impacts

1. Number and Species Composition of Turtles Accidentally Caught in Fishing Nets

Data on turtle by-catch in Sebatik Island-based fisheries is not readily available, and do not generally include reliable (if any) species identification data. Data obtained from the survey are shown in **Table 7.**

Table 3. Number and species composition of turtle by-catch in Sebatik and Bunyu Islands, North Kalimantan during 2017

Fishing gear (mesh size, length/width)	Average turtle by-catch per setting	Fishing Ground	Average annual turtle by-catch	Entangled turtle condition (% live/dead)
Bawal gillnet (mesh size 6.75-7 inches; 1800-2200 m long x 4.5-10 m wide)	1	Pulau Bunyu/Gusung Burung	10 - 66	94 % Live 6% dead
Bawal gillnet (mesh size 6.75-7 inches; 1800-2200 m long x 4.5-10 m wide)	1	Tanjung Aus	5 - 15	Live (99 %), dead (1%)
Tenggiri gillnet (mesh size 3.25-4.5 inches; 675- 2700 m long x 7-10 m wide)	1	Pulau Bunyu, Tanjung Aus, Ambalat, Border (Indonesia-Tawau)	2 - 30	Live (98%), dead (2%)

Source: primary data, 2017 survey.

Additional data from key informant interviews with Sebatik Island fishermen and fisheries officers indicate that the real figures are much higher, and that at least three turtle species can become accidentally entangled in some of the fishing gears used by Islanders, especially nets. These are: (i) the olive ridley (*Lepidochelys olivacea*), Indonesian name *penyu lekang*; (ii) the green turtle (*Chelonia mydas*), Indonesian name *penyu hijau*; (iii) the hawksbill turtle (*Eretmochelys imbricata*), Indonesian name *penyu sisik*. Although species identification based on descriptions for fishermen may be unreliable, based on turtle shape (round) and size (diameter of about 20 cm) the interview data indicate that olive ridleys seem to be the most frequent by-catch, especially in trammel nets. As mentioned in the inception report, an injured olive ridley was washed ashore shortly before the first field visit, confirming the presence of this species in the area.

2. Estimate of Economic Losses Due To Turtle By-catch

Turtles can provide many benefits through their ecological roles in maintaining ecological balance and food webs, with positive impacts on fisheries, ecosystem services, eco-tourism development, and science. Although their role in seagrass ecosystems is perhaps better known, turtles also play a role in maintaining coral reef health and resilience. One way in which sea turtles contribute to marine ecosystems is through the food they eat and the way in which their faeces are distributed, providing valuable nutrients to support marine plants and other organisms at the base of the food chain (Lutz et al., 2003). In addition, it is now realised that turtles and other marine megaherbivores play a role in carbon sequestration, and are thus important in the global carbon budget, an important consideration in the context of climate change, and one which should be taken into account in climate modelling and mitigation (Nellemann et al., 2009; Lutz & Martin, 2014).

One way in which turtles are important for maintaining fisheries resources is their role as jellyfish predators. In the marine foodweb, jellyfish are predators of many fishes of commercial interest, especially in their juvenile stages. The loss of marine turtles, especially leatherbacks, would likely contribute to growing jellyfish populations. Large swarms of jellyfish tend to reduce the abundance of fishes, and thus reduce the catch of fishermen. Small-scale fishermen, who cannot go far offshore to catch fish, would be the most affected. The turtle species best known as an obligate jellyfish eater is the leatherback. However, most other species also eat jellyfish sometimes, especially loggerhead turtles. If one turtle is able to eat 10 jellyfish per day, and each jellyfish can eat 1 silver pomfret or other fish per day, then the economic value of turtles to fishermen can be calculated. With an average market price of Rp. 30,000/kg for silver pomfret, and an average of 3-4 fish/kg, then the annual value of turtle jellyfish eating services is around Rp. 31,300,000/year/turtle.

Turtles and their habitat are important for science and the development of human knowledge, for example through research and education. Turtles are known to be one of the oldest species still living today, having survived several mass extinction events to become rare relicts of a long ago era, well before the emergence of the dinosaurs. This makes them especially valuable to biological and environmental science, including the study of evolution.

Willingness to pay (WTP) represents the willingness of people to pay for some service or benefit; in this case, the benefits provided by sea turtles. The average WTP of Sebatik Island fishermen ranged from Rp. 100,000 to Rp. 1,000,000.

3. Fishermen's Perceptions Regarding Turtle By-catch

Out of the five Sub-Districts in Sebatik Island, sea turtle by-catch is only common among the fishermen from Sebatik Sub-District. One example occurred on 21 February 2017, when a turtle was accidentally caught in the gill net belonging to H. Lahaseng; the turtle was so badly entangled in the net that it was very difficult to release it. As H. Lahaseng had reason to be in a hurry to return to shore, and was afraid that his net might be badly torn if he attempted the release at sea, he decided to take the turtle with him so that he could release it slowly and carefully on the beach. That way, the damage to the net was relatively slight and injuries to the turtle were also avoided.

The Sebatik Islanders, especially the fishermen who often found turtles caught in their fishing gear, said that entangled turtles were usually released. They said that turtles had no commercial value, and could be considered a nuisance to fishermen. There were however a few respondents who said that turtles could be sold in Tawau, Malaysia, and that turtles sold in Tawau came from Indonesia as well as Malaysia, including from the waters close to Sebatik.

Some respondents had found entangled turtles that were already dead, usually because the nets had been set for a long period of time, up to 24 hours. Turtles can only stay under water for a limited amount of time, and so those caught in these nets would have very little chance of survival.

The cost for repairing gillnets damaged due to turtle by-catch (alive or dead), either before or during the release process, was generally within the range Rp. 5,000 – Rp. 200,000. It should be noted that the fishermen only considered the materials to repair the net, and not the time spent by themselves, their wives, or other family members, to repair the torn nets.

III. TURTLE HABITAT AND ENVIRONMENTAL CONDITION

A. Turtle Nesting Habitat

1. Turtle Nesting Habitat Characteristics and Location

Initial data on turtle nesting beaches was obtained through interviews and focus group discussions (FGD). The general characteristics of turtle nesting grounds for the six species found in Indonesia, mostly based on Nuitja (I. N., 1992), are shown in **Table 8**. The two most abundant turtle species in Indonesia are the green turtle *Chelonia mydas* and the hawksbill turtle *Eretmochelys imbricata*. Most hawksbills look for in white sandy beaches such as coral sand for their nesting grounds, like those often found around small islands, along the east coast of Kakaban and throughout the Derawan Island.

Table 1. General nesting beaches characteristics of turtles found in Indonesia

No.	Species	Nesting Habitat
1	Green turtle (*Chelonia mydas*)	Beaches lined with coastal vegetation comprising Hibiscus tiliacus, Terminalia catappa and Pandanus tectorius, quartz dominated sands
2	Flatback turtle (Natator depressus)	White sand beaches, especially when backed by sand dunes; little coastal vegetation, limited to grasses and scrubby vegetation
3	Olive ridley turtle (Lepidochelys olivacea)	Mostly black or relatively dark sand beaches of predominantly terrogenous origin; more frequently along continental shores including close to river mouths rather than oceanic islands; often (but not always) nest in very large groups (arribadas)*
4	Hawksbill turtle (Eretmochelys imbricata)	White or pale-coloured coral sand beaches created through bioerosion and wave action
5	Leatherback turtle (Dermochelys coriacea)	Often choose the same beaches as green turtles (or similar ones). The distance between the false and real nests is a distinguishing characteristic: 1-2 metres for green turtles and 2-5 metres for leatherbacks
6	Green turtle (Caretta caretta)	Medium-grained sandy beaches, dominated by silica sand; at Heron Island in Australia, nest on coral sand beaches

Source : Nuitja, I. N., 1992.

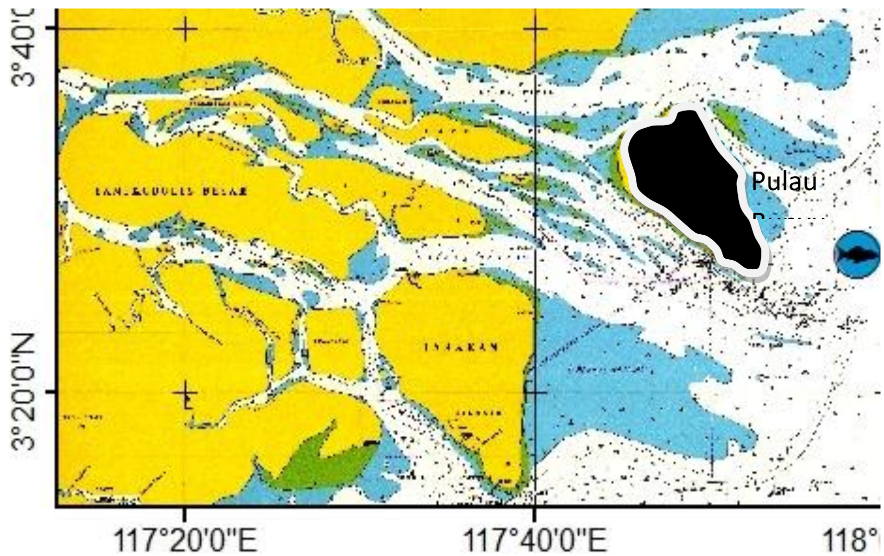
There are very few areas suitable as turtle nesting sites around the coasts of Sebatik Island and Tarakan, as there are many river estuaries, sediment loads are high, and much of the coast is lined with mangrove forests and muddy beaches. Turtles tend to nest on clean sandy beaches, free from mud or silt and scrubby vegetation above the high tide line. The turtles swimming and getting caught around the study site seem to be using the fishing grounds as a feeding area; although there were indications that some beached may have been used for nesting in the past the survey did not find any conclusive evidence of current nesting activity.

According to the Sebatik Islanders, the only regular turtle nesting area nearby was to the south, on Bunyu Island, situated between Tarakan and Sebatik Islands. Additionally, Sebatik Island fishermen said that they are always finding turtles caught in their nets when fishing around Bunyu Island. According to secondary data, the beaches of Bunyu Island have fine dark sand, formed from sediments carried downstream by the rivers and streams on the island. Such dark coloured quartz sands of riverine origin can be used for nesting by both green turtles (*Chelonia mydas*) and olive ridley turtles (*Lepidochelys olivacea*), however the latter has rarely been reported nesting in Indonesia. Based on this initial information, it was decided to conduct a survey of Pulau Bunyu, with the turtle nesting habitat as the main focus.

2. Turtle nesting habitat around Pulau Bunyu

Pulau Bunyu is situated around 47 km from Sebatik Island, still within Kalimantan Utara Province, at around 3^o 35"N and 118^o 00' E (Figure 8). Roughly triangular in shape, the maximum length and breadth are 22 km and 11 km, with a coastline of approximately 44.18 km in length.

Figure 1. Map of the Tarakan area showing Pulau Bunyu



Pulau Bunyu is about 43 km from Tarakan harbour and can be reached in about one hour by speedboat (fitted with twin 80 HP outboard engines). Pulau Bunyu is a low-lying island with mainly flat topography. The western coast of Pulau Bunyu is only around 9 km from the Kaltara River estuary, and water quality is affected by this and other large rivers discharging heavy sediment loads from the Kalimantan hinterland into the sea. The coordinates and type of the 20 observation sites around Pulau Bunyu are given in **Table 9**.

Table 2. Observation Sites around Pulau Bunyu

No.	Latitude			Longitude			Remarks
1	30°	29'	58.13"	117°	51'	33.88"	Tourism
2	30°	29'	32.76"	117°	52'	49.28"	Coral and sand
3	30°	29'	07.81"	117°	51'	56.26"	Sandy (nesting site)
4	30°	28'	54.46"	117°	52'	04.27"	Sandy (nesting site)
5	30°	28'	48.92"	117°	52'	10.61"	Sandy (nesting site)
6	30°	27'	39.93"	117°	52'	29.41"	Coral, sand, seagrass, algae
7	30°	27'	38.79"	117°	52'	32.31"	Mud, sand
8	30°	27'	05.33"	117°	51'	39.25"	Sandy (nesting site)

No.	Latitude			Longitude			Remarks
9	30°	27'	05.57"	117°	51'	32.11"	Sandy (nesting site)
10	30°	26'	54.64"	117°	51'	49.06"	Sandy (nesting site)
11	30°	26'	55.34"	117°	51'	50.21"	Sandy (nesting site)
12	30°	25'	51.46"	117°	51'	45.31"	Upwelling
13	30°	26'	38.41"	117°	52'	13.46"	Coral and sand
14	30°	26'	36.58"	117°	52'	05.70"	Sandy
15	30°	26'	37.64"	117°	52'	06.55"	Coral, sand, rock
16	30°	26'	39.03"	117°	51'	58.09"	Coral, sand, rock
17	30°	26'	40.92"	117°	51'	54.31"	Coral, sand, rock

Human activity around Bunyu Island. Only a small proportion of the Pulau Bunyu community are fishermen. These fishers operate using gillnets and or handline gear. The gillnet fishermen mostly have boats and operate quite far from shore, however some people also use beach seine nets and gillnets set in shallow coastal waters without the use of boats. The reason given for not using boats was that these fishermen could not afford to buy boats. There were also two milkfish hatcheries sited on the south coast. The island has a coal mining industry and a harbour operated by the oil company Pertamina.

Figure 9. Gillnet fishing activities with and without boats (a and b above); Interviews with gillnet fishermen and hatchery staff (c and d below)

Beaches around Pulau Bunyu and Nesting Sites. The beaches which surround most of the Pulau Bunyu coastline are predominantly covered with pale (white) sand, although there are cliffs with rock containing coal deposits on the southeast coast, sometimes extending into the intertidal zone **(Figure 9**). According to local people, turtles frequently nest on the many gently shelving sandy beaches, especially those with pale/white sand. No turtle nests were found or reported on the southeast coast with coal cliffs; although wide expanses of sand are exposed at low tide, when the tide comes in this sand is generally covered, and in bad weather breakers reach the cliff base.

Coral reef and seagrass ecosystems are found in the shallow waters in front of the beaches. Both ecosystems are poorly developed, probably due to the high sedimentation and turbidity of the coastal waters mentioned above. The sand is predominantly biogenic, formed of fine carbonate particles from the shells and skeletons of marine animals, including corals. Thus, the sand presumably originates from these shallow-water coastal ecosystems. Behind the sandy beaches, coastal vegetation includes scrubby pines and *Pandanus* sp. or mixed scrub, all of which provide suitable conditions for turtles to nest (**Figure 10**).

Figure 10 . Views of the Pulau Bunyu coast and potential nesting sites

Pulau Bunyu coast - view from the sea

A turtle nesting beach

Coast with coal cliff, unsuitable for turtle

Turtle nesting beach

***Pandanus* sp, provide suitable nesting conditions**

Some nest sites were found during the survey (**Figure 11**). Local people are well aware of turtle nesting sites, not least because they collect the eggs. The information obtained indicates that green turtles are the main species visiting and nesting on this island. The laws protecting turtles include full protection for their eggs, but there do not appear to have been any efforts made to enforce the law or provide any protection for turtles or their nests. Turtle egg collection by the community (?) is highly competitive and totally unregulated.

Figure 1. Examination of a turtle nest among the *Pandanus* sp. on Pulau Bunyu

Turtle Feeding Grounds. The coast and beaches around Pulau Bunyu can provide suitable nesting habitat for turtles, but the survey indicated that feeding grounds around the island might be limited in both extent and quality. The seagrass beds could provide some nourishment, while sponges and algae would also be available from the fringing coral reefs. At the time of the survey there were very few jellyfish which could serve as a food source. In addition, the waters around Pulau Bunyu are quite dynamic from an oceanographic perspective, with strong currents and visible turbulence during incoming tides. To the south and southeast of the island, the tides were seen to change direction during the tidal cycle from west-southeast to north-south. The heavy load of suspended particles made the visibility low throughout the cycle. The limited opportunities for feeding around the island indicate that the main reason turtles keep coming back to Pulau Bunyu is that they are driven by the instinct to reproduce (nest) rather than to feed, most likely including the instinct to return to their hatching ground.

Turtle observations and by-catch. During the survey, which included extensive manta towing and diving, turtles were only seen twice; both times were when they came to the surface to breath. Both were green turtles of around 1 m carapace length. The poor visibility limited the ability of the divers to observe turtles in the water column, so that there may have been more turtles present but not observed. It is likely that these adult turtles belonged to the population which nests on Pulau Bunyu. According to fishermen, turtles are often seen close inshore during the period before they go ashore to lay their eggs. Indeed, they often see turtles coming to the surface in the coastal waters, in areas which seem to have potential as turtle feeding grounds.

Despite the lack of any law enforcement or special protection, the turtles around Pulau Bunyu seem to be relatively safe from deliberate exploitation, unlike their eggs. Fishermen, turtle egg traders and other community members all said that the Pulau Bunyu fishermen have never intentionally caught turtles. However, some turtles are caught as by-catch in thegillnets operated by both locals and fishermen from further afield (which would include the Sebatik Island fishermen). Almost every week the Pulau Bunyu fishermen find one or more turtles entangled in the gillnets which are set in shallow coastal waters when the tide is falling.

Turtle Conservation Needs. Although by-catch is an issue, as can be seen from the data in Table 7, the most pressing turtle conservation need on Pulau Bunyu is protection for turtle nests/eggs. The nesting sites are well-known, and it is likely that very few nests/eggs escape collection and could have a chance to hatch. Although socialisation might have some impact, without effective surveillance and enforcement the situation is unlikely to improve to a meaningful degree. In addition to on-island consumption, it should be noted that turtle eggs are openly sold in the nearby larger population centres, including Tarakan.

B. Water Quality and Pollution Issues

The waters around Sebatik Island tend to be brownish in colour, with high turbidity due to the sediment loads from large rivers to the north and southwest of Sebatik Island as well as smaller rivers to the south. The high turbidity lasts all year round, because of the ongoing conversion of the native forests into palm oil plantations. The top soil from these extensive palm oil plantations erodes very easily, leading to sedimentation along the coast and high turbidity in the coastal waters.

1. Turbidity

The coastal waters from Sebatik Island to Tarakan are generally turbid with low visibility. Observations using a Secchi disc at five sampling stations all gave readings of less that 1 m. Due to the volume of water and sediment coming from the rivers, the sediment plumes with their turbid conditions spread well out to sea. Suspended particles and sediment come from reclamation, and from the sand mining at Batu Lamampu, as well as the felling of the forests for conversion to palm oil plantations. Examples are shown in **Figure 12**.

Figure 2. High turbidity around Sebatik Island

The tidal currents around Sebatik island cause turbulence which stirs up the sediments and helps keep particles suspended through slowing down coagulation and deposition of the particles in suspension. Due to this phenomenon, sediment particles are often carried out to sea, up to 5 nautical miles from the nearest shore. At Karang Unarang, where visibility is sometimes relatively good, tidal currents can cause very swift changes to conditions of high turbidity and extremely low visibility.

2. Visual Evaluation of Garbage/Pollution

Relatively little waste was visible along most of the beaches or in the waters of Sebatik and Tarakan Islands. However, the survey team found waste that had accumulated and washed up in a small bay (Fig. 9a). The quantity and variety of garbage, especially plastics, around human settlements, especially the dwellings of many Sebatik Islanders, indicates a lack of awareness regarding the importance of a clean environment, and avoiding the disposal of waste in the sea. Garbage was often piled up along the shore, as in Sei Taiwan Village, Sebatik Sub-District. Because of the coastal dynamics, especially the strong tidal currents, any garbage below the high tide line tends to get swept away. While much goes out to sea, some returns and accumulates in eddies and sheltered areas such as the bay in **Figure 13** (left).

Figure 3. Garbage washed up on one of the beaches and ghost fishing on a coral reef

The underwater visual surveys revealed another waste problem. Nylon nets which had caught on the corals damage and often kill the colonies they cover. In addition, such abandoned fishing gear continues to ensnare organisms which became entangled in them and die, a process known as ‘ghost fishing’. Ghost fishing can be a significant threat to larger animals such as turtles, although no cases have yet been reported. This is hardly surprising as, should turtle deaths from ghost fishing occur, it is highly unlikely anyone would dive in the right place and at the right time to witness the event. However some examples of the effects of ghost fishing from other areas can be seen in **Figure 14.**

Figure 4. Examples of the dangers ghost fishing poses for turtles and other animals

C. Coral reefs, seagrass meadows and other benthic ecosystems

1. Coral reefs

Coral reefs are important as turtle habitat, including as nursery grounds, for foraging and as resting/stopping places on migratory routes. Coral reefs are especially important as the main habitat and feeding grounds for hawksbill turtles (*Eretmochelys imbricata*) but are also used by other species (Lutz et al., 2003).

The Rapid Reef Assessment (RRA) method was used to estimate substrate composition and coral reef condition. This method involves diving for a set time in a pre-determined location, to observe the substrate and benthic organisms present. Categories observed include live coral, dead coral, sand, silt, soft coral, sponges, and other benthic organisms. The RRA method also involves recording the number and species or species group of reef fishes and pelagic fishes observed. The RRA survey sites are shown in **Figure 15**, and the coordinates are given in Table 10. In addition, where conditions permitted, the underwater photo transect (UPT) method was also used to provide quantitative data on benthic cover, with a higher degree of accuracy than the RRA method.

Figure 5. Map of the RRA survey sites around Sebatik Island

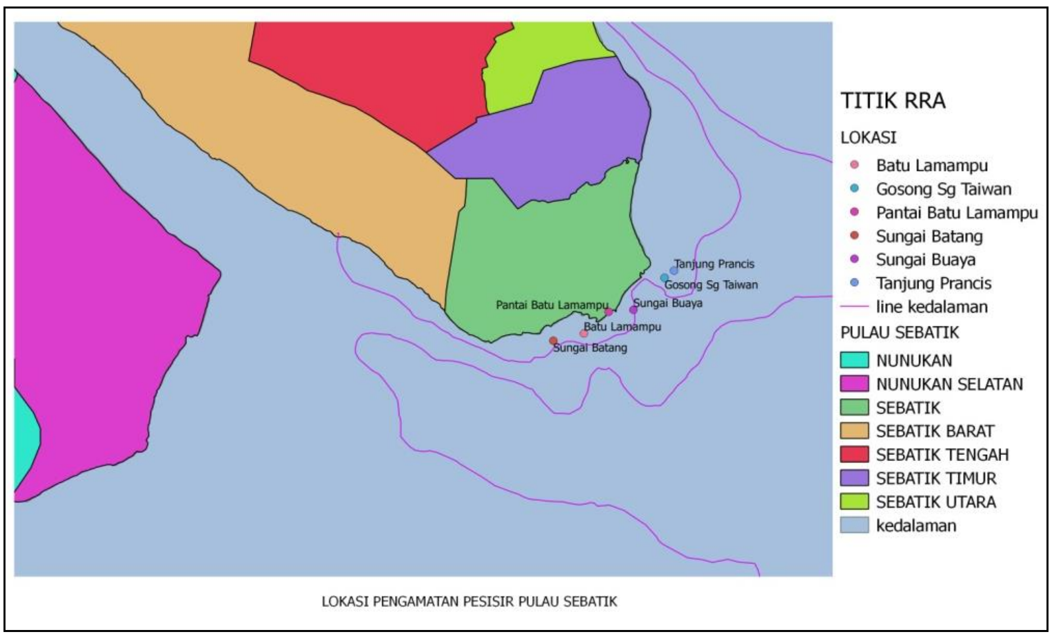


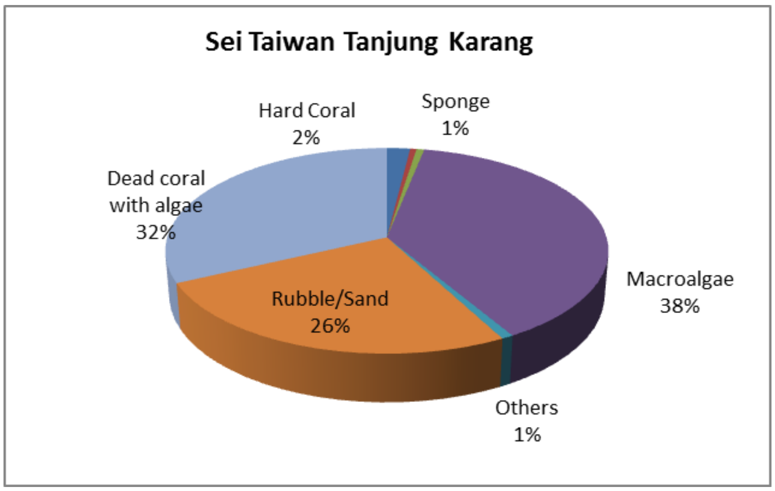
Table 1. Coordinates of the coral reef survey stations around Sebatik Island and Ambalat

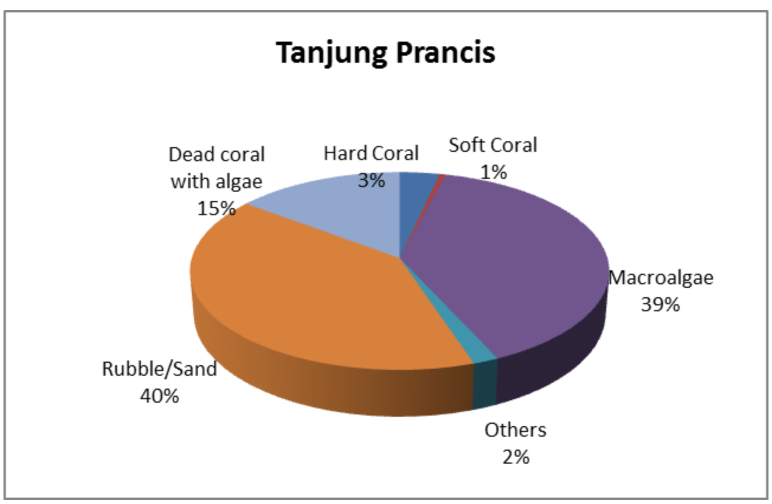
No	Survey Station	Coordinates	
		East	North
1	Sungai Buaya	117.919014	4.0447383
2	Batu Lamampu	117.899055	4.0350266
3	Sungai Batang	117.886765	4.0320535
4	Tanjung Karang, Sei Taiwan	117.931564	4.0578430
5	Tanjung Prancis	117.935360	4.0608080
6	Karang Unarang (Ambalat)	118.081410	4.0108232

Rationale for the choice of coral reef survey methods used at each site. At three sites, (1) Sei Buaya, (2) Batu Lamampu, and (3) Sungai Batang, underwater coral and fish surveys could not be carried out due to the high turbidity. The substrate could not be seen, and the habitat was dominated by mud and sand. Substrate surveys could only be carried out at two stations around Sebatik Island, i.e. stations 4 and 5 (Sei Taiwan and Tanjung Prancis). At these sites, the reef rapid assessment (RRA) was used, involving both snorkelling and SCUBA diving. At the 6th station (the Karang Unarang patch reef in Ambalat), the underwater photo transect (UPT) method could be used, as the higher visibility enabled a clear view of the coral reef substrate.

The substrate composition data for Tanjung Prancis and Sei Taiwan are shown in **Figure 16**. Based on a 20-minute RRA survey dive time, the Tanjung Karang substrate was dominated by abiotic substrate consisting of rubble (broken dead corals) and sand, followed by macroalgae, respectively covering just over and just under 40%. Live hard coral cover was very low, only 3.5 %, although the high dead coral and rubble cover indicates that this is not a natural condition, but rather the result of relatively recent degradation. Conditions at Sei Taiwan, Tanjung Karang, based on RRA during a 30 minute dive, were not very different in terms of hard coral cover (2%) and macroalgal cover (38%), however there was less rubble and sand (26%), while around a third of the substrate was dead coral rock, mostly overgrown with algae (32%).

Figure 6. Coral reef substrate composition using RRA methods at the Sei Taiwan Tanjung Karang and Tanjung Perancis survey stations





The observed threats to the fringing coral reef ecosystems at these two sites (Tanjung Prancis and Sei Taiwan) were affecting both physical and chemical aspects of the coastal environment. In particular, heavy sedimentation loads and eutrophication of the coastal waters due to land-based activities. Coral colonies will die if the sedimentation rate is too high, so that the living polyps cannot remove the particles; they will become smothered and eventually even buried. Sedimentation also reduces light penetration due to the turbidity, reducing or preventing photosynthesis by the symbiotic zooxanthellae within the tissues of the coral polyps.

The high alga cover, both macroalgae and the algal overgrowth on dead corals, is almost certainly related to the high nutrient levels in the coastal waters at both sites. These eutrophic conditions are caused by the heavy use of fertilisers and other sources of nutrient-rich waste entering the rivers in this area. In particular, the concentrated fertilizers used on palm oil plantations, which is one of the mainstays of the local economy. Examples of the turbid conditions prevailing at these and other survey sites are shown in **Figure 17**.

Figure 7. Examples of the turbid conditions observed at many sites, including around the Indonesian Boundary Marker at Karang Unarang, Ambalat

Turbid waters off Sei Buaya

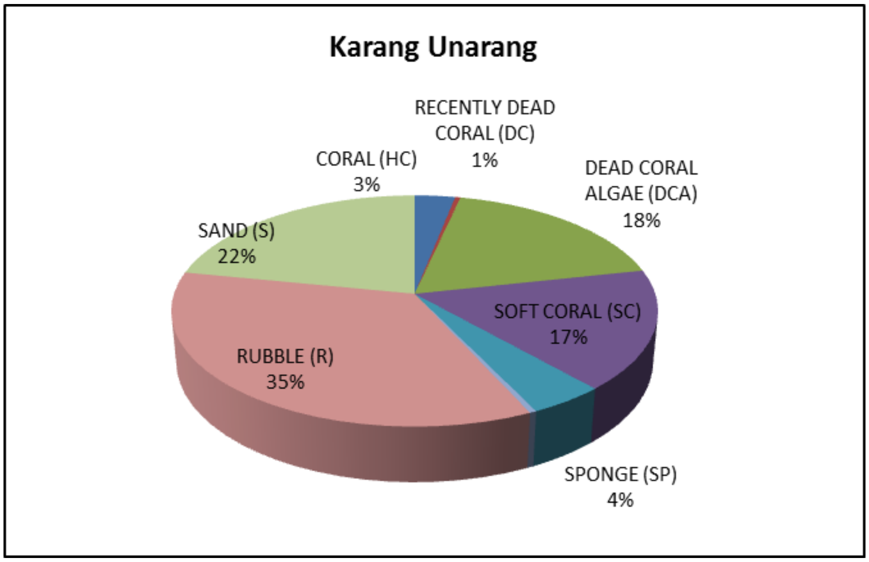
Very turbid waters at Batu Lamampu

Corals in turbid water at Tanjung Prancis

Massive coral in turbid waters off Sebatik

Karang Unarang, visibility was 6-7 metres. The coral reef survey using the Underwater Photo Transect (UPT) method gave a substrate composition dominated by dead coral, with 35% Rubble and 22% Dead Coral Algae 22 %; soft coral covered 17 %, while live hard coral cover was only 3 % (**Figure 18**). The high percentage of rubble at the Karang Unarang site seems to be due to long-standing use of destructive fishing activities, especially bomb fishing. Soft corals were growing over some of the damaged areas, possibly part of a succession process.

Figure 8. Benthic cover composition at Karang Unarang, Ambalat

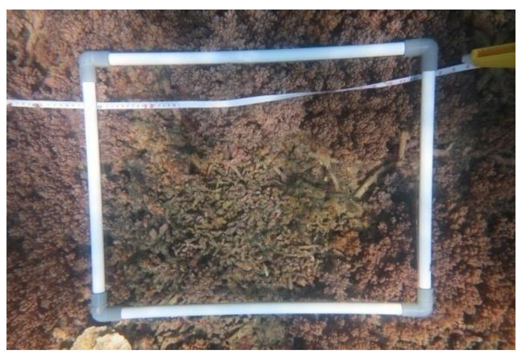


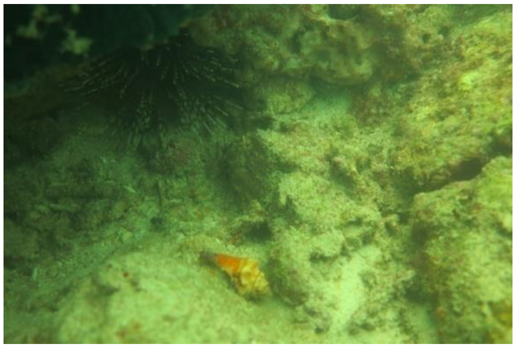
The prevalence of algae growing over dead corals indicates that the reefs of Karang Unarang are also very likely impacted by eutrophication. During the survey, there was a sudden switch from calm conditions to a strong current, which brought turbid conditions not only through the suspended particles carried by the current, originating from rivers close to Sebatik Strait, but also through stirring up the sediment deposited on the seabed. Examples of conditions observed during the survey are shown in **Figure 19**.

The substrate condition and composition will affect the availability of food for turtles, and could thus have an influence on the presence or the amount of time spent by turtles in shallow water sites. Turtles will be more likely to stay and even to nest in proximity to productive feeding grounds. For some of the marine turtle populations along the western shore of the Makassar Straits, it would seem that the waters around Sebatik and Nunukan Island serve as feeding grounds, while the main nesting area is the Derawan Islands to the south.

Figure 9. Examples of coral reef condition and benthic organisms at Karang Unarang, Ambalat


Soft corals - dominant benthic cover


Underwater photo transect

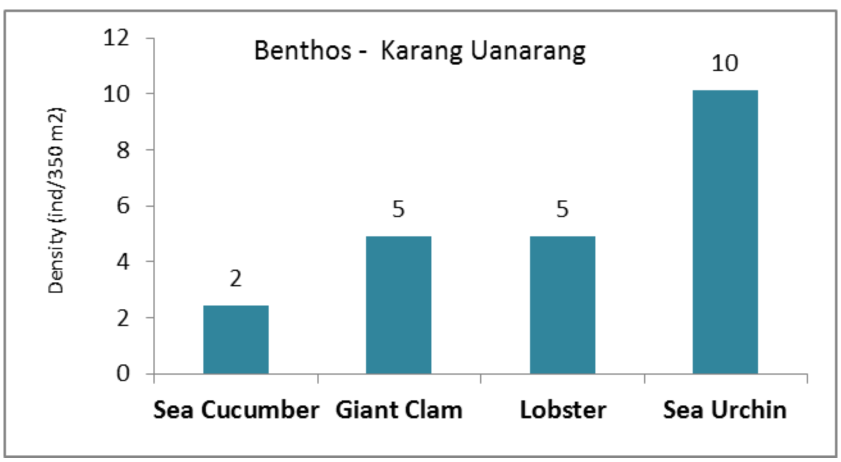


Sea urchins

Lobster

With respect to feeding and nesting area potential, four main groups of macro-benthic organisms of commercial and ecological importance were observed. These were sea cucumbers (Holothuridae), giant clams (Tridacnidae), lobsters (Palinuridae) and sea urchins (Diadematidae and Toxopneustidae). Some examples are shown in **Figure 20**. Of these four groups, the sea urchins were the most numerous, despite reports that these species are heavily exploited in Sabah, Malaysia, and commonly sold and consumed in Tawau, largely by Malaysians of Indonesian origin (Parvez et al., 2016a, 2016b). The observed densities of the highly valued lobsters and seacumbers were respectively 5/350 m^2 and 2/350 m^2. The density of the protected tridacnid clams was 5/350 m^2, giving a normalised density of 0.02/m^2, for both lobsters and clams, and 0.007/m^2 for seacucumbers. The presence of seacucumbers, which can be eaten by some turtles, indicates that the sites could be used as turtle feeding grounds.

Figure 10. Macrobenthic organism density at Karang Unarang (ind/m^2)



Lobsters are a key target species, attracting fishermen from Sebatik Island and other areas to the waters around Karang Unarang. Some of these fishermen also catch seacucumbers. According to respondents, the lobster fishermen see turtles as a nuisance, especially when they become entangled in the lobster nets. In addition, some turtles could compete for seacucumbers; however the species likely to be found in the waters around Sebatik Island are unlikely to do so.

2. Seagrass Meadows and Other Habitat

Globally, seagrass meadows are widely distributed around coasts and shallow seas. Seagrass meadows are highly productive, with important bio-physical linkages to neighbouring ecosystems, and provide many ecosystem services. The roots and rhizomes spread out and stabilise sand and other sediments, stabilising beaches and shorelines. This role is important along mainland coasts and around small islands. Seagrass ecosystems provide spawning, nursery and feeding grounds, as well as protection from predators for many marine fauna. In particular, Samanya (2015) underlined the key role of seagrass meadows as habitat for the herbivorous green turtles who feed predominantly on the seagrass blades.

Many of the organisms living in seagrass habitat are valued by humans for consumption (food) or for other uses, at subsistence level or for trade. Seagrass ecosystems are dynamic and subject to change, in terms of extent (area), density, biomass, species composition, growth rate and productivity; such changes can occur individually or in many combinations, and may act synergistically (Victor & Oldias, 2009). Despite indications of historical presence, hardly any seagrass plants were seen during the survey, and there were no seagrass meadows. The intertidal zone comprised extensive sand and mud flats with very shallow slopes. The substrate was very dynamic, shifting in response to wave action and tidal currents, with heavy sediment loads carried downstream from large and small rivers. The sediment apported and deposited was dominated by fine particles, so that the waters were turbid and the beaches/flats were increasingly muddy rather than sandy. These factors could all inhibit the settlement and growth of seagrasses, and thus it is not surprising that seagrass meadows were absent (**Fig. 21**). This means that the coastal areas of Sebatik Island are likely to be less productive than those surrounded by seagrass meadows.

Figure 11. A typical example of the extensive beaches, with no seagrass or corals, which are common around the shores of Sebatik Island

Beach substrate with no seagrass

A Sebatik Island sandy mudflat

The presence of sea turtles is often linked to that of seagrasses, in particular for the green turtle. Seagrass beds not only provide food in the form of seagrasses, but also macroalgae and the associated fauna, including echinoderms (seacucumbers and sea urchins), sponges, molluscs, and small fish. Thus, other turtle species may also use seagrass beds as feeding grounds, mostly feeding on small invertebrates which are generally abundant in healthy seagrass ecosystems (please provide citation).

D. Relative abundance of fishes and other organisms

Reef fish surveys using the Underwater Visual Census (UVC) method were carried out at Karang Unarang. The belt transect was 70 metres long by 5 metres wide, giving a survey area of 350 m^2. Reef fish (UVC) surveys could not be carried out at the coastal sites around Sebatik Island due to the high turbidity.

The reef fish recorded at Karang Unarang comprised 46 individuals from 6 target fish families and one indicator fish family (Chaetodontidae). The target fish abundance of 30/350 m^2 was substantially higher than the 12/350 m^2 recorded at Langkai Island in the Spermonde Island group close to Makassar City (Yusuf et al., 2016). The coral reef associated fish species and families observed during the survey are shown in **Table 11** and some examples can be seen in **Figure 22.**

Table 2. Species and number of fish recorded at Karang Unarang Ambalat

No	Family	Species	Ind/350 m^2
1	Chaetodontidae	*Chaetodon octofasciatus* *Chaetodon kleinii*	16
2	Acanthuridae	*Acanthurus lineatus*	1
3	Lutjanidae	*Lutjanus decussatus*	2
		Lutjanus monostigma	1
4	Serranidae	*Epinephelus fuscoguttatus*	1
		Epinephelus merra	2
5	Siganidae	*Siganus guttatus*	5
		Siganus canaliculatus	1
6	Carangidae	*Caranx sp.*	5
7	Caesionidae	*Caesio caerulaureus*	7
		Caesio terres	3
		Pterocaesio diagramma	2
Total	**7**	**11**	**46**

Figure 12. Examples of fish species from two Families (Siganidae and Chaetodontidae) observed at Karang Unarang

Target fish: Siganidae at Karang Unarang

Indicator fish: *Chaetodon kleinii*

IV. INTERACTION OF MARINE TURTLES WITH THEIR HABITAT AND FISHING ACTIVITIES AT THE PROJECT SITE

A. Estimates of Turtle Abundance

No turtles were seen during the surveys at six sampling stations around Sebatik Island and Karang Unarang. Despite this lack of direct observations, the team obtained data and information from local respondents including fishermen, other community members, and government officers. These survey data indicate that fishermen often see turtles at sea; as these sightings are year-round rather than seasonal, it is likely that these turtles are feeding rather than migrating, and thus that several at least of the local fishing grounds are also turtle feeding grounds. Furthermore, the fishermen frequently find turtles caught in their fishing gear (by-catch), and other locals (community members and government officers) report finding turtles washed up (mostly but not always dead) on the shores of Sebatik Island. Based on these reports, turtle feeding grounds extend quite far, and turtle-fisheries interactions occur around Sebatik Island, Karang Unarang, Tanjung Bilas, all the way to Bunyu Island and Tarakan.

The number of turtles feeding around Sebatik Island and Karang Unarang cannot be known with any certainty and is very difficult to estimate. However a figure of around 90-120 turtles was considered a reasonable, albeit conservative, estimate. The high turbidity and low productivity are likely to be limiting factors, so the resident population is unlikely to be much higher.

Fishermen who find turtles caught in their nets usually release them. Most are aware of the protected status of turtles, but the main reason they gave for releasing the turtles was that the turtles did not have an economic value (meaning there was currently no market for them). Furthermore, they considered that the turtles were in fact a nuisance, and interfered with their fishing activities. Several fishermen respondents had found dead turtles in their nets; the nets had been set for up to 24 hours and the turtles would have been entangled for several hours, and thus had no real chance of surviving.

Based on the described size and shape of the turtles (roundish and quite small), as well as the type of gear and habitat, it is likely that most of the turtles caught were olive ridleys. This would explain the dichotomy between the fishermen's statements that turtles had no value and the information from other respondents that turtles were sold in Tawau, because the species traded throughout the Makassar Straits/Sulawesi Sea region (including Sulawesi as well as Kalimatan and Tawau) are the green and hawksbill turtles, for their meat and shells, respectively.

Only green and hawksbill turtles are known to nest in the Makassar Straits south of the border with Malaysia. However, although there are no published records of olive ridley turtles in northern Kalimantan or the Makassar Straits area, leading turtle expert Nicholas Pilcher confirmed identification of a turtle washed ashore injured on Sebatik island as an olive ridley. Furthermore, he said that there is a nesting population in Sabah, Malaysia whose range almost certainly extends south of the Malaysian-Indonesian border, and thus could be feeding regularly in the fishing grounds of the Sebatik Island fishermen. These findings indicate a need for further, preferably cross-boundary, research on turtle populations in the area.

B. Reasons for the presence of turtles in this area

There are several reasons why turtles could be found in the waters around Sebatik Island and Karang Unarang, but it is likely that the most common use of these waters by sea turtles is as a feeding ground. One indicator is the presence of suitable food (prey) for sea turtles to eat. Some of the most common food items/prey of the turtle species reported from the Sulu-Sulawesi (SSME) area and the Makassar Straits (Lutz et al., 2003; http://www.seeturtles.org/sea-turtle-diet/) are as follows:

- Green turtle: juveniles are omnivorous, and will eat most planktonic organisms; adults are herbivorous, consuming seagrasses and macroalgae, although many epiphytes and epifauna are also entrained
- Hawksbill turtles: predominantly carnivorous, sponges are the main prey item, including species which can become invasive/considered pests on coral reefs, particularly degraded reefs. Prey items also include soft corals, shrimp, squid, and other invertebrates

- Leatherback turtles: often referred to as gelatinivores, feed almost entirely on pelagic Cnidaria such as jellyfish, sea jellies, seacombs and salps, however they can also feed on tunicates and sea squirts
- Olive ridley turtles: these omnivorous turtles eat a wide variety of marine plants and animals, including algae, fish, crustacea (lobster, crabs, and shrimps) and echinoderms (especially sea urchins) as well as jellyfish and other soft bodied animals. Their food habits make them especially vulnerable to becoming by-catch in several types of fishing gear, especially nets, longlines and trawls, as they often prey on fisheries target species (fish and crustacea) (Abreu-Grobois & Plotkin, 2008; Wallace et al., 2013)
- Loggerhead turtles: juveniles are omnivorous; adults of this predominantly carnivorous species have powerful jaws, they can crush the shells of molluscs and crustacea (crab, shrimp) and horseshoe crabs, but also eat soft-bodied animals like jellyfish

There are several factors which could make these waters a good feeding ground for turtles. Firstly, the year-long eutrophic conditions make the waters fertile and conducive to the growth and reproduction of large schools of jellyfish. Secondly the abundance of small fishes (e.g. anchovies) and crustaceans (shrimps, crabs and even lobsters) are also suitable prey for more than one turtle species. Thirdly, despite the high turbidity, there are still benthic organisms which turtles can feed on, such as algae, sessile organisms such as soft corals and sponges, as well as vagile benthic organisms such as sea cucumbers, sea urchins and molluscs, especially around Karang Unarang where the reefs are still in relatively good condition (**Fig. 23**).

Figure 1. Some organisms eaten by sea turtles

Soft coral *Dendronephthea sp*

Soft coral Sinularia sp

Macroalgae (wild)

Jellyfish (seen washed up onshore)

In addition to wild seaweeds, turtles could also feed on the farmed seaweeds, although this would seem to be rare so far, possibly because the seaweed farming activities are mostly in areas which do not seem to be part of the normal turtle migrations routes or other habitat. Coral reefs can also provide many sources of food for turtles, as described in a review on sea turtles biology and ecology by Nuitja (1992). Several turtle species feed on the plants which can be found in coral reef areas, including macroalgae such as *Sargassum* and many other genera, e.g. *Codium, Caulerpa,* and *Gelidium*. Seagrass genera preferred by green turtles include *Cymodocea*, *Halodule,* and *Thalassia*, all of which can be found in coral reef and reef flat environments as well as seagrass beds. Reef associated invertebrates which can provide food for turtles include sponges, jellyfish, crustacea, molluscs and echinoderms in coral reef areas (Lutz et al., 2003).

C. Direct and indirect correlations between fish abundance and fishing activity

As mentioned above, the abundance of target fish species at Karang Unarang (46/350 m^2 or 1314/Ha) is quite high compared to the Spermonde Islands near Makassar, for example Langkai Island (13/350 m^2 or 371/Ha). This relatively high abundance attracts fishermen to this reef, especially as there are other high value commodities such as lobsters.

Photo 13. Long-line fishers seen in the field

Photo 14. Target fish (*Caranx* sp.) seen on site

The lobster fishery is unregulated and attracts many fishermen to the area, even though lobsters are usually only a small proportion of the catch. There are no data on the lobster stocks at this reef or along the North Kalimantan coast. The survey at Karang Unarang (using a 50 m transect) indicated that fisheries resources are still quite abundant and do not appear to be over fished. There was relatively little observed damage to the reef from lobster fishing gear, indicating that the gears used are relatively environmentally friendly, at least in terms of impact on the habitat. However turtle by-catch is clearly an issue which needs to be addressed in this fishery.

V. TESTING OF ALTERNATIVE FISHING GEAR TO REDUCE TURTLE BY-CATCH

A. Turtle-repellent Lights and Discs

The currents around Sebatik Island tend to be strong or very strong, so that fishermen tend to wait for a suitable time (stage in the tidal cycle) to engage in fishing operations at sea. The survey showed that there are at least four fishing gear types used by Sebatik Island fishermen which are extremely likely to catch turtles. These are all different kinds of nets, locally called *pukat lobster, pukat bawal, pukat tenggiri* and *pukat gonrong*. It is not realistically possible to forbid the use of these fishing gear types.

One alternative solution trialled was to place green lights on the nets as shown in **Figure 24**. These lights are supposed to repel turtles, so that they will not get close enough to the nets to become entangled. These lights were placed on *pukat bawal* nets, which are set overnight. For daytime, computer discs (CDs) were trialled as turtle repellents, as shown in **Figure 25**. These discs reflect sunlight in a way which has been reported to deter turtles from approaching them.

Figure 1. Green lights fixed to nets to repel turtles at night

Figure 2. Computer discs (CDs) used to repel turtles during the day

Trials of these turtle repellent devices took place in the waters off Pulau Bunyu, with fishermen operating *pukat bawal* gillnets. The main species of turtle caught in this fishery are green and hawksbill turtles. The green flashing lights were attached to the nets at night, and the CD discs were attached during the daytime. Both devices were attached using snap clips which are readily available, and locally called *peniti rawai*. The light from the lights and the reflections from the discs were both visible underwater, even though the turbidity was quite high, though only over relatively short distances.

The fishermen found that the devices did not cause any problems during fishing activities, and did not seem to affect the target species catch. During the trials, no turtles were caught in the (*pukat bawal*) nets fitted with lights (at night) or CDs (during the day). A turtle caught in the control net, which was not fitted with lights, is shown in **Figure 26**. These results indicate that the lights and CDs have the potential to reduce turtle by-catch. However the lights are quite expensive, and care is needed to avoid leaks which ruin the lights, especially when changing the batteries.

Figure 3. Turtle caught in a pukat bawal gillnet in the waters of Pulau Bunyu

B. Trammel-net Modification

The *pukat gonrong* is a kind of trammel net widely used by fishermen operating in the waters to the south and east of Sebatik Island. Each fisherman generally sets 20-30 nets or pieces (called *utas*) which when joined together form a wall of netting around 690 *depa*, a traditional measure which is equivalent to around 1000m. This combined net is set in a straight line across the current, so that it drifts down-current, sweeping the sea floor. The main target is shrimp (a prey item for olive ridley turtles); however several other species are also caught including crabs and fish. The way in which these trammel nets are operated means that there is a high likelihood of turtle by-catch, with both feeding and resting turtles being vulnerable.

In order to reduce the likelihood of turtle by-catch, it was decided to combine two approaches. Firstly, shortening the nets; and secondly changing the way in which the nets are set, from passive drifting to active encircling. During the trials, three pieces were joined (as opposed to the current norm of 20-30 pieces). The resulting net was released and towed by the boat in such a manner as to form a circle. Weights (5 kg) were used to anchor the centre and edges of the circle. Initial trials proved that the *pukat gonrong* net can be deployed in this manner using the existing fishing boats. Thee trials were carried out in shallow water (around 3 m), much shallower than the normal fishing grounds, which is probably the reason why no shrimp were caught. The results indicate that a slightly longer trammel net (perhaps five pieces, still much shorter than the 20-30 piece drift net systems) could be operated as an active fishing gear. The shorter net length, reduced swept area and greatly reduced time underwater should result in reduced turtle by-catch, however further development and testing are still required.

C. Crab Pots

In addition to gear modifications, some Sebatik Island fishermen could potentially switch to different fishing gear type(s), with different target species. One gear type which was trialled is the crab pot (called *rakkang*) shown in **Figures 26** and **27**.

Figure 4. *Rakkang* Crab pot being set off Sebatik Island

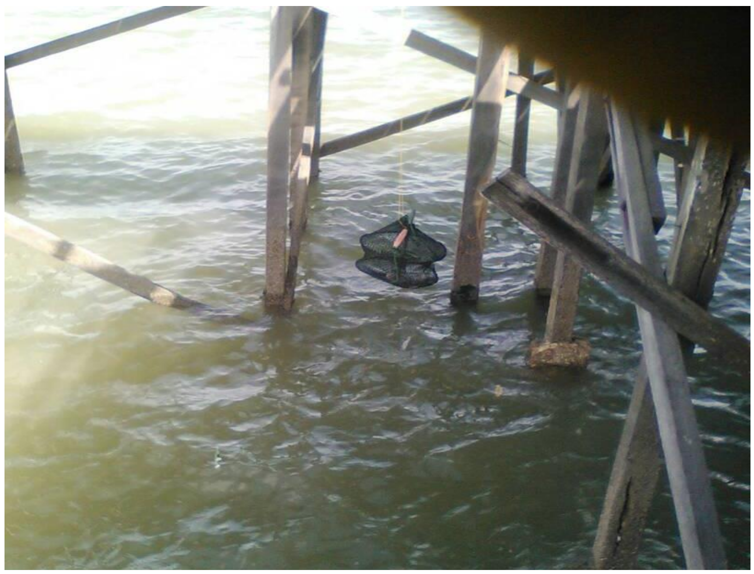


Figure 5. Mudcrabs caught in a *rakkang* crab pot off Sebatik Island

This trap gear was designed based on conditions in and around the extensive mangrove forests of Sebatik Island. These mangrove forests are still in good to excellent condition, with abundant mud-crab (*Scylla* sp.) populations. Five crab pots were constructed. After being set and left for 1.5 hours, seven crabs were caught. One pot had caught three crabs, while the others had one or two crabs in them. The price of mudcrabs is quite high in Malaysia, reaching or even exceeding Rp. 100,000/kg. Catching mudcrabs could be a viable alternative for at least some of the fishermen, or could at the very least reduce their dependency on the gill and trammel net types with high turtle by-catch rates.

VI. CONCLUSIONS AND RECOMMENDATIONS

The results of this study, including the recommendations, will be submitted to the Kalimantan Utara Marine and Fisheries Service as well as other key stakeholders, in order to inform policy and support program development. Some key conclusions from this study, and recommendations for follow-on action based on the results of activities undertaken during this project, are listed below.

1. The results of this study raise many questions, and indicate that previous assumptions regarding turtle species composition and turtle movements in the waters around Sebatik and nearby waters may need substantial revision. There is a need for a well-designed tagging program to track turtle movements in the waters around Sebatik and Pulau Bunyu. This program should target all three species observed in these waters and aim to chart migration routes form/between better studied areas as well as turtle behaviour and habitat use within the area. Ideally, the program would involve networking between scientists working in both Indonesia and Malaysia (Sabah).

2. The trials of turtle repellent devices (flashing green lights and CDs) showed promising results. Further research is needed to prove the effectiveness, and optimise the technical aspects. This includes seeking or developing more rugged and cost-effective lighting systems.

3. Turtle mortality due to by-catch seems to be strongly related to gear setting times, as entangled turtles can only survive underwater without surfacing for a limited time. Thus, where avoidance of turtle-fishery interaction is difficult or all but impossible, efforts need to be made to reduce the length of time between setting and hauling of fishing gears. In this context, modification of trammel net gear in terms of net length and switch from passive (drifting) to active (encircling) setting needs further research. .

4. Pulau Bunyu seems to be an important turtle nesting site and should be given serious consideration as a turtle conservation site. Further research is required to evaluate the conservation potential and to support the design and implementation of turtle conservation at this site, for example through protected area designation. Fine-scale zonation of these waters, taking turtle conservation requirements into account, is one approach which could be considered. Turtle-based eco-tourism might also be a possibility with potential for income diversification and as an alternative to income from turtle egg sales.

5. Although most respondents in this study denied that turtles (other than their eggs) were exploited commercially or consumed, there were strong indications that some illegal trade does occur, including through Tawau in Malaysia. This needs to be addressed, possibly through international initiatives such as the Sulu Sulawesi Marine Ecoregion (SSME), the Coral Triangle Initiative on Coral Reefs,

Fisheries and Food Security (CTI-CFF), and the Southeast Asia MoU on turtle conservation, as well as through culturally sensitive socialisation.

6. The economic valuation of turtles and their ecosystem services (e.g., preying on as jellyfish that feed on pomfret, a commercially-important species) needs to be pursued in more detail, and followed by socialisation to raise awareness among key stakeholder groups, including coastal communities and decision-makers.

REFERENCES

Abreu-Grobois, A., Plotkin, P. 2008. *Lepidochelys olivacea*. IUCN SSC Marine Turtle Specialist Group, The IUCN Red List of Threatened Species 2008: e.T11534A3292503. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11534A32 92503.en.

Anonymous 2012. Fasilitasi Penyusunan Rencana Zonasi Rinci Wilayah Pesisir and Pulau-Pulau Kecil Pulau Sebatik. Dinas Kelautan dan Perikanan Kabupaten Nunukan in partnership with PT. Andalan Rereka Consultindo, Jakarta, Indonesia.

Badan Pusat Statistik Nunukan District. 2016. Statistik Daerah Kecematan Sebatik, Nunukan, Nunukan, Indonesia.

Dinas Kelautan dan Perikanan Kabupaten Nunukan. 2016. Data Statistik Perikanan, Kabupaten Nunukan. Nunukan, Indonesia.

FAO. 2004. Expert Consultation on Interactions between Sea Turtles and Fisheries within an Ecosystem Context. FAO Fisheries Report No. 738. Food and Agriculture Organization of the United Nations, Rome, Italy. 45 pp.

FAO. 2005. Report of the Technical Consultation on Sea Turtles Conservation and Fisheries, Bangkok, Thailand, 29 November – 2 December 2004. FAO Fisheries Report No. 765. Food and Agriculture Organization of the United Nations, Rome, Italy. 40 pp.

Gilman, E., Gearhart, J., Price, B., Eckert, S., Milliken, H., Wang, J., Swimmer, Y., Shiode, D., Abe, O., Chaloupka, M., Hall, M., Mangel, J., Alfaro-Shigueto, J., Dalzell, P., Ishizaki, A. 2009. Mitigating Sea Turtle Bycatch in Coastal Gillnet and Pound Net Fisheries. International Union for the Conservation of Nature, Gland, Switzerland. 37 pp.

Lutz, P.L.II., Musick, J.A., Wyneken, J. (Eds). 2003. The biology of sea turtles. CRC Press, Boca Raton, Florida, USA. 510 pp.

Lutz, S.J., Martin, A.H. 2014. Fish Carbon - Exploring Marine Vertebrate Services. Blue Climate Solutions and GRID-Arendal, Arendal, Norway. 36 pp.

Nellemann C., Corcoran E., Duarte C.M., Valdés L., De Young C., Fonseca L., Grimsditch G. (Eds). 2009. Blue Carbon. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal, Arendel, Norway. 80 pp.

Nuitja, I.N.S. 1992. Biologi dan Ekologi Pelestarian Penyu Laut. IPB Press. Bogor Indonesia. 143 pp.

Parvez, S., Rahman, M. A., & Yusoff, F. 2016a. Sea Urchin Fisheries in Malaysia: Status, Potentials and Benefits. International Journal of Chemical, Environmental & Biological Sciences (IJCEBS), 4(1), 64–66

Parvez, S., Rahman, M. A., Yusoff, F. 2016b. Status, Prospects and Potentials of Echinoid Sea Urchins in Malaysia. International Journal of Chemical, Environmental & Biological Sciences (IJCEBS), 4(1), 93–97

Pusat Pendaratan Ikan Pulau Sebatik. 2017. Pendataan PPI Sebatik. Sebatik Utara Sub-District. Nunukan, Indonesia.

Samanya, R. 2015. Biologi konservasi penyu. http://www.researchgate. DOI : 10.13140/RG.2.1.1369.0323.

Tripathy, B., Shanker, K., Choudhury, B. 2003. Important nesting habitats of olive ridley turtles *Lepidochelys olivacea* along the Andhra Pradesh coast of eastern India. Oryx, 37(4), 454-463

Trono, R.B., Cantos, J.A.B. 2002. Conserving Migratory Species Through Ecoregion Conservation Approach: The Case of Sea Turtles in Sulu-Sulawesi Marine Ecoregion. Tropical Coasts, December, 2002: 44-49

Yusuf, S. et al.. 2016. Kondisi terumbu karang and ekosistem terkait di Kota Makassar. Coremap LIPI-UNHAS, Jakarta, Indonesia.

Victor, S., Oldias, N.W. 2009. Manual for Monitoring Seagrass in Palau. PICRC Technical Report 09-001. Palau International Coral Reef Center. Koror, Palau. 16 pp.

Wallace, B.P., Kot, C.Y., DiMatteo, A.D., Lee, T., Crowder, L.B. and Lewison, R.L., 2013. Impacts of fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. Ecosphere, 4(3): 1-49