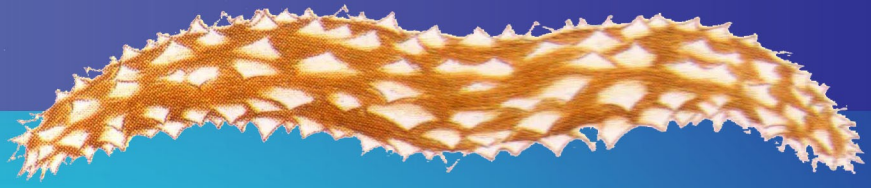
Sea cucumber survey

New Ireland Province

Pislama wok painim aut long

Niu Ailan Provins



NATIONAL FISHERIES AUTHORITY

March 2007

PNG NATIONAL FISHERIES AUTHORITY
COASTAL FISHERIES
Management and Development Project
ASIAN DEVELOPMENT BANK

GPA

Tautai

Ailan Awareness Inc.

The Nature Conservancy

National Library Service Cataloguing-in-Publication:

National Fisheries Authority (Papua New Guinea).

Sea cucumber survey, New Ireland Province -- [Kavieng] : National Fisheries Authority and Coastal Fisheries Management and Development Project, 2007.

37 p. ; cm.

ISBN 9980-86-092-8

1. Holothurians – Papua New Guinea – New Ireland Province. I. Title. II. Coastal Fisheries Management and Development Project (Papua New Guinea).

593.96099583 -- dc22

Printed by Star Printers, Port Moresby.

By:
Ursula Kaly
Garry Preston
Joel Opnai
John Aini

Reviewers:
Kim DesRochers
Warwick Nash
Paul Lokani

Database:
Dave Burgess
Ursula Kaly

Data entry:
Belinda Buken
Stella Waikapi

Fieldwork:

Ailan Awareness
John Aini
John Igua
Kilangis Komet

The Nature Conservancy
Tapas Potuku
Litau Pomat
Lawrence Litau

Sea cucumber pictures from:
Cannon, L.R.G. & Silver, H. 1986. Sea cucumbers of northern Australia. Queensland Museum.

SAVING THE LAST GREAT PLACES ON EARTH

SAMARI

Dispela wok painim aut ol i bin karim aut long Niu Ailan Provins long klostu long pinis bilong yiar 2006, em iwan pela long ol wok Coastal Fisheries Management na Development Project (CFMDP) bilong National Fisheries Authority (NFA) i mekim. Dispela em wanpela long ol wok CFMDP i wok long en long taraim painim aut gut long namba na sais bilong ol pislama istap iet long rip na solwara long Niu Ailan Provins. Dispela tu em iwanpela long ol wok CFMDP karim im aut long painim aut na save gut moa long ol liklik coastal piseries long Niu Ailan, Morobe na Milen Bei Provinses. Dispela wok long Niu Ailan, tupela NGO grup em long Ailan Awareness na The Nature Conservancy (TNC) iwok bung wantaim CFMDP long karim aut.

Dispela wok painim aut, em ol ilukluk long tupela hap rip long wan wan long 21 pela ward insait long 4 pela LLG long sait long noten Niu Ailan (Kavieng district). Planti long ol peles dispela wok painim aut istap long en, CFMDP ibin wokim pinis wan pela wok painim aut long saet long sosio na ekomik, long yiar 2004. Narapela tupela hap rip tu dispela wok painim aut ibin wok long en, em tupela istap insaet long tupela ward long Simberi na Tatau long Tabar ailan insait long Central Niu Ailan LLG. Dispela tupela hap rip ol iusim olsem kontrol na tupela istap insaet long Tabu bilong tumbuna o Mok. Ibin igat 40 pela hap rip olegta dispela wok painim aut ibin wok long ol, istat long Lovongai LLG, Kavieng LLG, Tikana LLG na liklik hap long Sentral Niu Ailan LLG. Namel long 4 na 7 pela kaen kaen rip ol ibin lukluk long en, long olgeta hap rip ia. Long nambis igo long sibruruk na bihaen long siburuk igo inap long 10 pela mita daon. Ol ilukluk tu long ol hap we ikolostu long nabis o kolostu long siburuk o sapos hap rip ia ikolostu long alien na sapos igat sigras longen o nogat. Long ol dispela hap ol ipulim tep sesa na makim wan wan banis olsem 50 mita longpela bilongen na 8 pela mita waed. Ol imakim 10 pela long ol dispela banis antap long ol wan wan kaen rip. Insait long dispela banis ol i kadim ol wan wan spesis long pislama na makim bigpela bilong ol. Ol ibin lukluk to long sampela pislama autsait long ol banis on ibin makim pinsi. Mak na namba bilong ol banis na hamas ol kaen kaen rip bambai this pela wok painim aut bai lukluk long en em ibin beis long narapela wok ol sampela laen ibin wok pinis longen long Manus. Dispela bai inap long dispela wok bai panim aut sapos igat senis long namba long wanwan rip na tu sapos igat senis long taim.

Long dispela wok painim aut, ibin igat 24 pela olgeta ol kaen kaen spesis bilong pislama ol ibin painim, insaet lng despela 20,971 pislama ol ibin kandim na makim sampela inap olsem 5,947. Planti long ol pislama emi bin Loli pis (we prais bilong ol iliklik tasol) na Dipwara redpis. Ol dispela tupela spisis em ol i bin pulap long Tatau na Kulangit rip. Planti moa ol ibin istap long antap long rip na liklik namba tasol long insaet long solwara na long lagun.

Sapos yumi lukluk long ol narapela wok painim aut ol iwokim pinis Niu Ailan olsem long yiar 1992, iluk olsem long dispela hap long noten Niu Ailan, namba bilong pislama ibin pudaun pinis. Dispela wok painim aut ibin, kandim bilong pislama em i 4.5 million na long bipo long 1992 emi bin istap antap olsem 34.7 milion. Dispela wok painim aut itok strong long putim sampela wei long biringim kaek namba long pislama igo antap. I gutpel long passim hariap dispela piseri long pislama givim sampela taem long nambe bilong pislama long Niu Ailan igo antap na biringim bek dispela risos bilong wok mani bilong ol pipol bilong Niu Ailan.

SUMMARY

This sea cucumber survey was undertaken in New Ireland Province in late 2006 as part of the National Fisheries Authority's Coastal Fisheries Management and Development Project (CFMDP). Its purpose was to provide information for describing the state of sea cucumber resources as part of a series of interventions designed to characterise small-scale fisheries and monitor the outcomes of the project in New Ireland, Milne Bay and Morobe provinces. The work was carried out through a cooperative partnership between the CFMDP and two non-government organisations, The Nature Conservancy and Ailan Awareness.

Two sites were surveyed at each of 21 wards spread over 4 local level government (LLG) areas in the northern part of the province. Most of the sites were the same as those surveyed in earlier CFMDP socio-economic surveys undertaken in 2004. In addition to those sites, the survey included two 'control' sites under traditional management at Simberi and Tatau wards, in Central Niu Ailan Province. Overall 40 sites were surveyed over Lovongai, Kavieng, Tikana and part of Central Niu Ailan LLGs. Between 4 and 7 habitats were identified at each site, and sampling was carried out separately in those present. This included several subtidal and intertidal habitats, defined by depth, location in relation to reefs and land or islands, and the presence of seagrass beds or coral patch reefs. Ten replicate 50x8 m transects were used in each combination of habitat and site to enumerate all sea cucumbers present and gather information on habitat characteristics. Additional information was collected on sizes of sea cucumbers within and outside of the transects. The sampling effort used was determined using a power analysis of data previously collected from Manus Province before the survey began in order to optimise the design so that it could be expected to detect at least a 50% difference among sites or change over time with 80% power.

Twenty-four species of sea cucumbers were recorded during the survey, with 20,971 animals counted and 5,947 measured. The most abundant sea cucumbers were lollyfish (which is of low commercial value but becoming more important in the fishery) and deepwater redfish, found at Tatau and Kulangit. These two species accounted for more than 91% of all sea cucumbers counted, and the two sites about 84%. The greatest densities of sea cucumbers were found in intertidal habitats, with smaller numbers in offshore areas or lagoons.

Compared with an earlier survey undertaken in the province and work carried out elsewhere, the sea cucumbers in the area are severely depleted with numbers only a fraction of what they were in 1992 when they were already considered overfished. The total stock in northern New Ireland estimated during this survey was around 4.5 million sea cucumbers, compared with an estimate of 34.7 million for 1992, using information from Lokani 1996a. Strong measures, including a period of closure, are urgently needed to allow this fishery to recover its productivity and income-earning capacity for New Irelanders.

CONTENTS

Introduction

Background

This report is part of a series focused on the status of resources, fisheries catches, market sales, the activities of buyers and socio-economic conditions in three provinces of Papua New Guinea. These surveys were designed to characterise small-scale fisheries and to monitor the outcomes of the Coastal Fisheries Management and Development Project (CFMDP) in New Ireland (NIP), Milne Bay (MBP) and Morobe (MOR) provinces.

Characterisation of small-scale fisheries, including the state of the resources, forms a part of the CFMDP which is being implemented by the National Fisheries Authority (NFA) with loan funding provided from the Asian Development Bank (ADB) (1925 PNG-SF). The overall aim of the CFMDP is to contribute to the reduction of poverty in rural areas through increasing, or preventing a further decline in the incomes of coastal communities. This includes improving the monitoring and management of resources and creating sustainable earning and employment opportunities for coastal communities. Mechanisms that improve access to information on fisheries, and the construction of wharves, jetties and other social infrastructure also form part of the project.

This report describes a survey undertaken through a cooperative partnership between CFMDP, The Nature Conservancy (TNC) and Ailan Awareness (AA), two non-government organisations (NGOs). AA is based in Kavieng, New Ireland Province and carries out environmental awareness programmes in the area. AA was contracted by the project to carry out fieldwork. TNC provided SCUBA divers who made it possible to survey sea cucumbers at greater depths. The survey focused on the distribution and abundance of sea cucumbers or beche-de-mer found throughout the northern end of New Ireland Province to provide information necessary for assessing the status of the resources.

A further function of the survey was to assemble and, where necessary, train a professional team that could be used in the future to carry out similar surveys on behalf of NFA.

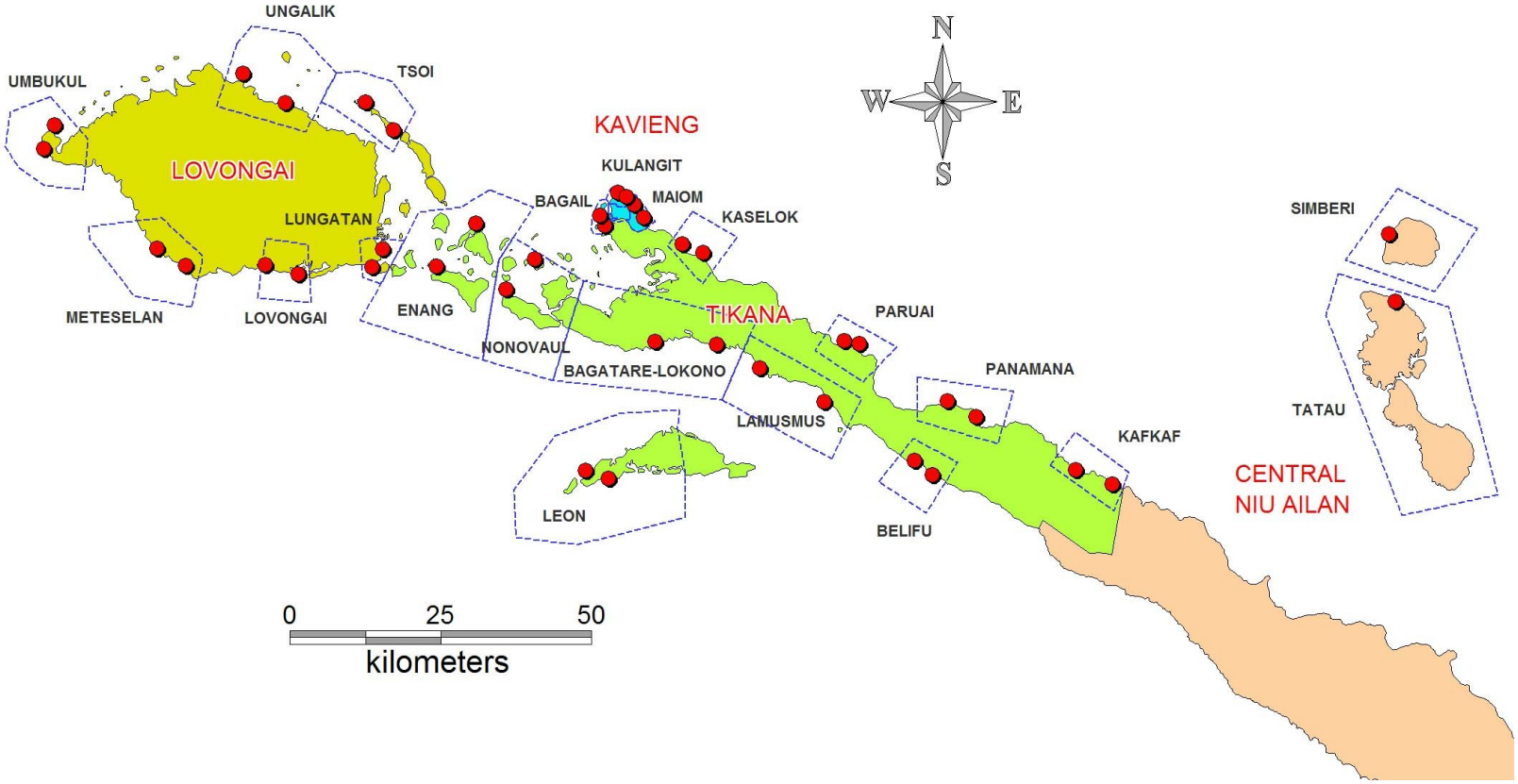
Scope of the Survey

This report presents some of the findings of a sea cucumber survey undertaken during late 2006. The survey was designed to provide information required to:

- Identify patterns of distribution and abundance of sea cucumbers in different coastal areas of northern New Ireland Province
- Identify areas with poor or good stocks for the purposes of information and management
- Identify any species that may appear to be under stress (heavily depleted)
- Estimate (roughly) the total size of stocks, separated by species
- Provide the basis for later identification of any correlations that might exist between sea cucumber abundance and socio-economic variables as measured during the CFMDP socio-economic (SE) Survey in New Ireland

- Identify whether there is a repository of sea cucumbers in deeper waters below normal snorkelling depths (as often argued by buyers) that might indicate the populations are in better condition than may be initially thought
- Compare sea cucumber densities in fished and managed areas to obtain an initial appreciation of the effects of these management regimes on stocks (i.e. open access vs management), and
- Compare sea cucumber densities and distribution in late 2006 with any suitable earlier surveys to examine changes over time and trends in the resources.

Figure 1: Map of Northern New Ireland Province showing position of all sites surveyed (red dots), ward areas and their names (blue envelopes, black labels) and local level governments (LLGs) (shading, red labels).



General approach & Sampling framework

The sea cucumber survey was undertaken collaboratively by Ailan Awareness contracted by NFA-CFMDP and The Nature Conservancy in October-December 2006. The survey focused on the same wards and LLGs that were sampled during the NIP socio-economic survey undertaken in 2004 in order to provide a basis for future investigations of relationships between the state of resources and the welfare of the people using them. As such, the nearshore habitats of 21 wards spread across 4 LLGs were surveyed, including 4 wards from Kavieng LLG, 6 from Lovongai, 10 from Tikana and 2 control sites in wards from Central Niu Ailan LLG. The different numbers of wards in each LLG are related to the absolute number available and geographic spread (Figures 1 & 2).

Two sites were surveyed at each ward (identified only by a pre-assigned site number), with up to 7 habitats at each site. Sites were pre-selected and defined for the survey using a GIS satellite map. GPS readings were also taken at each site to cross-check the accuracy of the map locations.

Four habitats thought to be available at all sites were surveyed as core habitats, with additional habitat types surveyed where they were present.

The compulsory habitats in the subtidal zone were: Reef slope (10m depth) and Reef front (5m depth). In the intertidal zone they were: Outertidal (or reef crest) and Innertidal (or back reef) (Figure 3). Additional habitats, if present could include lagoon habitats: seagrass beds, patch reef areas and sandy lagoon floor, in addition to seagrass-dominated innertidal/ backreef areas. Divers working in the Reef slope habitat carried out additional visual inspections of areas 20+m depth to identify any additional populations of sea cucumbers at depths not often harvested by fishers using snorkel.

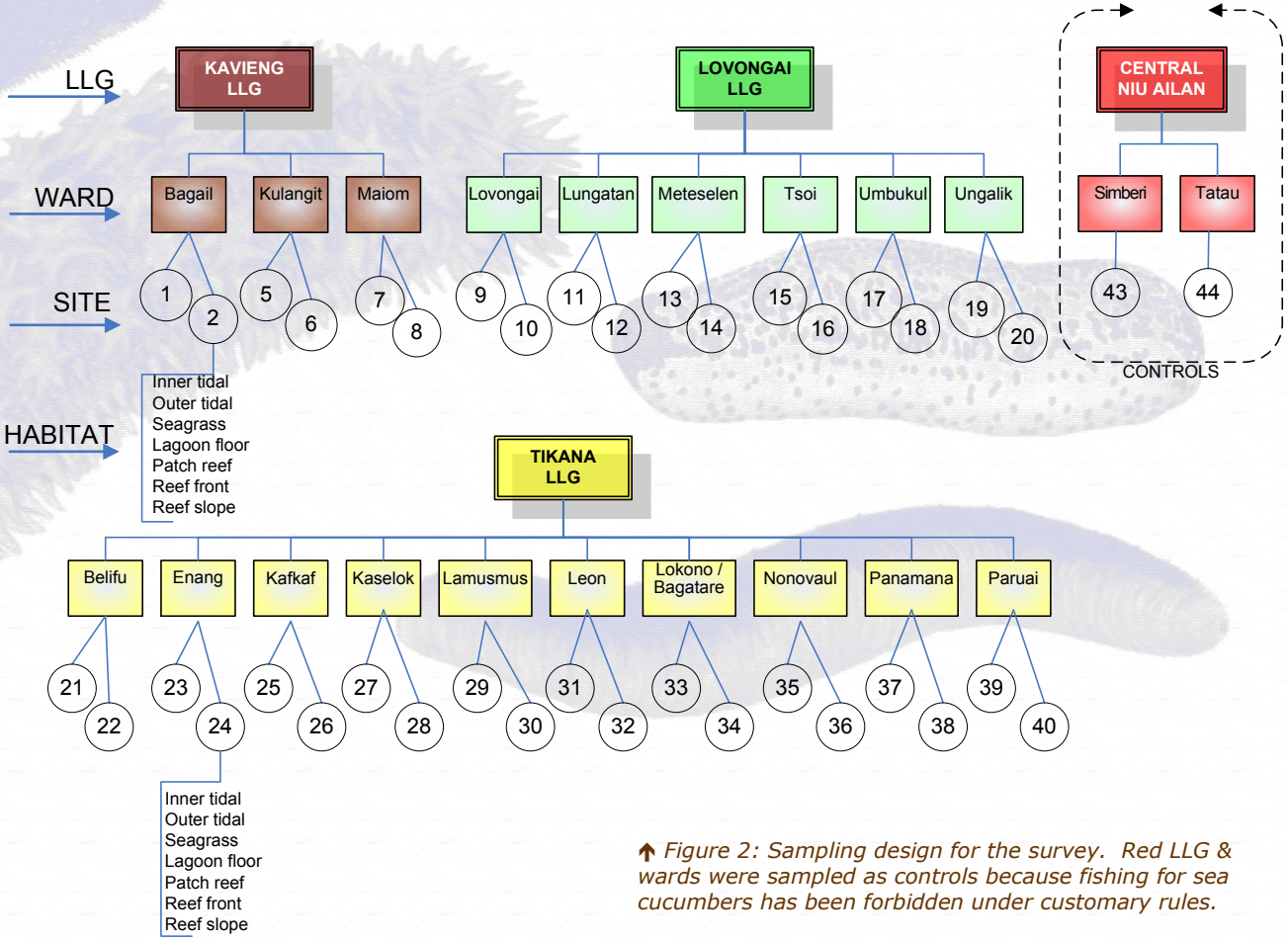
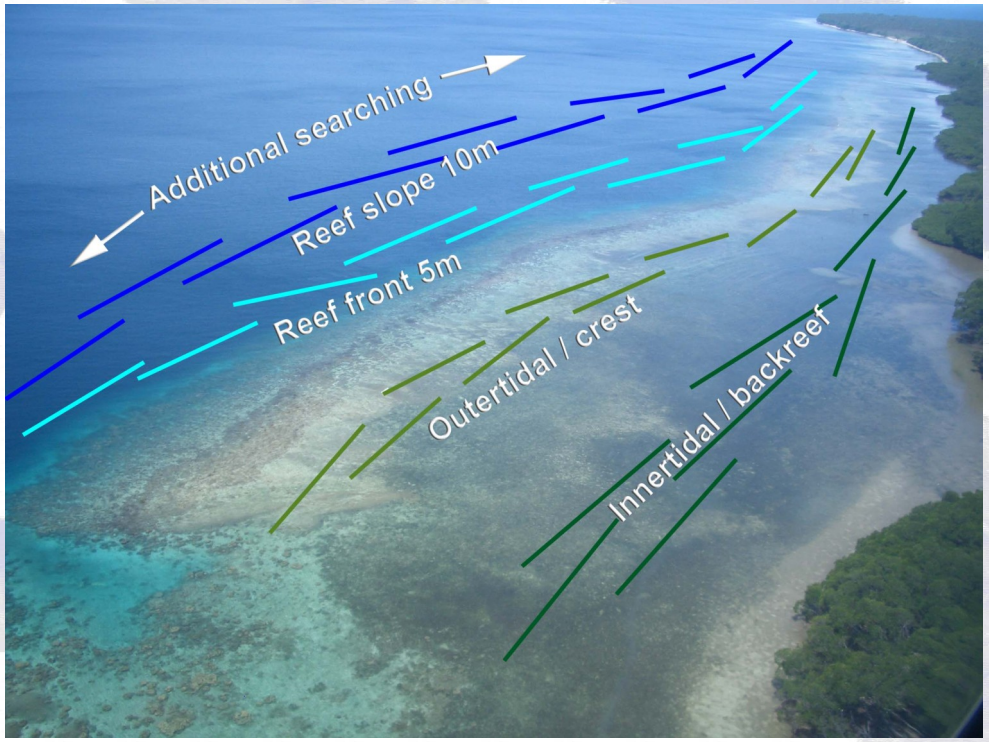


Figure 2: Sampling design for the survey. Red LLG & wards were sampled as controls because fishing for sea cucumbers has been forbidden under customary rules.

Within each combination of habitat, site, ward and LLG, the teams surveyed 10 replicate 50 x 8m transects, identifying and counting all sea cucumbers present, and recording a range of other environmental variables such as substratum type based on estimates of cover by corals, seagrasses, algae and non-living materials (e.g. sand). Substratum type was characterised using a point intercept method by recording the substratum category present under 50 pre-marked points along each transect. Additional information on sea cucumbers was collected by measuring the length and width of up to 100 individuals of each species in each habitat.

Optimising the sampling design

The amount of sampling effort required to detect geographic patterns in the distribution, abundance and sizes of sea cucumbers, and changes over time was optimised using a "power analysis". This analysis was done before the start of the survey using data previously collected by NFA in Manus in 2001 (Lokani 2001). Although it would have been better to use data collected in NIP, none that were suitable were available. The transects used in the Manus study (50 x 6m) were slightly smaller than those we used (50 x 8m). In that study, 214 transects were evaluated, 87 in coral reef habitat, 32 on the lagoon floor and 95 in seagrass areas. The data came from 60 sites, with up to 6 transects surveyed per site. The purpose of this optimisation study was to find out how many transects would be required to be able to detect a 50% difference in mean abundance (among sites and/or times) with a power of 80%. This equates to a 20%, or less, chance of missing a real difference or change in abundance of the animals. The outcome of the power analyses suggested that between 9 and 16 replicates would be required per site to detect a 50% difference in the total number of sea cucumbers. Note that for individual species, power would generally be less. Using these results, we chose to survey 10 replicate transects per site and habitat.



↑ *Figure 3: Photo of a sampling site showing layout of replicate transects in the 4 core habitats positions. Note in this photo the Innertidal area is dominated by seagrass and at some sites, additional habitats are present if a lagoon habitat has developed. Additional inspections were done further offshore to locate any additional stocks not observed during the formal survey.*

Controls

Two of the sites surveyed were designated as controls. These were selected before the survey began on the basis that they were under traditional management and were not being fished for sea cucumbers. The two controls were at Simberi and Tatau wards in Central Niu Ailan LLG. Including them presented some difficulties for the logic

of the sampling design because they are located outside of the geographic area that encompasses all other sites in the survey and could differ for reasons other than management.

Data collection, handling and analysis

Data were collected in the field by two field teams: three surveyors targeting deeper water habitats working on SCUBA, and three working in intertidal areas by walking or snorkelling. Surveyors laid out transect tapes and identified and counted sea cucumbers located within 4m of either side of the tape. These data, and information on bottom types were recorded onto pre-printed waterproof sheets and later entered into a purpose-built Access database for storage. Data were analysed using Excel, Statistica or by plotting them as graphs or onto a map using Mapinfo.

Survey strengths

1. The survey is a milestone in the establishment of locally-outsourced capability to meet NFA's data needs for resource management. The approach used here could be applied or adapted to suit other provinces and needs.
2. Care was taken to ensure that the information collected had the capability to detect important changes over time and differences among sites. Many studies are statistically weak and cannot be relied on to detect differences or changes because they have not been optimised.
3. The survey was logistically challenging, requiring SCUBA and travel to remote areas of the province. Further, weather conditions were often rough and relay teams to bring freshly filled tanks to divers were required. The teams demonstrated that they are capable of working successfully under such conditions.

Survey weaknesses

1. There is a logical weakness in the design brought about by the absence of suitable management areas within the same geographical range as the main part of the survey. This 'confounding' means that differences we may find between fished and unfished areas in this study could be due to reasons other than fishing.
2. Due to the desire to collect data that could later be correlated with the results of socio-economic, landings and buyer surveys carried out over the same geographical area as part of the CFMDP, there was insufficient effort placed in lagoon areas. Future surveys should include additional sites to provide better abundance estimates for these habitats in the area between the mainland and New Hanover (Tigak Islands).
3. The concept of stratification of sampling into specific habitats was not fully understood by the field team during the survey. This led to some errors of habitat definition and measurements taken in inappropriate areas. The innertidal areas with and without seagrass were often confused and needed further clarification with the team. This problem only affected sub-habitats and would not have significantly affected the overall stratified estimates of abundance.
4. The data on sea cucumber widths (taken at the same time as length) were not used because the two teams used different techniques for this measurement. Better team coordination is required for future surveys.
5. For future surveys, additional attention will be required on day-to-day aspects of data monitoring. Some data were lost through confused record-keeping. With improvement in this area, the teams should be able to provide a reliable data service.

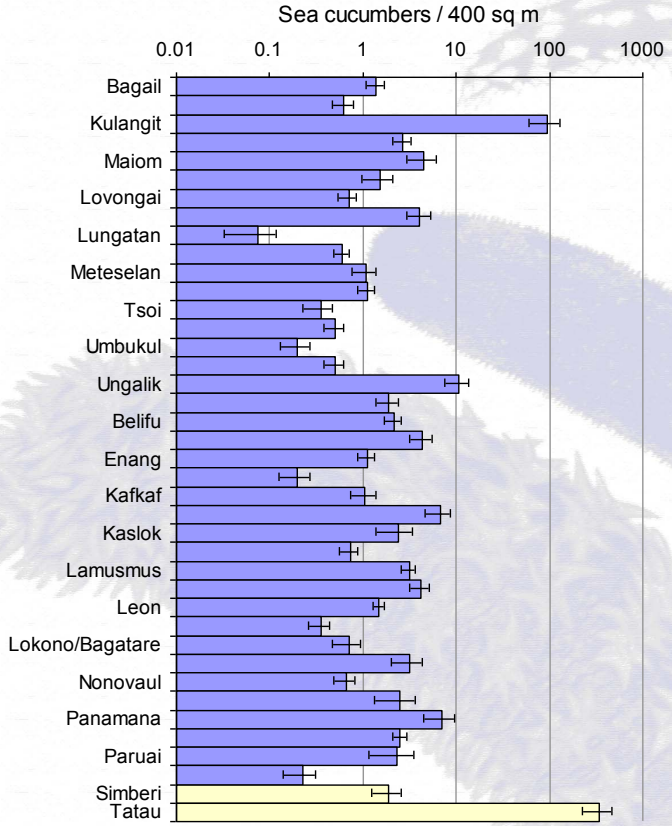
Results

Abundance

Almost 21,000 sea cucumbers of 24 species were identified and recorded in 1,750 transects over the survey (Table 1). At 400 m² per transect, this represents a total search area of 700,000 m² (70 hectares). The overall average density for the survey was about 300 sea cucumbers per hectare or 12 animals per transect. However, these figures are inflated by very large numbers of sea cucumbers recorded at one managed site (control) at Tatau Ward and to a lesser extent at Kulangit Ward. These two sites contributed 84% of all sea cucumbers counted (Table 2). At Tatau, this was equivalent to 346 animals per transect, 0.86 per square metre or 8,640 per hectare. For most sites, the average number of sea cucumbers per transect ranged between 0.08 and 10.58, translating to a count of 1.9 to 264 per hectare.

Scientific name	Common name	Number	%
Holothuriidae			
Actinopyga echinites	Deepwater redfish	3,720	17.7
Actinopyga lecanora	Stonefish	9	<0.1
Actinopyga mauritiana	Surf redfish	60	0.3
Actinopyga miliaris	Black fish	40	0.2
Actinopyga palauensis	Pannings blackfish	1	<0.1
Bohadschia argus	Tigerfish / Leopard fish	130	0.6
Bohadschia similis	Chalkfish	100	0.5
Bohadschia vitiensis	Brown sandfish	35	0.2
Holothuria atra	Lollyfish	15,427	73.6
Holothuria coluber	Snakefish	151	0.7
Holothuria edulis	Pinkfish	209	1.0
Holothuria fuscogilva	White teatfish	39	0.2
Holothuria fuscopunctata	Elephant trunkfish	5	<0.1
Holothuria hilla	Tigertail	170	0.8
Holothuria nobilis	Black teatfish	32	0.2
Holothuria scabra	Sandfish	520	2.5
Holothuria versicolor	Black sandfish	*	*
Pearsonothuria graeffei	Flowerfish	229	1.1
Stichopodidae			
Stichopus hermanni	Curryfish	13	0.1
Stichopus horrens	Dragonfish	13	0.1
Stichopus chloronotus	Greenfish	1	<0.1
Thelenota ananas	Prickly redfish	43	0.2
Thelenota anax	Amberfish	22	0.1
Thelenota rubralineata	Candy-cane	2	<0.1
Grand Total		**20,971**	**100**

↑ *Table 1: Total number of sea cucumbers of each species recorded in transect counts during this survey. * Black sandfish were recorded only from size data. This subspecies was pooled with sandfish by most of the team.*



→ *Figure 4: Average numbers of sea cucumbers per transect at each site (+/-SE). Note the log scale.*

↓ *Table 2: Total number of sea cucumbers recorded in transect counts at each site during this survey. Sites in yellow are the controls, or managed areas.*

Ward	Site	Total	%
Bagail	Site 01	55	0.3
	Site 02	25	0.1
Kulangit	Site 05	3784	18.0
	Site 06	108	0.5
Maiom	Site 07	181	0.9
	Site 08	61	0.3
Lovongai	Site 09	28	0.1
	Site 10	163	0.8
Lungatan	Site 11	3	0.0
	Site 12	30	0.1
Meteselan	Site 13	43	0.2
	Site 14	44	0.2
Tsoi	Site 15	14	0.1
	Site 16	25	0.1
Umbukul	Site 17	10	0.0
	Site 18	30	0.1
Ungalik	Site 19	423	2.0
	Site 20	75	0.4
Belifu	Site 21	85	0.4
	Site 22	174	0.8
Enang	Site 23	44	0.2
	Site 24	14	0.1
Kafkaf	Site 25	42	0.2
	Site 26	267	1.3
Kaslok	Site 27	96	0.5
	Site 28	29	0.1
Lamusmus	Site 29	125	0.6
	Site 30	165	0.8
Leon	Site 31	89	0.4
	Site 32	21	0.1
Lokono/Bagatare	Site 33	28	0.1
	Site 34	126	0.6
Nonovaul	Site 35	33	0.2
	Site 36	150	0.7
Panamana	Site 37	279	1.3
	Site 38	100	0.5
Paruai	Site 39	94	0.4
	Site 40	9	0.0
Simberi	Site 43 Maraquen	76	0.4
Tatau	Site 44 Sos	13823	65.9
Total		20971	100

ALL SPECIES OF SEA CUCUMBERS (ABUNDANCE)

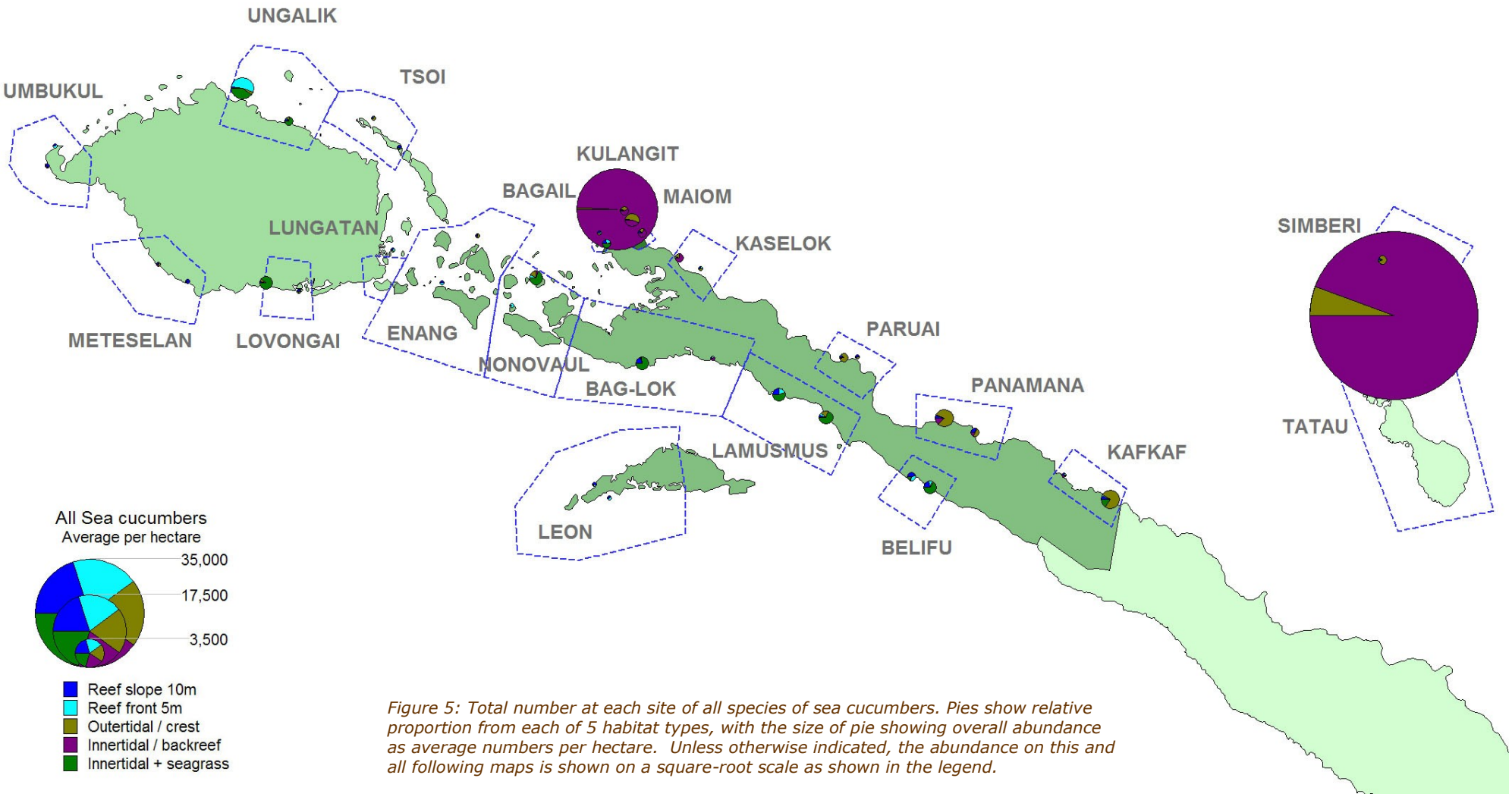


Figure 5: Total number at each site of all species of sea cucumbers. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance as average numbers per hectare. Unless otherwise indicated, the abundance on this and all following maps is shown on a square-root scale as shown in the legend.

Geographic patterns of abundance and the influence of habitat

The large differences in numbers of sea cucumbers found at each site is shown geographically in Figure 5. The large number of sea cucumbers recorded at Tatau and at Kulangit were found mostly in the innertidal areas, closest to shore, with significantly smaller numbers in the outertidal area. On the square root scale used, most of the other sites appear as small dots highlighting the much smaller numbers of sea cucumbers found there.

In Figure 6 the same data are shown on a logarithmic scale, used to de-emphasise the large site differences and show the habitats in each area supporting the most sea cucumbers. On the northern coast of the New Ireland mainland and northern offshore islands, most sea cucumbers are found in intertidal areas, with relatively small numbers found offshore. In the northern part of this region most sea cucumbers were found in the innertidal or backreef area (Tatau, Kulangit, Maiom and Kaselok), while in the southern part of Tikana (Paruai, Panamana and Kafkaf) most sea cucumbers were found in the outer intertidal area close to the reef crest (and breakers). On the south coast of the mainland and at Lovongai and part of Ungalik, most sea cucumbers were found in backreef seagrass areas, with greater numbers occurring in the reef front habitat. In Leon (Djaul Island), the south-western part of New Hanover (Lovongai LLG) and the Tigak Islands more sea cucumbers were found in subtidal areas.

Details of geographic and habitat distribution are shown in Figures 7-11 for the 5 most common sea cucumber species: lollyfish, deepwater redfish, sandfish, flowerfish and pinkfish.

Lollyfish account for almost 74% of all of the sea cucumbers counted during this survey and were found at all sites. These account for most of the large numbers of sea cucumbers recorded at Tatau (Figure 7). Moderate numbers of this species were also recorded at Ungalik, Panamana, Kafkaf and Kulangit. Throughout most of the area, lollyfish were found in intertidal habitats. In Tatau and Kulangit they were mostly found in the innertidal area, and on the southern coast of the mainland often in the same place but dominated by seagrass. For most of the north coast and Lovongai, lollyfish were most common in the outertidal area. In Ungalik, they were most common in the shallow subtidal reef front area.

Deepwater redfish accounted for almost 18% of all sea cucumbers counted in the transects. They were most abundant in intertidal habitats, particularly the innertidal and innertidal with seagrass habitats at Kulangit, Maiom and Lamusmus. At one site in Kulangit they reached a maximum density of 8,885 animals per hectare, with an overall average number of 53 animals per hectare. Deepwater redfish were absent from counts in 11 of the wards, including both controls (Tatau and Simberi) as well as Enang, Leon, Lungatan, Meteselan and Umbukul (Figure 8).

Sandfish were generally found in intertidal areas dominated by seagrass (Figure 9). Their overall abundance was 7.4 animals per hectare, reaching a maximum in Ungalik and Lovongai of over 300 animals per hectare. Their abundance is very patchy, with large numbers recorded at one site in a ward, and the other site in the same ward recording zero. A few individuals were recorded on the reef slope at one site in Tsoi, but otherwise no animals were recorded from the outertidal, lagoon or reef front habitats. This species, the third most abundant overall, accounted for only 2.5% of all sea cucumbers counted during the survey.

ALL SPECIES OF SEA CUCUMBERS (HABITAT PREFERENCES)

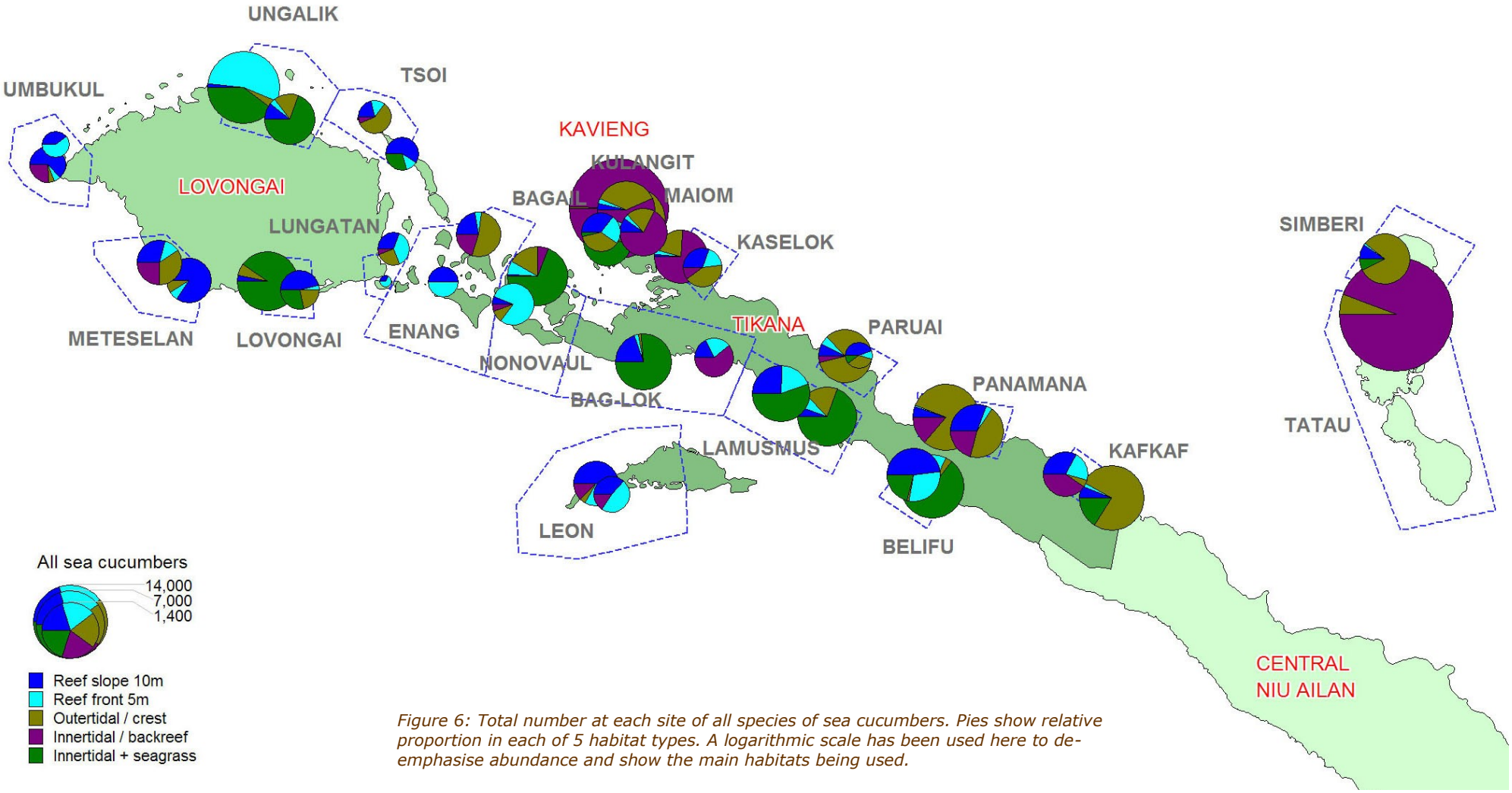


Figure 6: Total number at each site of all species of sea cucumbers. Pies show relative proportion in each of 5 habitat types. A logarithmic scale has been used here to de-emphasise abundance and show the main habitats being used.

LOLLYFISH

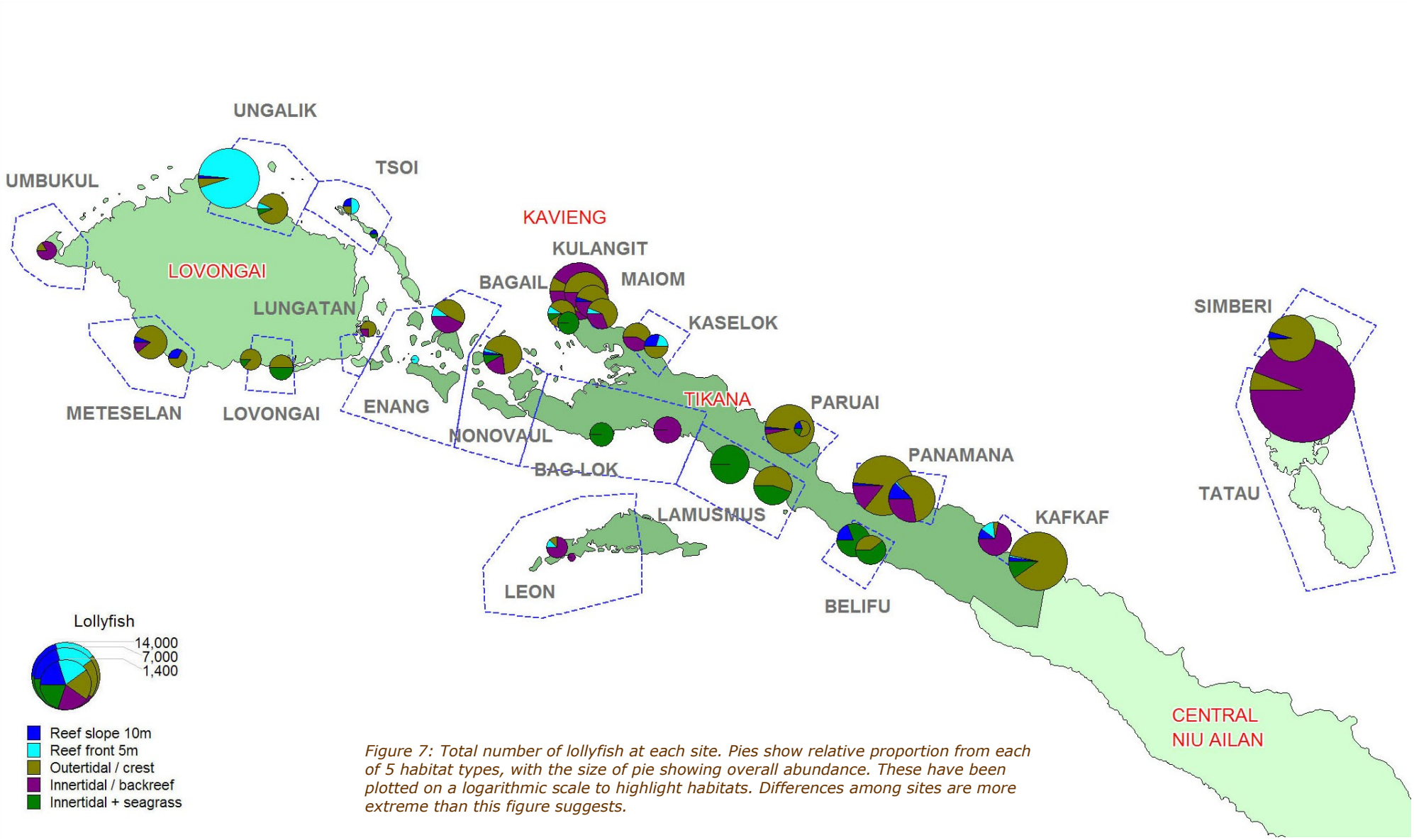
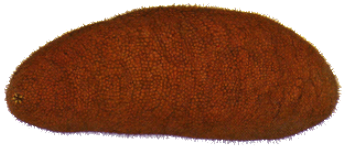


Figure 7: Total number of lollyfish at each site. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance. These have been plotted on a logarithmic scale to highlight habitats. Differences among sites are more extreme than this figure suggests.

DEEPWATER REDFISH



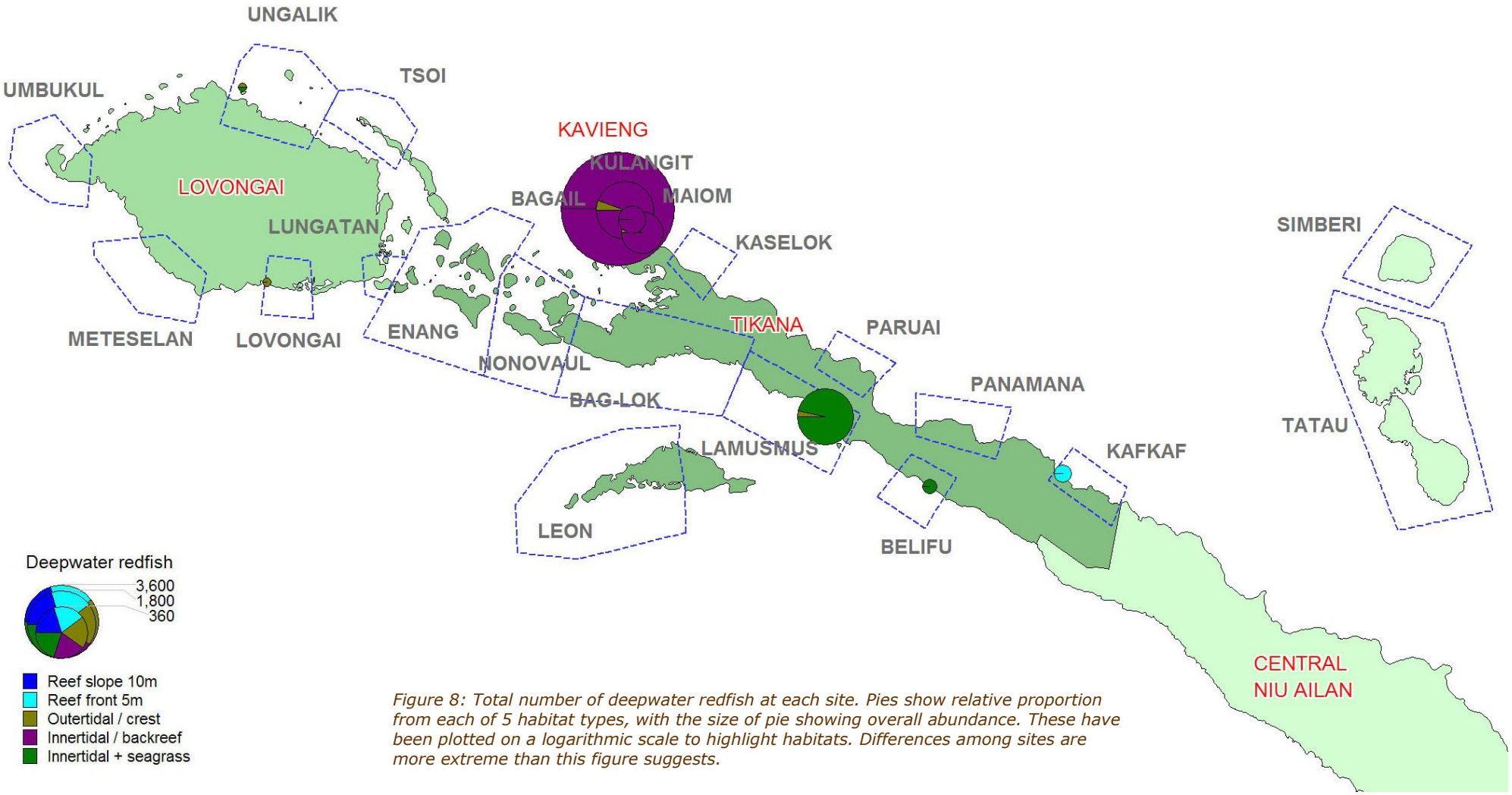


Figure 8: Total number of deepwater redfish at each site. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance. These have been plotted on a logarithmic scale to highlight habitats. Differences among sites are more extreme than this figure suggests.

SANDFISH

Figure 9: Total number sandfish at each site. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance.

Flowerfish had an overall average density of 3.3 animals per hectare, with the greatest numbers being recorded in the reef front and reef slope habitats. These sea cucumbers were most common at one site in Kaselok, where in the innertidal habitat they were found at a density of about 18 per hectare. Flowerfish accounted for 1.1% of all sea cucumbers recorded and were the fourth most abundant species at 229 animals recorded over the entire survey. This species was not recorded from the innertidal with seagrass or sandy lagoon floor habitats (Figure 10).

Pinkfish were mostly found in subtidal habitats, including the reef slope and front, and lagoon floor areas. Their overall abundance was around 3 per hectare, reaching a density of 8 per hectare in the reef slope (Figure 11). A total of 209 of this species was recorded during the survey, with greatest numbers recorded at one site in Leon with 58 per hectare in the lagoon and 53 per hectare on the reef slope habitats. At Meteselan they were found at a density of 48 per hectare on the reef slope.

Influence of substratum types

Percent cover by different substratum types varied with geographic location within the survey area. Figure 12 shows the percentages of hard and soft corals, algae, seagrasses, foraminifera (single-celled sand-forming organisms) and non-living (rock and sand) bottom types recorded. These values are averages across the reef slope, reef front, outertidal and innertidal habitats to identify broad patterns in the types of places that sea cucumbers might be found.

Overall the subtidal and intertidal habitats in Nonovaul, Enang, Tsoi and Leon wards (the island areas) tended to be more sandy than in other areas surveyed. Hard coral cover was greatest around the Kavieng area and Umbukul, with moderately-high cover on the south coast of New Hanover (Lovongai LLG) and in the Bagatare, Lokono, Lamusmus and Belifu areas. Soft corals were relatively rare and found as a small part of the cover in habitats of the Tigak Islands, and the area to the north of New Hanover Island. Recently-dead corals were most common on the north coast of the New Ireland mainland between Kafkaf and Kulangit (Figure 12).

A significant cover of algae was found throughout the study area, averaging 32% cover and ranging up to 60% at one site in Meteselan. Cover by seagrasses ranged between 0 and 32%, with an overall average cover of 9%. Seagrasses were most abundant in Tsoi, but tended to be common on the southern coasts of Tikana, at Simberi and on the north and south sides of Lovongai LLG (New Hanover).

FLOWERFISH

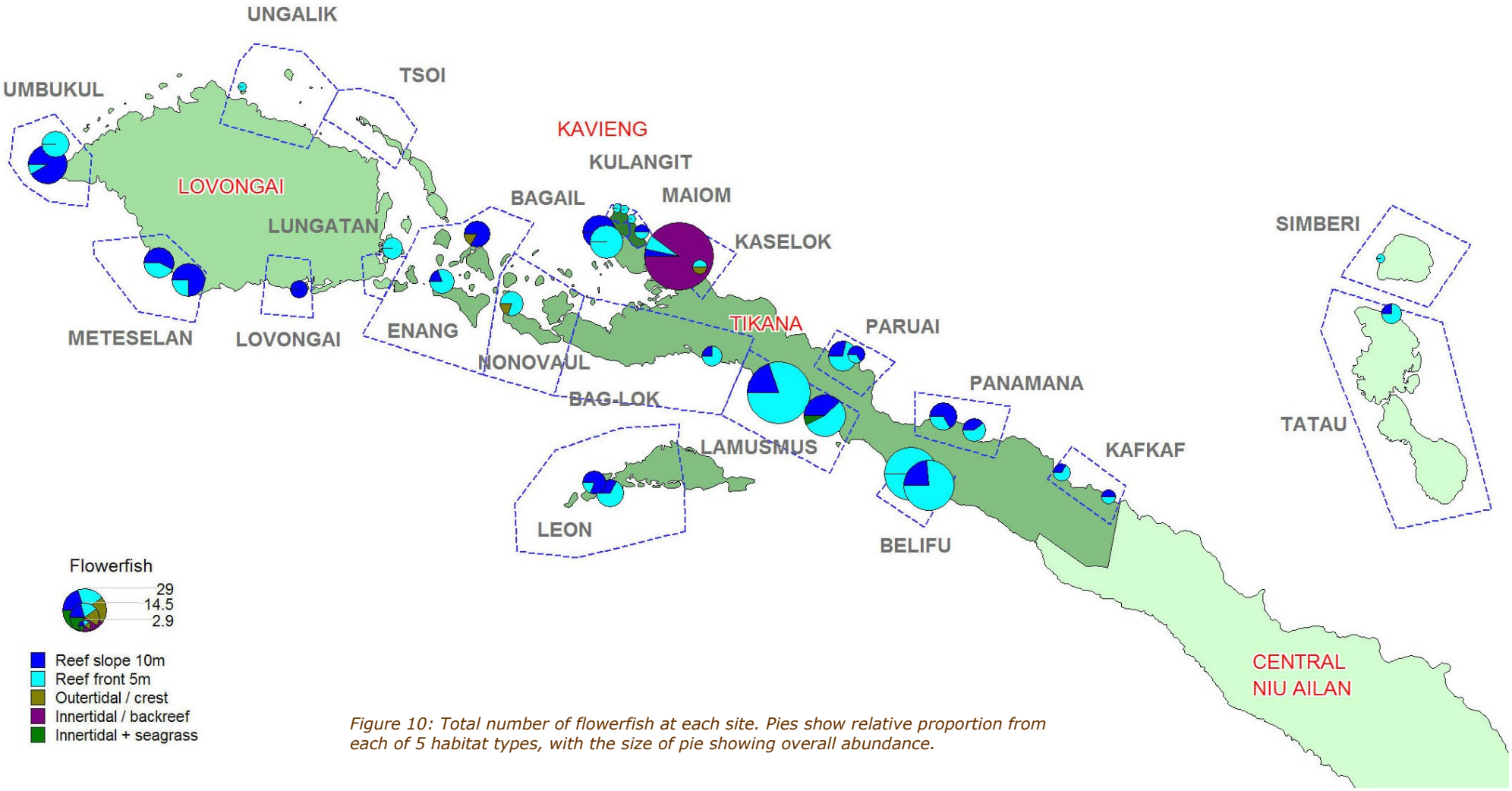


Figure 10: Total number of flowerfish at each site. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance.

PINKFISH

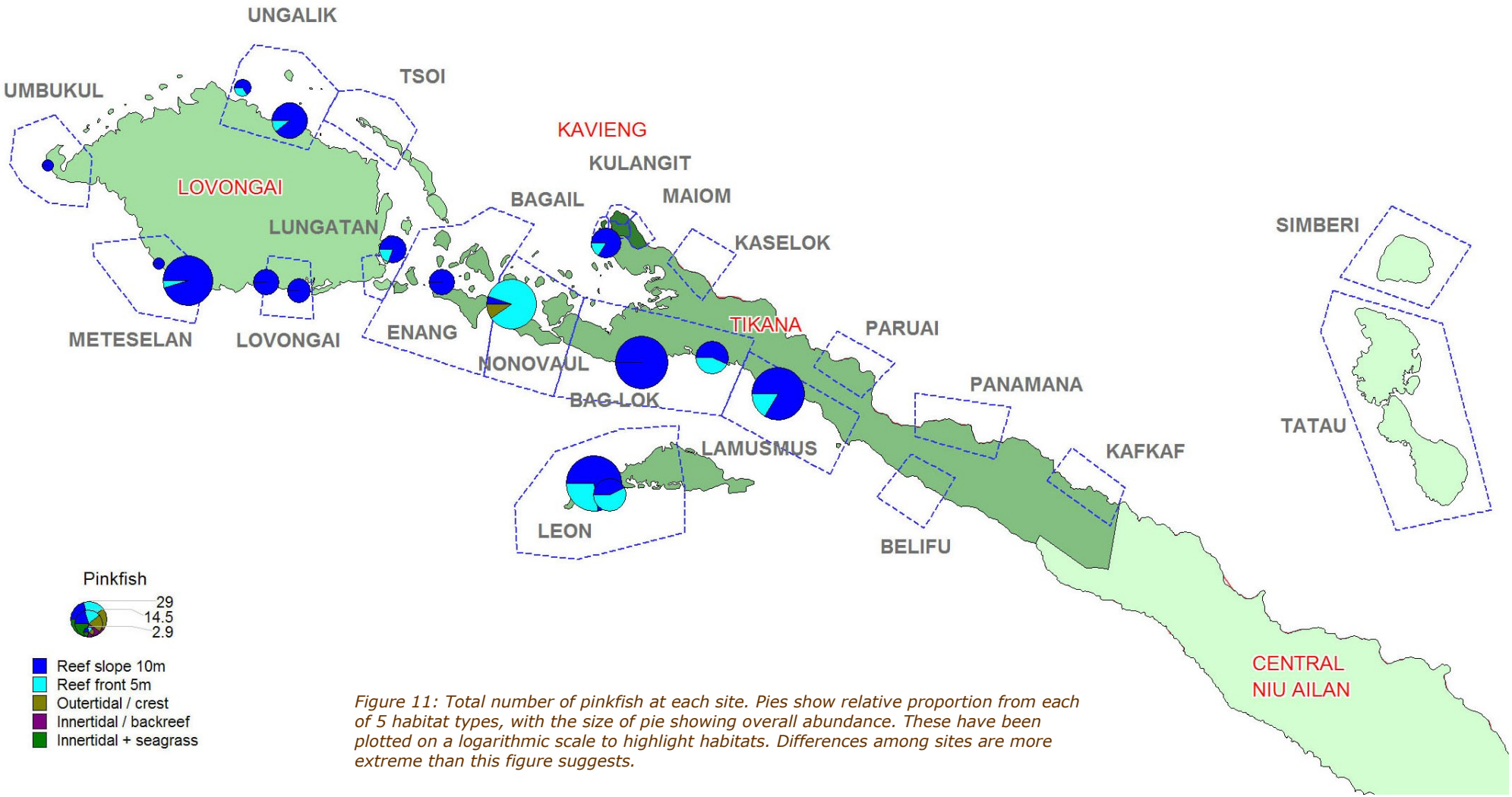


Figure 11: Total number of pinkfish at each site. Pies show relative proportion from each of 5 habitat types, with the size of pie showing overall abundance. These have been plotted on a logarithmic scale to highlight habitats. Differences among sites are more extreme than this figure suggests.

SUBSTRATUM TYPES

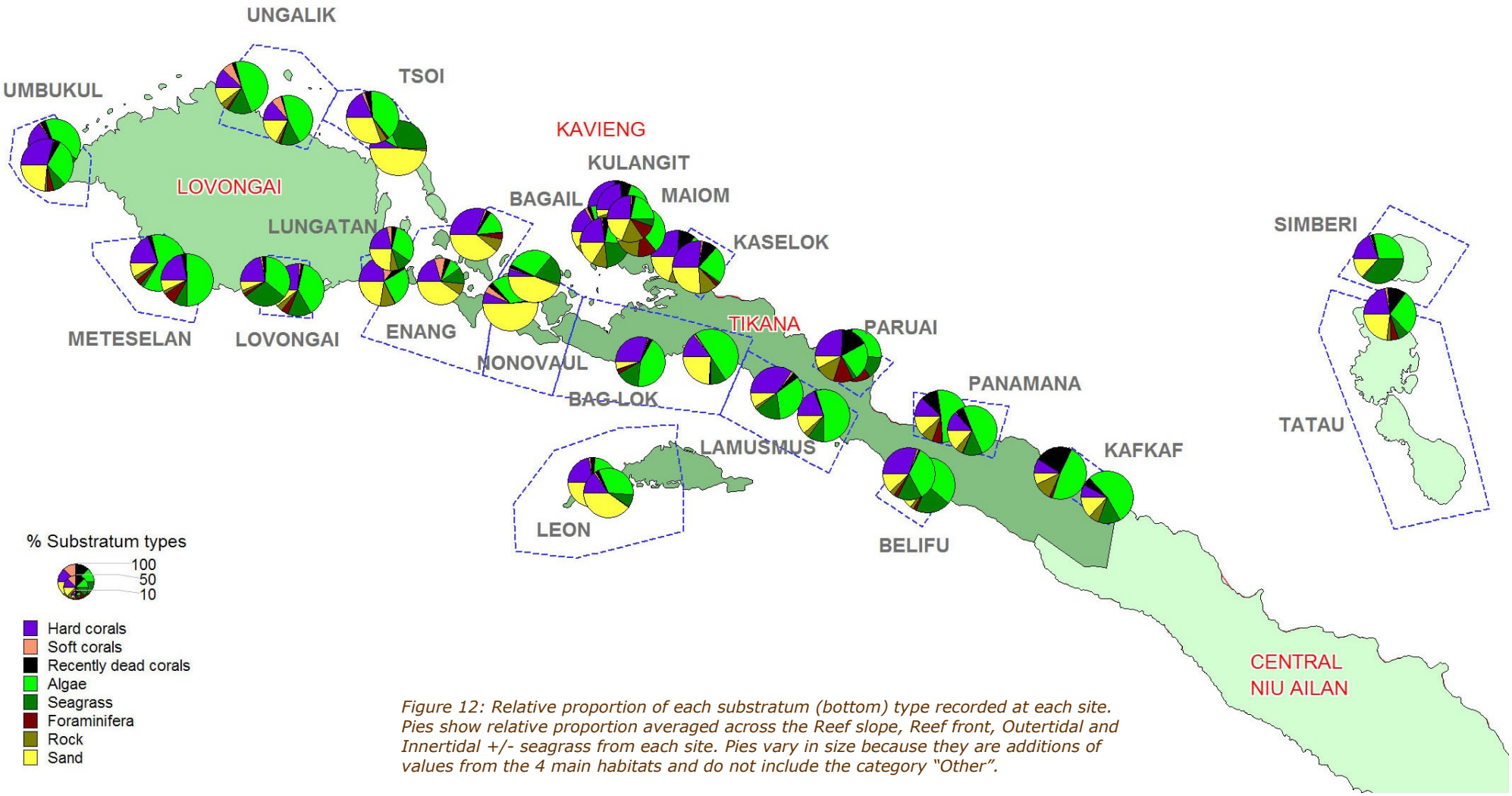


Figure 12: Relative proportion of each substratum (bottom) type recorded at each site. Pies show relative proportion averaged across the Reef slope, Reef front, Outertidal and Innertidal +/- seagrass from each site. Pies vary in size because they are additions of values from the 4 main habitats and do not include the category "Other".

CORRELATIONS WITH DEPTH AND BOTTOM FEATURES

At a more localised scale, some species of sea cucumbers tended to be either positively or negatively associated with features of their habitats (Figure 13). That is, the number of sea cucumbers was in some way related to water depth, or bottom characteristics such as the amount of hard corals, algae, seagrasses and types of non-living materials (rock, rubble, sand etc) that were present. This does not necessarily mean that there are more or less sea cucumbers at a place *because* of a feature. It may simply mean, for example, that sand tends to accumulate in the same kind of places that lollyfish like to live for entirely different reasons.

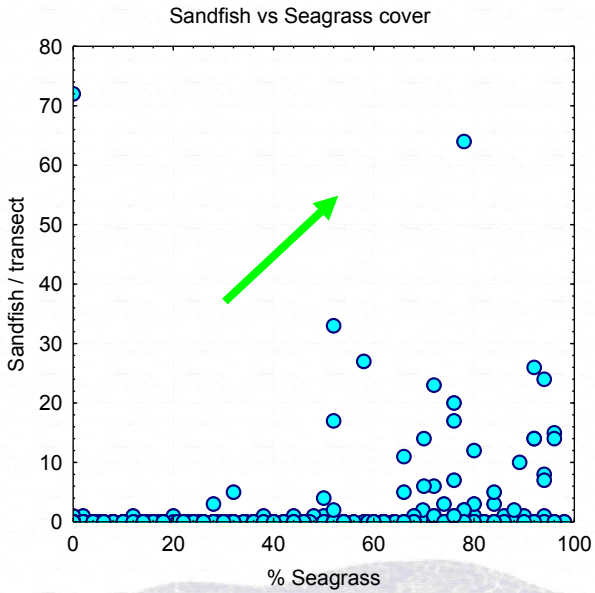
Associations such as these can tell us whether we could expect to see more or fewer sea cucumbers at a site if a certain feature is present. For some of the species there were positive correlations (green squares in Table 3). This means that there tended to be *more* sea cucumbers as the amount of a feature *increased*. For example, in Figure 13, the numbers of sandfish and chalkfish tended to be greater where there were more seagrasses, and pinkfish tended to be more abundant in deeper water.

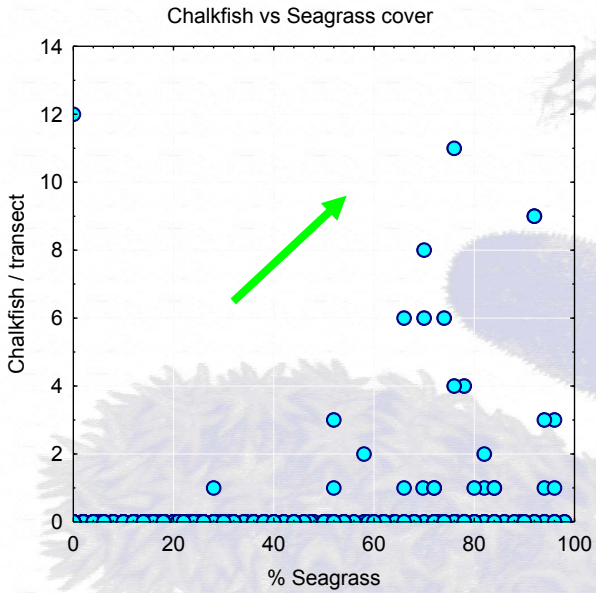
For some species, the presence of a feature meant that there tended to be *fewer* sea cucumbers. For example, the number of snakefish tended to *decrease* with increasing depth. Many of the species were negatively correlated with hard corals.

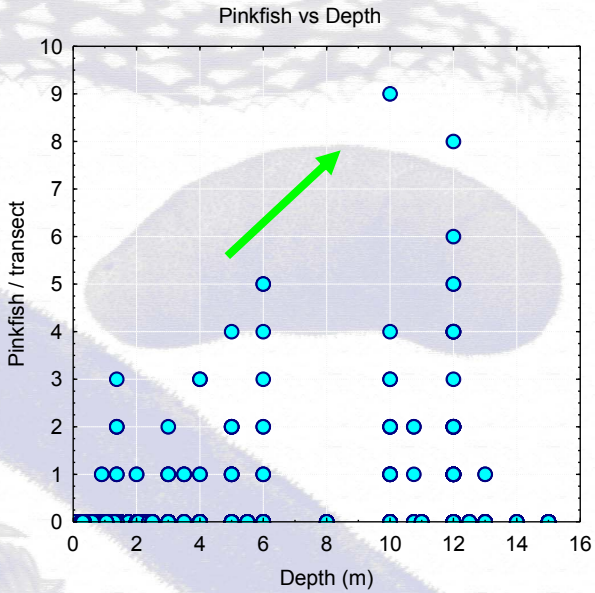
Not all sea cucumber species were correlated with the features we measured. No species showed any correlation with cover by soft corals. Two species showed no correlations at all, but this is likely to be related to the very few observations used in the analysis. These sea cucumbers were generally in very low abundance in the survey.

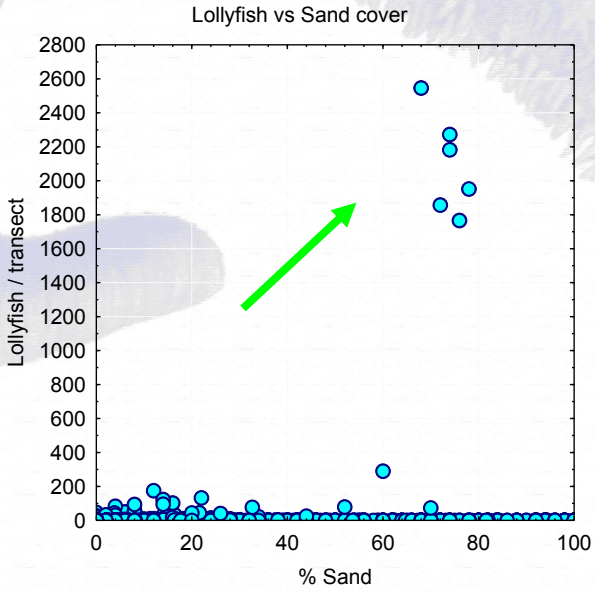
Table 3: Correlations of abundance of sea cucumbers with water depth and habitat characteristics. Green squares show a significant positive correlation, and orange squares a negative one (p=0.05).

	Depth	%HC	%SC	%SDC	%ALG	%SG	%Foram	%Rock	%Sand
All Sea cucumbers	-0.07	-0.07					0.06		0.12
Deepwater redfish	-0.05	-0.05					0.24		
Stonefish									
Surf redfish	-0.08	-0.06					0.15		
Blackfish	-0.06	-0.07				0.09			
Tigerfish	0.22			0.06		-0.07	-0.06	-0.06	
Chalkfish	-0.07	-0.07			-0.06	0.25			
Brown sandfish		-0.08			-0.06	0.14		-0.05	0.08
Lollyfish	-0.06	-0.06							0.13
Snakefish	-0.10	-0.09		-0.06		0.15			
Pinkfish	0.19				-0.06	-0.08	-0.06	-0.08	
White teatfish	0.18								0.10
Elephant trunkfish	0.07								
Tigertail	-0.06						0.07	0.10	
Black teatfish	0.15	0.05		0.06		-0.05			
Sandfish	-0.08	-0.08			-0.05	0.25			
Flowerfish	0.07	0.14		0.09		-0.08	-0.06		-0.05
Greenfish									
Curryfish		-0.05							0.14
Dragonfish	-0.07	-0.05					0.06	0.10	
Prickly redfish	0.22			0.14		-0.06			
Amberfish	0.17								
Candy cane	0.08								









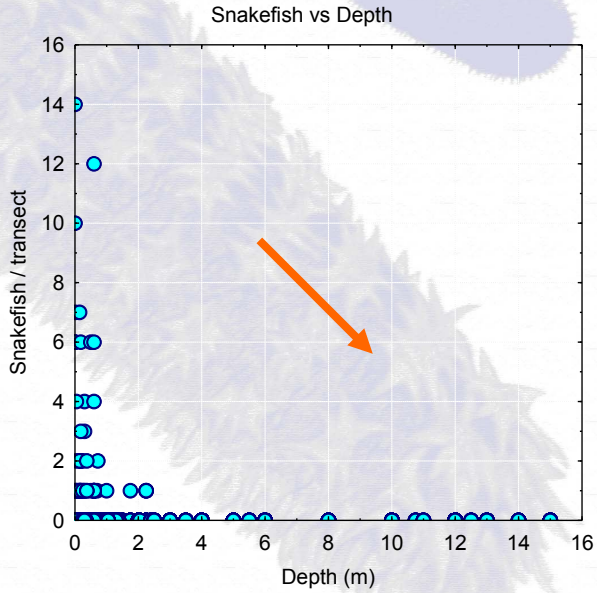


Figure 13: Graphs of selected significant correlations found between the number of sea cucumbers and features of their habitat (p=0.05). Note the presence of many zeros from sites with almost no sea cucumbers tends to make relationships hard to see.

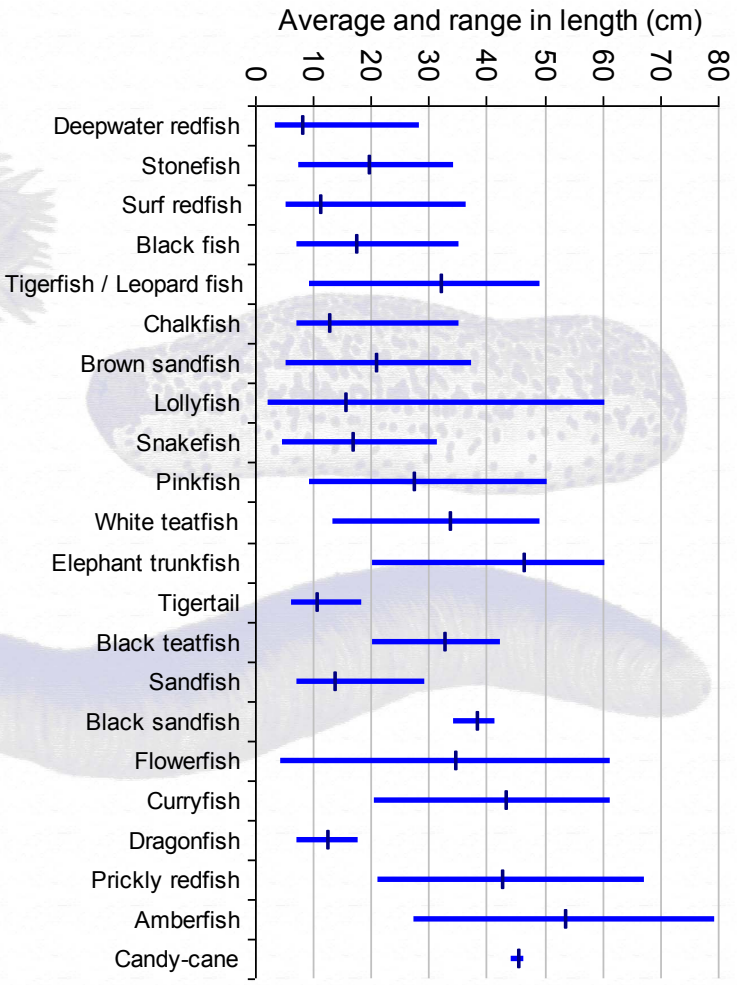
Sizes of Sea Cucumbers

A total of 5,947 sea cucumbers were measured during the survey. These were derived from 22 species and included individuals found inside or outside of the transects at all sites. The smallest number of any species that was measured was 2 individuals. With lollyfish and deepwater redfish the most common species in the survey, over 3,100 and 1,000 of these was measured respectively (Table 4).

The smallest sea cucumber measured was 2 cm long and was a lollyfish, while the largest at 79 cm length was an amberfish (Figure 14). Most of the species showed a broad size range across the survey, with an overall average size range of over 30 cm. The species with the greatest size ranges were lollyfish, flowerfish and amberfish.

Scientific name	Common name	Number
Holothuriidae		
Actinopyga echinites	Deepwater redfish	1,037
Actinopyga lecanora	Stonefish	10
Actinopyga mauritiana	Surf redfish	57
Actinopyga miliaris	Black fish	30
Bohadschia argus	Tigerfish / Leopard fish	146
Bohadschia similis	Chalkfish	98
Bohadschia vitiensis	Brown sandfish	48
Holothuria atra	Lollyfish	3,176
Holothuria coluber	Snakefish	88
Holothuria edulis	Pinkfish	229
Holothuria fuscogilva	White teatfish	63
Holothuria fuscopunctata	Elephant trunkfish	13
Holothuria hilla	Tigertail	18
Holothuria nobilis	Black teatfish	35
Holothuria scabra	Sandfish	538
Holothuria versicolor	Black sandfish	3
Pearsonothuria graeffei	Flowerfish	232
Stichopodidae		
Stichopus hermanni	Curryfish	16
Stichopus horrens	Dragonfish	11
Thelenota ananas	Prickly redfish	60
Thelenota anax	Amberfish	37
Thelenota rubralineata	Candy-cane	2
Grand Total		**5,947**

↑ *Table 4: Breakdown of the number of sea cucumbers measured by species during the survey.*

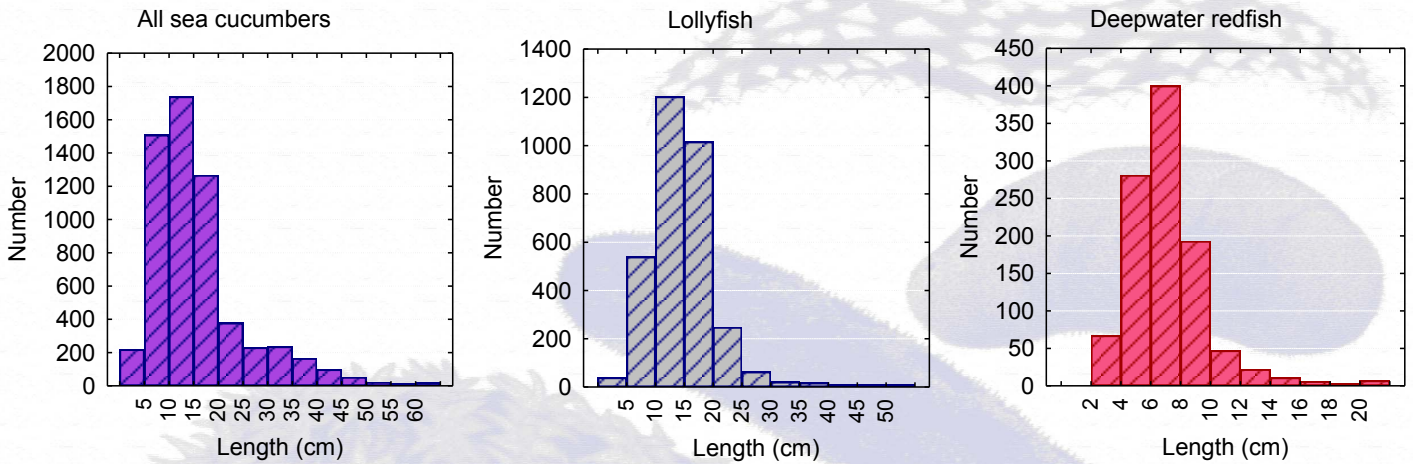


➔ *Figure 14: Size range and average size of each species of sea cucumber measured across the survey. Size measurement used was length in centimetres.*

Overall, the most common sizes for sea cucumbers were between 5 and 20 cm, a pattern that appears to be mostly driven by the large number of lollyfish and deepwater redfish in that range. Most lollyfish were between 10 and 15 cm long, while the most common size for deepwater redfish was between 6 and 8 cm length (Figure 15).

The sandfish recorded in this survey were very small for the species. The average size of sandfish overall was 13 cm, with most between 10 and 14 cm. In 1992 Lokani (1996a) recorded sandfish sizes at an average of 17 cm for survey data and 28 cm for fishery data.

Flowerfish, pinkfish and amberfish were generally much larger species. Most of the flowerfish measured were between 35 and 40 cm length and averaged 34 cm. Pinkfish were an average of 27 cm long, but with large numbers between 20-25 and 30-35 cm. Although only few amberfish were found and measured during the survey they had the largest average size at 53 cm.



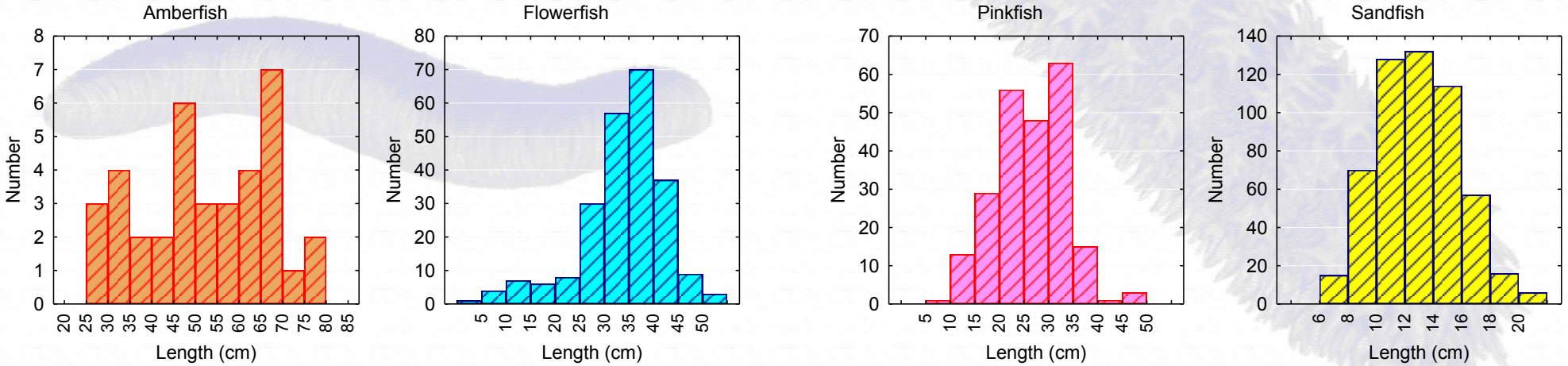


Figure 15: Size distribution of selected species of sea cucumbers measured across the survey. Size measurement used was length in centimetres.

Geographic variation in sizes

All of the species of sea cucumbers surveyed during the study showed large variations in their sizes in different parts of the province. In addition to the overall size distributions for selected species shown in the previous section and Figures 14 and 15, we plotted average sizes on the GIS maps of the survey area to examine size differences among sites.

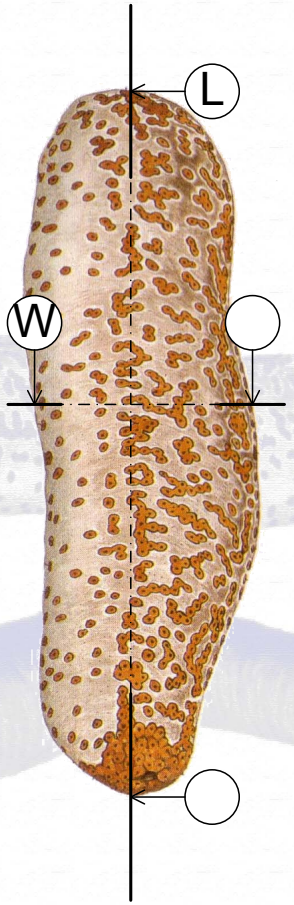
The overall average size of lollyfish was 15.3 cm length, but the average size at a site ranged between 12.9 and 28.7 cm. That is, at some sites, the lollyfish tended to be small, and at others larger (Figure 16). The largest lollyfish were recorded from Meteselan, Kafkaf, Kaselok, Umbukul and Tsoi, and the smallest average sizes found at least one site in Enang, Kulangit and Tatau. Interestingly, three sites with the greatest densities of lollyfish, Tatau, Kulangit and Ungalik also had among the smallest average sizes. Some of the largest lollyfish are found in areas with the lowest average densities.

Most of the deepwater redfish recorded during this survey were small, with an overall average size of 7.7 cm length and a range of 7-26 cm. The largest deepwater redfish were found at Bagail, Kafkaf and Kaselok (Figure 17). In the area of greatest density of these sea cucumbers, the sizes tended to be small, as was found for lollyfish.

Flowerfish had an average length of 34 cm and a range between 21 and 45 cm in length. The largest flowerfish were recorded from Leon, Umbukul, and the control site at Simberi (Figure 18). Very small flowerfish (21-25 cm long) were found at 3 sites at Maiom, Kaselok and Enang. At most other sites, the size of this species of sea cucumbers did not vary very much.

The size of pinkfish ranged between 22 and 40 cm in length, with an overall average of 27 cm. This species only occurred at the sites north and west of Lamusmus, and tended to be largest on the south coast of New Hanover (Lovongai LLG) (Figure 19). Similar to the pattern seen in other species, the pinkfish found in the places with the greatest abundance, tended to be small such as at Leon, Lamusmus, Bagatare-Lokono and Meteselan. This pattern was much weaker in pinkfish for which sites with both low numbers and very small sizes were also found (e.g. Ungalik and Lovongai).

The average size of sandfish at sites ranged between 8 and 17 cm, small for the species (see previous section). The smallest average size at a site was at the control site in Simberi at an average of 8 cm length (Figure 20). Small sandfish were also recorded from Bagail and Lovongai. The largest average sizes were found in Tsoi and Bagatare-Lokono.



Measuring length and width of sea cucumbers

LOLLYFISH SIZES

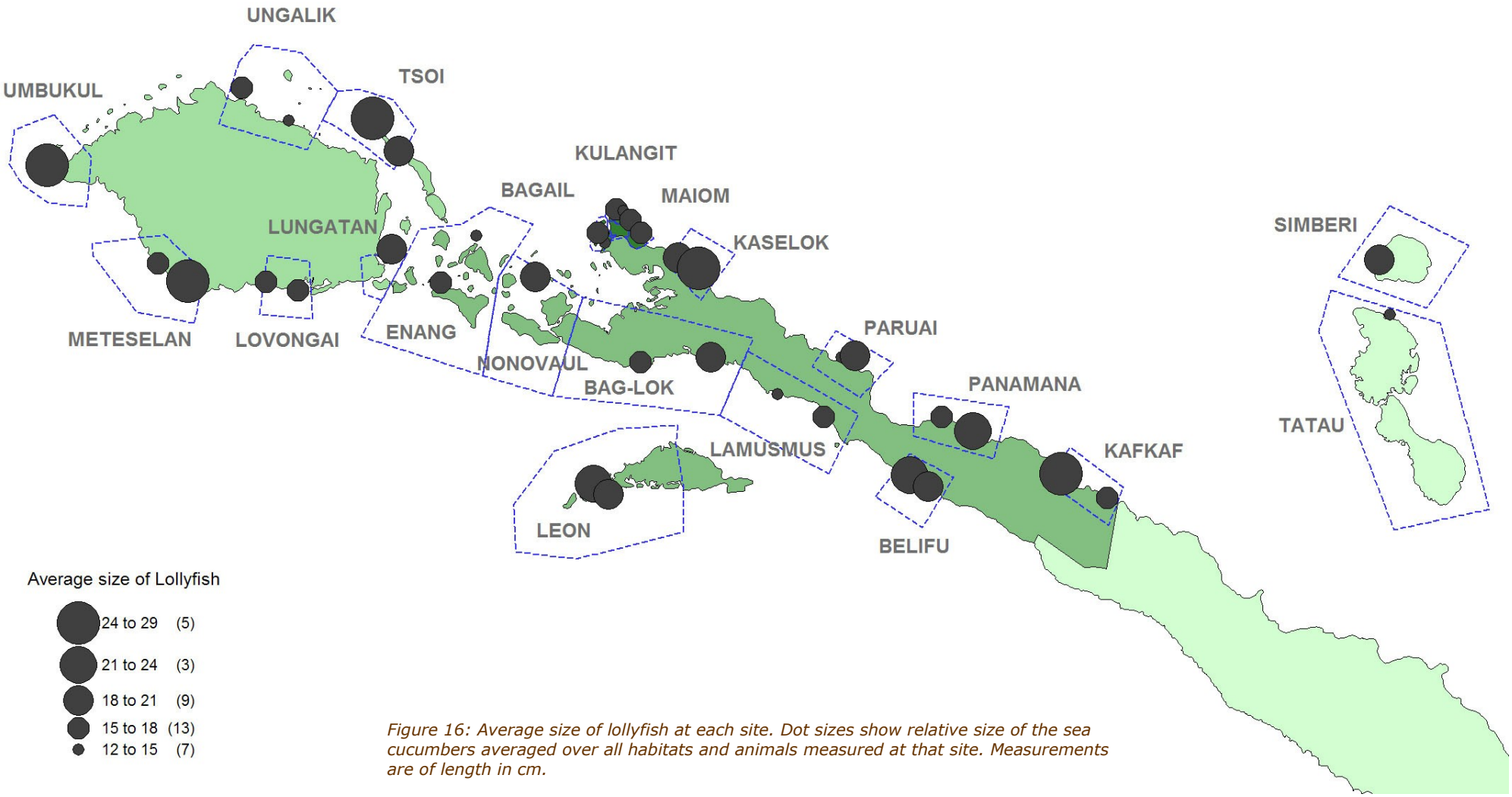


Figure 16: Average size of lollyfish at each site. Dot sizes show relative size of the sea cucumbers averaged over all habitats and animals measured at that site. Measurements are of length in cm.

DEEPWATER REDFISH SIZES

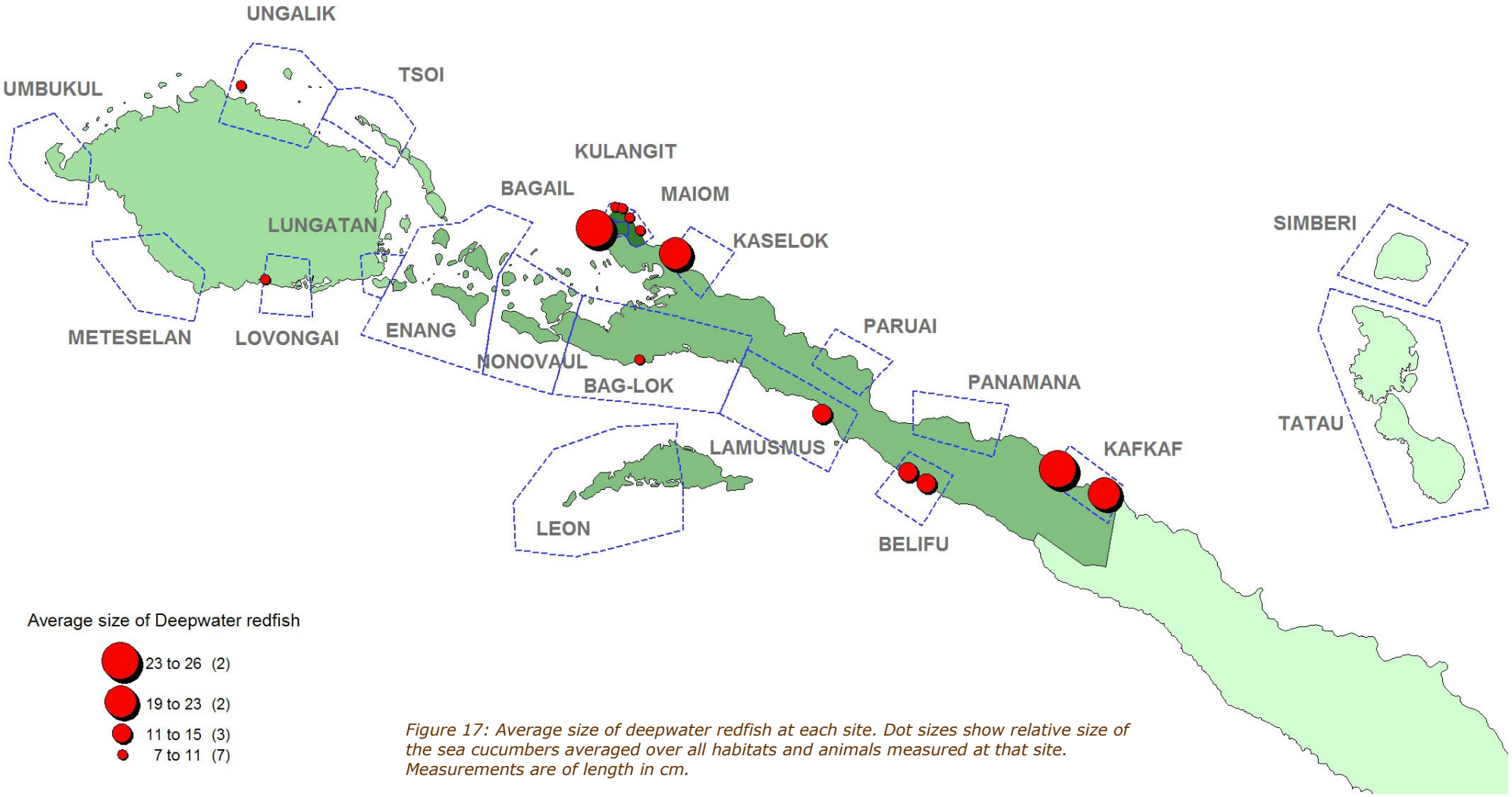


Figure 17: Average size of deepwater redfish at each site. Dot sizes show relative size of the sea cucumbers averaged over all habitats and animals measured at that site. Measurements are of length in cm.

FLOWERFISH SIZES

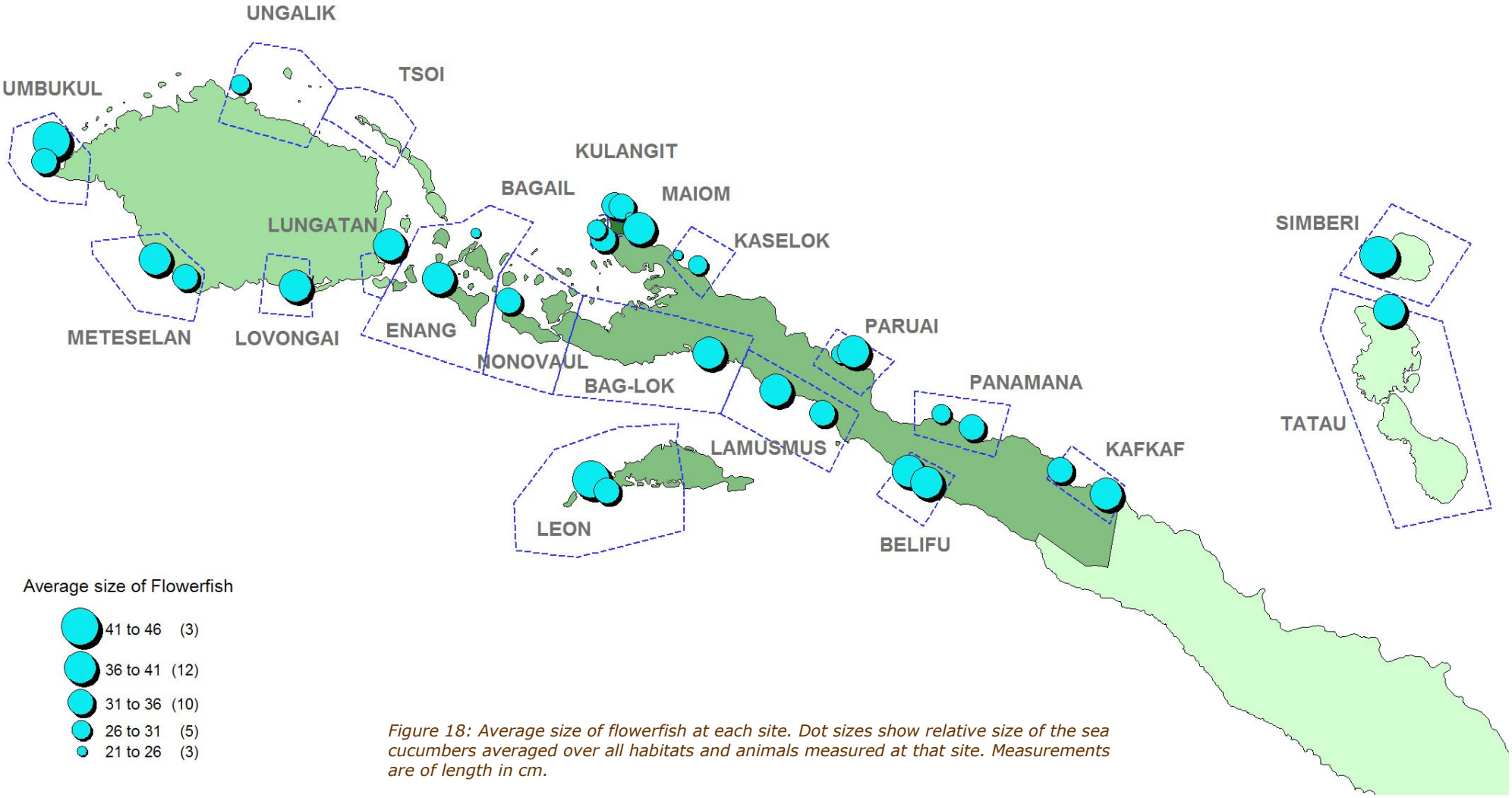


Figure 18: Average size of flowerfish at each site. Dot sizes show relative size of the sea cucumbers averaged over all habitats and animals measured at that site. Measurements are of length in cm.

PINKFISH SIZES

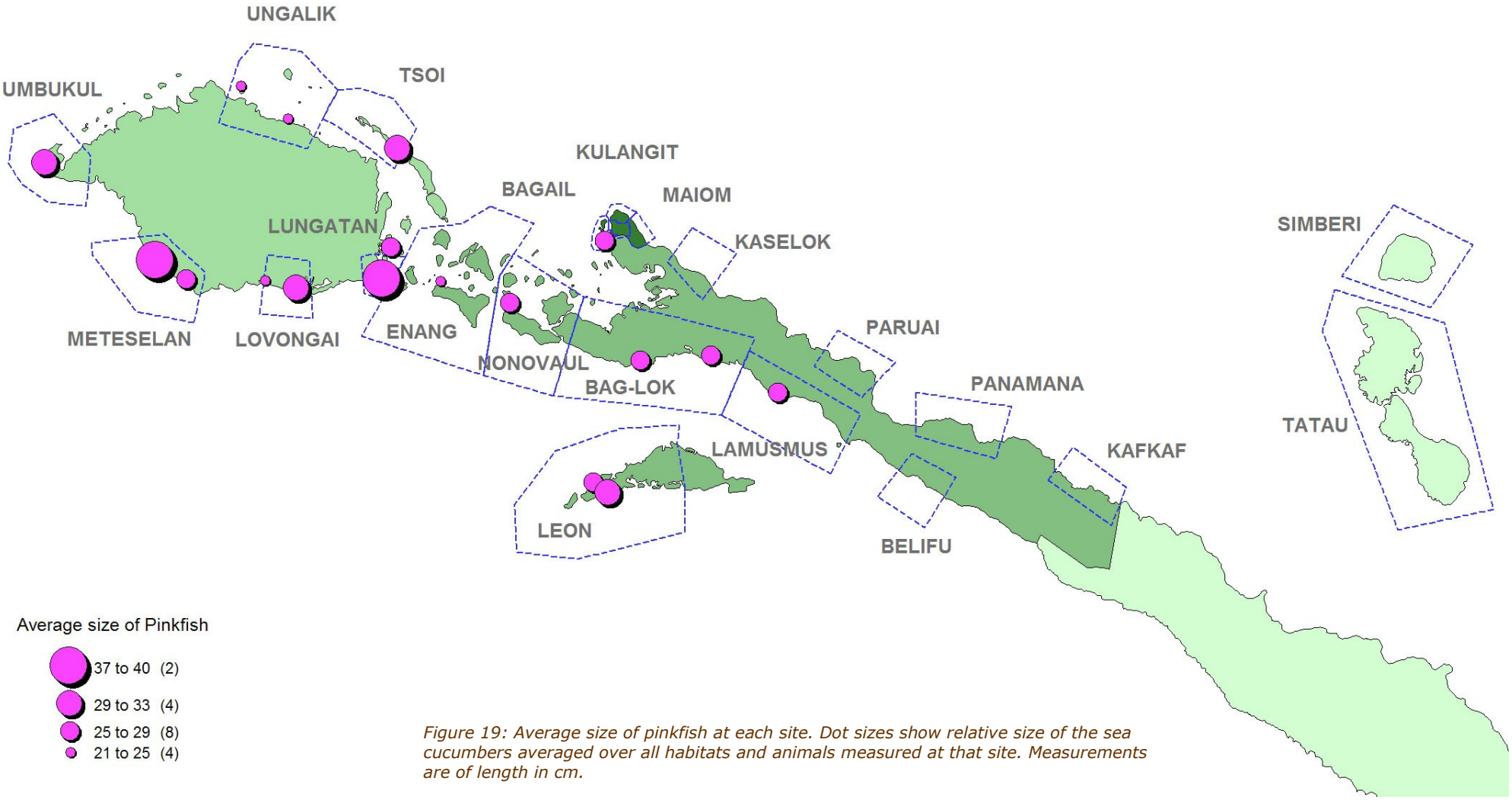


Figure 19: Average size of pinkfish at each site. Dot sizes show relative size of the sea cucumbers averaged over all habitats and animals measured at that site. Measurements are of length in cm.

SANDFISH SIZES

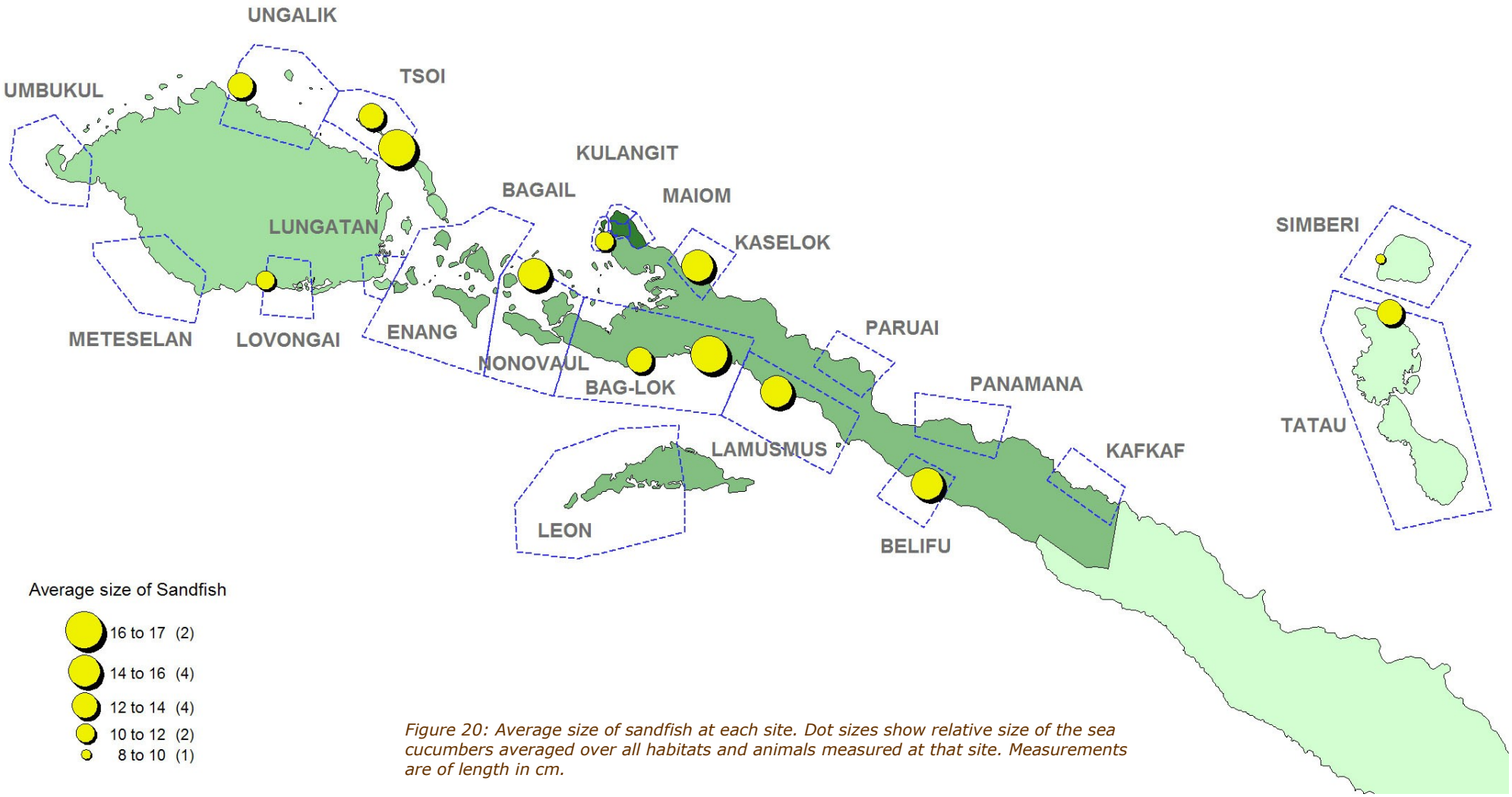


Figure 20: Average size of sandfish at each site. Dot sizes show relative size of the sea cucumbers averaged over all habitats and animals measured at that site. Measurements are of length in cm.

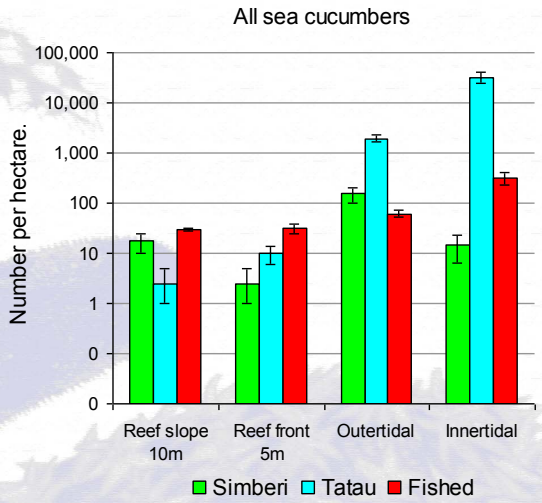
Fished versus managed (tambu) areas

Two of the sites included in this survey were located outside of the main geographic area which has been the focus of the CFMDP. Kavieng, Tikana and Lovongai LLGs were the focus of project activities because of their proximity to Kavieng and significant economic ties there.

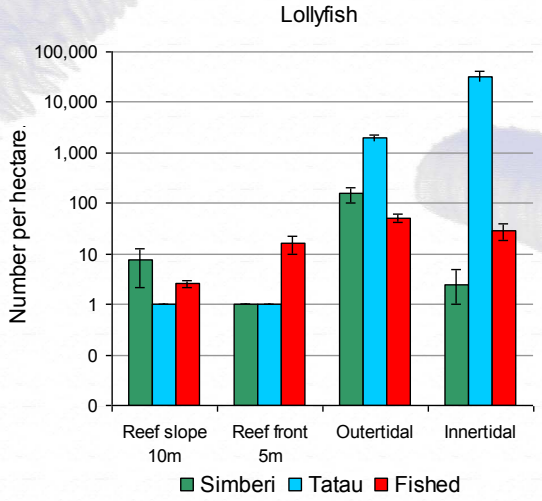
A single site each in Simberi and Tatau wards, at Maraquen and Sos, were included as 'control' or managed sites where 'tambu' (traditional prohibitions on fishing) were reported to be in place. These sites, located in Central Niu Ailan LLG, were included so that we could test the effects of traditional management on the local sea cucumber stocks, compared with the open fishing occurring throughout the rest of the area surveyed. No areas consistently closed to sea cucumber fishing were found within Kavieng, Tikana and Lovongai LLGs. Sites recently closed to fishing by communities under the CFMDP's community-based fisheries management (CBM) programme were considered too new for the needs of this survey.

Maraquen, Simberi Ward

According to the Wildlife Conservation Society (WCS) field report the area being managed at



↑↓ *Figure 21: Average densities of sea cucumbers at each site. Data are mean numbers per hectare +/-SE.*



Maraquen includes a low-lying island and a sandbank, including about 900 m of shore length. The reefs surrounding these areas have been closed to any fishing activity and access. The closure dates from 2002 and is said to be permanent. Its purpose is to preserve the marine environment, especially turtle breeding grounds. In the past, pressure on trochus shells, sea cucumbers, lobsters and giant clams was 'extensive'.

Sos, Tatau Ward

The site at Sos includes about 3 km of fringing reef and is considered 'permanently closed but with exceptions'. WCS has determined that the area was closed to fishing to enforce family tenure and to restock resources such as trochus and sea cucumbers. Both of these resources were fished heavily in the past. The owners of the area have reported that poaching is occurring in the area, particularly at night. They also say that they do allow fishing for special occasions, restricting these to less than 10 times per year. It is not clear how long the area has been under tambu.

Effects of tambu on sea cucumbers

The tambu areas at Simberi and Tatau are at present showing little overall benefit for promoting sea cucumber abundances. In subtidal areas, densities of sea cucumbers were higher, on average, in the fished sites (all other sites surveyed) than in the tambu sites (Figures 21 and 22). The only exception is a greater per hectare density of tigerfish at Simberi than the average

for fished areas, but the effect is not also found at the Tatau control.

In tidal areas there are generally significantly more sea cucumbers per hectare than at fished sites, except at the innertidal of Simberi which has a lower density than fished areas (Figure 21). The result for 'all sea cucumbers' is mostly driven by the large number of lollyfish recorded during the survey, particularly in tidal areas at Tatau, but also in the outertidal / reef crest area at Simberi. For most other species found in tidal areas, densities were greater at fished sites. The apparently greater numbers of Blackfish recorded in the outertidal at Tatau compared with fished areas was not a statistically significant one.

It is generally expected that protecting sites under the right conditions will lead to recovery of marine resources. The reasons that these tambu sites have not resulted in improved sea cucumber numbers are not clear. Some of the possible factors could include:

- Tambus have not been running long enough
- Poaching is occurring
- The occasional fishing that is allowed is enough to remove some species faster than they can recover
- There has not yet been a large number of young sea cucumbers come into the area to replenish stocks. This could especially be part of the problem if numbers are low everywhere (as this study suggests) and breeding or recruitment has been affected (low densities can lead to low fertilisation of eggs)
- There are pre-existing differences between the sites not related to fishing.

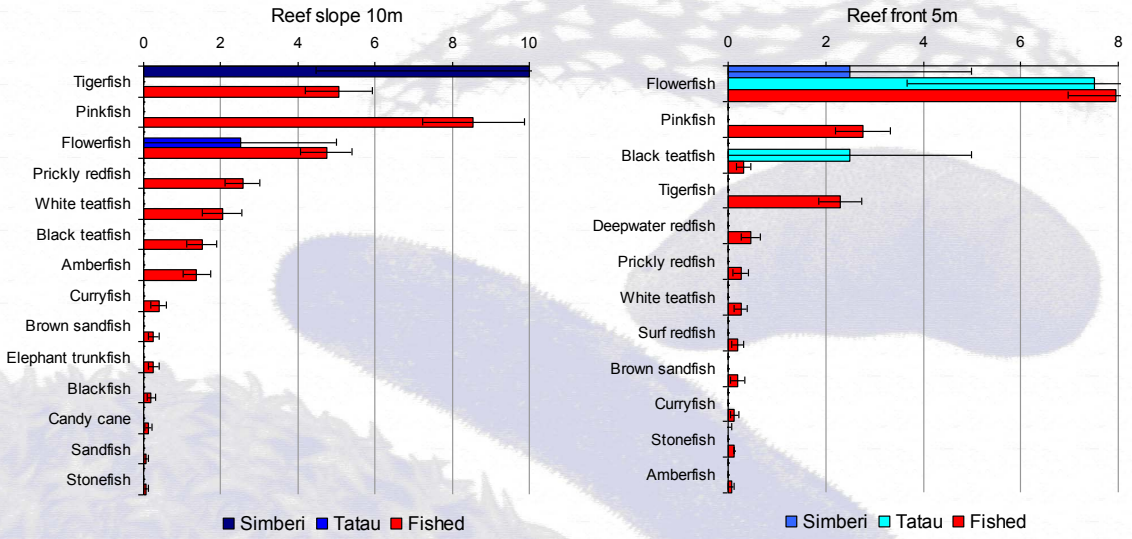
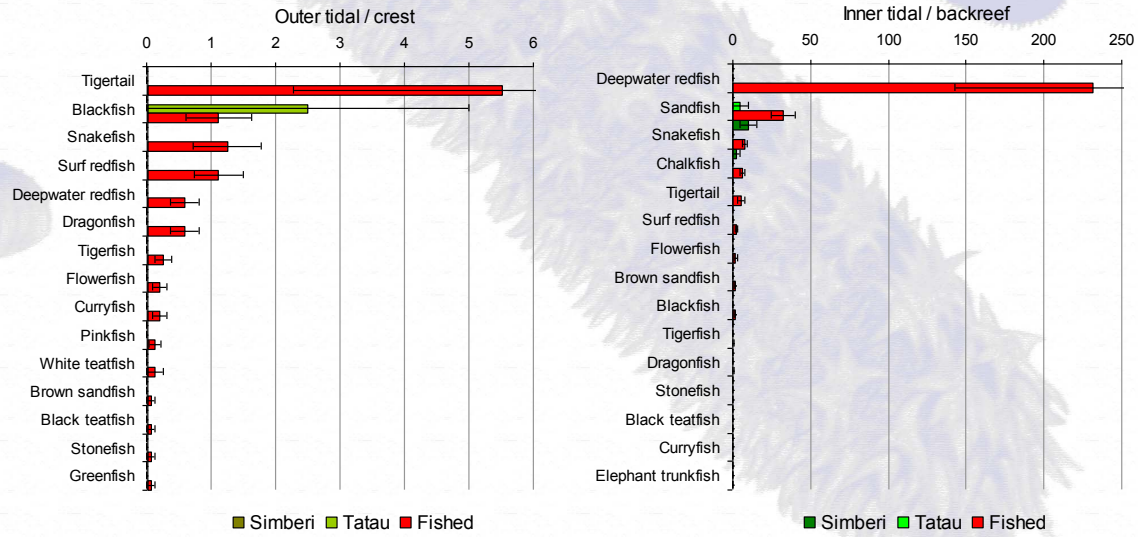


Figure 22: Average density of sea cucumbers at the 2 controls compared with the average of all fished sites in 4 habitats. Values are number per hectare +/-SE.



Current stocks and past surveys

The situation in 2006

The counts of sea cucumbers we obtained in transects were used to calculate density per hectare for each species in each surveyed habitat (Table 5). Using the geographic information system (GIS) maps of New Ireland, onto which we projected a composite satellite photo, we estimated the area of each habitat type present in 3 LLGs (excluding Central Niu Ailan because we only surveyed it partially). This was done to estimate the total stock size of sea cucumbers potentially available in the northern part of the province (Figure 23).

The total area of tidal habitats was calculated at 212.8 km² and of lagoons 220.7 km². The total length of intertidal-subtidal border was estimated at 1,117 km. Using the definition that inner and outertidal areas were each defined as half of the available area, and that the Reef slope and Reef front habitats were an average of 35m and 15m wide, respectively, we calculated total areas of each surveyed habitat as follows:

- Reef slope 3,910 ha
- Reef front 1,676 ha
- Outertidal 10,640 ha
- Innertidal 10,640 ha
- Lagoons 22,070 ha.

Using these areas and estimates of sea cucumber density (excluding control sites), we estimate a total stock of around 4.5 million sea cucumbers in northern New Ireland province by late 2006 (Table 6). This estimate includes Kavieng, Tikana and Lovongai LLGs, but excludes Central Niu Ailan.

	Reef slope		Reef front		Outertidal		Innertidal		Lagoon		Overall	
Deepwater redfish			0.5	*0.4*	0.6	*0.6*	231.5	*220.5*			55.7	*53.1*
Lollyfish	2.6	*2.6*	16.3	*15.4*	50.4	*100.1*	29.6	*804.5*	4.0	*4.0*	23.1	*220.4*
Sandfish	0.1	*0.1*					32.3	*30.9*			7.8	*7.4*
Flowerfish	4.7	*4.6*	8.0	*7.8*	0.2	*0.2*	1.7	*1.6*	0.2	*0.2*	3.4	*3.3*
Pinkfish	8.6	*8.1*	2.8	*2.6*	0.1	*0.1*			6.7	*6.7*	3.1	*3.0*
Tigertail					5.5	*5.3*	5.4	*5.1*			2.5	*2.4*
Snakefish					1.3	*1.2*	7.7	*7.6*	1.0	*1.0*	2.2	*2.2*
Tigerfish	5.1	*5.1*	2.3	*2.2*	0.3	*0.3*	0.3	*0.3*	1.0	*1.0*	1.9	*1.9*
Chalkfish							6.2	*6.0*			1.5	*1.4*
Surf redfish			0.2	*0.2*	1.1	*1.1*	2.4	*2.3*	0.2	*0.2*	0.9	*0.9*
Prickly redfish	2.6	*2.4*	0.3	*0.3*							0.6	*0.6*
Blackfish	0.2	*0.2*			1.1	*1.1*	1.2	*1.1*			0.6	*0.6*
White teatfish	2.0	*1.9*	0.3	*0.3*	0.1	*0.1*			0.4	*0.4*	0.6	*0.6*
Brown sandfish	0.3	*0.3*	0.2	*0.2*	0.1	*0.1*	1.3	*1.3*	1.2	*1.2*	0.5	*0.5*
Black teatfish	1.5	*1.4*	0.3	*0.4*	0.1	*0.1*	0.1	*0.1*			0.5	*0.5*
Amberfish	1.4	*1.3*	0.1	*0.1*							0.3	*0.3*
Curryfish	0.4	*0.4*	0.1	*0.1*	0.2	*0.2*	0.1	*0.1*			0.2	*0.2*
Dragonfish					0.6	*0.6*	0.3	*0.2*			0.2	*0.2*
Stonefish	0.1	*0.1*	0.1	*0.1*	0.1	*0.1*	0.3	*0.2*	0.2	*0.2*	0.1	*0.1*
Elephant trunkfish	0.3	*0.3*	0				0.1	*0.1*			0.1	*0.1*
Candy cane	0.1	*0.1*	0								0.03	*0.03*
Pannings blackfish									0.2	*0.2*	0.01	*0.01*
Greenfish					0.1	*0.1*					0.01	*0.01*
All sea cucmbers	**30**	***29***	**31**	***30***	**62**	***111***	**320**	***1082***	**15**	***15***	**106**	***300***

← *Table 5: Summary of the number of sea cucumbers recorded for each species and in each main habitat type surveyed. Values are average number per hectare. Figures in italics in the right-hand column of each habitat type are values calculated including the 2 control sites from Central Niu Ailan LLG.*

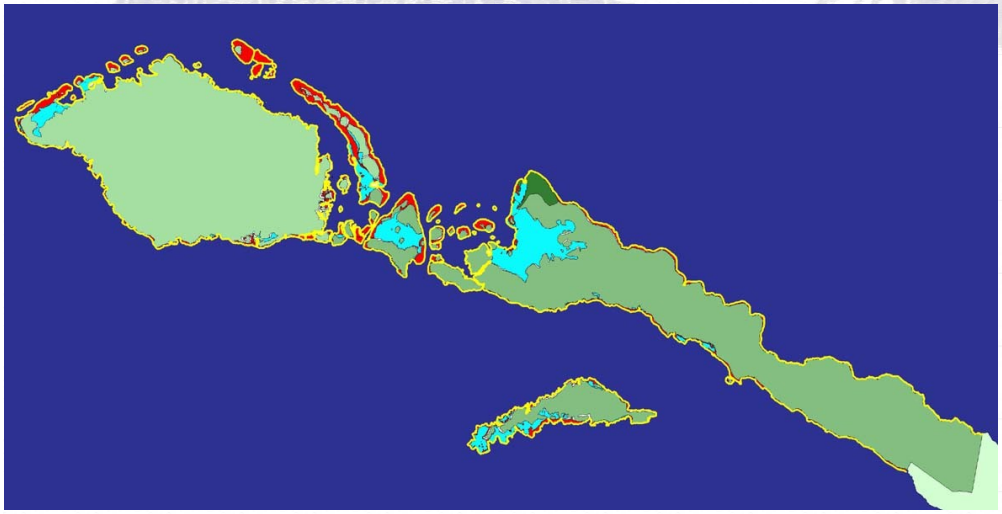
↓ *Table 6: Estimated total number of sea cucumbers of each species and in each habitat type in the study area during this survey. Species are ranked in order of abundance.*

	Reef slope	Reef front	Outertidal	Innertidal	Lagoon	Total
Deepwater redfish	0	772	6,300	2,463,160	0	2,470,232
Lollyfish	10,031	27,227	536,200	314,545	89,129	977,132
Sandfish	257	0	0	343,805	0	344,062
Flowerfish	18,519	13,338	2,100	17,955	4,244	56,156
Pinkfish	33,437	4,630	1,400	0	148,548	188,014
Tigertail	0	0	58,800	57,190	0	115,990
Snakefish	0	0	13,300	81,795	21,221	116,316
Tigerfish	19,805	3,858	2,800	3,325	21,221	51,009
Chalkfish	0	0	0	65,835	0	65,835
Surf redfish	0	331	11,900	25,935	4,244	42,410
Prickly redfish	10,031	441	0	0	0	10,472
Blackfish	772	0	11,900	12,635	0	25,307
White teatfish	7,973	441	1,400	0	8,488	18,303
Brown sandfish	1,029	331	700	13,965	25,465	41,490
Black teatfish	5,916	551	700	1,330	0	8,497
Amberfish	5,401	110	0	0	0	5,512
Curryfish	1,543	220	2,100	1,330	0	5,194
Dragonfish	0	0	6,300	2,660	0	8,960
Stonefish	257	220	700	2,660	4,244	8,082
Elephant trunkfish	1,029	0	0	665	0	1,694
Candy cane	514	0	0	0	0	514
Pannings blackfish	0	0	0	0	4,244	4,244
Greenfish	0	0	700	0	0	700
All sea cucumbers	**116,513**	**52,470**	**657,300**	**3,408,790**	**331,050**	**4,566,123**

Composition of the estimated stock

In terms of overall abundance or stock size the most common species was the deepwater redfish, which accounted for around 54% of the estimated total number of sea cucumbers. This result contrasts with the estimates of density in previous sections because it takes into account the total amount of each habitat available. lollyfish, with little commercial value but increasing importance in the fishery, was the second most abundant species in terms of total numbers and accounted for another 21% all sea cucumbers. Note that these values exclude the large numbers of lollyfish found at Tatau in Central Niu Ailan LLG (Tatau is outside of the region (Figure 21) for which the total area of habitat was evaluated). In Central Niu Ailan data were collected only as controls for the purpose of providing information on managed areas.

The remaining species together account for 25% of the stock, with sandfish and pinkfish the next most abundant contributing 7.5% and 4.1% of the stock each. Most of the sea cucumber stock in this study was found in tidal habitats.



↑ Figure 23: Estimates of the area of each habitat type were made for Kavieng, Tikana and Lovongai LLGs from a satellite image projected onto a GIS. Red areas are intertidal, light blue are lagoons and yellow lines show length of shoreline. Note the small scale of this extract from the GIS map means that narrow areas of intertidal habitat and small lagoons are not clearly visible in this graphic.

Changes since 1992

The numbers of sea cucumbers recorded in this survey were significantly lower than the estimates given by Lokani in his 1992 survey (Figure 24 and Tables 7 and 8) (Lokani 1996a).

Using our estimates of the total area of the 3 main habitats he surveyed, the total stock size at that time would have been approximately 35 million sea cucumbers, significantly higher than reported here (Table 7). That is, the sea cucumber stock in 1992 may have been as much as 7 times higher than the values we obtained in 2006. It would also have contained a much greater proportion of commercially valuable species, with larger stocks of sandfish, chalkfish, and dragonfish, and a range of other valuable species. The calculations from the 1992 data should be read with caution because they are based on values collected from a relatively small area of the province (the Tigak Islands) and may not apply to the full geographic range covered in this survey.

↓ Table 7: Estimated total number of sea cucumbers of each species and in each habitat type reported in 1992 by Lokani (1996a).

	Subtidal	Tidal	Lagoon	Total
Lollyfish	115,330	12,428,158	386,225	12,929,714
Deepwater redfish	0	532,000	0	532,000
Sandfish	0	2,596,586	0	2,596,586
Flowerfish	24,239	0	0	24,239
Tigerfish	30,327	0	55,175	85,502
Chalkfish	0	8,753,741	0	8,753,741
Surf redfish	66,741	0	0	66,741
Prickly redfish	12,678	0	183,843	196,521
Blackfish	18,207	319,200	18,318	355,725
White teatfish	0	0	514,893	514,893
Brown Sandfish	0	2,884,930	0	2,884,930
Black teatfish	30,327	66,394	91,811	188,531
Amberfish	6,032	0	18,318	24,350
Curryfish	6,032	665,000	18,318	689,350
Dragonfish	0	4,588,606	0	4,588,606
Stonefish	18,207	0	0	18,207
Elephant trunkfish	0	0	92,032	92,032
Greenfish	139,625	0	55,175	194,800
Total				**34,736,467**

Changes in density (number per hectare)

Of 18 species recorded in both surveys, 16 showed significant reductions between 1992 and 2006 in at least one of Lokani's main habitat types, i.e. in subtidal, tidal or lagoon areas. The changes in abundance since 1992 tended to be large. The species that declined the least did so in subtidal areas: lollyfish, tigerfish, Prickly redfish and amberfish showed reductions in abundance by 2006 to between 46 -67% of 1992 levels. Most species showed much greater reductions, with 2006 densities declining to between 0% and 38% of 1992 levels.

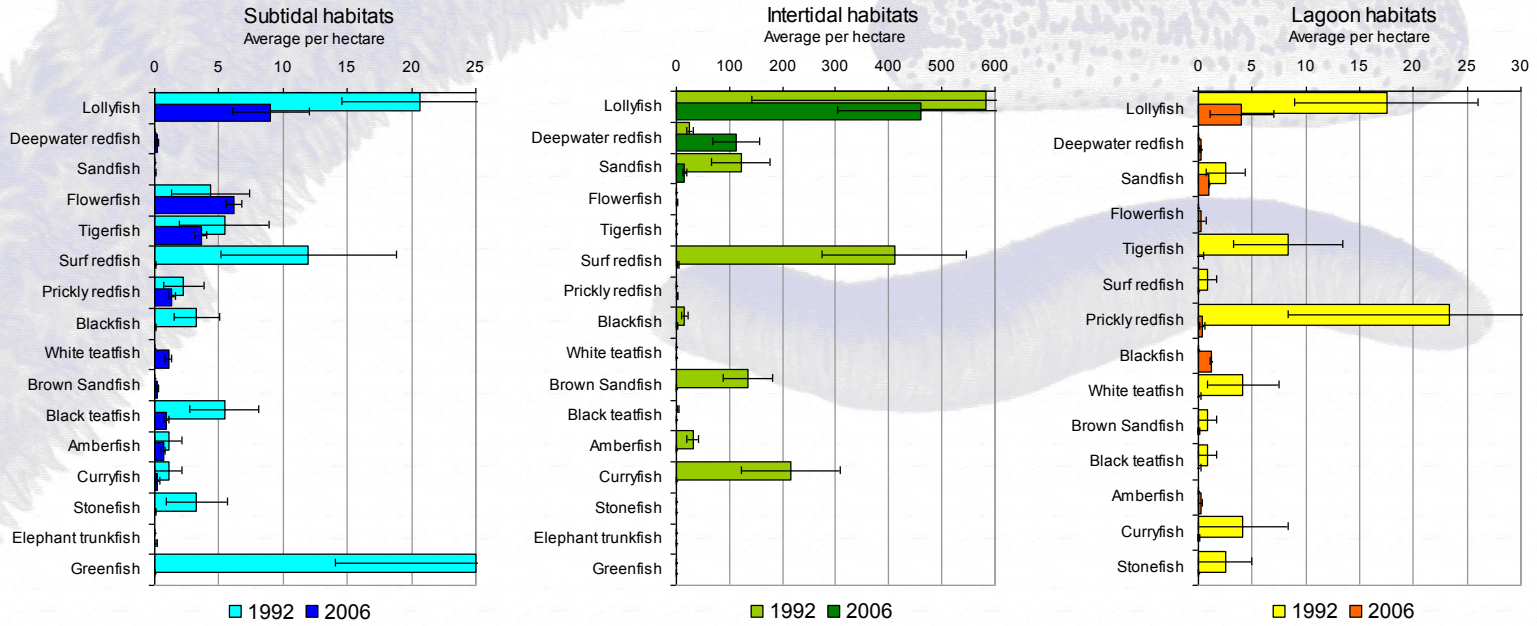
Two species, deepwater redfish and flowerfish, showed an increase in density of 476% and 146%, respectively, over the same time period. There were also species that, in some habitats, were recorded in this survey but not the 1992 survey (Table 8). These new appearances are all of very low densities, all less than 1.7 sea cucumbers per hectare, and most less than 1 per hectare. Their 'appearance' may be related to Lokani's study being limited to the Tigak Islands, while this one included New Hanover (Lovongai LLG), Djaul Island and the rest of Tikana LLG.

➔ *Table 8: summary of number of sea cucumbers per hectare recorded in this survey against the values recorded in 1992 by Lokani (1996a). Values are percent increase or remaining. * indicates species not reported in 1992.*

	Subtidal	Tidal	Lagoon
Lollyfish	46	7	23
Deepwater redfish	*	476	
Sandfish	*	14	
Flowerfish	146	*	*
Tigerfish	68	*	38
Chalkfish		1	
Surf redfish	0.8	*	*
Prickly redfish	62		0
Blackfish	3	8	0
White teatfish	*	*	2
Brown Sandfish	*	0.5	*
Black teatfish	17	3	0
Amberfish	67		0
Curryfish	24	0.5	0
Dragonfish		0.2	
Stonefish	3	*	*
Elephant trunkfish	*	*	0
Greenfish	0	*	0

% increase since 1992
% remaining since 1992
* New appearance in 2006 survey
Not present in habitat

➔ *Figure 24: Comparison of number of sea cucumbers per hectare recorded by in 1992 by Lokani (1996a) and in this survey. Values are average numbers per hectare +/-SE (standard errors).*



CONCLUSIONS

More than a decade ago, Lokani (1996b) concluded that sea cucumber stocks in New Ireland were overfished and had shown a shift in the species being collected from more valuable to less valuable. He also concluded that levels of production at that time were low because of heavy fishing since 1988. Lokani identified a need to allow stocks to recover and to limit the number of buyers, exporters and total allowable catch.

Sandfish was the sole target species until April 1989. After that time, the fishery expanded to include other sea cucumbers, so that by 1992 sandfish had dropped to 13% of the catch. Over the same period, however, the sizes of sandfish (and therefore their grade and value) declined.

In 1996 a sea cucumber management plan was put in place by NFA and the total allowable catch for the province set at 80 tonnes per year. In 1999 the fishery was closed for one year (Opnai 2007). Since that time, the stocks of sea cucumbers have continued to decline.

By 2006 many of the species recorded by Lokani (1996a) had fallen even further in abundance. This suggests that levels of fishing are unarguably too high and that the stock has fallen to critically low levels. To allow stocks to recover and increase levels of production to make the sea cucumber fishery in New Ireland sustainable will require significant changes in the way that the fishery is managed and used.

Scientific name	Common name	Lokani 1992	This study 2006	Preston 1993
Holothuriidae				
Actinopyga echinites	Deepwater redfish	25	119	847-1,800
Actinopyga lecanora	Stonefish	3	0.19	
Actinopyga mauritiana	Surf redfish	12	1.79	
Actinopyga miliaris	Black fish	15	1.15	512
Actinopyga palauensis	Pannings blackfish		0.19	
Bohadschia argus	Tigerfish / Leopard fish	5	3.68	
Bohadschia similis	Chalkfish	411	3.17	
Bohadschia vitiensis	Brown sandfish	136	1.15	
Holothuria atra	Lollyfish	584	40	545
Holothuria coluber	Snakefish		4.55	
Holothuria edulis	Pinkfish		6.73	
Holothuria fuscogilva	White teatfish	23	1.15	11-18
Holothuria fuscopunctata	Elephant trunkfish	4	0.13	22
Holothuria hilla	Tigertail		5.45	
Holothuria nobilis	Black teatfish	5	0.92	13-19
Holothuria scabra	Sandfish	122	17	683-2,900
Holothuria versicolor	Black sandfish			82
Pearsonothuria graeffei	Flowerfish	4	6.35	
Stichopodidae				
Stichopus hermanni	Curryfish	31	0.26	
Stichopus horrens	Dragonfish	216	0.42	
Stichopus chloronotus	Greenfish	25	0.03	
Thelenota ananas	Prickly redfish	8	1.41	17-18
Thelenota anax	Amberfish	1	0.72	41
Thelenota rubralineata	Candy-cane		0.07	

← Table 9: Comparison of average densities of sea cucumbers recorded in 1992 (Lokani 1996a), during this study in 2006 and elsewhere around the Pacific between 1981 and 1991 (Preston 1993). Values are average numbers per hectare. For the New Ireland studies, values for the habitat with greatest density for a species is given.

Subtidal
Intertidal
Lagoon

The results of this survey suggest that the fishery should be closed for several years to allow stocks to recover. After 2-3 years another survey similar to this, but which places additional effort into the lagoon areas of the Tigak Islands, should be undertaken to measure any improvements in the abundance of sea cucumber species. It is not known what the unfished stock size of sea cucumber species might have been in New Ireland Province prior to the start of the sea cucumber fishery. As a result, it is not clear what densities should be used as a management benchmark to ensure that a target of 50% of the original biomass is maintained in the fishery. Preston (1993) reviewed the Pacific sea cucumber fisheries and reported much higher average per hectare densities for all sea cucumber species. The values shown for New Ireland and elsewhere in Table 9 suggest that returning densities to at least 1992 levels might be a good place to start.

REFERENCES

Lokani, P. 2001. Survey of beche-de-mer resource in Manus. Final Report to National Fisheries Authority.

Lokani, P. 1996a. Fishery dynamics and biology of Beche -de-mer in the Tigak Islands, Papua New Guinea. Technical Report, Research, Surveys and Assessment Branch, National Fisheries Authority, 24pp.

Lokani, P. 1996b. Management of the New Ireland Beche -de-mer fishery. Technical Report 96-09, Research, Surveys and Assessment Branch, National Fisheries Authority, 8pp.

Opnai, J. 2007. The Marine Resources of New Ireland Province, Papua New Guinea. National Fisheries Authority and Coastal Fisheries Management and Development Project.

Preston, G.L. 1993. Chapter 11: Beche-de-mer. In Wright, A & Hill, L. (eds). Nearshore marine resources of the South Pacific. IPS / FFA / ICOD, 710pp.

Sea cucumber survey

New Ireland Province

NATIONAL FISHERIES AUTHORITY

PNG NATIONAL FISHERIES AUTHORITY
COASTAL FISHERIES
Management and Development Project
ASIAN DEVELOPMENT BANK

GPA

Tautai