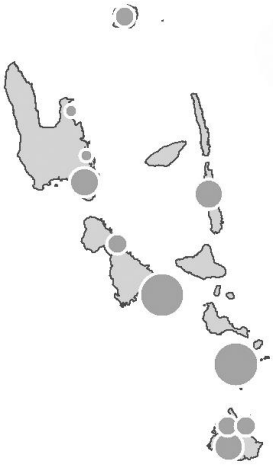
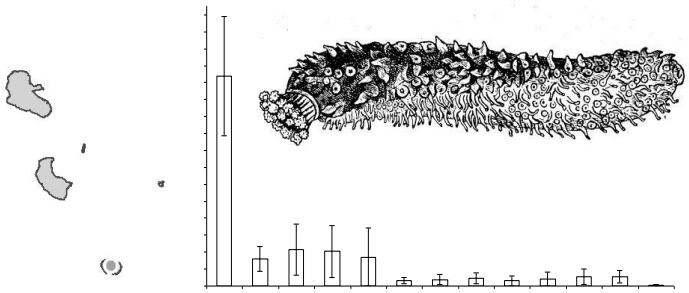


BICHLAMAR PROJECT

2013-2014

Sea Cucumber Stock Assessment in Vanuatu



Final Report

May 2015

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Last but not the least we gratefully acknowledge people who have shared ideas and information in regards to sea cucumber fisheries resources in Vanuatu during this project.

1. INTRODUCTION

Sea cucumbers use to be one of the most important commercial inshore fisheries in Vanuatu. Traditionally, sea cucumbers, commonly known in Vanuatu as 'beche-de-mer', are not consumed locally; the resource is harvested and exported to overseas market particularly to the Asian countries where it is a food delicacy.

Sea cucumber belongs to a group of Echinoderms called Holothurians. They are sluggish, tube-shaped, bottom dwelling animals that are found inshore from 0-50 m depth. Sea cucumber sexual strategies include sexual, asexual, and hermaphroditic strategies. Their spawning season is usually around warmer months and for only few species on cooler months. Mature adult are around 2 – 3 years old depending on species. In Vanuatu, sea cucumbers are wildly distributed to almost every island. They use to be important commercial fishery resources, however the stocks have been depleted over the past years due to high fishing pressure.

Harvest and export of sea cucumbers (or beche-de-mer) is believed to have started in the early 19th century. In 2005[1], the fishery contributed to an estimated value of about 1-2 million vatu to the rural economy. Department of Fisheries records showed that at the national level, beche-de-mer exports brought in about 13 million VT per year for six years between 1999 and 2005. Sea cucumber was therefore a valuable wealth and a priority income source for the rural coastal people in different islands across Vanuatu.

Sea cucumber fishery "boomed" in the 1990s when exports peaked at around 70 metric tons. The boom period however indicated that the pressure from the industry to exploit the resources was beyond the control of communities although many of them and resource custodians implemented locally-based management measures with the support of the Department of Fisheries. This resulted in the depletion of the resources in most islands in Vanuatu. Since the 1990s production peak beche-de-mer exports continued to decline until 2007 when the situation prompted the government to declare a moratorium.

In December 2007 the Department of Fisheries of Vanuatu (DoF) declared a national closure on commercial harvesting of sea cucumber fisheries for a period of five years commencing on 1st January 2008 to 1st January 2013[2] .The ban was declared in order to increase the depleted stocks. The Fisheries regulations order no.28 of 2009 stated that after the period the 5 years, the sea cucumber fisheries shall be re-opened for fishing activities. This would however depend on the surveys and assessments that will be carryout to determine the stocks size.

[1] Fisheries Department annual report 2008

[2] Fisheries Department Regulation order 28 of 2009

2. BACKGROUND OF THE BICHLAMAR PROJECT

Vanuatu Government (namely the DoF) requested the financial assistance from the French Government through its embassy in Port-Vila in 2010 to fund a project to complement research activities of the DoF. An agreement was signed by both Governments to fund the BICHLAMAR project ("Sea cucumber stock assessment in Vanuatu"). The project activities have been developed by the DoF and the IRD scientists since then.

The Department of Fisheries began to implement the first phase of the BICHLAMAR project (2011-2012) in January 2011. Ongoing collaboration was initiated between the DoF and the Fisheries Division of the Northern Province of New Caledonia through join sea cucumber stock assessment surveys in Vanuatu (Malekula and North of Efate) and in the pilot management site in the Northern Province (Ham et al. 2013), where a small-scale sandfish (*Holothuria scabra*) fishery has been successful managed since 2008 (Léopold et al. 2013). Based on the biological results of the project that showed low level of resource recovery since 2008 in the survey sites in Vanuatu, the national moratorium was extended on 1st January 2013 for another 5 years. It was eventually lift in February 2014 following a spatial TAC-based strategy as presented in the present report.

The BICHLAMAR project received further funding assistance from the New Caledonia Government in 2013 to continue the sea cucumber stock assessment program in Vanuatu and support the drafting of the national management plan for sea cucumber fisheries. This report presents the activities that were undertaken in 2013 and 2014 during this second phase of the BICHLAMAR project.

3. OBJECTIVES OF THE PROJECT

As part of the BICHLAMAR project, the Department of Fisheries has implemented a permanent biological monitoring program of sea cucumber resources in Vanuatu since 2011, including the development of specific computer tools to assist in data analysis and decision-making.

Specifically the BICHLAMAR project aimed at:

1) Estimating the current sea cucumber stocks in the different islands of Vanuatu: this means to collect *in situ* biological data, to estimate and describe the biomass and size structure of commercial sea cucumber species using the BDMer 2.0 database (http://bdmer.ird.nc/), and to produce marine habitat and fisheries maps through GIS (Geographical Information System).

2) Sustainably managing sea cucumber fisheries in Vanuatu: the data collected through stock assessment surveys has been analyzed to provide directions to develop the national sea cucumber management plan and national regulations for sea cucumber fisheries, specifically quotas (or Total Allowable Catch, TAC) for each commercial species and each management area.

Stock assessments started in September 2011 during the 2008-2012 moratorium, and have been conducted in seven islands since then (Figure 1): Efate (4 sites), Malekula (2 sites), Santo (3 sites), Pentecost (1 site), Aneityum (1 site), Emae (1 site), and Gaua (1 site) islands.

4. PROJECT ACTIVITIES

The BICHLAMAR project significantly contributed to the following activities in 2013 and 2014 (Table 1):

- Resource surveys in six islands and seven management areas in Vanuatu;
- Harvest planning and monitoring in the seven pilot management areas in Vanuatu that were opened to fishing in 2014;
- Update of the BDMer 2.0 database;
- Strengthening of the collaboration between the Fisheries Division of the Northern Province of New Caledonia and the DoF through exchange visits;
- Inputs to the national fisheries regulations and management plan for sea cucumber fisheries in Vanuatu.

The budget was allocated to these activities as indicated in Table 2. The detailed budget allocation is provided in the financial report of the project. Activities are detailed here below.

Table 1. Schedule of the project activities (2013-2014)

	2013		2014	
Project activities	**S1**	**S2**	**S1**	**S2**
Resource surveys*				
- Efate island (2 sites)	X			
- Pentecost island (1 site)		X		
- Aneytium island (1 site)		X		
- Santo island (1 site)			X	
- Emae island (1 site)			X	
- Gaua island (1 site)				X
Harvest planning and monitoring (pilot management areas)			X	X
Database update (BDMer 2.0)		X		
Exchange visits (Vanuatu <--> New Caledonia)		X	X	
Contribution to national fisheries regulations and plan	X		X	X
* Survey reports are available at the DoF (see project outputs)				

Table 2. Budget allocation per activity (2013-2014)

Project activities	**~% Budget**
Resource surveys	45%
Harvest planning and monitoring	10%
Update of the BDMer 2.0 database	25%
Exchange visits	10%
TOTAL	100%

4.1 Resource surveys

Sea cucumber stocks have been assessed following the same approach developed by IRD and the Fisheries Division, New Caledonia. Data collected include 23 species of sea cucumber.

4.1.1 Survey sites

Seven sites were surveyed during the 2nd phase of the BICHLAMAR project. These sites were located in Aneityum, South of Efate, Northwest of Efate, Emae-Cook reef, Gaua, Pentecost and Santo islands (Figure 1).

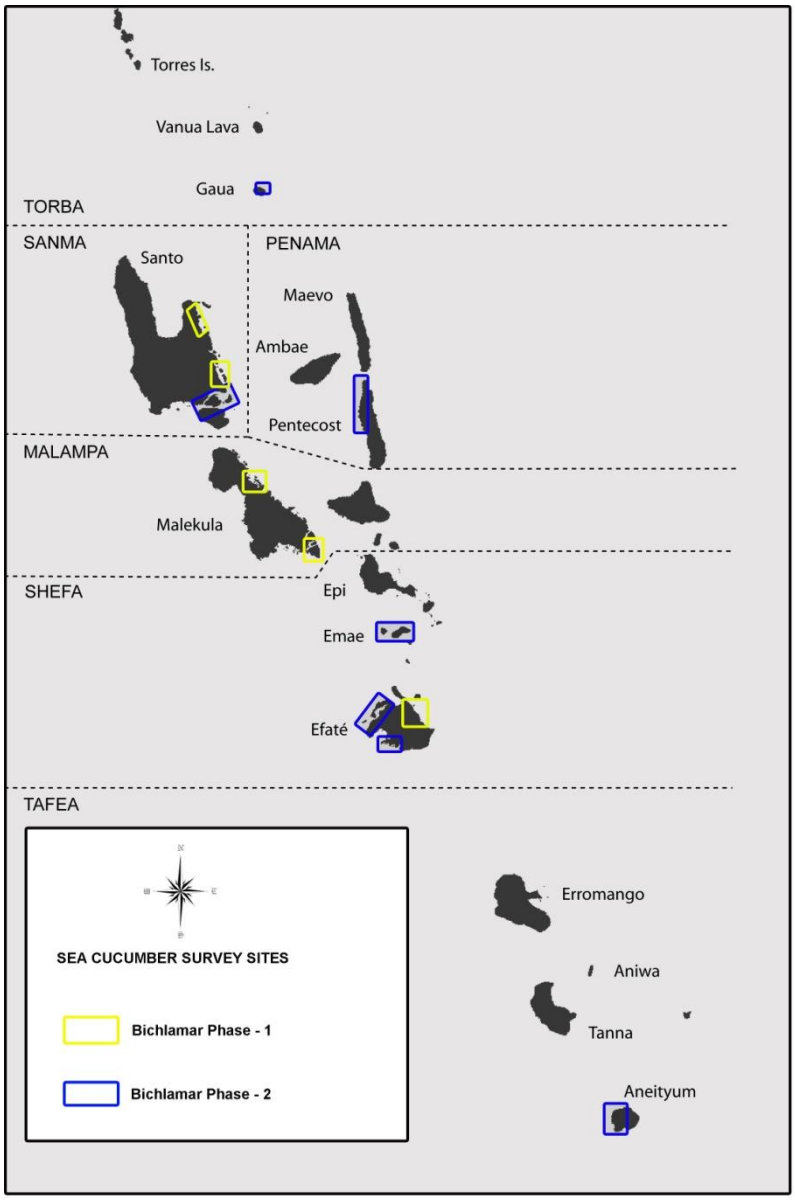


Figure 1. Survey sites of the BICHLAMAR project: 2011-2012 phase 1 (in yellow, n=5) and 2013-2014 phase 2 (in blue, n=7).

4.1.2. Sampling design and survey method

High resolution satellite images (Quickbird and Worldview 2) were purchased and used in all survey sites to determine categories of marine habitats: sea grass beds, inner reef flats, outer reef slopes, reef crest and lagoons. A stratified sampling was used to survey all habitats suitable for target sea cucumber species. Observation stations were randomly determined before survey using GIS tools. The sampling rate depends on availability of human power, costs, and reef heterogeneity; it ranged between 8 and 32 stations per km² of reef area (Table 3). Distance between neighbor stations in a given habitat zone averaged 300-500 m. The sea cucumber stock assessment surveys involved local fishermen and divers and lasted between two to five days.

Maps of survey sites and sampling designs are provided in the Appendix section.

Table 3 Characteristics of resource surveys and survey sites of the BICHLAMAR project in 2013 and 2014.

	Field work		Survey area				
Survey sites	Survey dates (n)	Surveyers (n)	Boats (n)	Days (n)	Reef area (km²)	Habitat zone (n)	Sampling station (n)
Efate Island (South area)	11-15 June 2013	4	3	5	5.83	85	186
Efate Island (Northwest area)	11-15 February 2013	5	3	5	11.7	100	266
Pentecost island	10-12 September 2013	4	1	3	4.25	14	81
Aneityum island	4-7 December 2013	5	3	4	15.88	57	273
Santo Islands	17-21 May 2014	5	2	5	18.55	71	216
Emae island	13-17 May 2014	3	3	5	16.23	34	207
Gaua island	26 Aug - 2 September	5	2	5	9.87	46	161

A single survey method was used in all sites. It included walking, free diving and scuba diving according to depth, tide hours and marine habitats. We used standardized transects of 100 m length and 2 m width (200 m²), involving two observers including one local observer and one IRD scientist or Fisheries officer. Transect lines were laid to ensure that the sample area is equal to 200 m². In each side of the transect, all sea cucumbers were counted and measured (body length and width, nearest mm) in order to calculate individual weights and estimate their abundance and biomass in the whole survey areas.

Each team of surveyors surveyed around 15-20 stations per day using this cost-effective method.

Count and size data was collected for 20 species of sea cucumbers: *Actinopyga echinites, Actinopyga lecanora, Actinopyga mauritiana, Actinopyga miliaris, Bohadschia argus, Bohadschia marmorata, Bohadschia vitiensis, Holothuria atra, Holothuria edulis, Holothuria fuscogilva, Holothuria fuscopunctata, Holothuria scabra, Holothuria whitmaei, Stichopus herrmanni, Stichopus chloronotus,*

Thelenota ananas, Thelenota anax, Pearsonothuria graffei, Holothuria lessoni, Stichopus horrens.

The presence of additional sea cucumber species outside the transect area within the habitat zone was also recorded.

Survey data has been analyzed using the BDMer 2.0 database (Léopold et al. 2014). This tool generates estimates of the abundance and biomass in total, per size class and of legal-sized sea cucumbers of each observed species. 95 % confidence intervals of all estimates were also calculated, however only the lower bounds of confidence intervals are provided in this report and used as conservative values.

This information is used to automatically derive recommendations for setting TAC by species in the survey area. TAC is equal to the legal-sized biomass (wet weight) provided that it does not exceed 20% to 50% of the total stock biomass.

4.1.3. Survey results on resource abundance

A total of 18 sea cucumbers species was observed on transects in surveyed sites. The most commonly found species were the lollyfish, greenfish, surf redfish, tigerfish, and brown sandfish (Table 4). High-value species (e.g., white teatfish, black teatfish, sandfish, prickly redfish) were more difficult to find and less abundant than commercially less valuable species. Observed abundance also greatly varied across sites (Table 4).

Table 4. Number of sea cucumbers recorded for the 18 observed species in the seven survey sites (all stations included).

Common Name	Scientific Name	Oberserved numbers						
		Anietyum	South Efate	West Efate	Emae-Cook reef	Pentecost	Santo Islands	Gaua
Lollyfish	*Holothuria atra*	10645	623	431	8638	66	137	234
Greenfish	*Stichopus chloronotus*	1632	271	305	0	137	243	157
Tigerfish	*Bohadschia argus*	7	88	38	90	43	44	12
Surf redfish	*Actinopyga mauritiana*	217	51	34	44	1	1	2
Brown sandfish	*Bohadschia vitiensis*	1	876	13	5	1	56	0
Black teatfish	*Holothuria whitmaei*	39	8	4	93	10	19	234
Curryfish	*Stichopus hermani*	0	36	23	0	0	2	0
Pinkfish	*Holothuria edulis*	0	7	84	23	0	2	2
prickyl redfish	*Thelonata ananas*	2	4	8	0	7	19	0
White teatfish	*Holothuria fuscogilva*	0	0	0	0	1	1	0
Red snakefish	*Holothuria fuscopunctata*	0	3	1	1	5	6	0
Flowerfish	*Pearsonathuria graeffei*	0	0	0	0	5	13	0
Sandfish	*Holothuria scabra*	0	32	0	0	0	0	0
chalkfish	*Bohadschia mamorata*	0	5419	0	0	0	1	2
Hairy blackfish	*Actinopyga milliaris*	2	5	2	6	0	0	0
Brown curryfish	*Stichopus Vastus*	0	44	0	0	0	0	0
Elephant triunkfish	*Thelonata anax*	0	1	5	0	3	0	1
Golden sandfish	*Holothuria lessoni*	0	0	0	0	0	1	0

The status of each species has been analyzed separately. Overall the study highlights two major features of the stocks (Table 5).

Firstly, stocks varied considerably across commercial species within a single zone (see Appendix and Figures 2-10). This can be partly explained by the zones' environmental potentials (geomorphology and marine habitats) and harvesting history. Five species (lollyfish, greenfish, surf redfish, tigerfish, and brown sandfish) showed the highest estimated stock biomass in all survey sites (except in Emae island). Lollyfih was the most abundant species in all survey sites (except in Pentecost island). The stocks of other species were similarly low to very low (except black teatfish in Emae island).

Table 5. Total stock estimates (biomass and abundance) of all species assessed in the seven survey sites. Uncertainty of estimations was taken into account considering the 95 % confidence intervals of stock estimates. The lower bound of these intervals was used as a conservative value and is presented here.

Common Name	Scientic Name	South Efate		Pentecost		Aneityum		West Efate		Emae		Santo Islands		Gaua	
		Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
		Total		Total		Total		Total		Total		Total		Total	
Lollyfish	*Holothuria atra*	48,000	11t	6,600	3t	834,000	202t	69,800	18.5t	230,000	65t	69,800	18.5t	80,000	33t
Greenfish	*Stichopus chloronotus*	-	-	1,900	<1t	320,000	38t	42,300	10t	51,000	11t	42,300	10t	22,000	3.4t
Tigerfish	*Bohadschia argus*	6,500	4t	7,100	9t	-	-	4,600	3.5t	23,000	15t	4,600	3.6t	24,000	2t
Surf redfish	*Actinopyga mauritiana*	3,800	1.7t	<1,000	<1t	21,000	8t	3,100	2.4t	3,600	2t	3,100	2.4t	<1,000	<1t
Brown sandfish	*Bohadschia vitiensis*	13,100	6t	<1,000	<1t	-	-	<1,000	<1t	<1,000	<1t	<1,000	<1t	-	-
Black teatfish	*Holothuria whitmaei*	-	-	<1,000	1t	6,200	11t	-	-	26,000	39t	-	-	<1,000	<1t
Curryfish	*Stichopus hermani*	2,400	2t	-	-	-	-	<1,000	<1t	<1000	2t	<1000	<1t	-	-
Pinkfish	*Holothuria edulis*	-	-	-	-	-	-	<1,000	<1t	2,700	<1t	<1,000	<1t	<1,000	<1t
White teatfish	*Holothuria fuscogilva*	-	-	<1,000	<1t	-	-	-	-	-	-	-	-	-	-
Prickly refish	*Thelenota ananas*	-	-	<1,000	<1t	-	-	-	-	3,000	7 t	-	-	-	-
Hairy blackfish	*Actinopyga milliaris*	-	-	-		-	-	-	-	<1,000	<1t	-	-	<1,000	<1t
Red snakefish	*Holothuria fuscopunctata*	-	-	<1,000	<1t	-	-	-	-	<1,000	<1t	-	-	-	-
Stonefish	*Actinopyga lecanora*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Deep water redfish	*Actinopyga echinites*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flowerfish	*Pearsonathuria graeffei*	-	-	<1,000	<1t	-	-	-	-	<1000	<1t	-	-	-	-
Sandfish	*Holothuria scabra*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
chalkfish	*Bohadschia Marmorata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Secondly, stock levels of a given species could vary considerably from one part of an island group to another, particularly for less valuable species. Interestingly, the estimated biomass of black teatfish was much higher in Emae island than in other sites. The trend was also observed within a single province in Vanuatu and even a single island (Figures 9 and 10).

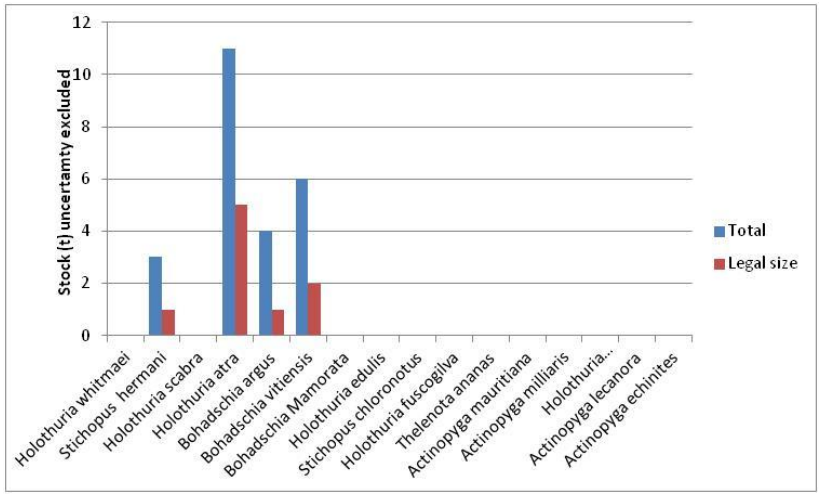


Figure 2. Conservative stock estimates (biomass) of main species in South Efate (2013).

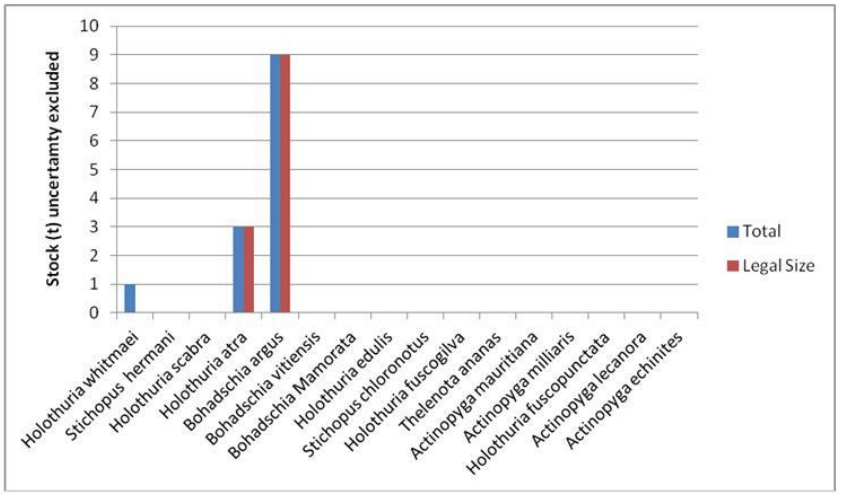


Figure 3. Conservative stock estimates (biomass) of main species in Pentecost (2014).

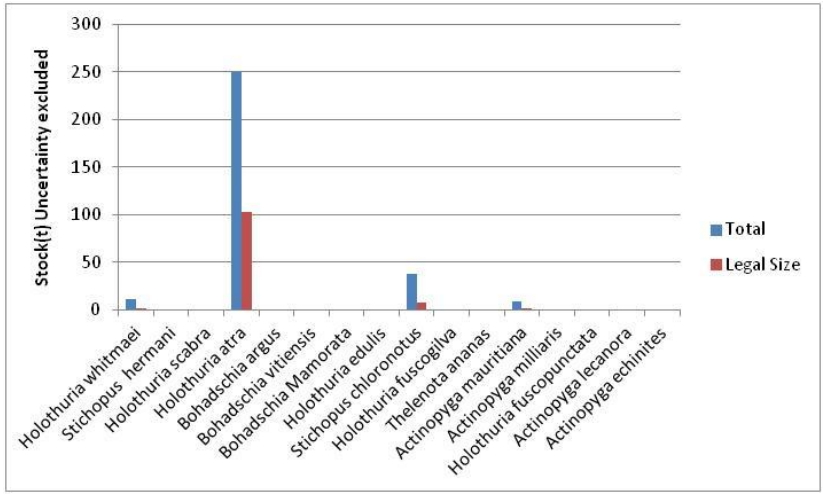


Figure 4. Conservative stock estimates (biomass) of main species in Aneityum (2013).

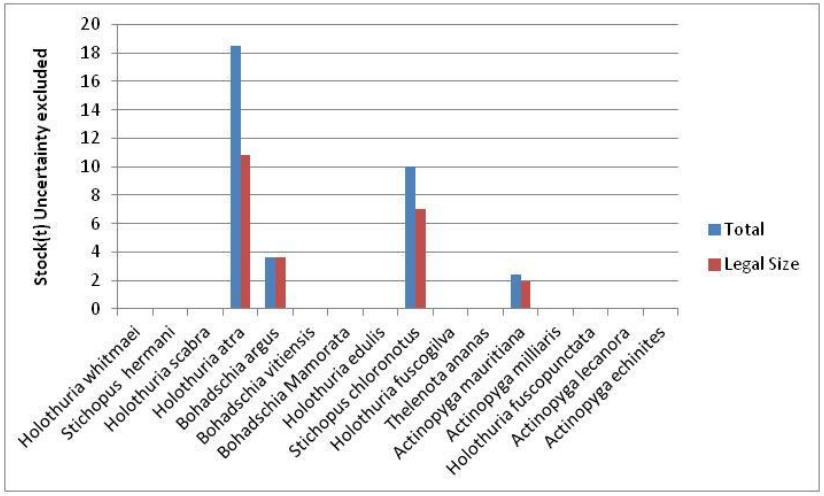


Figure 5. Conservative stock estimates (biomass) of main species in West Efate (2013).

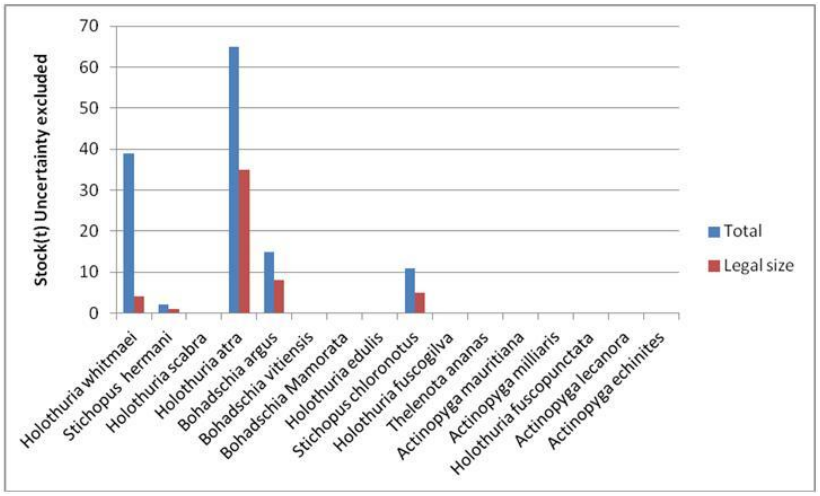


Figure 6. Conservative stock estimates (biomass) of main species in Emae-Cook Reef area (2013)

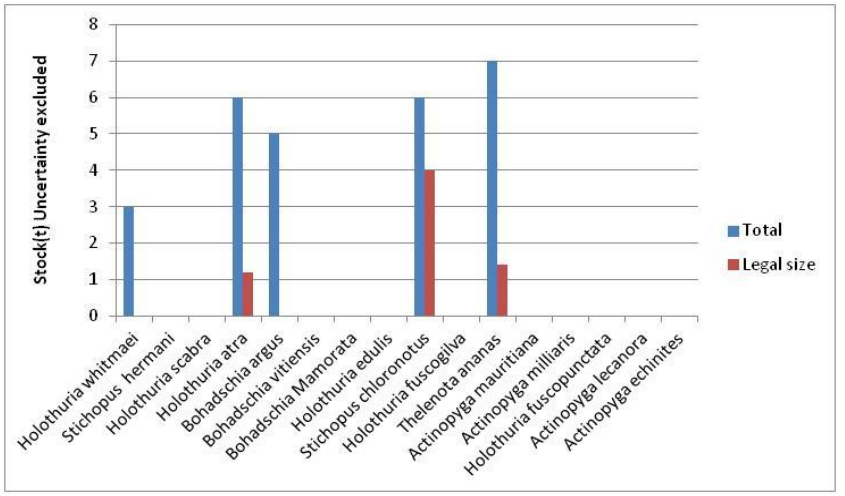


Figure 7. Conservative stock estimates (biomass) of main species in Santo Islands (2014).

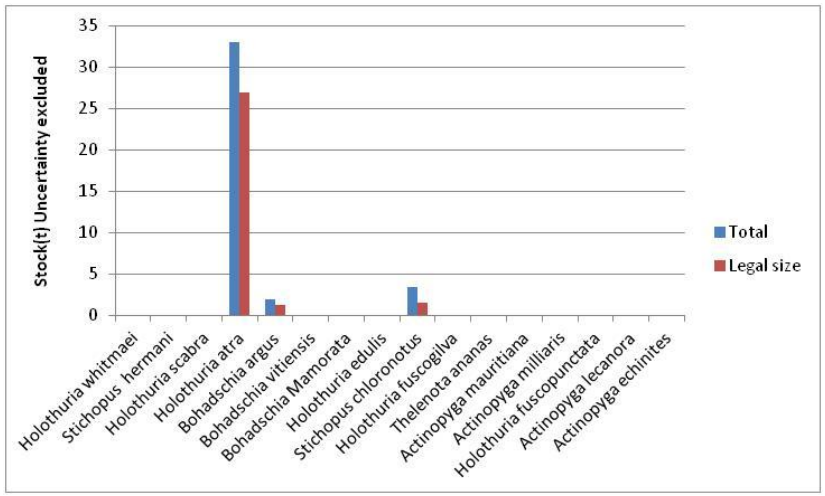


Figure8. Conservative stock estimates (biomass) of main species in Gaua island (2014).

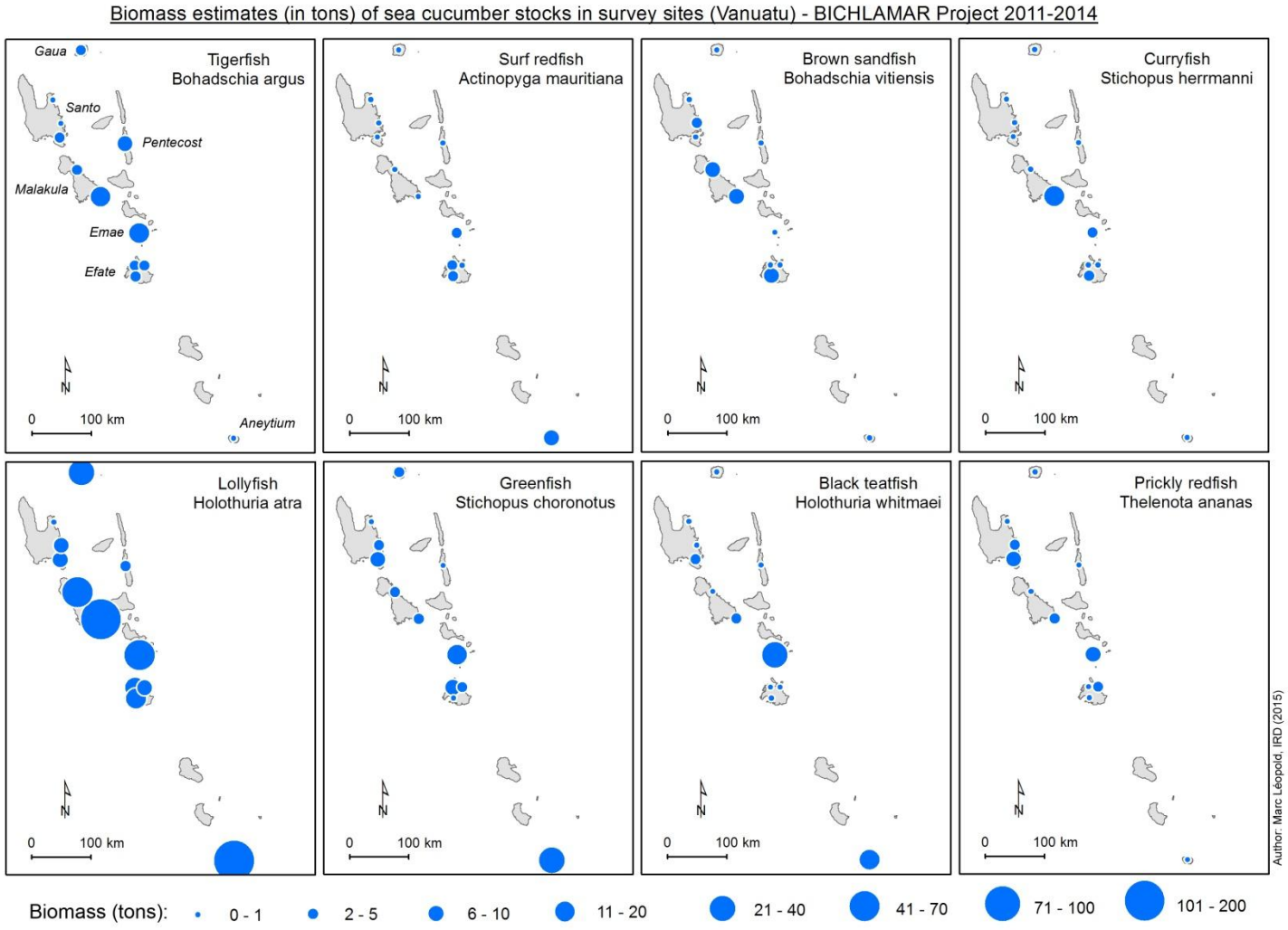


Figure 9. Biomass stock estimates of the 8 most abundant sea cucumber species (tigerfish, surf redfish, brown sandfish, curryfish, lollyfish, greenfish, black teatfish, and prickly redfish) in the 12 survey sites of Vanuatu (2011-2014 surveys). See Table 5 for estimate values and Figure 1 for site names.

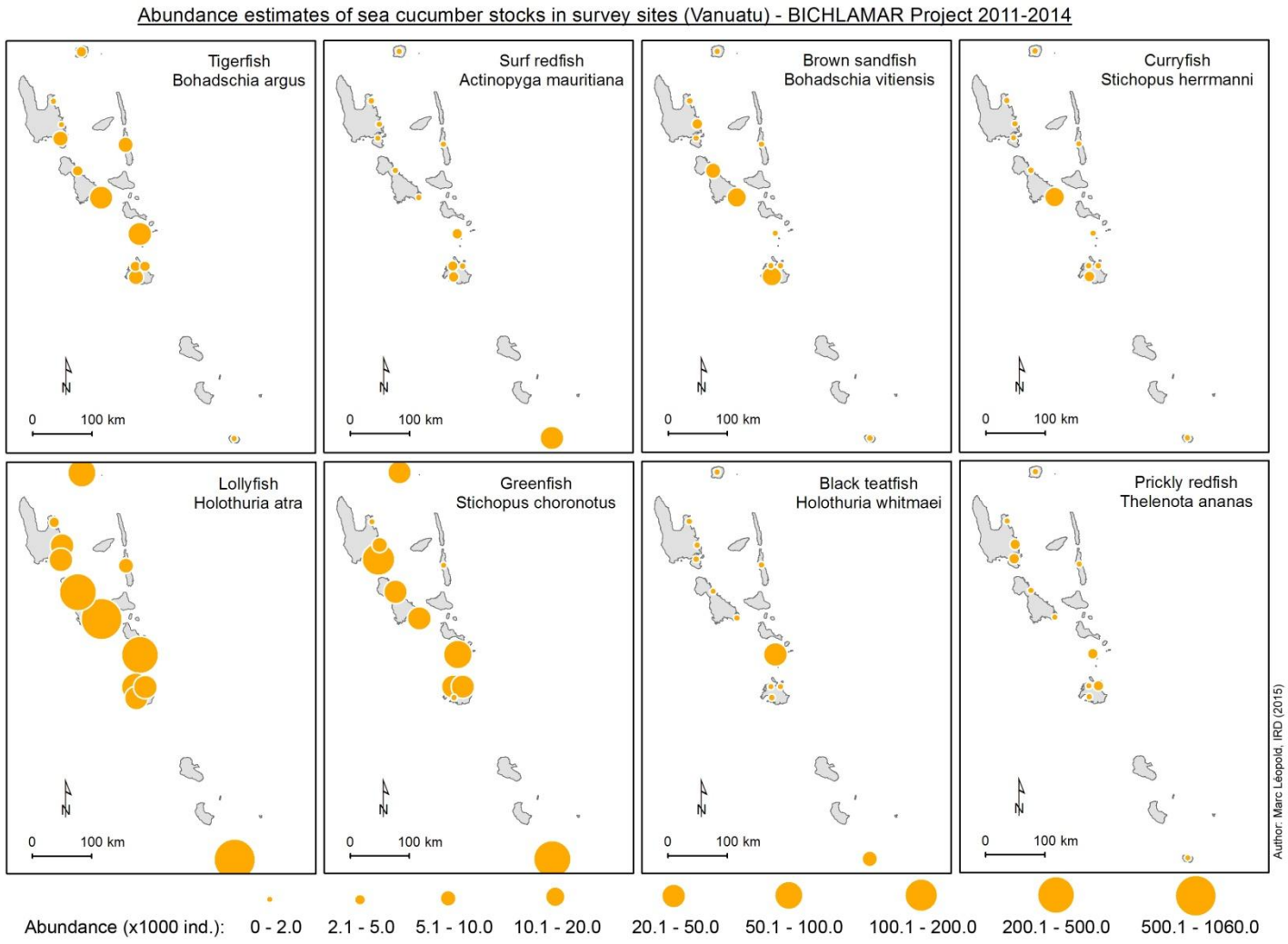


Figure 10. Abundance stock estimates of the 8 most abundant sea cucumber species (tigerfish, surf redfish, brown sandfish, curryfish, lollyfish, greenfish, black teatfish, and prickly redfish) in the 12 survey sites of Vanuatu (2011-2014 surveys). See Table 5 for estimate values and Figure 1 for site names.

4.1.4. Management recommendations

Sea cucumber stock assessment data has been analyzed for each species in each survey site (South Efate, West Efate, Emae & Cook reef, Pentecost, Santo islands, Aneytium, and Gaua sites). Overall we observed low abundance (legal sized individuals) of most species in all sites. The slow recovery of the resources despite the moratorium may have resulted from different factors. The most likely drivers are: 1) excessive fishing pressure taking place over the years before the ban of harvest was enforced by the Department of Fisheries (2008), 2) the recruitment of juvenile sea cucumbers may be very low due to low number of mature sea cucumbers (brood stock), and 3) limited illegal harvest of sea cucumbers occurred during the ban period (DoF, pers. com.).

The overall results of the surveys conducted in seven sites indicate that the stock biomass and abundance of the 18 commercial species greatly differ between sites and between species. These results are consistent with those of the first phase of the BICHLAMAR project concerning five other survey sites in Santo, Malekula and Efate islands (Ham et al. 2013). Therefore it is recommended that the Vanuatu Sea Cucumber Management Plan should include site-specific and species-specific TAC (Total Allowable Catch) based on conservative stock estimates. Such measures would allow for maintaining catch below overexploitation level.

The 6-year ban on sea cucumber fisheries (2008-2013) may then have be too short to allow for recovery of stocks expect for a few species in some sites. Low TACs were defined for these species and sites (see below). For other species and sites, another stock assessment should be conducted prior reopening the fishery to ensure that resources have increased since the present surveys.

4.2. Harvest planning and monitoring in pilot management areas

Underwater assessment results that had been conducted since 2011 suggested that limited harvests could be authorized in some sites for some species. Small TACs were defined for up to nine species (Table 6) in eight management areas that were surveyed (Figure 11) through Fisheries Regulation (Amendment) Order No11 of 2014 (7th February 2014). The low TACs were used to trial the new management system as well as to provide extra income for communities in areas where the stock biomass had been estimated.

Two processing and export companies purchased an annual license through the DoF. Cost of the license was set proportionally to the authorized catch to be processed by each company.

Prior to the sea cucumber harvest, an awareness meeting was conducted by the DoF on each management area to clarify the following issues:

- Remind the communities of which sea cucumber species were authorized for harvest, their legal sizes and wet weight, and the respective TACs;
- How the TACs can be shared among the nearby villages that were situated along the authorized area of harvest;

- Define the fishing period;
- Identify a landing spot that was easily accessed by all villagers and where the Fisheries officers were stationed to count each individual sea cucumber and record catch per species (see log sheets in Appendix 2);
- Inform communities that Fisheries officers would monitor the daily catch per species, so at the end of every fishing day, communities would know how many kilograms of sea cucumber are yet to be harvested, until TAC are reached.


The DoF organized an awareness meeting in management areas prior to harvest to clarify stock assessment results (biomass, TAC, etc.) and the new management and harvest rules. Fishers and chiefs very widely supported the TAC-based strategy and the monitoring and control mechanisms. Meetings occurred in Efaté island (Paonangisu, 01/04/2014; Mangaliliu, 03/04/2014), Malekula island (Crab Bay, 15/07/2014; Maskelynes, 15/07/2014), Emae island (22/05/2015), and Aneytium island (26/05/2014).

Harvest finally occurred in three management areas only in 2014 due to the high operational costs compared to low expected returns from catches. These three management areas included Malekula B (26-27 July and 5-8 August), Santo B (27th October to 3rd November) and Efate A (8-17 October) (see Figure 11).

In each of the three management areas, harvest usually occurred one area at a time and lasted for not more than two weeks to reduce operational costs and increase control effectiveness. During harvest, three log sheets were used by Fisheries officers to monitor the catch. Monitoring costs were covered by the authorized processing companies.

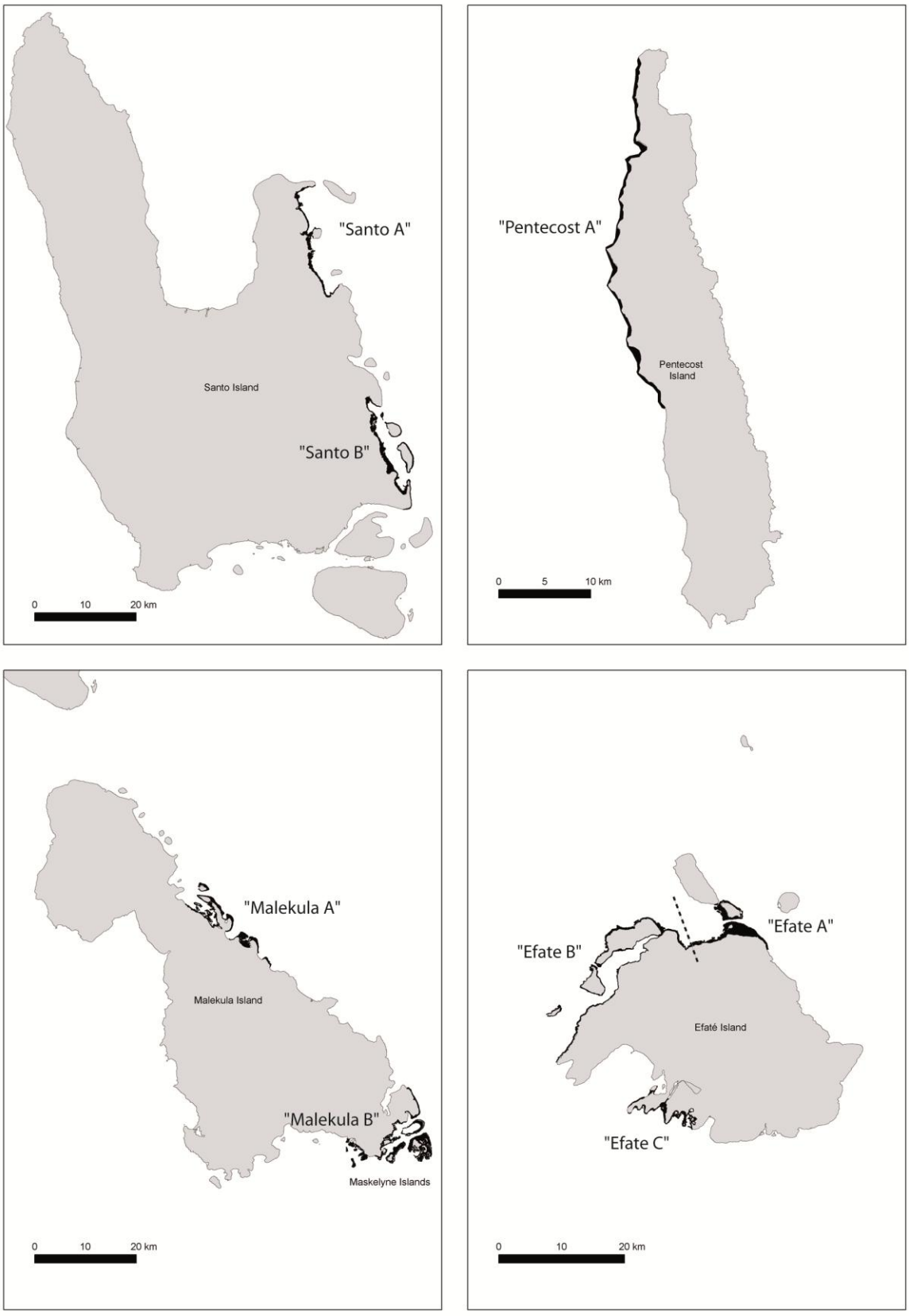


Figure 11. Pilot management areas (in black) for sea cucumber fisheries in Vanuatu (n=8). Authorized harvest areas were limited to these coastal reef areas in 2014.

Table 6. Total Allowable Catch (in tons) in the 7 pilot management areas in Vanuatu in 2014.

Species	Pilot management areas							
	Santo A	Santo B	Pentecost A	Malekula A	Malekula B	Efate A	Efate B	Efate C
Low value								
Holothuria atra	-	0,5	-	0,5	30,0	6,0	0,5	-
Holothuria edulis	-	-	-	0,5	0,5	-	0,5	-
Moderate value								
Actinopyga mauritiana	-	-	-	-	-	-	1,0	-
Bohadschia argus	-	0,5	6,0	2,0	-	1,5	1,8	-
Bohadschia vitiensis	0,5	1,3	-	2,5	4,0	-	0,5	-
Stichopus chloronotus	-	0,5	-	1,0	0,5	2,0	3,5	-
Stichopus herrmanni	-	-	-	0,5	6,0	-	0,5	-
Thelenota ananas	-	0,5	-	0,5	2,0	1,3	-	-
High value								
Holothuria fuscogilva	-	-	-	-	0,5	-	-	-
Holothuria scabra	-	-	-	-	0,5	-	-	-
Holothuria whitmaei	-	-	-	0,5	1,0	-	-	-

In the areas opened to fishing, TACs proved an effective means of restricting catches if an officer or authorized agent of the DoF was on site to supervise landings and first sales to processing companies. A local trained observer (or "resource monitor") also provided useful assistance. When on-site checks were not carried out by the DoF, unauthorized catches (i.e., exceeding TACs or of prohibited species) were later reported, despite arrangements reached with the local communities who had endorsed or even requested sending a monitoring officer as a condition for opening the harvesting season.

The pulse fishing strategy was successfully implemented to enhance the effectiveness and contain the cost of TAC monitoring, due to the large number and/or wide dispersal of fishers in the management areas. Fishing was allowed in each area for a very short time (i.e., a few continuous days) depending on the DoF's ability to monitor it. Such a small fishing window also facilitated joint monitoring of the TACs and feedback to fishers.

The strategy additionally featured a rotational pulse fishing system, which required that fishing be allowed in only one area at a time, thereby de facto restricting the number of harvests per year, as regulations required prior public notification periods for each open season. The DoF could thereby optimize the use of the human and financial resources available for assessments and for monitoring TACs.

Catch monitoring at Malekula B pilot management area (July 2014). Individual legal weight (see Table 8), catch per species per fisher and daily catch per species were monitored by a Fisheries officer with the assistance of a local observer.

4.3. BDMer 2.0 database

BDMer 2.0 (see Figure 12) is a user-driven computer tool for managing and analysing underwater data on benthic invertebrate resources (e.g., sea cucumbers, trochus, green snail). It was designed to meet management needs for sea cucumber fisheries and the technical capacities of Fisheries Departments, in New Caledonia and Vanuatu in particular.

BDMer 2.0 incorporates a multi-species and multi-sites database for underwater observations of invertebrate abundance and size, and marine habitat maps. This tool also allows for performing pre-defined statistical routines to estimate invertebrate stock status (abundance, biomass, density, size structure by species). Estimate uncertainty is also calculated to provide appropriate recommendations for setting TAC level.

BDMer 2.0 automatically displays analysis results using visual support (tables, graphs…) and the most relevant management indicators. Data and results may be downloaded for further analysis or exported to PDF files to publish standardized survey reports.

BDMer 2.0 is available online for backup and data sharing (at http://bdmer.ird.nc/), and on portable computers to provide on-time assessment results and management advice in survey sites. The IRD also provides free access to a demo version of BDMer 2.0 at: http://bdmer-test.ird.nc/. The demo version offers similar features, however data is neither validated nor saved.

The tool was greatly improved in 2013 (input and data analysis modules, results visualization module, etc.). As previous version, version 2.0 was developed by the Melanopus SARL company, Noumea, New Caledonia. All data stored in the 1.5 version was reformatted and transferred to the new database. The DoF is the administrator of the BDMer 2.0 and manages the routine uses for all stock assessments in Vanuatu. Funding for the 2.0 version was fully provided by the BICHLAMAR project. The total development costs (1.5 version in 2012 and 2.0 in 2013) was supported equally by the DoF and the Northern Province of New Caledonia.

Figure 12. BDMer 2.0 online database for managing and analysing underwater data on benthic invertebrate resources.

4.4. Collaboration between the DoF and the Northern Province of New Caledonia

4.4.1. Exchange visit to Vanuatu

Two Fisheries officers from the Northern Province in New Caledonia (Z. MOENTEAPO and L. BOURGINE) went to Vanuatu from 25 November to 11 December 2013. This visit was co-finded by the BICH2MER project.

The aim of the visit was to participate in the implementation of the entire assessment process, in the context of a multispecies sea cucumber fishery, located on heterogeneous reef habitats and extending over ~30 km. The Northern Province might indeed use the same system for managing sea cucumber fisheries.

The first week of this visit was devoted to the preparatory work for the assessment of sea cucumber stocks of the Aneytium Island (Tafea province): habitat mapping and sampling design using ArcGIS 10, training to the BDMer 2.0 database. This work was carried out in the DoF offices in Port-Vila.

The second week was devoted to a field trip for assessing sea cucumber stocks in Aneityum Island. Northern Province officers took part in the count survey, data entry using BDMer 2.0, TACs estimates, and the presentation of the survey results to local communities. The latter will eventually decide on the opening or the closure of their fishery in 2015. Overall, eight commercial species were observed, mainly lollyfish, greenfish, black teatfish and surf redfish. Low TACs were proposed (59 t, 7 t , 1.4 t and 1 t wet weight, respectively).

The stock assessment system in Vanuatu was found efficient and transferable to New Caledonia context.

Participants to the assessment survey in Aneytium Island, December 2013 : Northern Province of New Caledonia (L. Bourgine, Z. Moenteapo), Department of Fisheries of Vanuatu (J. Ham, R. Kaku) and IRD (M. Léopold).

4.4.2. Exchange visit to New Caledonia

Two officers from the DoF of Vanuatu (KAKU R. and J. HAM) did a visit to New Caledonia from 20-29th June 2014. They were accompanied on site by Z. MOENTEAPO, who is the project manager for the implementation of the provincial management plan for sea cucumber fisheries. The aim was to participate in the monitoring of the harvest of sandfish over the Plateau des Massacres (Boyen area). This fishery has indeed been successfully managed through a TAC-based system since 2008. This visit occurred before the expected reopening of the sea cucumber fishery in Vanuatu in 2014.

The two DoF officers took part in fishing activities on 24-25th June during the authorized open fishing period, and then attended sale on June 26th. Several tons of sandfish were landed that day. Strict monitoring of catch ensured the respect of the local TAC. This practical experience was found very helpful to implement similar measures in Vanuatu.

This trip was also an opportunity to visit two sea cucumber processing factories, based in Népoui and Nouméa. KAKU R. and J. HAM found that equipment and facilities for cooking and drying sea cucumbers varied between both factories, therefore providing beche-de-mer products of unequal quality.

Finally, R. KAKU migrated survey data to the updated BDMer 2.0 database and incorporated this data into the online database. The Northern Province now shares the same tool as the DoF.

4.5. Inputs to national fisheries regulations and management plan

The Department of Fisheries in Vanuatu has implemented a TAC-based system on sea cucumber fisheries for the first time. This management regime is based on annual TACs that are defined by species and by fishing area using biological surveys to estimate stock biomass. Fishing areas can be opened for harvest one at a time for short periods of time. The impact of harvesting and the outcome of the new management strategy can be estimated starting in 2016, when the next stock assessments will be conducted in the areas investigated.

The project activities were also used to define and amend the legal size limits regulation 28 of 2009 (Table 8).

The draft of the 2015-2019 national management plan for sea cucumber fisheries was finalized in December 2014.

Table 8. List of sea cucumber species (with amendment order No 11 of 2014 on order No 28 of 2009 on minimum harvest size and weight limits).

Local name	Common name	Minimum size (cm)		Minimum weight (g)		Minimum nb of pieces	Conversion rate
		wet	dry	wet	dry	1kg	wet --> dry
Ambafis	Amberfish	40	15	1600	80	12	0,05
Blak titfis	Black teatfish	30	15	1000	100	10	0,1
Blakfis	Blackfish	20	10	340	34	29	0,1
Braon karifis	Brown curryfish	20	10	260	10	96	0,04
Braon sanfis	Brown sandfish	25	12	700	28	35	0,04
Jokfis	Chalkfish	15	7	130	8	128	0,06
Karifis	Curryfish	35	15	1000	40	25	0,04
Dipwota blakfis	Deepwater blackfish	30	15	660	79	12	0,12
Elefenfis	Elephant trunkfish	40	20	1700	221	4	0,13
Flaoafis*	Flowerfish	30	15	470	19	53	0,04
Kolten sanfis	Golden sandfish	25	12	660	53	19	0,08
Krinfis	Greenfish	20	10	150	4	222	0,03
Lolifis	Lollyfish	20	10	280	14	71	0,05
Pinatfis*	Peanutfish	20	10	190	8	132	0,04
Pinkfis	Pinkfish	20	10	150	6	166	0,04
Paenapolfis	Prickly redfish	35	17	1300	91	11	0,07
Red snekfis*	Red snakefish	30	15	260	10	100	0,04
Sanfis	Sandfish	20	10	300	15	66	0,05
Snekfis*	Snakefish	40	20	340	14	73	0,04
Stonfis	Stonefish	20	10	650	32	30	0,05
Sefredfis	Surf redfish	25	12	500	30	33	0,06
Taikafis	Tigerfish	30	15	800	32	31	0,04
Waet titfis	White teatfish	35	16	1400	126	8	0,09

** Minimum weight not defined by Regulation Order No11 of 2014*

5. PROJECT OUTPUTS

5.1. Management outputs

The BICHLAMAR project has significantly contributed to improve the management of sea cucumber fisheries in Vanuatu through the design and implementation of an innovative TAC-based management strategy. Specifically, the following outputs have been achieved:

- Quantitative resource assessments of sea cucumbers (abundance/density, biomass, and size structure) conducted in six islands and seven sites in 2013 and 2014 (twelve sites since 2011);

- Definition of TAC for each species in eight pilot areas in 2014 based on biological surveys;

- Implementation and monitoring of village-based harvest operations in the pilot sites (2014);

- Significant contribution to national fisheries management plan and regulations for implementing best management practises;

- Increase in financial and technical capacities of the DoF including endogenous financial mechanisms, standard survey methodology, GIS, and simple statistics.

This study provides examples of the types of approach that could be developed for improving sea cucumber fisheries management. Although not exclusive to small-scale sea cucumber resources, the heavy pressure exerted by the industry and/or local fishers to increase TAC levels are weaknesses that will need to be overcome. As the trials are monitored in Vanuatu (and the Northern Province of New Caledonia), it will become apparent whether the biological and financial objectives have been reached nationally and/or provincially.

Against a backdrop of worldwide overharvesting in small-scale sea cucumber fisheries, the results of TAC-based spatial co-management would appear to justify extending this technique to other countries with modest financial and/or technical capabilities. The regular progress achieved in computer skills (GIS, databanks, data processing, etc.) by the DoF and other government Departments and institutional partners in these countries is an encouraging sign.

5.2. Networking

Management of sea cucumber fisheries has been an issue not only to Vanuatu but also to other Pacific island countries. The DoF of Vanuatu has collaborated with other Pacific island countries such as New Caledonia (see above), Fiji, and Papua New Guinea to work together, exchange ideas and methods, and share management costs (e.g., for developing the BDMer 2.0 database) to address common issues related to sea cucumber management.

Two officers from the DoF attended a conference and organized a workshop in Suva, Fiji in July 2014 (see Publications below). They presented their work on the new sea cucumber management strategy in Vanuatu and how this system could be implemented also in other Pacific island countries. Fiji and Papua New Guinea Fisheries institutions indicated their support and proposed that the Melanesian Spear Head Group (MSG) body should facilitate all agreement (Government Heads) to support and address these issues.

5.2. Computer tools

Part of the project component is to work with computer tools to design maps and also analysis survey data. The fisheries research officer involved in the project has obtain computer skills and knowledge on how to input data into the database (BDMER2.0) which produce all statistical analysis while the officers can extract final output from the database and create reports**.**

5.3. Publications

Survey reports (confidential)

Ham J., Kaku R., Léopold M. 2012. Sea cucumber stock assessment in Aneityum island. Department of Fisheries, Port-Vila, 9 pp.

Ham J., Kaku R., Léopold M. 2013a. Sea cucumber stock assessment in South Efate island. Department of Fisheries, Port-Vila, 9 pp.

Ham.J., Kaku R., Léopold M. 2013b. Sea cucumber stock assessment in West Efate island. Department of Fisheries, Port-Vila, 9 pp.

Kaku R., Léopold M. 2014a. Sea cucumber stock assessment in Emae island. Department of Fisheries, Port-Vila, 10 pp.

Kaku R., Léopold M. 2014b. Sea cucumber stock assessment in Pentecost island. Department of Fisheries, Port-Vila, 9 pp.

Kaku R., Léopold M. 2014c. Sea cucumber catch monitoring report in Malekula B area (21-27 July 2014). Department of Fisheries, Port-Vila, 5 pp.

Ham J., Kaku R., Léopold M. 2014a. Sea cucumber stock assessment in Gaua island. Department of Fisheries, Port-Vila, 9 pp.

Ham J., Kaku R., Léopold M. 2014b. Sea cucumber stock assessment in Santo Islands island.

Department of Fisheries, Port-Vila, 9 pp.

Neihapi P., Morris K. 2014. Sea cucumber catch monitoring report in Malekula B area (4-8 August 2014). Department of Fisheries, Port-Vila, 13 pp.

Journal articles

Léopold M., Cornuet N., Andréfouët S., Moenteapo Z., Duvauchelle C., Raubani J., Ham J. et Dumas P. 2013a. Comanaging small-scale sea cucumber fisheries in New Caledonia and Vanuatu using stock biomass estimates to set spatial catch quotas. Environmental Conservation 40: 367-379.

Léopold M., Ham J., Kaku R., Kaltavara J., Raubani J., Gereva S., Moenteapo Z., Andréfouët S. and Dumas P. 2013b. Towards a new management strategy for Pacific Island sea cucumber fisheries. SPC Information Newsletter 140: 43-48.

Léopold M., Ham J., Kaku R., Gereva S., Raubani J., Moenteapo Z. 2015. Spatial sea cucumber management in Vanuatu and New Caledonia. SPC Beche-de-mer Information Bulletin 35: 3-9.

User guide

Léopold M. 2014. BDMer Version 2.0 User Guide. 74 pp. (http://bdmer.ird.nc/index1.php?lang=en&pays=vnt).

Conferences (oral presentations)

Léopold M., Ham J., Kaku R., Gereva S., Raubani J., Moenteapo Z. 2014. Putting spatial management into practice: a case study of sea cucumber fisheries in New Caledonia and Vanuatu (Southwest Pacific). 2nd World Small-Scale Fisheries Congress, Mérida, México, 21-26 September 2014. https://2wsfc.wordpress.com/.

Kaku R., Ham J., Léopold M. 2014. Estimating sea cucumber stocks to inform fisheries management in Vanuatu. SCBO Conference, Suva, Fiji, 9-11th July 2014.

Ham J., Kaku R., Léopold M. 2014. Implementing more effective sea cucumber fisheries management in Vanuatu. SCBO Conference, Suva, Fiji, 9-11th July 2014.

6. APPENDICES

1. Sea cucumber landing log sheets: 1) daily bag records, 2) daily boat catch, and 3) total catch of the day.

2. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Aneityum islands

3. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Efate island (South area).

4. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Efate island (Northwest area).

5. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Emae island and Cook reef.

6. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Santo islands

7. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Pentecost island

8. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Gaua island

Fisheries Department of Vanuatu

SEA CUCUMBER LANDED CATCH RECORD SHEET 2014

Vanuatu Fisheries Department ***Sheet N°:***

Authorized officer: ***Product type:*** **Date:** / / 2014

Bags	Species	Weight (kg)	Pieces (nb)	Bags	Species	Weight (kg)	Pieces (nb)
1				46			
2				47			
3				48			
4				49			
5				50			
6				51			
7				52			
8				53			
9				54			
10				55			
11				56			
12				57			
13				58			
14				59			
15				60			
16				61			
17				62			
18				63			
19				64			
20				65			
21				66			
22				67			
23				68			
24				69			
25				70			
26				71			
27				72			
28				73			
29				74			
30				75			
31				76			
32				77			
33				78			
34				79			
35				80			
36				81			
37				82			
38				83			
39				84			
40				85			
41				86			
42				87			
43				88			
44				89			
45				90			

SEA CUCUMBER LANDING LOGSHEET - Vanuatu Fisheries Department

To be filled by Fisheries Observer or Fisheries Authorized Officer.

WARNING: One logsheet per boat, per fishing day and per buyer / processor.

ISLAND / PROVINCE	LANDING SITE	AUTHORIZED FISHING AREA	FORM ID

FISHER NAME(S)	No OF FISHERS	FISHING DATE DD / MM / YY

FISHING METHOD(S)	DEPTH (m)	BOAT TYPE	HOURS FISHING

BUYER / PROCESSOR LICENSE No	PROCESSING / BUYING COMPANY NAME

CATCH

SPECIES NAME	NUMBER OF PIECES	TOTAL WEIGHT (KG)	PRODUCT TYPE	PRICE PER KG

REMARKS

RECORDER NAME and SIGNATURE	BUYER / PROCESSOR NAME and SIGNATURE	DATE

Fisheries Department of Vanuatu

SEA CUCUMBER LANDED CATCH RECORD SHEET 2014

Vanuatu Fisheries Department

Sheet N°:

Authorized officer:

Recorded Date: / / 2014

Island:

Authorized Fishing Site:

Vilage/Area

Number of Boats:

Number of Fishers:

Fishing Date: / / 2014

Names of Fishers:

	TOTAL CATCH OF THE DAY (kg)		REMINDER		REMINDER	
Authorized Species	Life Weigth	Eviscerated Weigth	Total Allowable Catch (TAC) (kg)	Authorized Remaining Catch (kg)	Minimum Legal Size (cm)	Minimum Legal Weigth (kg)

Buyer #1: _____

PURCHASED CATCH OF THE DAY			
Authorized Species	Weight (kg)	Product Type	Price (VT/kg)

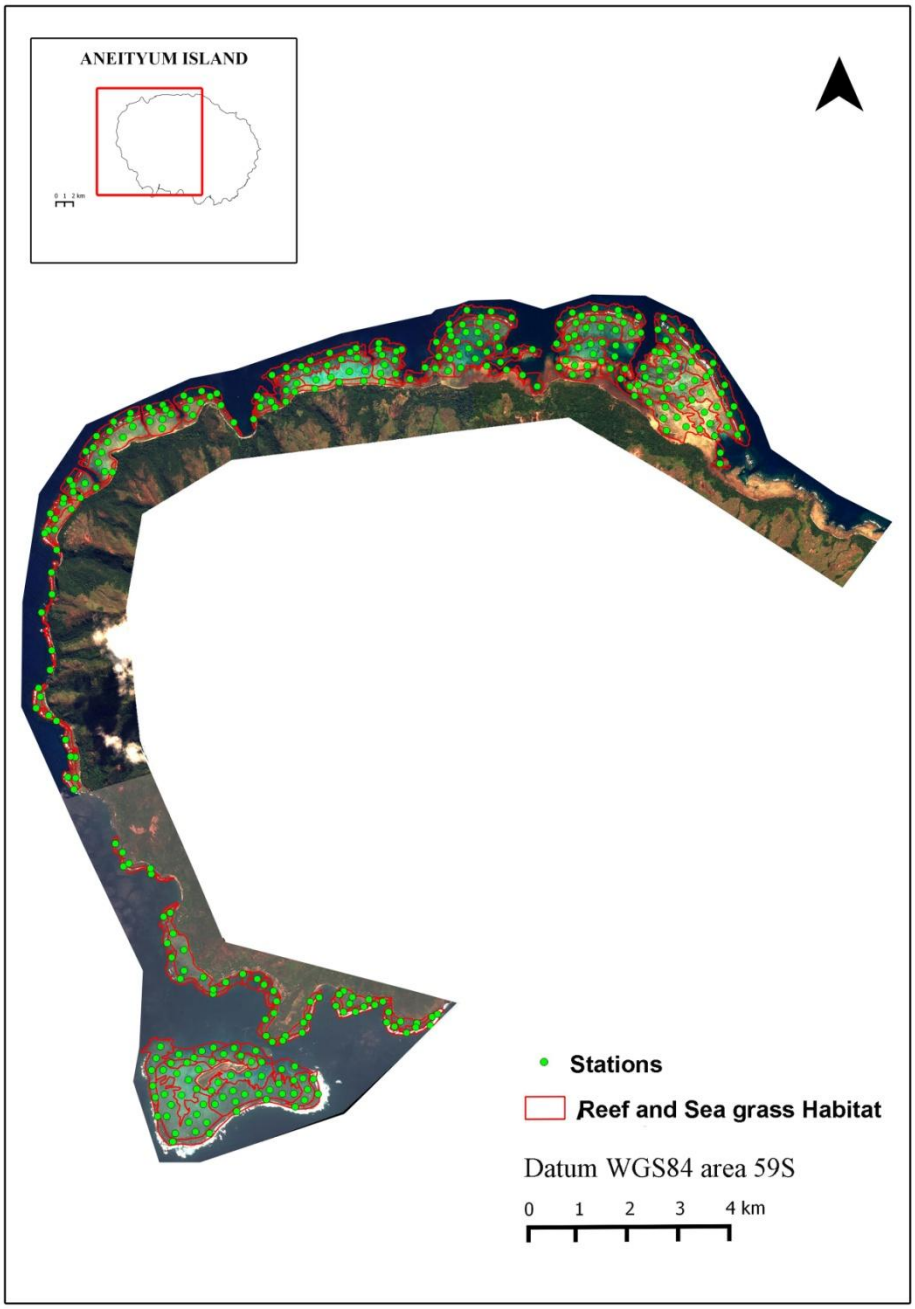
Buyer #2: _____

PURCHASED CATCH OF THE DAY			
Authorized Species	Weight (kg)	Product Type	Price (VT/kg)

Name and Signature:

_____

2. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Aneityum islands.



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Holothuria atra - ANEITYUM_2013-12

The selected data includes **56 habitat zone(s)** of the study area (**15.88 km²**). The field census occurred from 04/12/2013 to 07/12/2013. **255 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z008 ; Z009 ; Z010 ; Z011 ; Z012 ; Z013 ; Z014 ; Z015 ; Z016 ; Z017 ; Z018 ; Z019 ; Z020 ; Z021 ; Z022 ; Z024 ; Z026 ; Z027 ; Z030 ; Z031 ; Z032 ; Z033 ; Z034 ; Z035 ; Z036 ; Z037 ; Z038 ; Z040 ; Z041 ; Z042 ; Z043 ; Z044 ; Z045 ; Z046 ; Z047 ; Z048 ; Z049 ; Z051 ; Z052 ; Z053 ; Z054 ; Z055 ; Z056 ; Z058 ; Z059 ; Z060 ; Z061 ; Z062 ; Z063 ; Z064 ;

Outlying transects (removed from analysis) : T204;T025;T015;T100;T125;T122;T123;T124;T126;T188;T189;T190;T191;T192;T279;T017;T018;T019;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **249221 kg** (wet) and the conservative total abundance is **1653701 individual(s)**. This wet biomass is equivalent to **124611 kg** of gutted and salted products, and **12461 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **1041 individual/ha** and **156.9 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

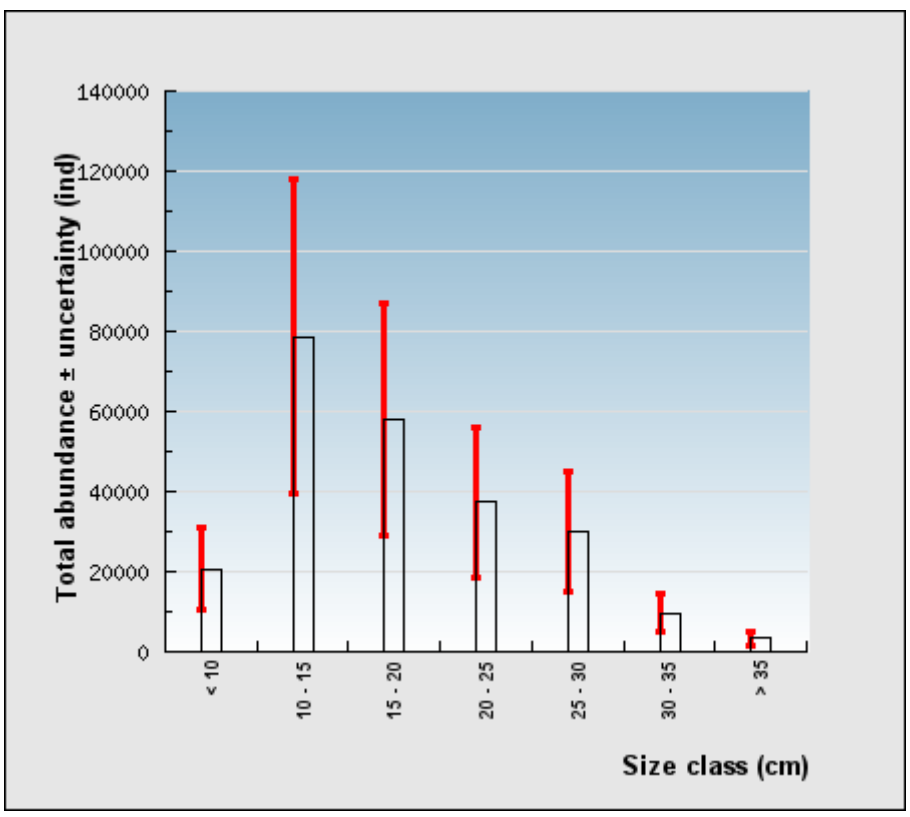
Biological interpretation

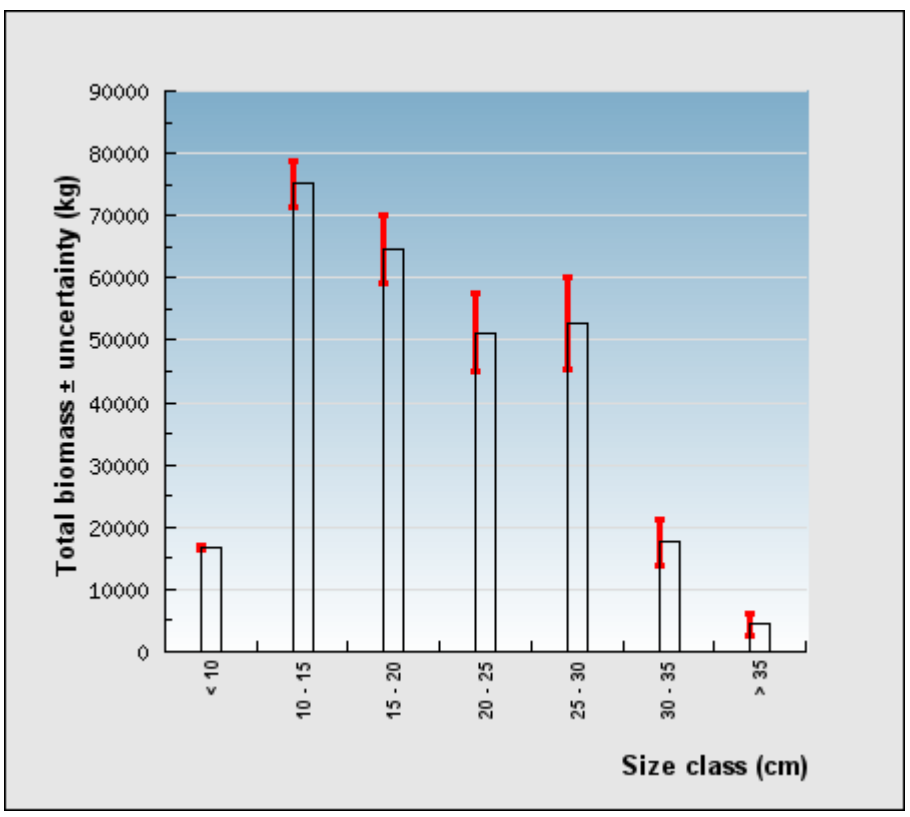
Legal-sized individuals (200 mm) represent **41 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 48.78 % and 73.17 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Holothuria atra	
(all sizes)	282.435 t ± 33.213 t

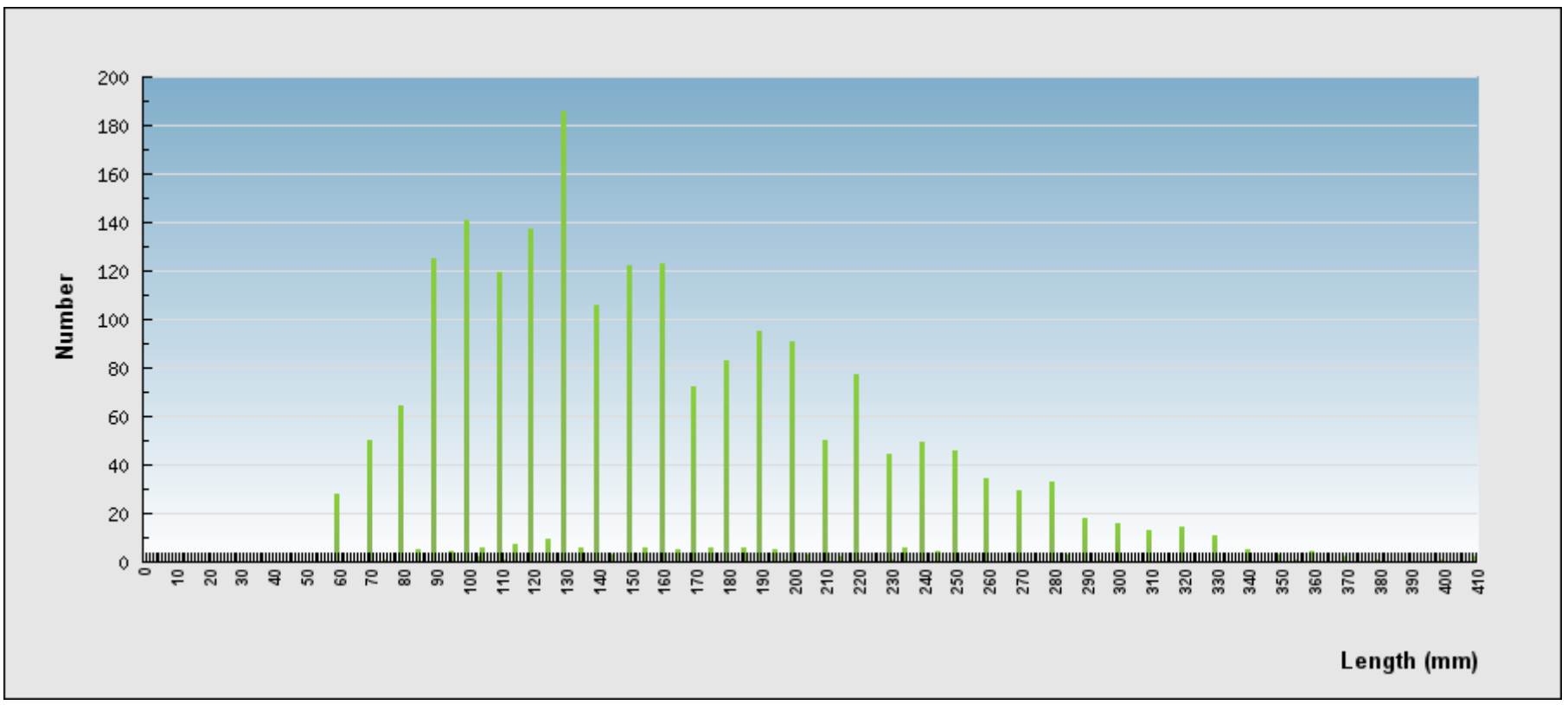
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	102.897 t
Salted and gutted products	51.449 t
Dried products (bêche-de-mer)	5.145 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=2090)



Stichopus chloronotus - ANEITYUM_2013-12

The selected data includes **57 habitat zone(s)** of the study area (**15.88 km²**). The field census occurred from 04/12/2013 to 07/12/2013. **273 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z008 ; Z009 ; Z010 ; Z011 ; Z012 ; Z013 ; Z014 ; Z015 ; Z016 ; Z017 ; Z018 ; Z019 ; Z020 ; Z021 ; Z022 ; Z024 ; Z026 ; Z027 ; Z030 ; Z031 ; Z032 ; Z033 ; Z034 ; Z035 ; Z036 ; Z037 ; Z038 ; Z040 ; Z041 ; Z042 ; Z043 ; Z044 ; Z045 ; Z046 ; Z047 ; Z048 ; Z049 ; Z051 ; Z052 ; Z053 ; Z054 ; Z055 ; Z056 ; Z058 ; Z059 ; Z060 ; Z061 ; Z062 ; Z063 ; Z064 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **37584 kg** (wet) and the conservative total abundance is **319966 individual(s)**. This wet biomass is equivalent to **18792 kg** of gutted and salted products, and **1128 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **201 individual/ha** and **23.7 kg/ha** over the selected habitat zones .

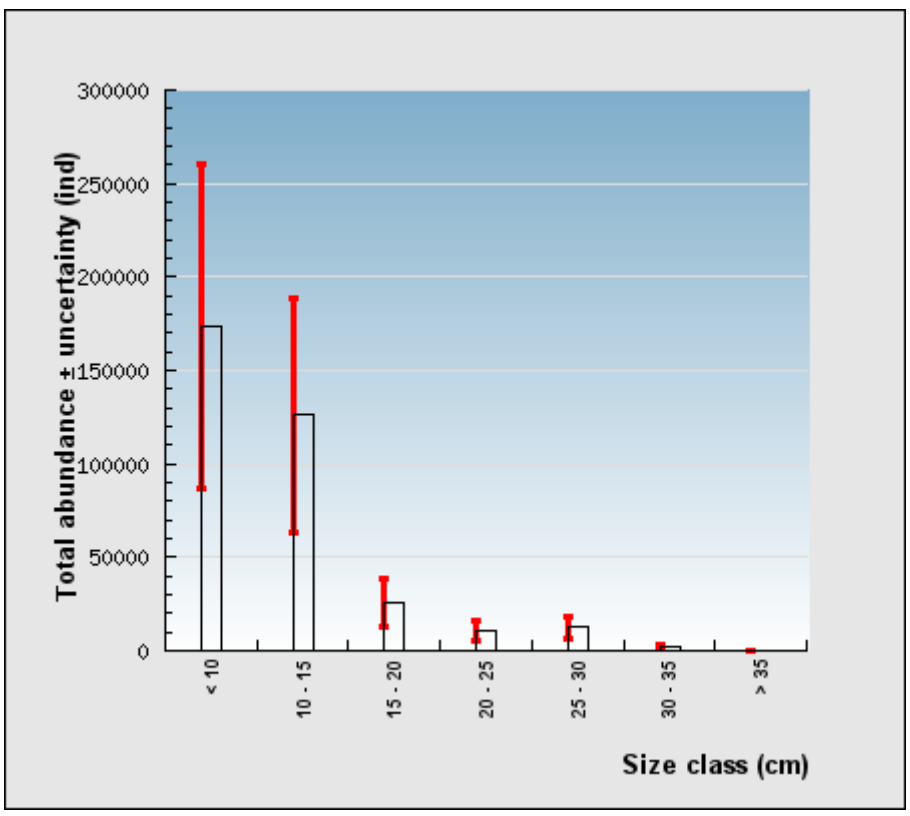
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

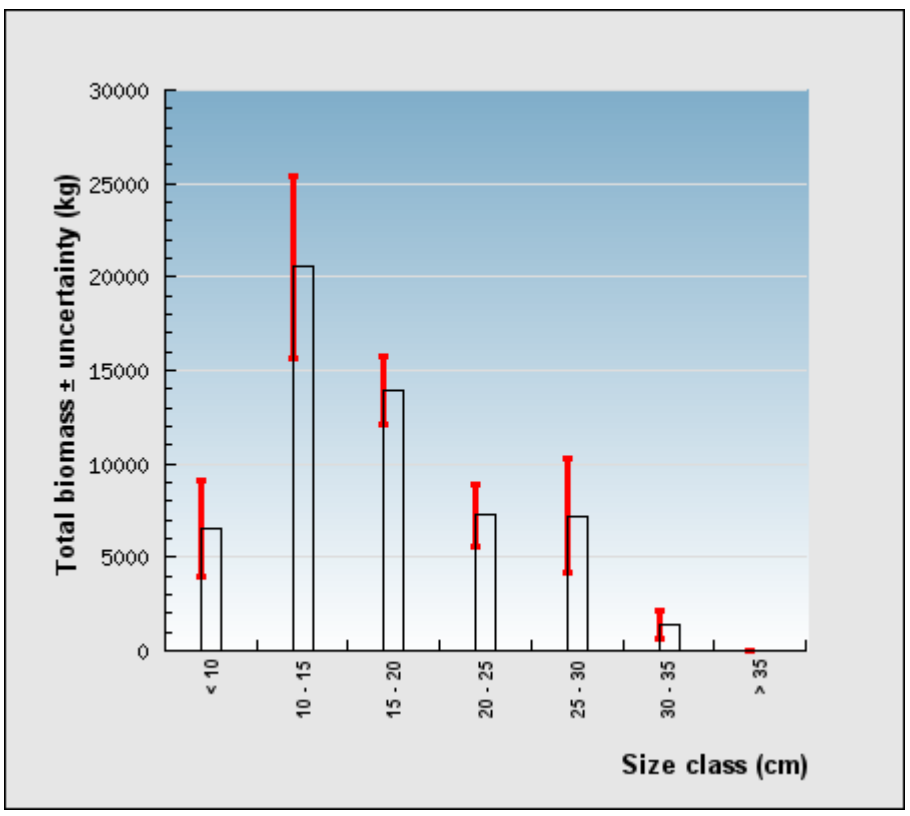
Biological interpretation

Legal-sized individuals (200 mm) represent **18 % of the total stock biomass**. This low proportion is attributable to the common observation of small individuals in the survey compared to adults (see charts below) and is indicative of local recruitment. **Resources may be harvested following the recommended TAC (see table).**

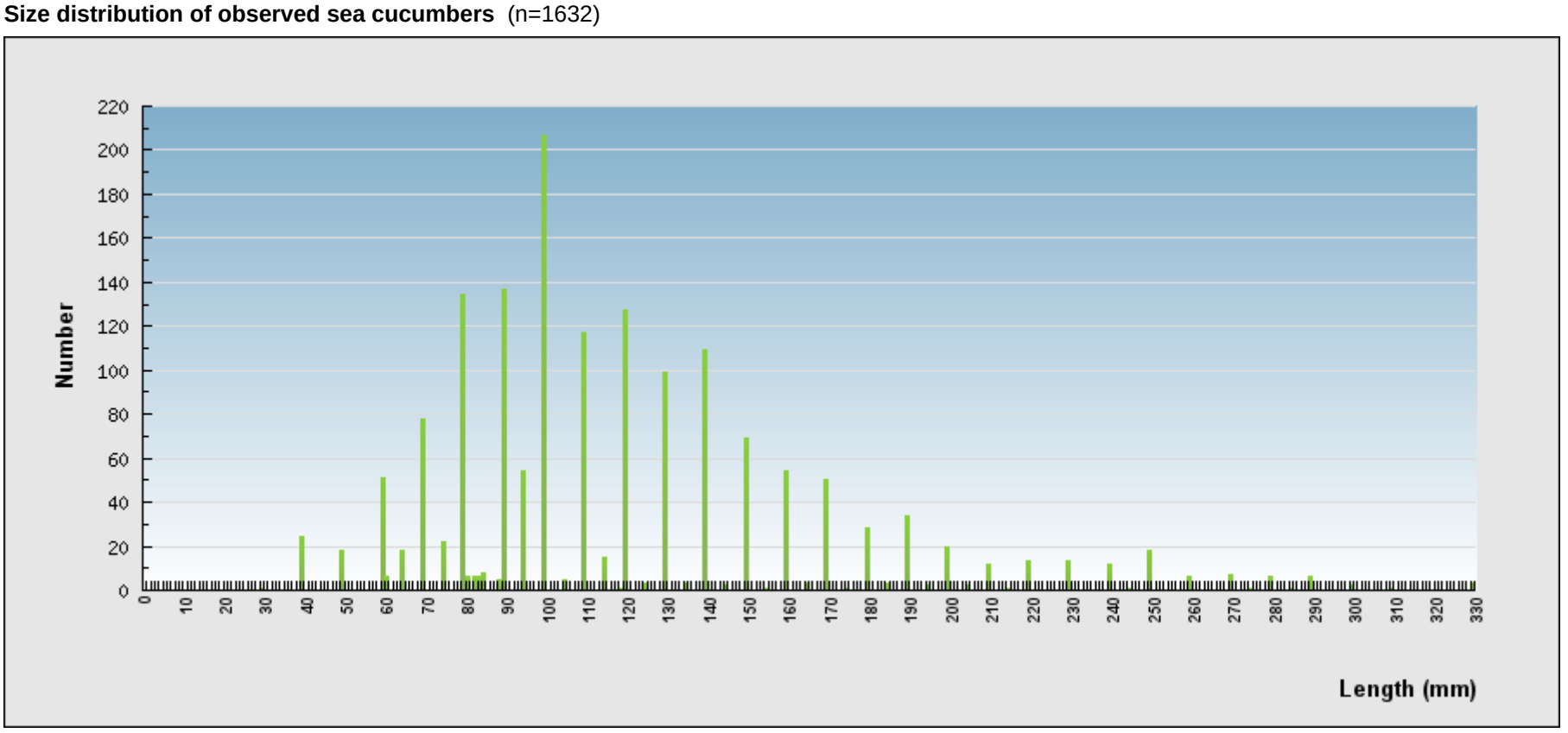
Total stock estimates for Stichopus chloronotus	
(all sizes)	56.806 t ± 19.223 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	6.853 t
Salted and gutted products	3.427 t
Dried products (bêche-de-mer)	0.206 t

Size structure of the whole stock of Stichopus chloronotus





Size distribution of observed sea cucumbers (n=1632)



Holothuria whitmaei - ANEITYUM_2013-12

The selected data includes **16 habitat zone(s)** of the study area (**5.81 km²**). The field census occurred from 04/12/2013 to 07/12/2013. **98 transects** are considered in the results below.

Zones : Z002 ; Z005 ; Z007 ; Z009 ; Z010 ; Z011 ; Z017 ; Z020 ; Z030 ; Z034 ; Z040 ; Z052 ; Z054 ; Z058 ; Z059 ; Z061 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **11302 kg** (wet) and the conservative total abundance is **6202 individual(s)**. This wet biomass is equivalent to **5651 kg** of gutted and salted products, and **1130 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **11 individual/ha** and **19.5 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

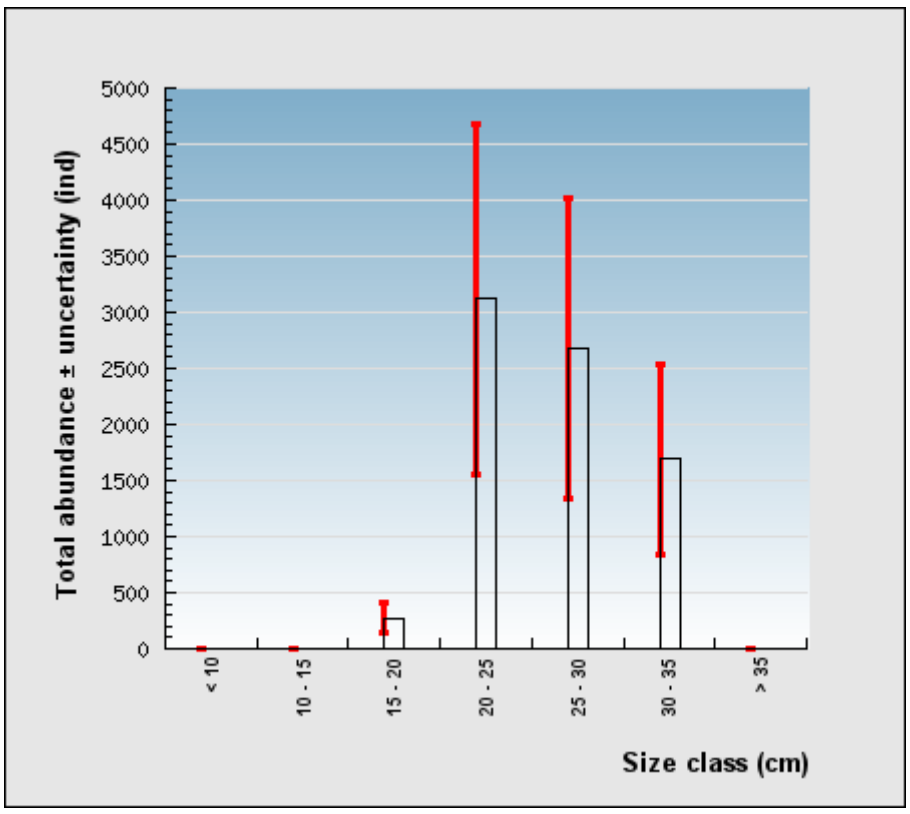
Biological interpretation

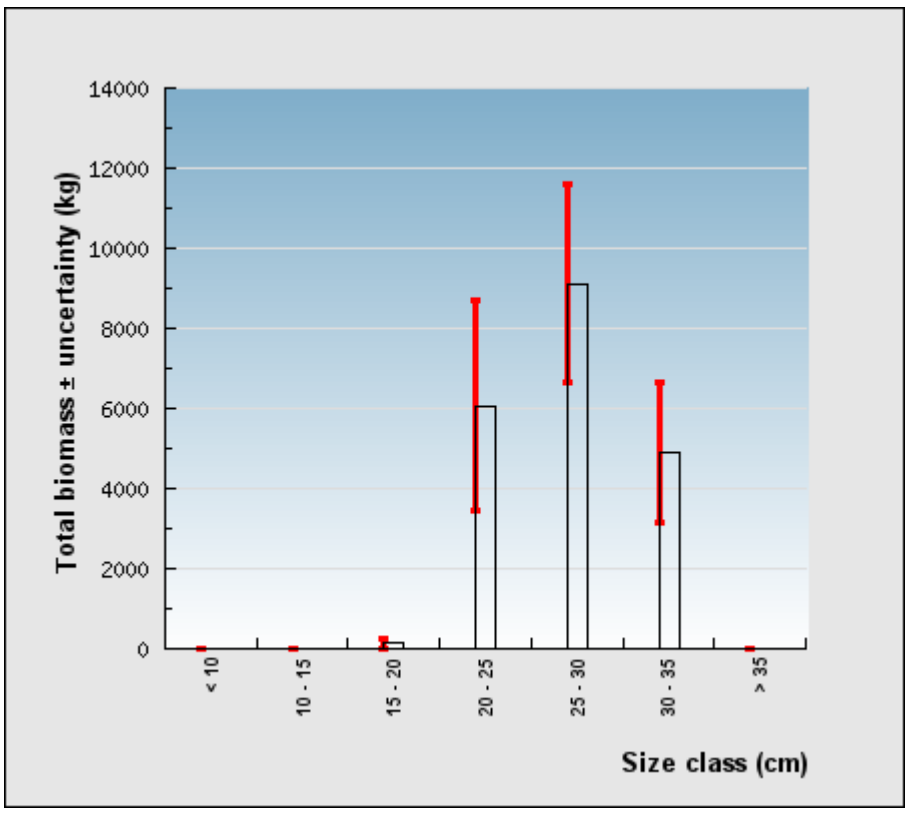
Legal-sized individuals (300 mm) represent **12 % of the total stock biomass**. This low proportion is attributable to the common observation of small individuals in the survey compared to adults (see charts below) and is indicative of local recruitment. **Resources may be harvested following the recommended TAC (see table).**

Total stock estimates for Holothuria whitmaei	
(all sizes)	20.218 t ± 8.917 t

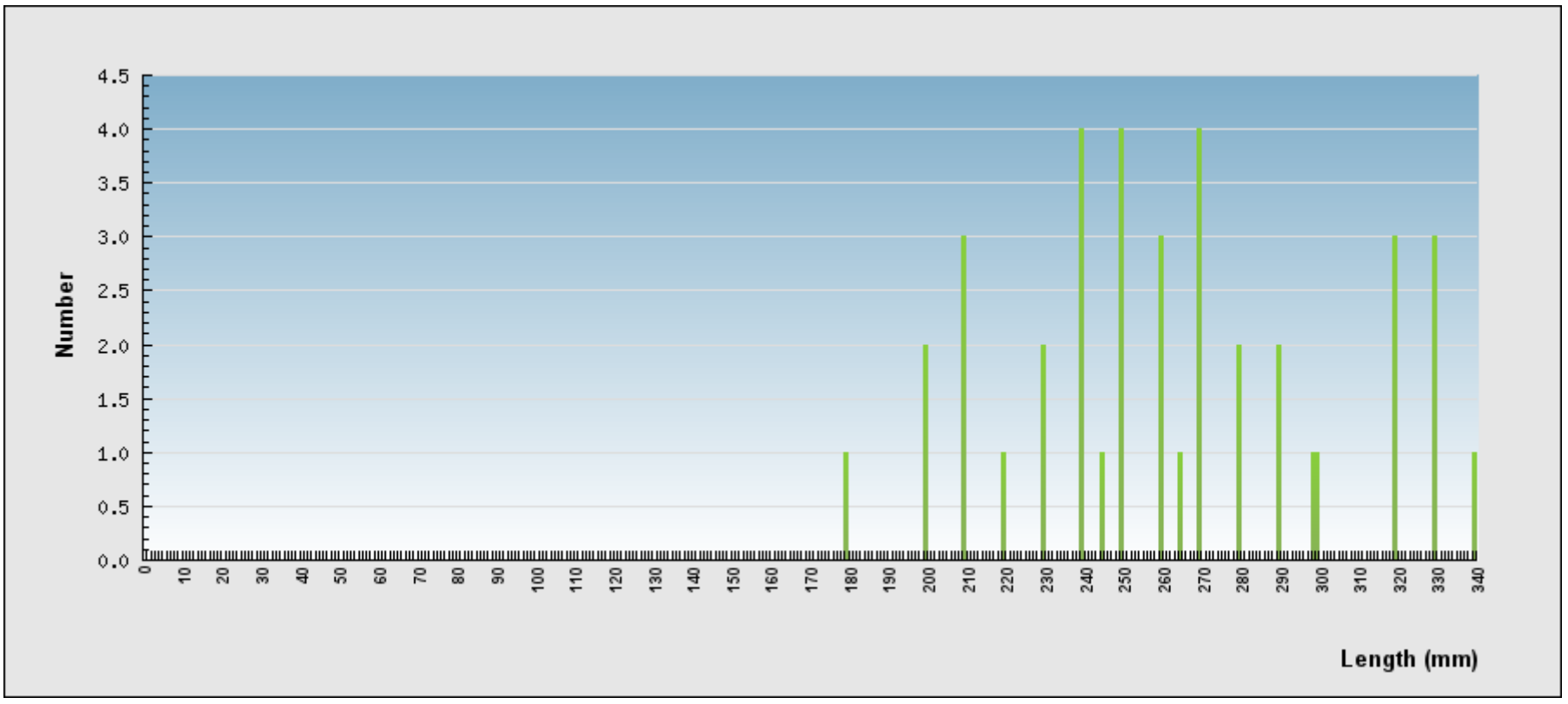
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (300 mm) :	
Fresh/wet products	1.384 t
Salted and gutted products	0.692 t
Dried products (bêche-de-mer)	0.138 t

Size structure of the whole stock of Holothuria whitmaei

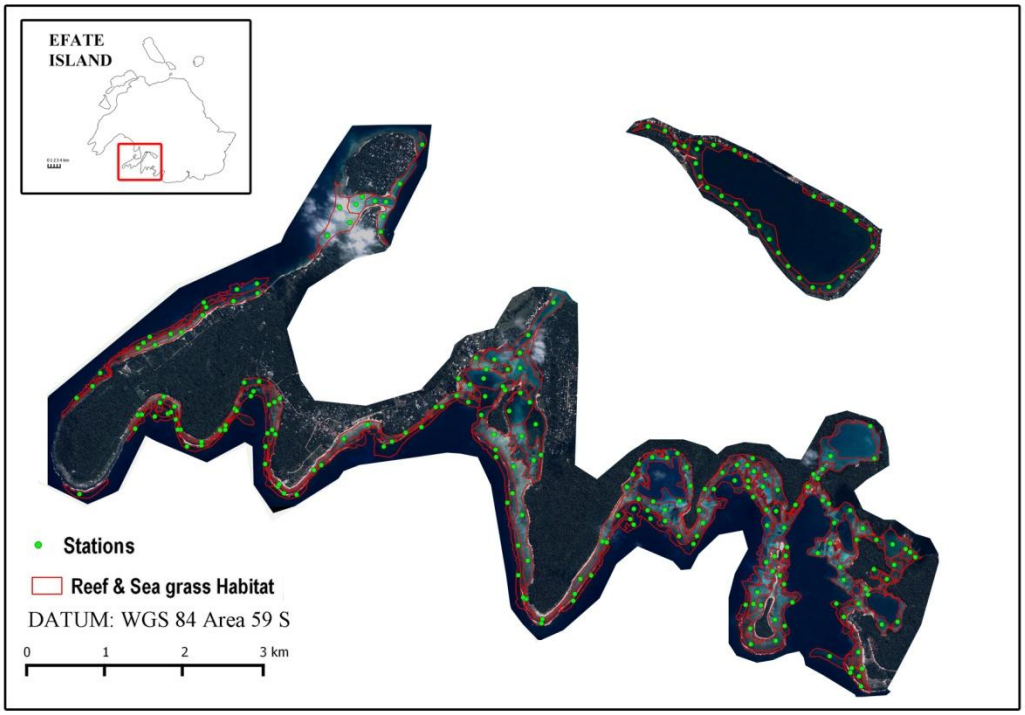




Size distribution of observed sea cucumbers (n=39)



3. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Efate island (South area).



Holothuria atra - EFATE-SOUTH_2013-06

The selected data includes **85 habitat zone(s)** of the study area (**5.83 km²**). The field census occurred from 03/06/2013 to 13/06/2013. **185 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z008 ; Z010 ; Z011 ; Z012 ; Z013 ; Z014 ; Z015 ; Z016 ; Z017 ; Z021 ; Z022 ; Z023 ; Z024 ; Z025 ; Z026 ; Z027 ; Z028 ; Z029 ; Z030 ; Z031 ; Z032 ; Z033 ; Z034 ; Z035 ; Z036 ; Z037 ; Z038 ; Z040 ; Z041 ; Z043 ; Z044 ; Z045 ; Z046 ; Z047 ; Z048 ; Z049 ; Z050 ; Z051 ; Z052 ; Z053 ; Z054 ; Z055 ; Z056 ; Z057 ; Z058 ; Z059 ; Z060 ; Z061 ; Z062 ; Z063 ; Z064 ; Z065 ; Z066 ; Z067 ; Z068 ; Z069 ; Z070 ; Z071 ; Z072 ; Z073 ; Z074 ; Z075 ; Z076 ; Z078 ; Z079 ; Z080 ; Z082 ; Z083 ; Z084 ; Z085 ; Z086 ; Z087 ; Z088 ; Z089 ; Z090 ; Z092 ; Z093 ; Z094 ;

Outlying transects (removed from analysis) : T045;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **11073 kg** (wet) and the conservative total abundance is **52490 individual(s)**. This wet biomass is equivalent to **5536 kg** of gutted and salted products, and **554 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **90 individual/ha** and **19 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

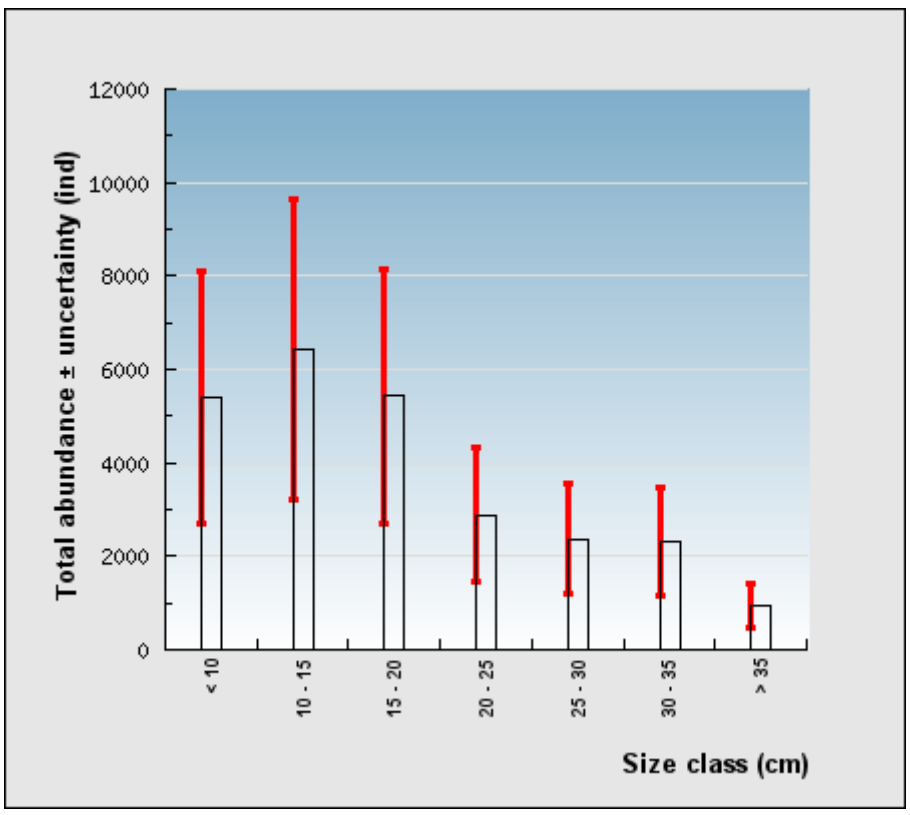
Biological interpretation

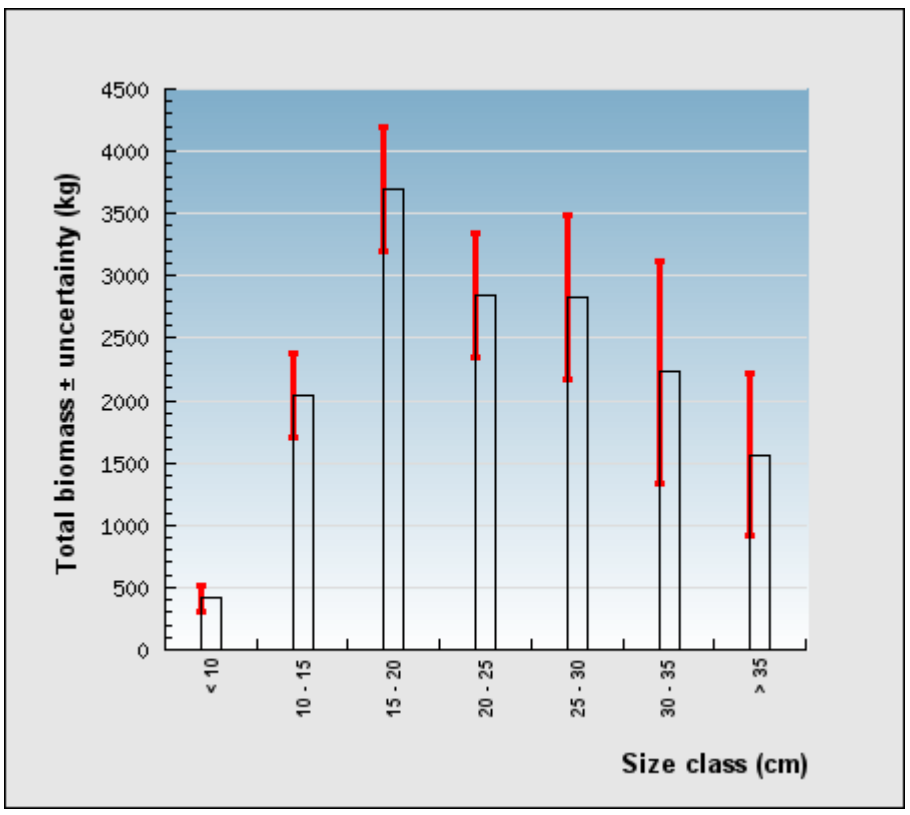
Legal-sized individuals (200 mm) represent **47 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 42.55 % and 63.83 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Holothuria atra	
(all sizes)	15.608 t ± 4.535 t

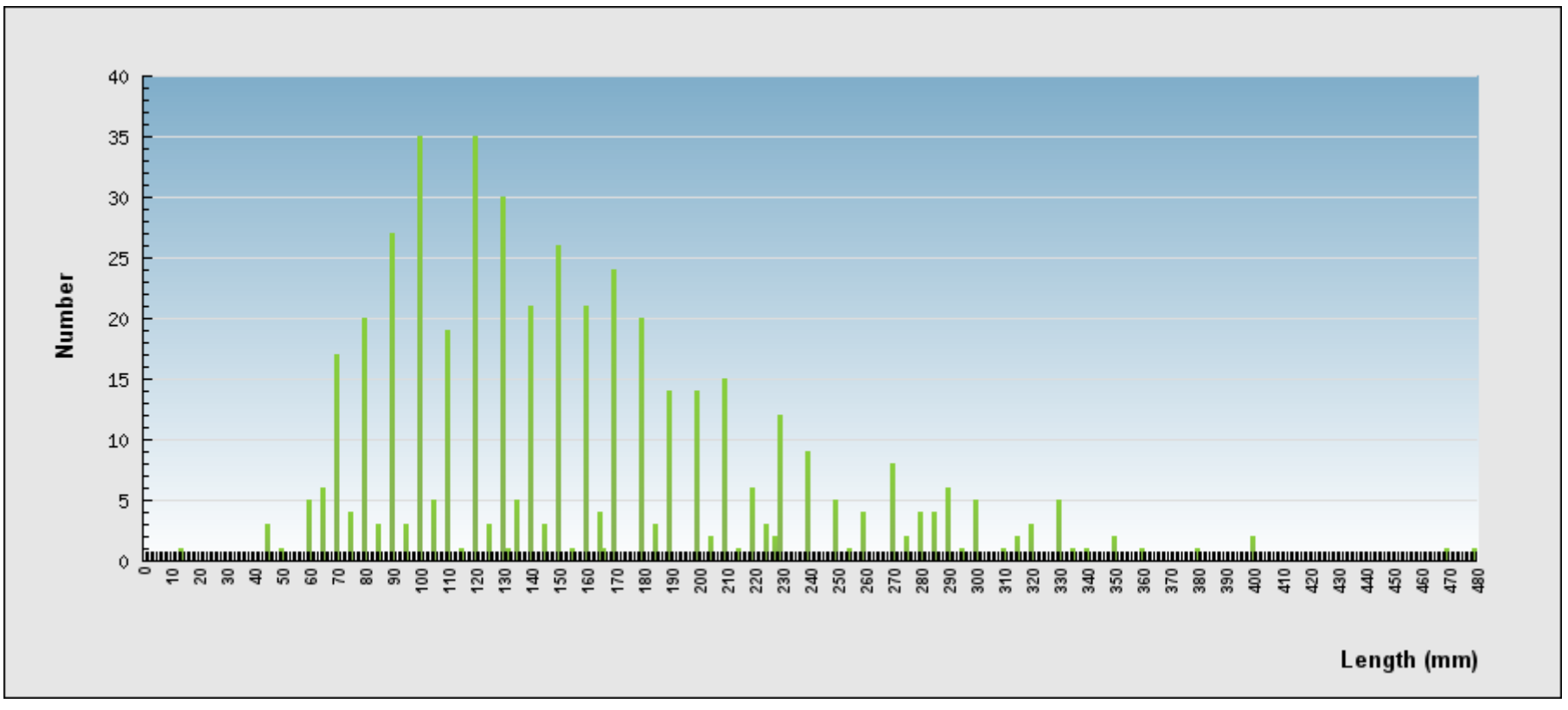
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	5.198 t
Salted and gutted products	2.599 t
Dried products (bêche-de-mer)	0.26 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=487)



Bohadschia vitiensis - EFATE-SOUTH_2013-06

The selected data includes **32 habitat zone(s)** of the study area (**2.5 km²**). The field census occurred from 03/06/2013 to 13/06/2013. **74 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z015 ; Z023 ; Z024 ; Z025 ; Z026 ; Z027 ; Z030 ; Z035 ; Z043 ; Z044 ; Z046 ; Z047 ; Z048 ; Z049 ; Z050 ; Z051 ; Z055 ; Z056 ; Z058 ; Z066 ; Z067 ; Z068 ; Z069 ; Z075 ; Z078 ; Z083 ; Z090 ; Z092 ; Z093 ; Z094 ;

Outlying transects (removed from analysis) : T205;T211;T208;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **6391 kg** (wet) and the conservative total abundance is **13123 individual(s)**. This wet biomass is equivalent to **3195 kg** of gutted and salted products, and **256 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **52 individual/ha** and **25.5 kg/ha** over the selected habitat zones .

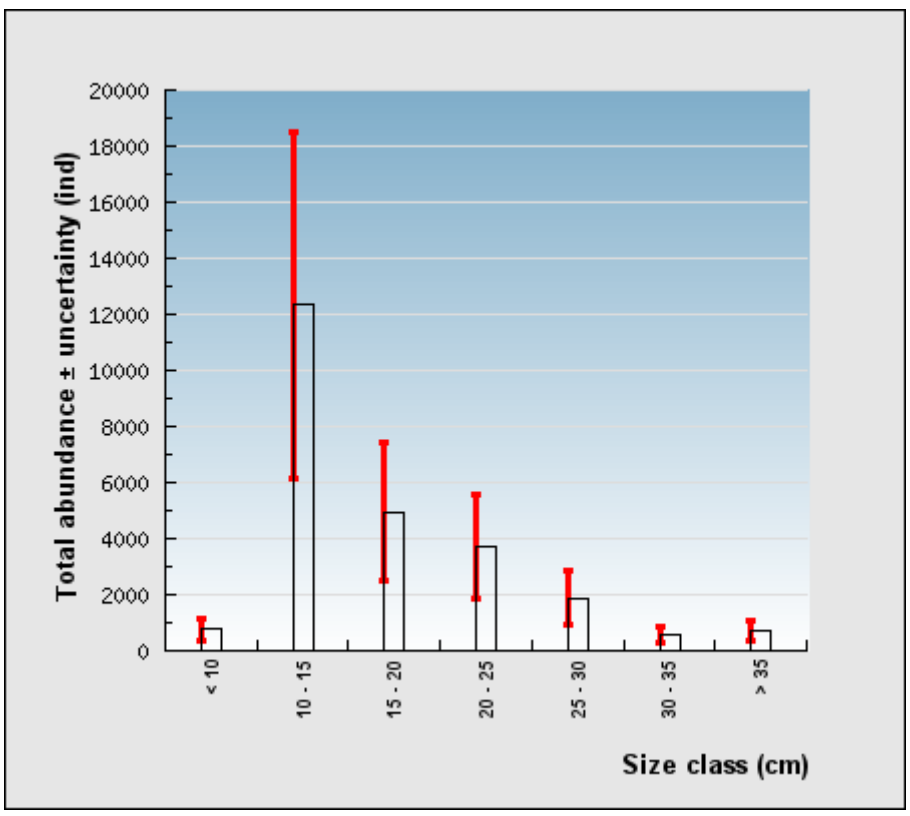
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

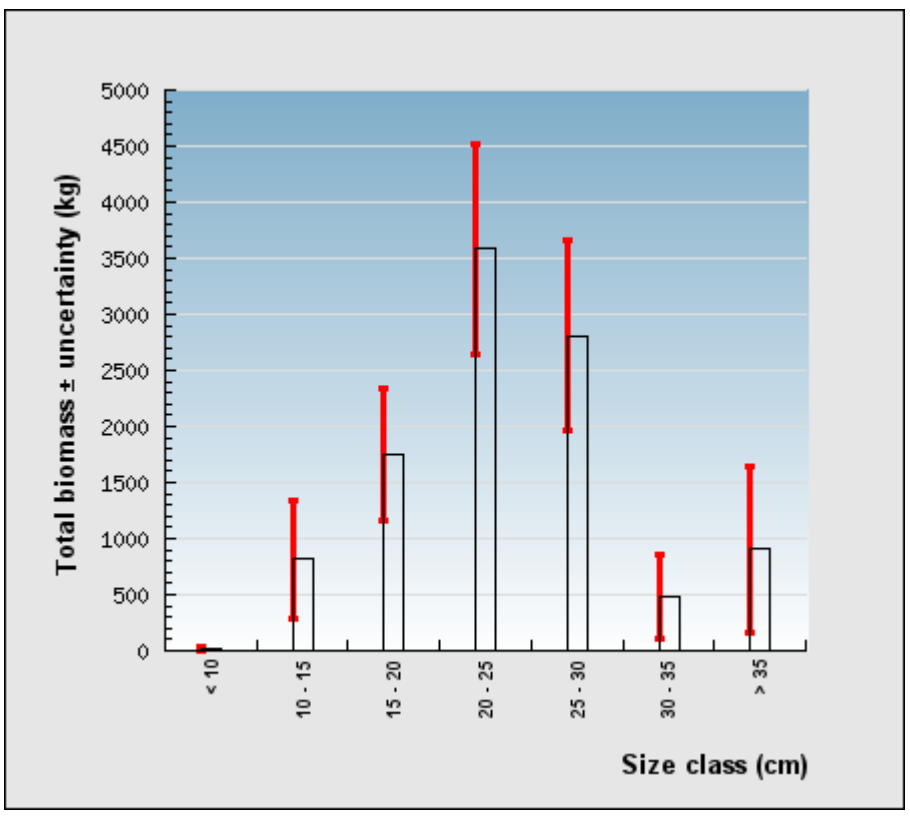
Biological interpretation

Legal-sized individuals (250 mm) represent **26 % of the total stock biomass**. This low proportion is attributable to the common observation of small individuals in the survey compared to adults (see charts below) and is indicative of local recruitment. **Resources may be harvested following the recommended TAC (see table).**

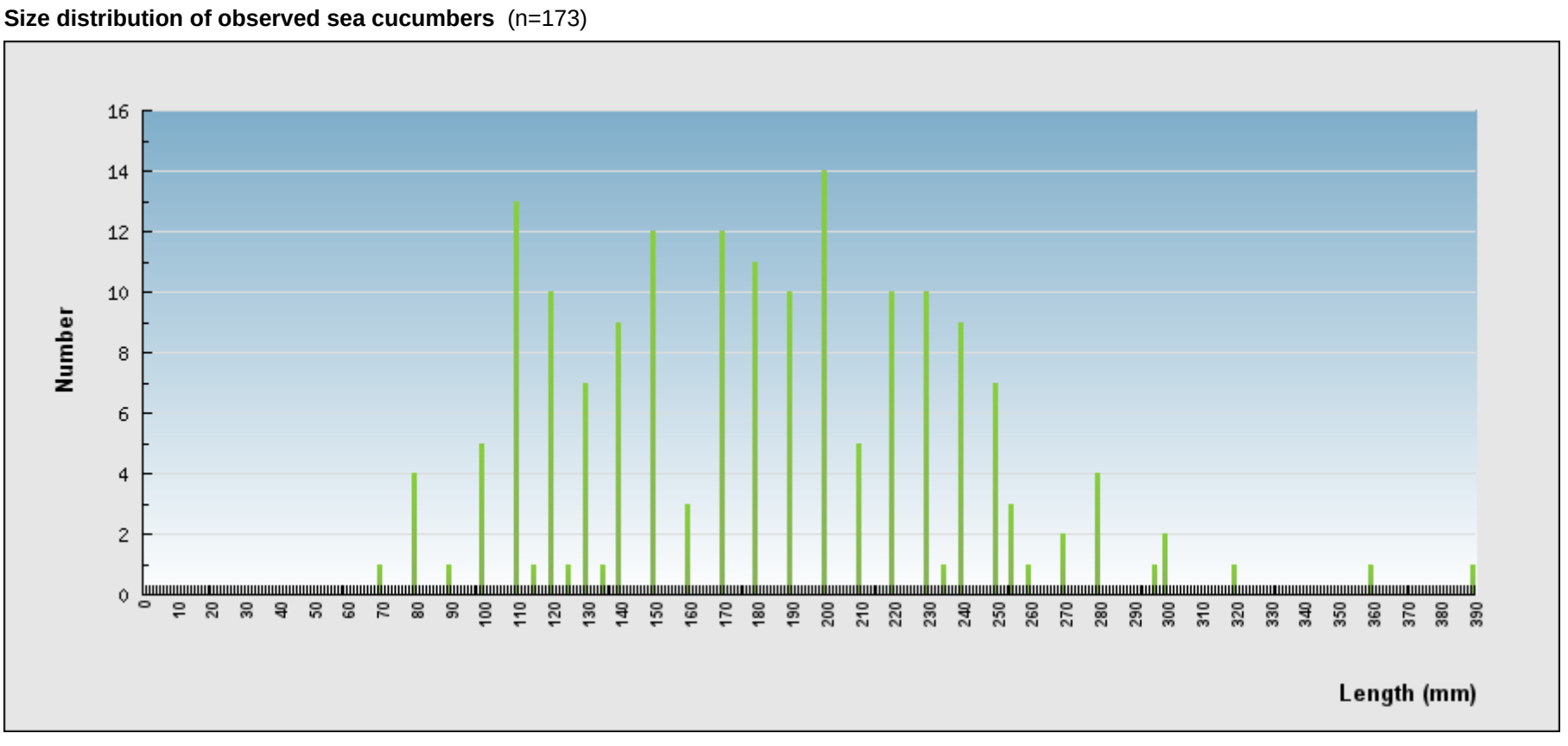
Total stock estimates for Bohadschia vitiensis	
(all sizes)	10.354 t ± 3.964 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (250 mm) :	
Fresh/wet products	1.65 t
Salted and gutted products	0.825 t
Dried products (bêche-de-mer)	0.066 t

Size structure of the whole stock of Bohadschia vitiensis

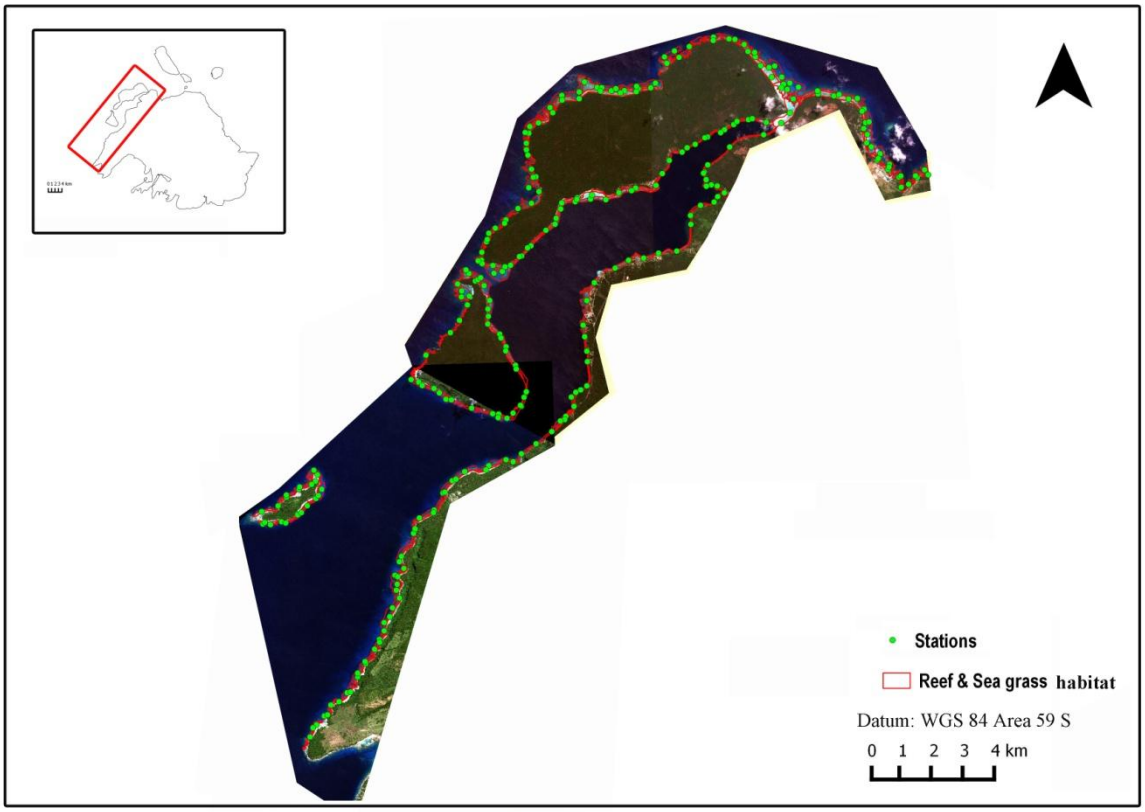




Size distribution of observed sea cucumbers (n=173)



4. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Efate island (Northwest area).



Holothuria atra - EFATE-WEST_2013-02

The selected data includes **54 habitat zone(s)** of the study area (**7.29 km²**). The field census occurred from 11/02/2013 to 20/03/2013. **163 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z005 ; Z006 ; Z007 ; Z008 ; Z010 ; Z011 ; Z012 ; Z013 ; Z015 ; Z016 ; Z022 ; Z026 ; Z029 ; Z030 ; Z034 ; Z035 ; Z036 ; Z037 ; Z039 ; Z040 ; Z041 ; Z042 ; Z044 ; Z045 ; Z050 ; Z052 ; Z066 ; Z067 ; Z069 ; Z070 ; Z072 ; Z073 ; Z074 ; Z075 ; Z076 ; Z077 ; Z078 ; Z079 ; Z080 ; Z081 ; Z082 ; Z084 ; Z087 ; Z088 ; Z089 ; Z090 ; Z092 ; Z094 ; Z095 ; Z096 ; Z098 ;

Outlying transects (removed from analysis) : T070;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **17710 kg** (wet) and the conservative total abundance is **66463 individual(s)**. This wet biomass is equivalent to **8855 kg** of gutted and salted products, and **886 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **91 individual/ha** and **24.3 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

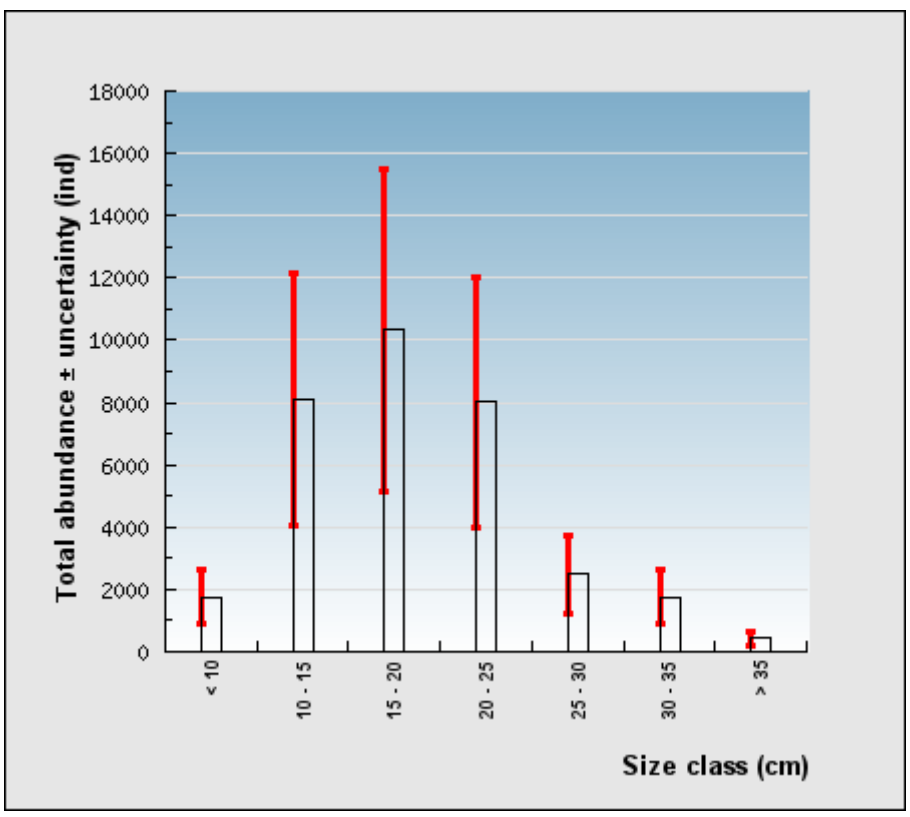
Biological interpretation

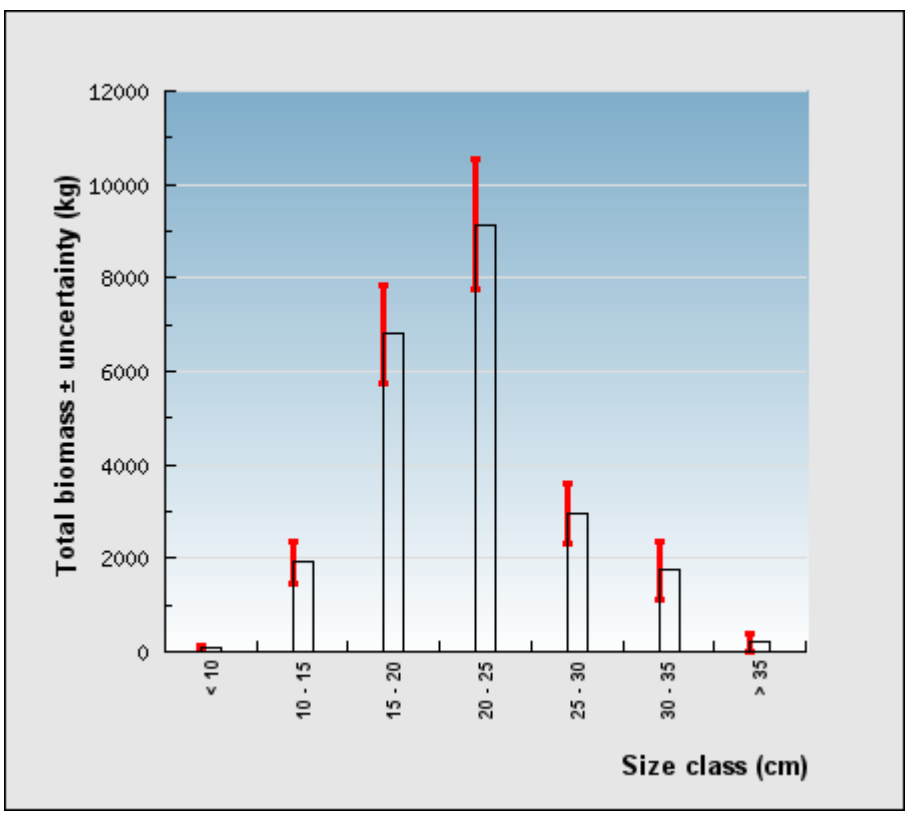
Legal-sized individuals (200 mm) represent **59 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 33.9 % and 50.85 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for *Holothuria atra*	
(all sizes)	22.838 t ± 5.128 t

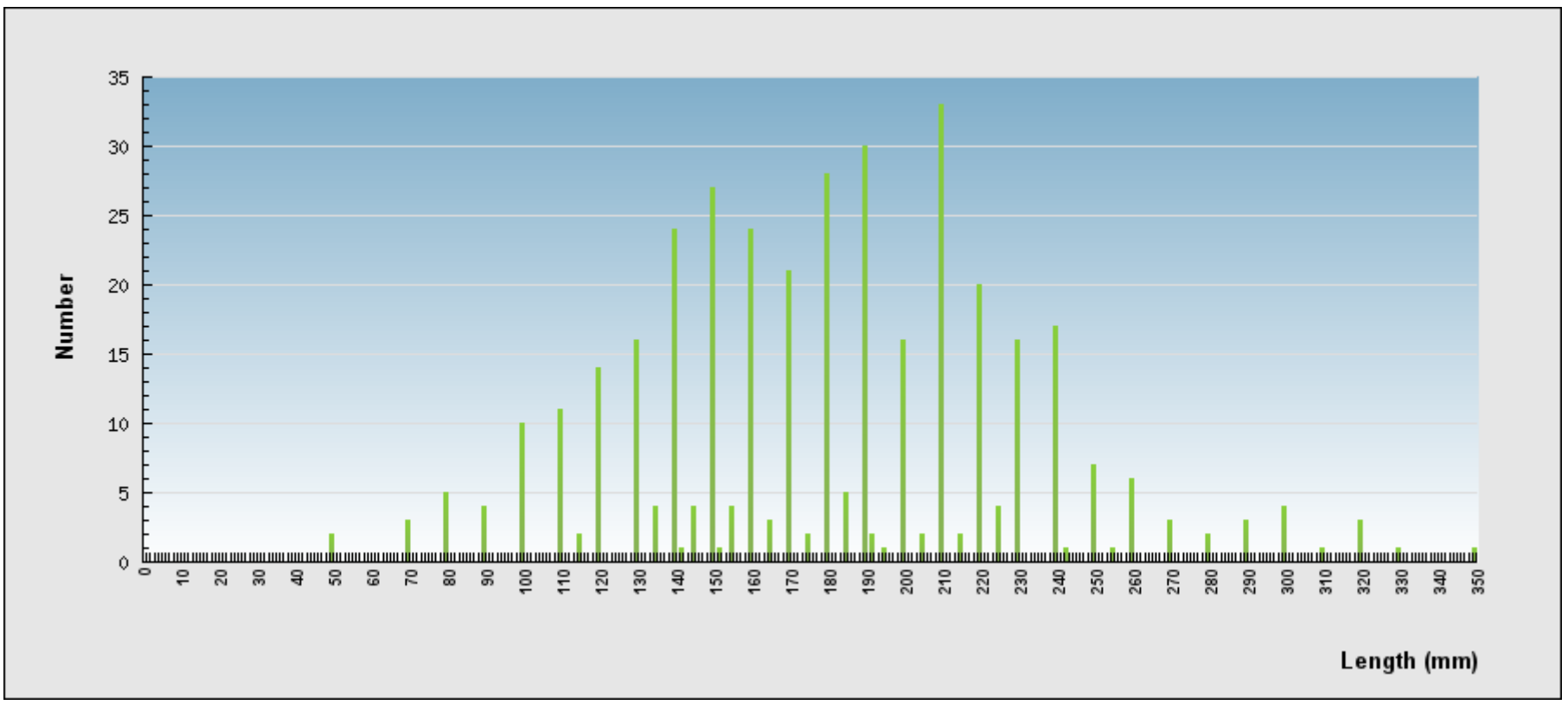
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	10.435 t
Salted and gutted products	5.218 t
Dried products (bêche-de-mer)	0.522 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=391)



Stichopus chloronotus - EFATE-WEST_2013-02

The selected data includes **45 habitat zone(s)** of the study area (**5.83 km²**). The field census occurred from 11/02/2013 to 20/03/2013. **131 transects** are considered in the results below.

Zones : Z001 ; Z009 ; Z010 ; Z012 ; Z015 ; Z016 ; Z017 ; Z023 ; Z026 ; Z035 ; Z037 ; Z040 ; Z041 ; Z042 ; Z043 ; Z044 ; Z045 ; Z048 ; Z053 ; Z055 ; Z057 ; Z060 ; Z063 ; Z064 ; Z067 ; Z069 ; Z070 ; Z071 ; Z072 ; Z073 ; Z074 ; Z075 ; Z076 ; Z077 ; Z079 ; Z080 ; Z082 ; Z087 ; Z089 ; Z092 ; Z094 ; Z095 ; Z096 ; Z098 ; Z101 ;
Outlying transects (removed from analysis) : T188;T193;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **9583 kg** (wet) and the conservative total abundance is **36963 individual(s)**. This wet biomass is equivalent to **4792 kg** of gutted and salted products, and **287 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **63 individual/ha** and **16.4 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

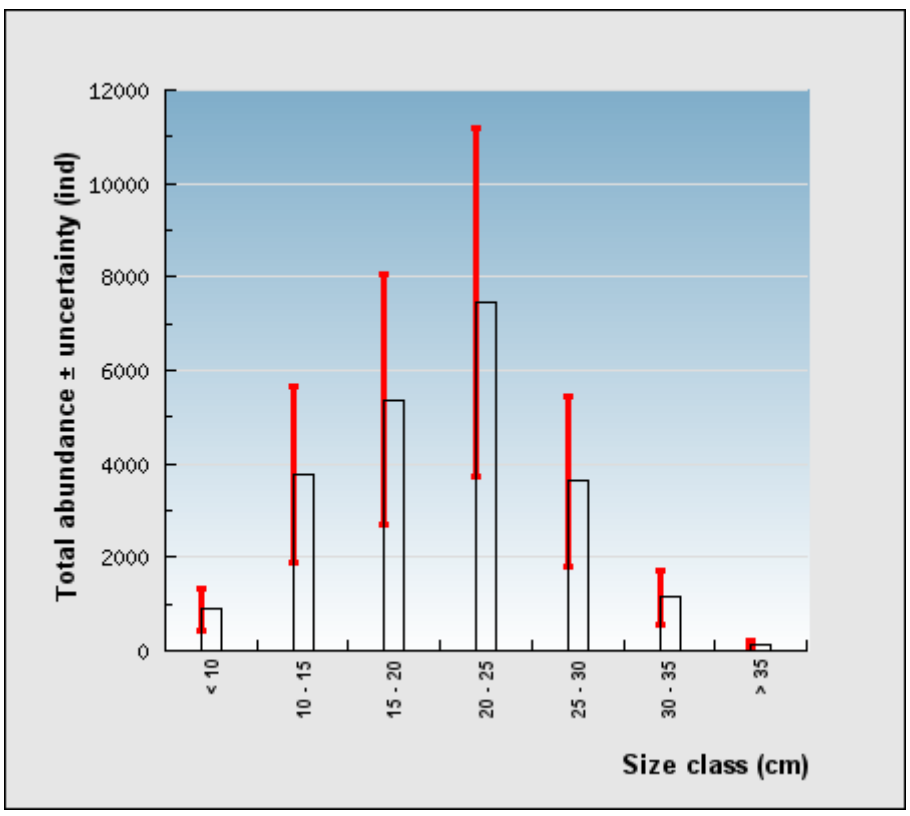
Biological interpretation

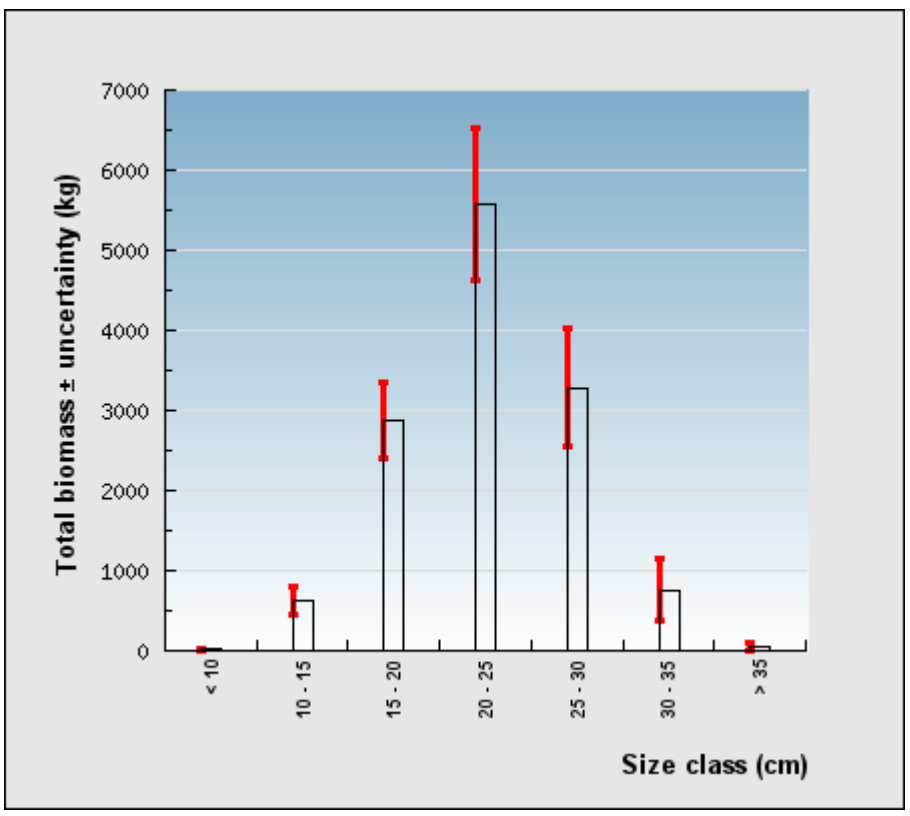
Legal-sized individuals (200 mm) represent **70 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 28.57 % and 42.86 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for *Stichopus chloronotus*	
(all sizes)	13.186 t ± 3.603 t

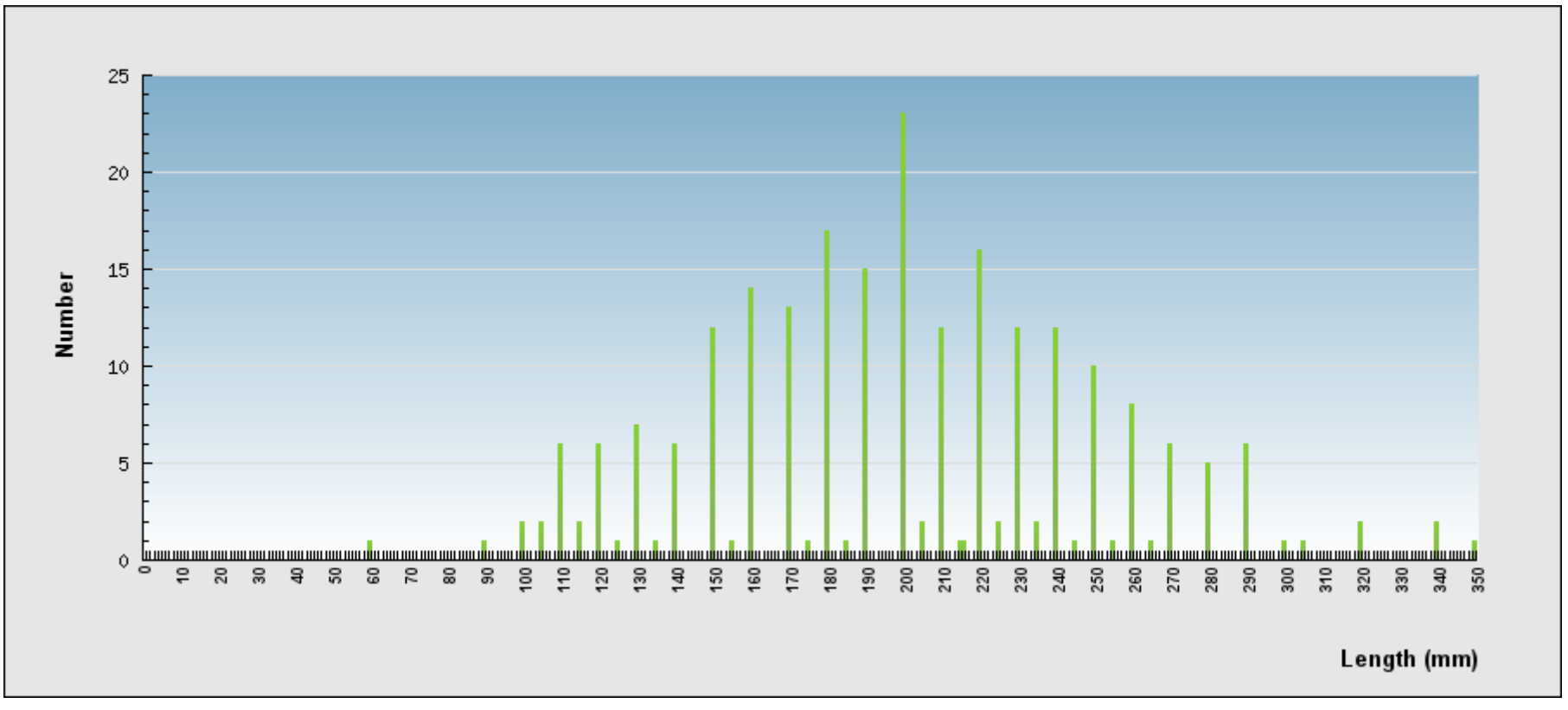
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	6.712 t
Salted and gutted products	3.356 t
Dried products (bêche-de-mer)	0.201 t

Size structure of the whole stock of Stichopus chloronotus

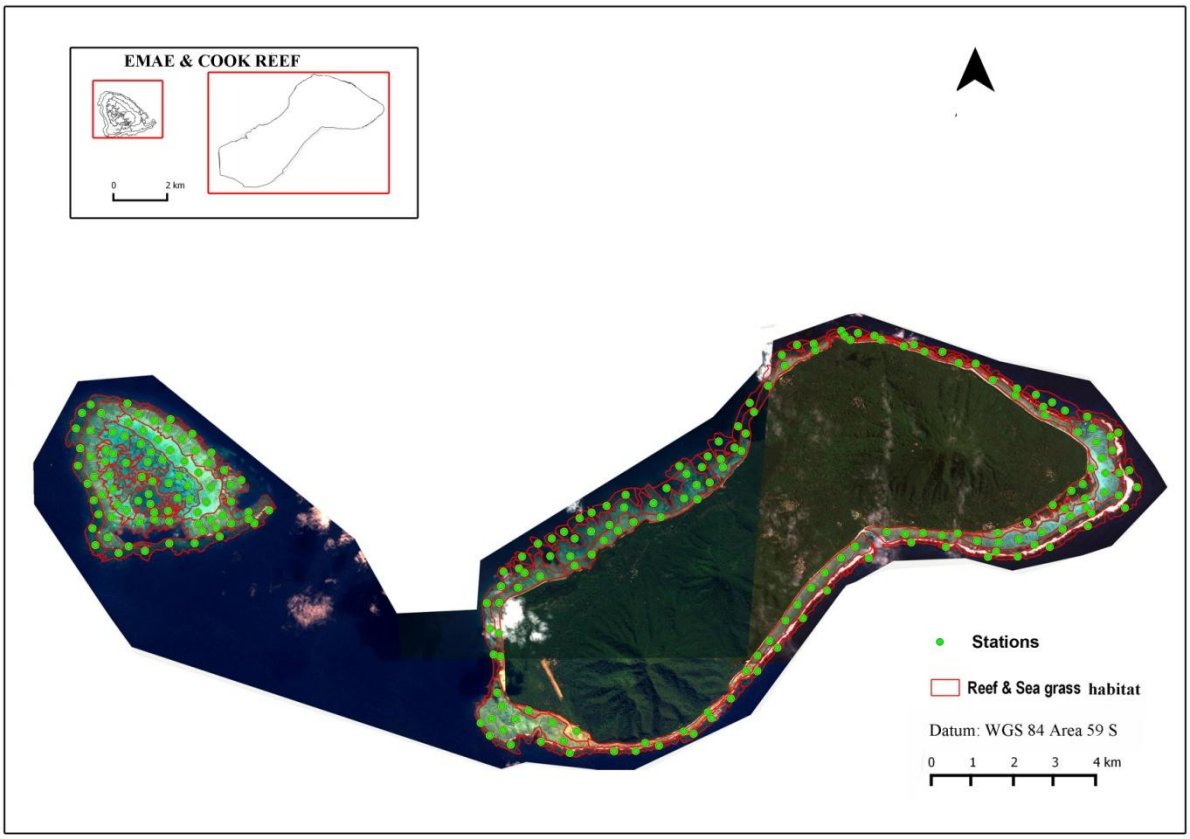




Size distribution of observed sea cucumbers (n=237)



5. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Emae island and Cook reef.



Holothuria atra - EMAE-COOK-REEF_2014-05

The selected data includes **23 habitat zone(s)** of the study area (**13.1 km²**). The field census occurred from 13/05/2014 to 17/05/2014. **150 transects** are considered in the results below.

Zones : Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z010 ; Z011 ; Z016 ; Z018 ; Z019 ; Z020 ; Z021 ; Z022 ; Z025 ; Z026 ; Z027 ; Z029 ; Z030 ; Z033 ; Z034 ; Z035 ; Z038 ; Z039 ;
Outlying transects (removed from analysis) : T011;T016;T017;T018;T019;T020;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **65210 kg** (wet) and the conservative total abundance is **233356 individual(s)**. This wet biomass is equivalent to **32605 kg** of gutted and salted products, and **3260 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **178 individual/ha** and **49.7 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

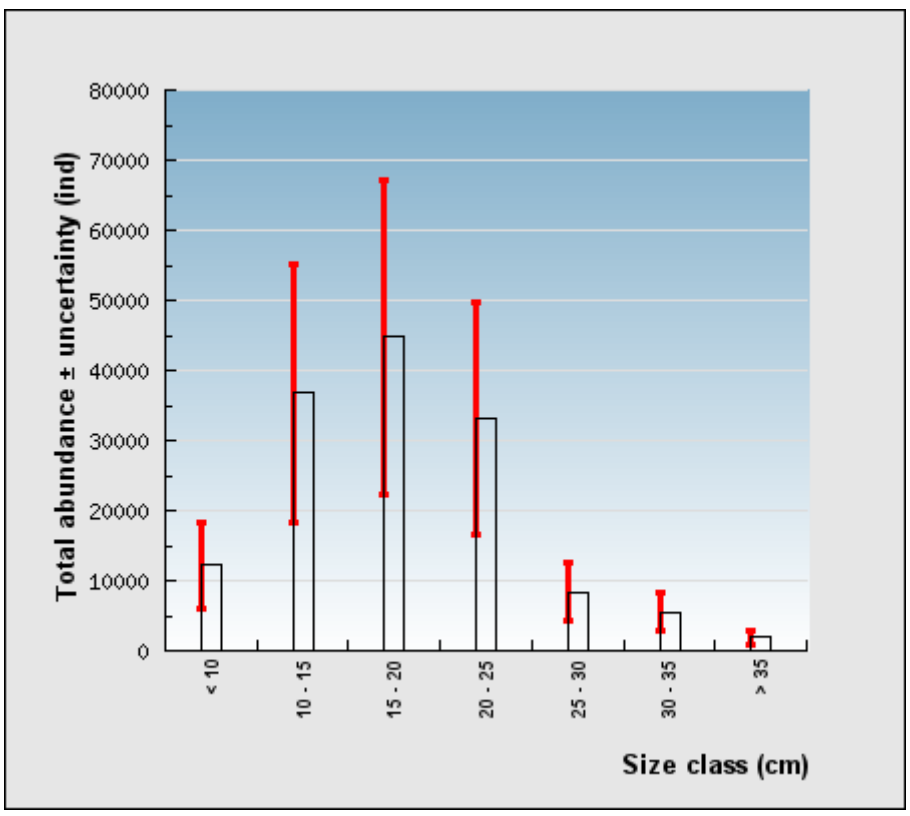
Biological interpretation

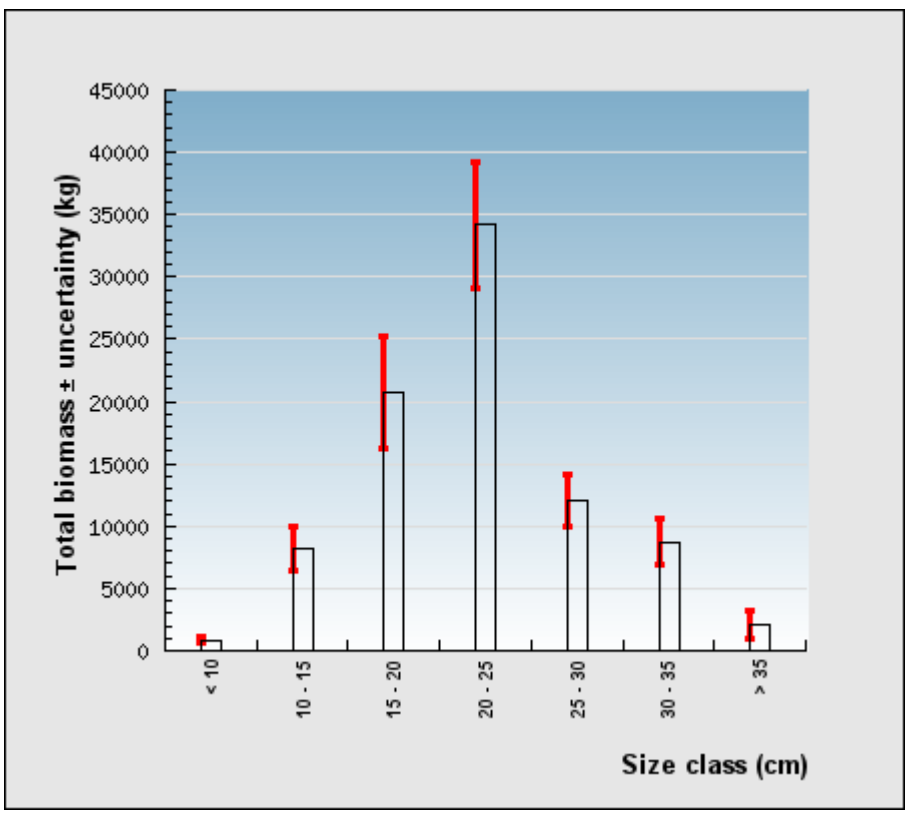
Legal-sized individuals (200 mm) represent **69 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 28.99 % and 43.49 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Holothuria atra	
(all sizes)	86.772 t ± 21.562 t

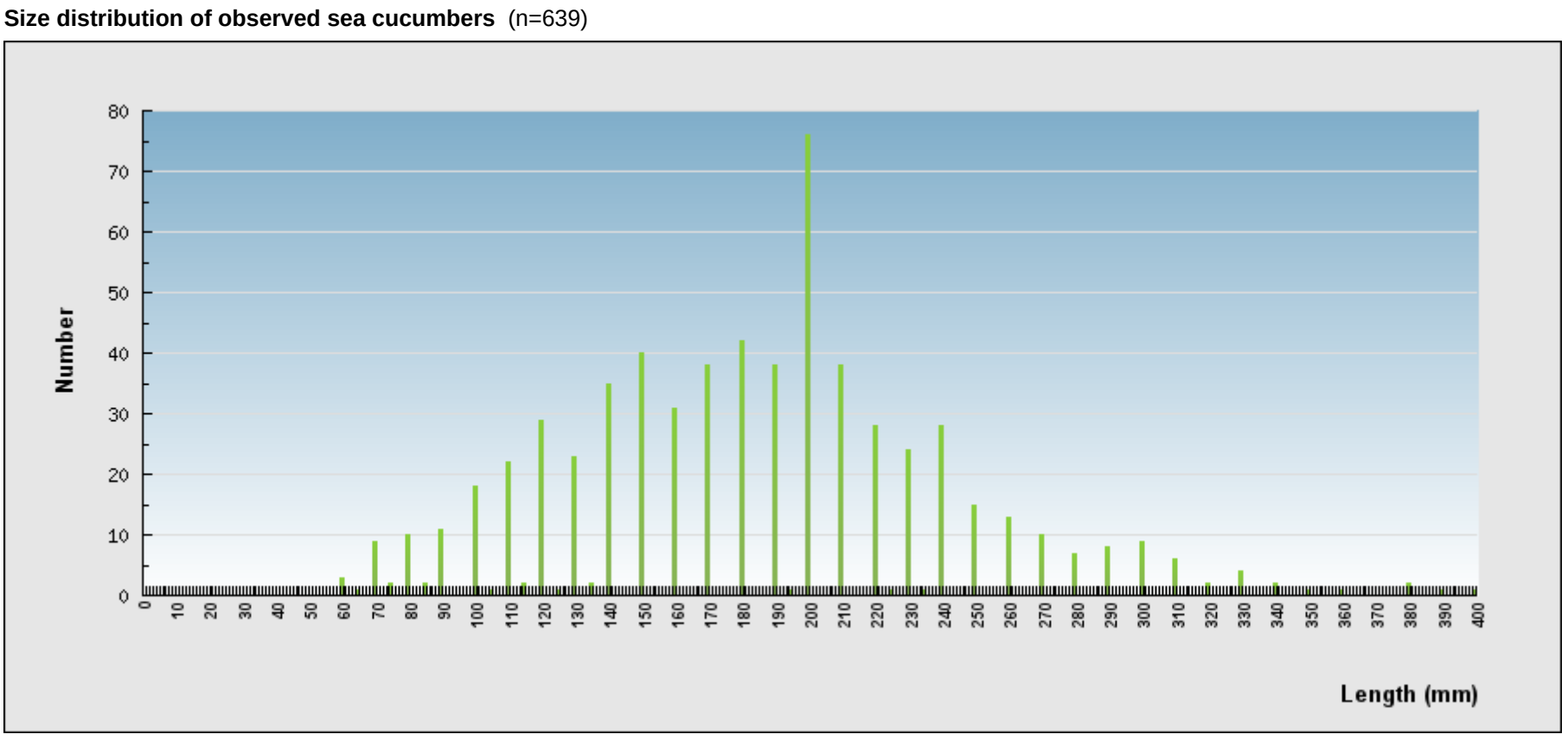
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	45.071 t
Salted and gutted products	22.536 t
Dried products (bêche-de-mer)	2.254 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=639)



Bohadschia argus - EMAE-COOK-REEF_2014-05

The selected data includes **20 habitat zone(s)** of the study area (**11.68 km²**). The field census occurred from 13/05/2014 to 17/05/2014. **154 transects** are considered in the results below.

Zones : Z003 ; Z004 ; Z005 ; Z007 ; Z011 ; Z017 ; Z020 ; Z021 ; Z022 ; Z025 ; Z026 ; Z027 ; Z028 ; Z030 ; Z031 ; Z032 ; Z033 ; Z034 ; Z035 ; Z039 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **15413 kg** (wet) and the conservative total abundance is **22939 individual(s)**. This wet biomass is equivalent to **7706 kg** of gutted and salted products, and **617 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **20 individual/ha** and **13.2 kg/ha** over the selected habitat zones .

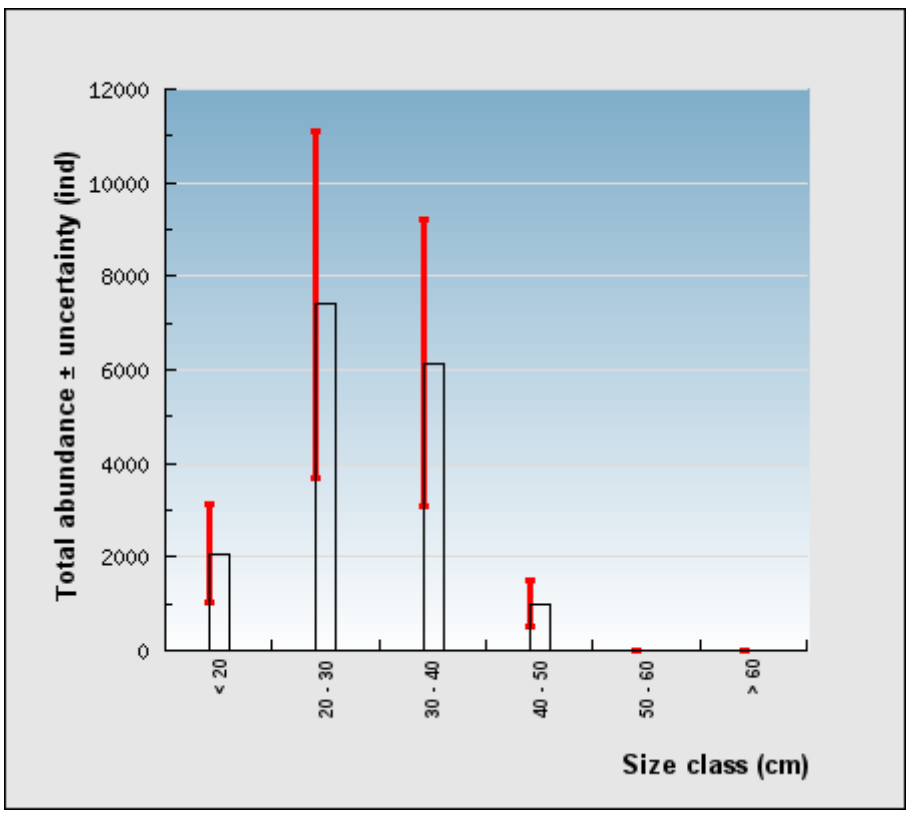
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

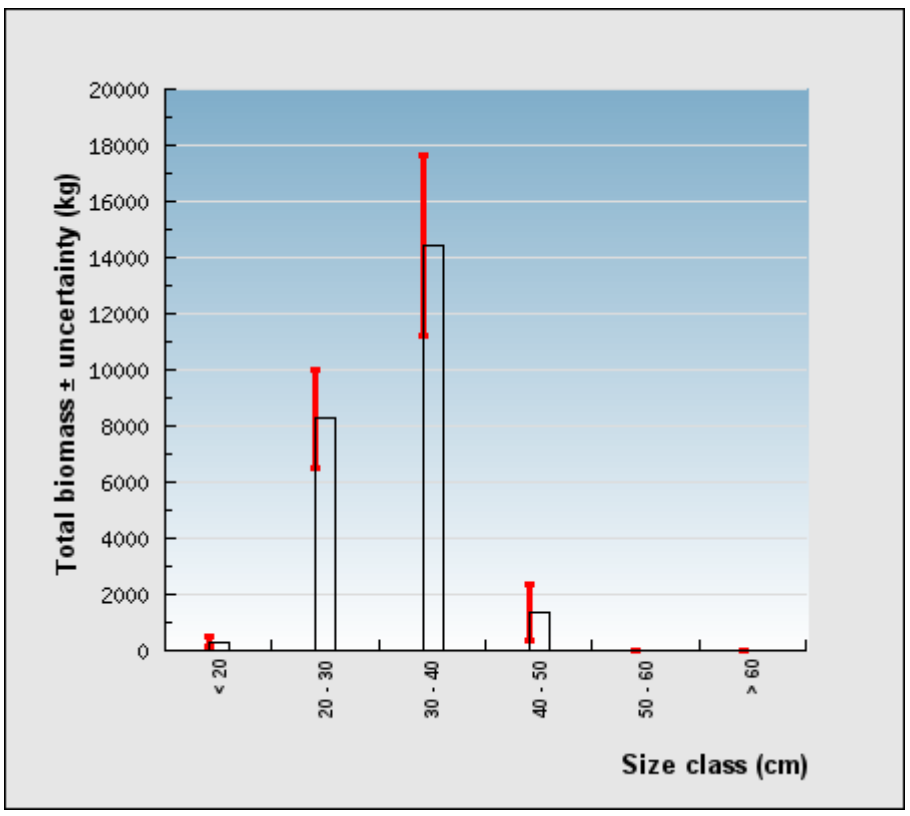
Biological interpretation

Legal-sized individuals (300 mm) represent **54 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 37.04 % and 55.56 % of the estimated TAC (see table) as a precautionary approach.**

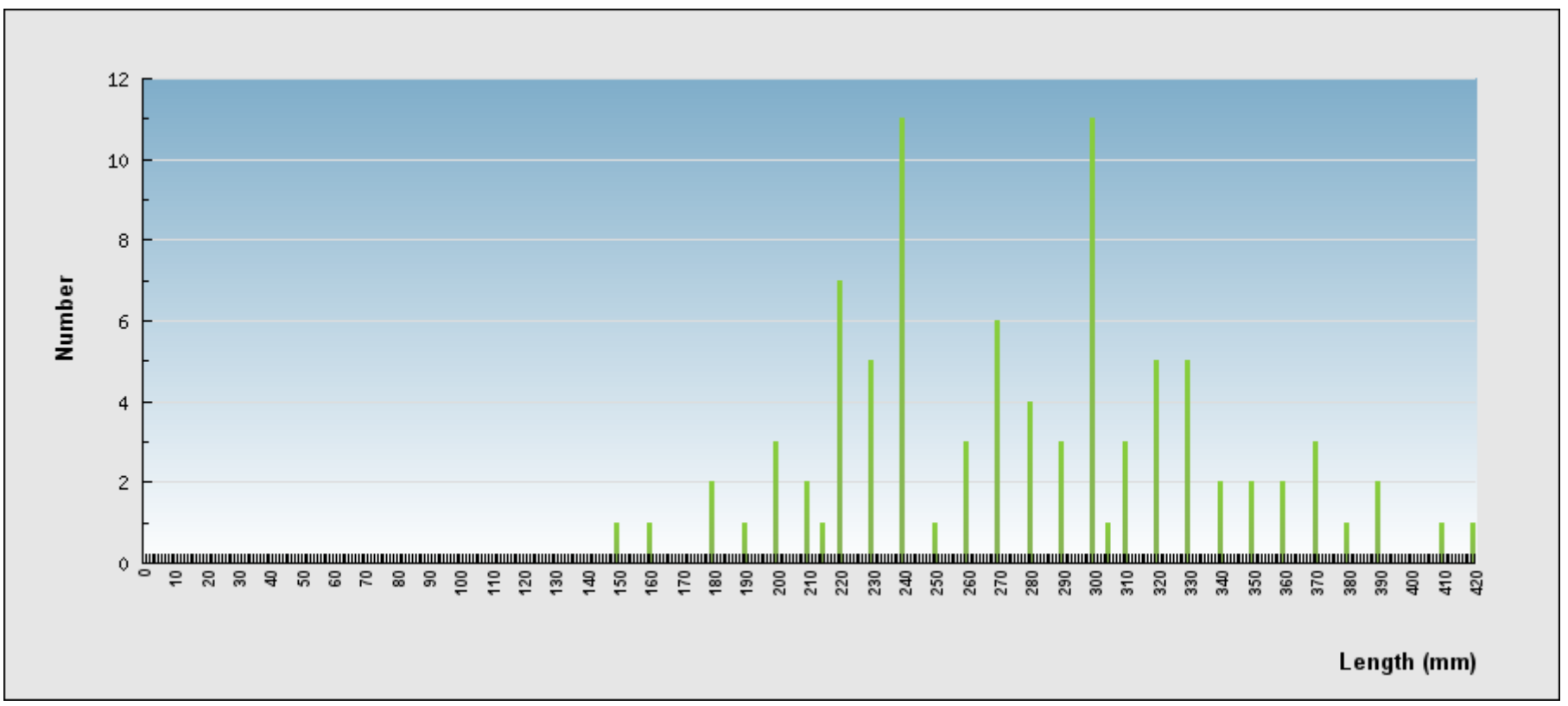
Total stock estimates for Bohadschia argus	
(all sizes)	24.383 t ± 8.97 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (300 mm) :	
Fresh/wet products	8.289 t
Salted and gutted products	4.144 t
Dried products (bêche-de-mer)	0.332 t

Size structure of the whole stock of Bohadschia argus





Size distribution of observed sea cucumbers (n=90)



Holothuria whitmaei - EMAE-COOK-REEF_2014-05

The selected data includes **18 habitat zone(s)** of the study area (**10.26 km²**). The field census occurred from 13/05/2014 to 17/05/2014. **127 transects** are considered in the results below.

Zones : Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z011 ; Z017 ; Z019 ; Z020 ; Z021 ; Z024 ; Z027 ; Z028 ; Z030 ; Z031 ; Z033 ; Z038 ; Z039 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **39488 kg** (wet) and the conservative total abundance is **25821 individual(s)**. This wet biomass is equivalent to **19744 kg** of gutted and salted products, and **3949 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **25 individual/ha** and **38.5 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

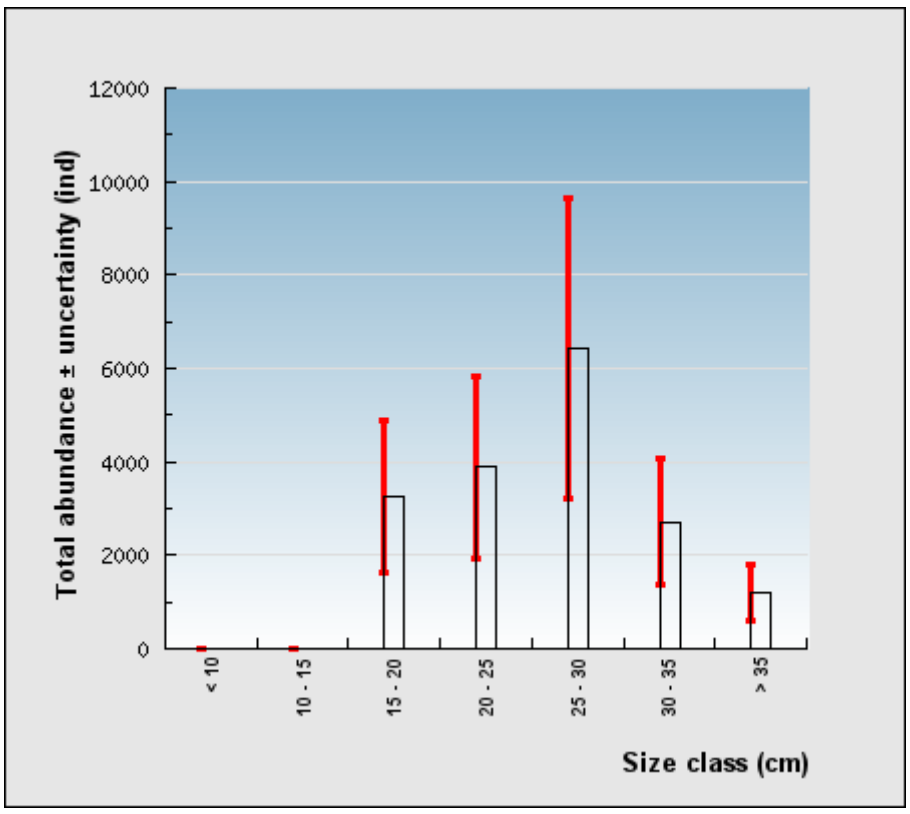
Biological interpretation

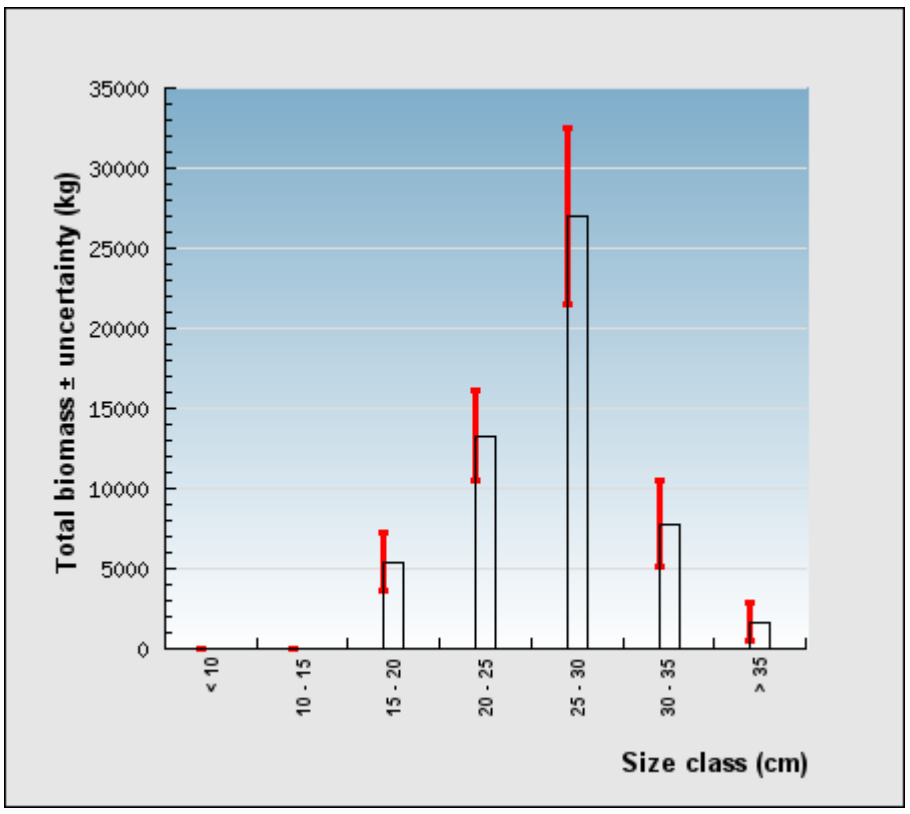
Legal-sized individuals (300 mm) represent **9 % of the total stock biomass** . This low proportion is attributable to the common observation of small individuals in the survey compared to adults (see charts below) and is indicative of local recruitment. **Resources may be harvested following the recommended TAC (see table).**

Total stock estimates for Holothuria whitmaei	
(all sizes)	55.064 t ± 15.575 t

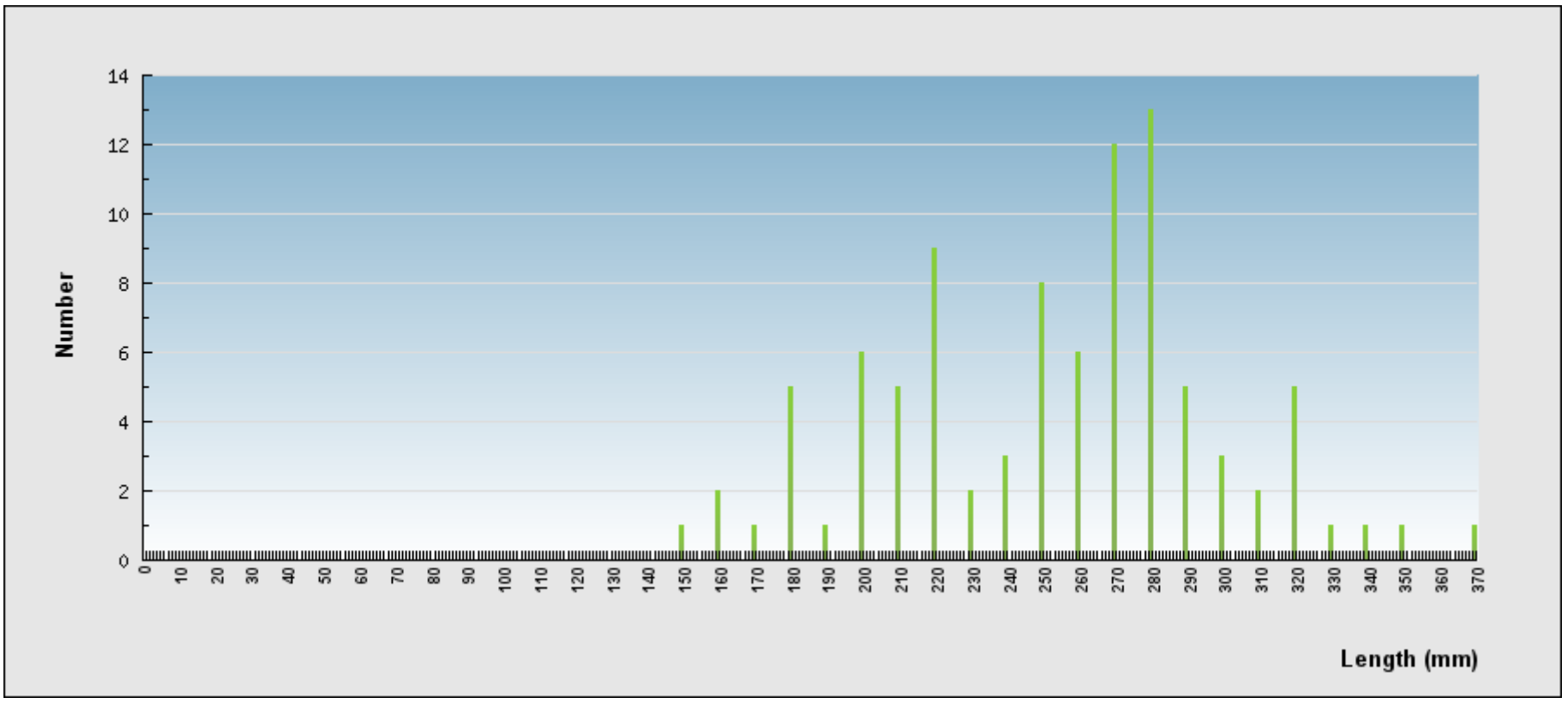
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (300 mm) :	
Fresh/wet products	3.659 t
Salted and gutted products	1.83 t
Dried products (bêche-de-mer)	0.366 t

Size structure of the whole stock of Holothuria whitmaei

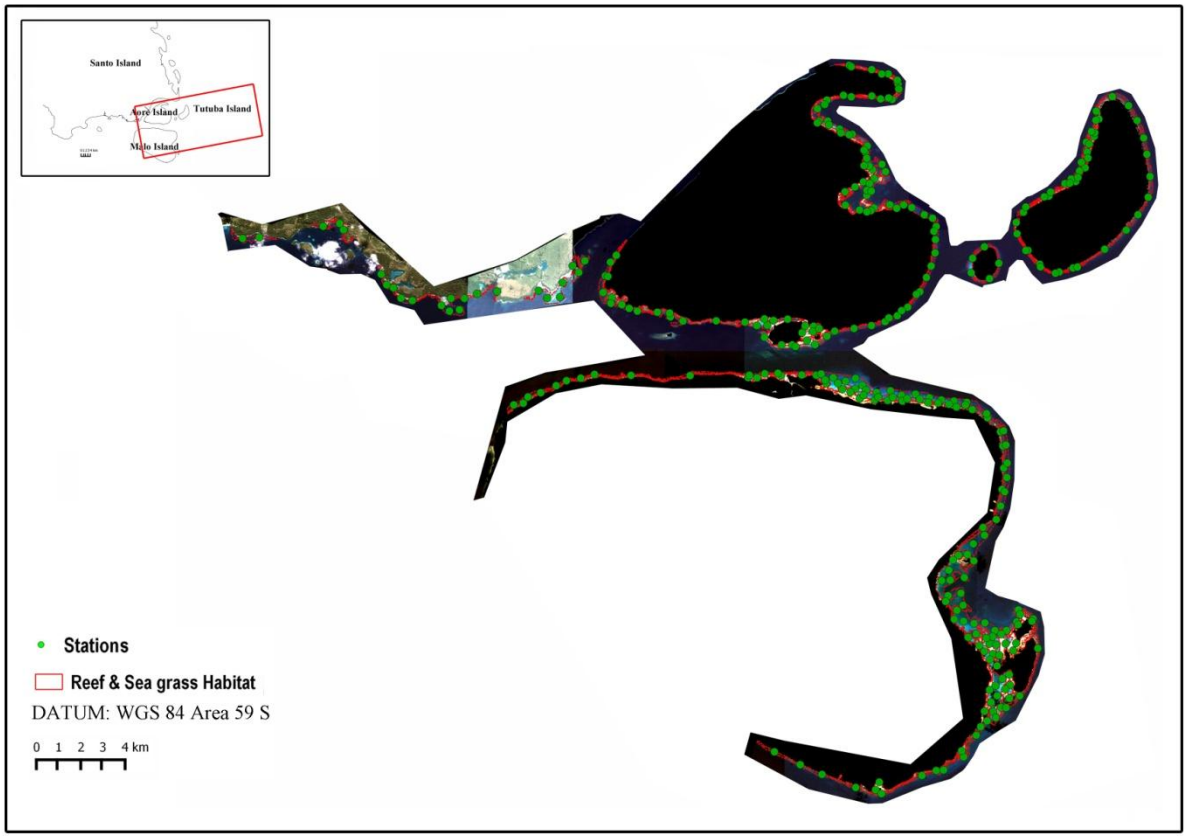




Size distribution of observed sea cucumbers (n=93)



6. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Santo islands



Holothuria atra - SANTO-ISLANDS_2014-03

The selected data includes **28 habitat zone(s)** of the study area (**7.54 km²**). The field census occurred from 17/03/2014 to 21/03/2014. **93 transects** are considered in the results below.

Zones : Z005 ; Z006 ; Z009 ; Z010 ; Z012 ; Z013 ; Z018 ; Z019 ; Z022 ; Z025 ; Z029 ; Z032 ; Z037 ; Z038 ; Z043 ; Z052 ; Z054 ; Z057 ; Z058 ; Z059 ; Z065 ; Z066 ; Z068 ; Z071 ; Z075 ; Z078 ; Z080 ; Z081 ;

Outlying transects (removed from analysis) : T072;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **6125 kg** (wet) and the conservative total abundance is **17879 individual(s)**. This wet biomass is equivalent to **3062 kg** of gutted and salted products, and **306 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **24 individual/ha** and **8.1 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

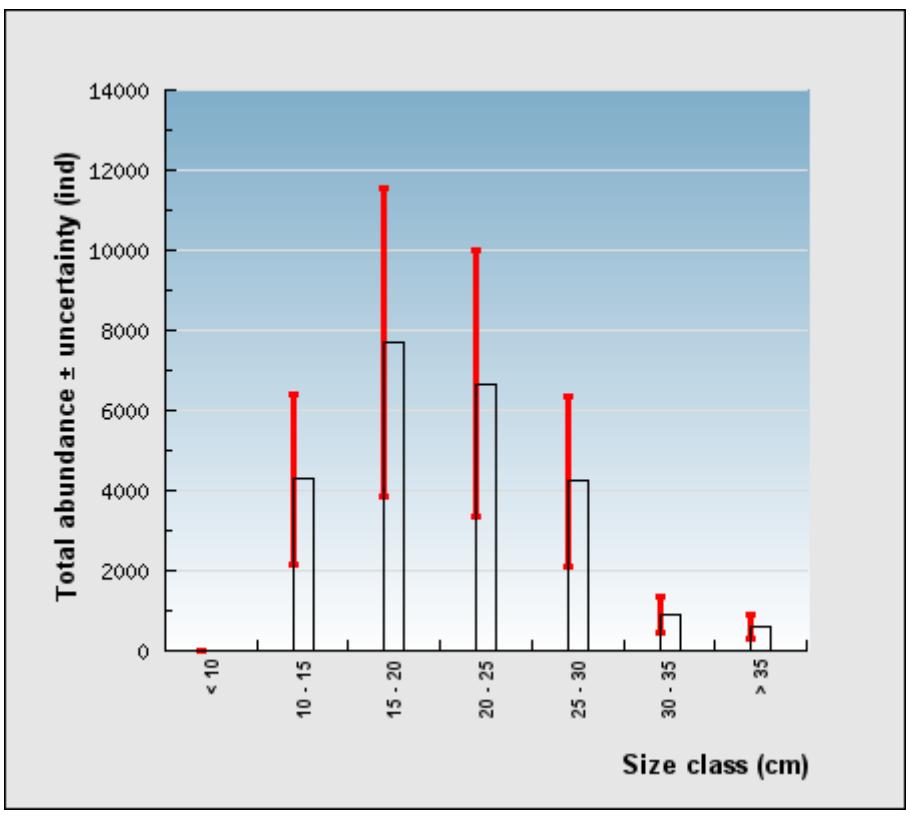
Biological interpretation

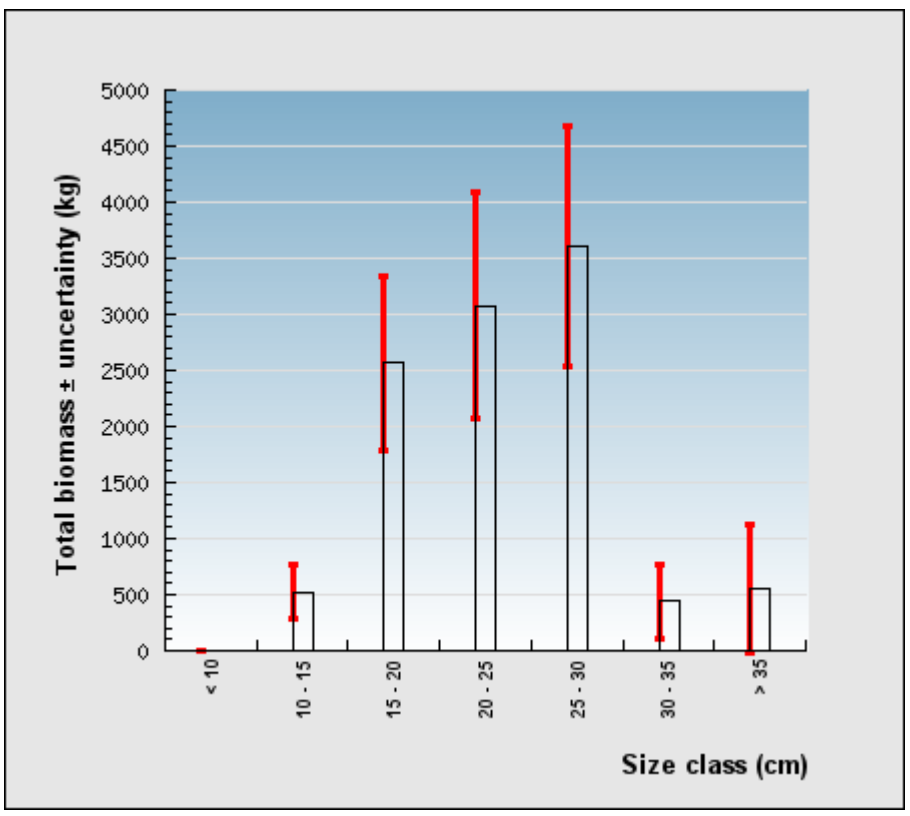
Legal-sized individuals (200 mm) represent **71 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 28.17 % and 42.26 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Holothuria atra	
(all sizes)	10.781 t ± 4.656 t

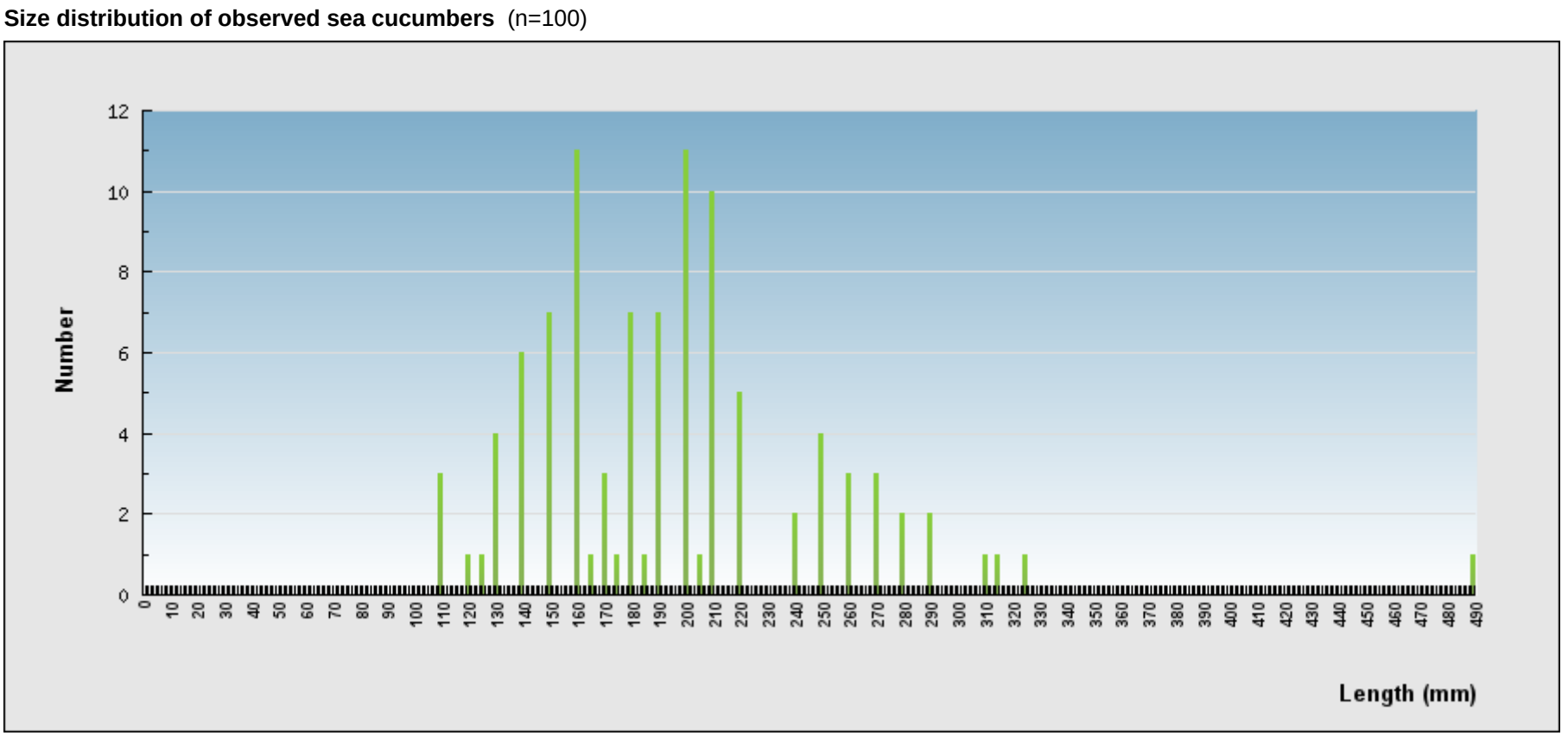
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	4.353 t
Salted and gutted products	2.177 t
Dried products (bêche-de-mer)	0.218 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=100)



Thelenota ananas - SANTO-ISLANDS_2014-03

The selected data includes **12 habitat zone(s)** of the study area (**3.65 km²**). The field census occurred from 17/03/2014 to 21/03/2014. **49 transects** are considered in the results below.

Zones : Z022 ; Z025 ; Z026 ; Z034 ; Z035 ; Z036 ; Z039 ; Z041 ; Z044 ; Z057 ; Z079 ; Z081 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **7236 kg** (wet) and the conservative total abundance is **2883 individual(s)**. This wet biomass is equivalent to **3618 kg** of gutted and salted products, and **507 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **8 individual/ha** and **19.8 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

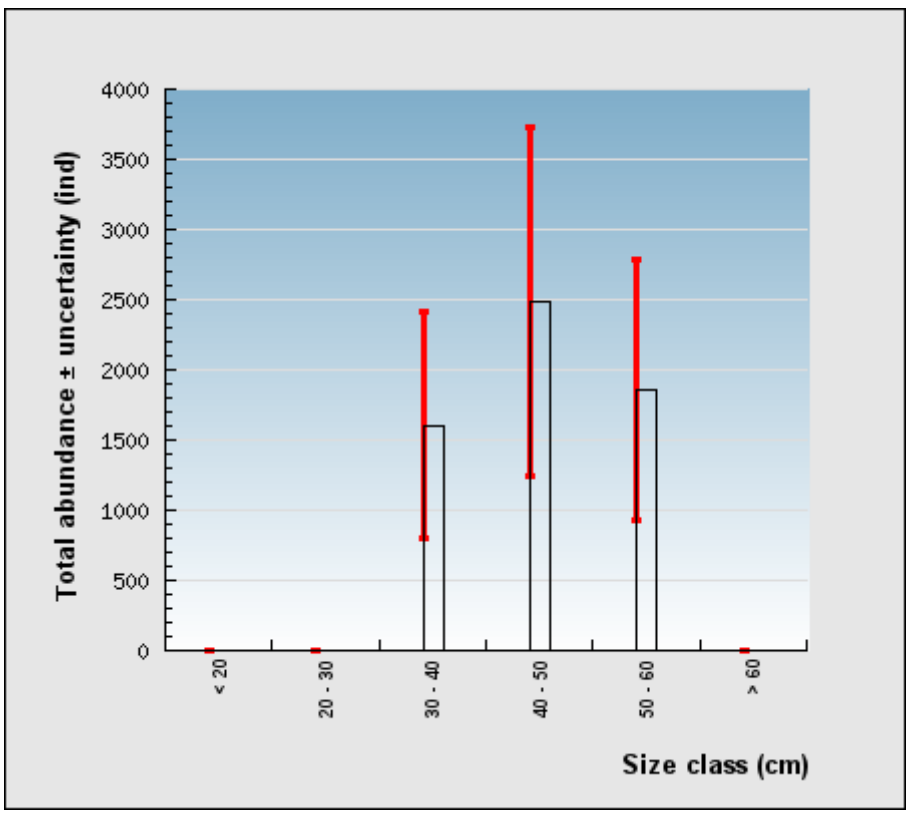
Biological interpretation

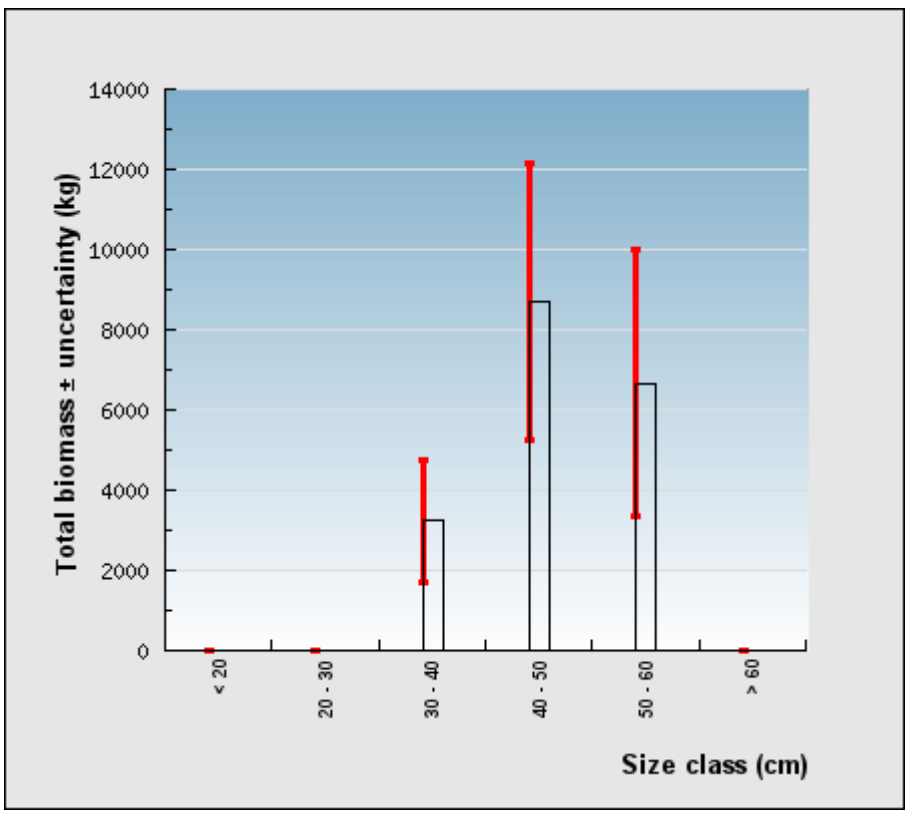
Legal-sized individuals (350 mm) represent **92 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 21.74 % and 32.61 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Thelenota ananas	
(all sizes)	18.604 t ± 11.368 t

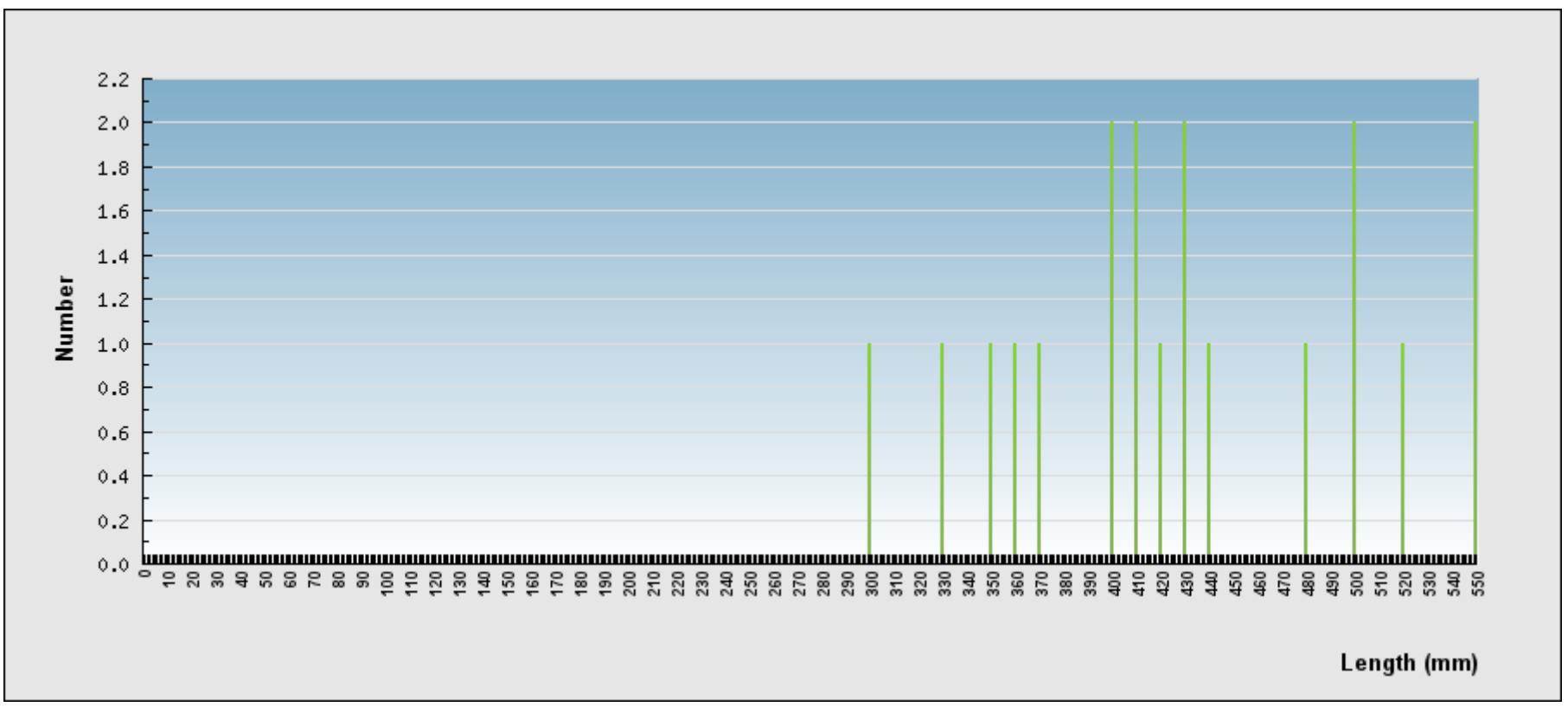
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (350 mm) :	
Fresh/wet products	6.649 t
Salted and gutted products	3.325 t
Dried products (bêche-de-mer)	0.465 t

Size structure of the whole stock of Thelenota ananas





Size distribution of observed sea cucumbers (n=19)



Stichopus chloronotus - SANTO-ISLANDS_2014-03

The selected data includes **25 habitat zone(s)** of the study area (**8.68 km²**). The field census occurred from 17/03/2014 to 21/03/2014. **95 transects** are considered in the results below.

Zones : Z005 ; Z006 ; Z007 ; Z009 ; Z010 ; Z014 ; Z018 ; Z019 ; Z021 ; Z022 ; Z024 ; Z025 ; Z029 ; Z030 ; Z034 ; Z036 ; Z037 ; Z038 ; Z041 ; Z054 ; Z058 ; Z066 ; Z074 ; Z075 ; Z080 ;

Outlying transects (removed from analysis) : T181;T141;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **6001 kg** (wet) and the conservative total abundance is **20296 individual(s)**. This wet biomass is equivalent to **3000 kg** of gutted and salted products, and **180 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **23 individual/ha** and **6.9 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

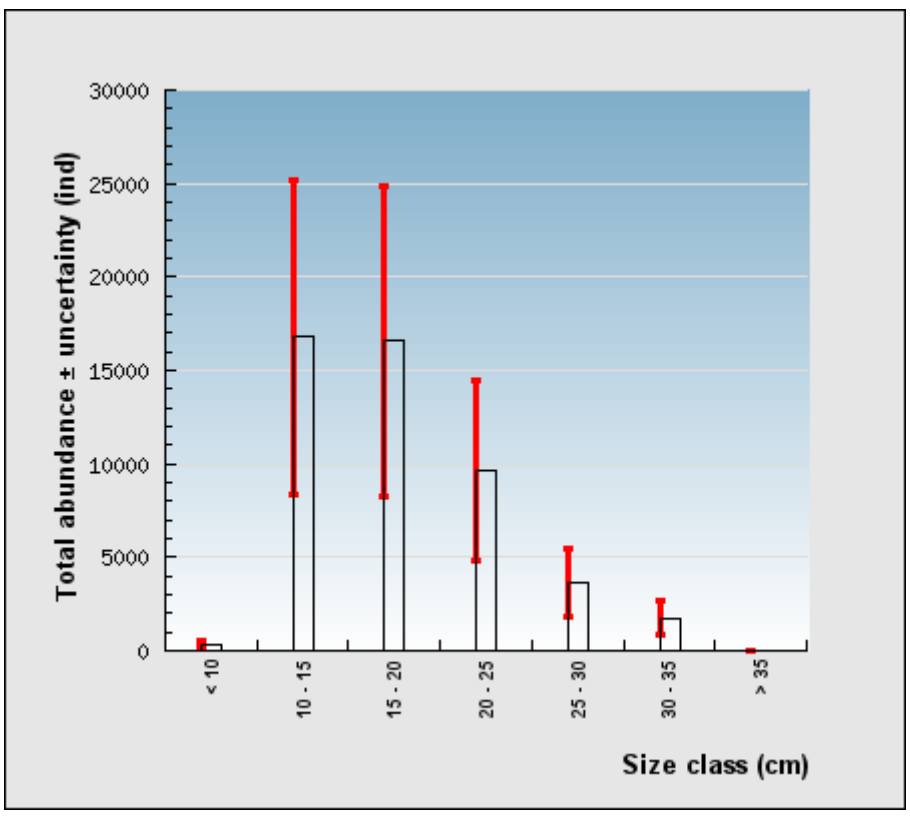
Biological interpretation

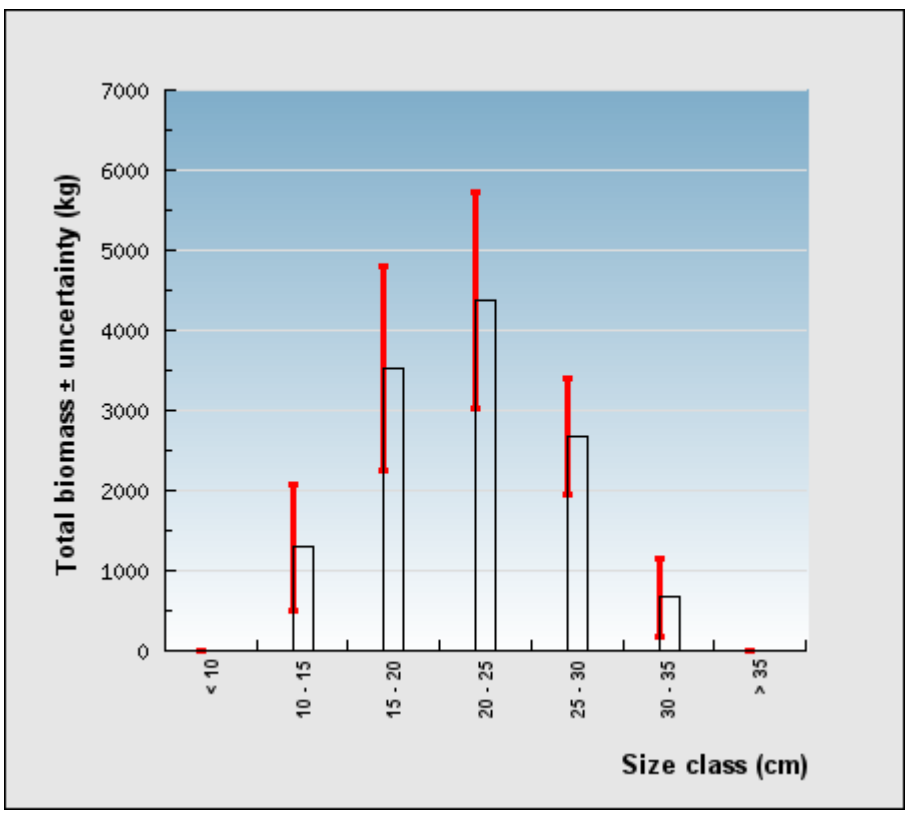
Legal-sized individuals (200 mm) represent **60 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 33.33 % and 50 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for Stichopus chloronotus	
(all sizes)	12.535 t ± 6.535 t

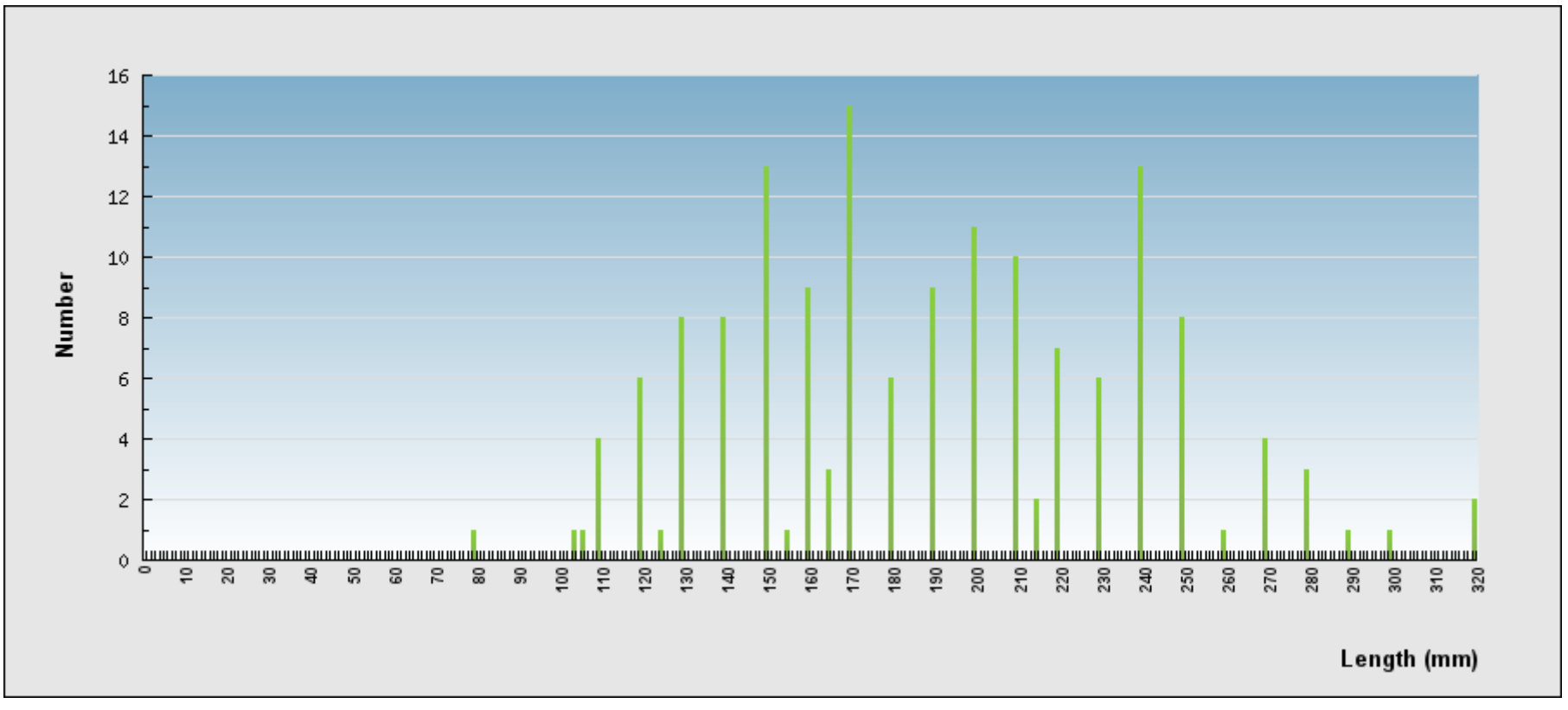
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	3.593 t
Salted and gutted products	1.796 t
Dried products (bêche-de-mer)	0.108 t

Size structure of the whole stock of Stichopus chloronotus

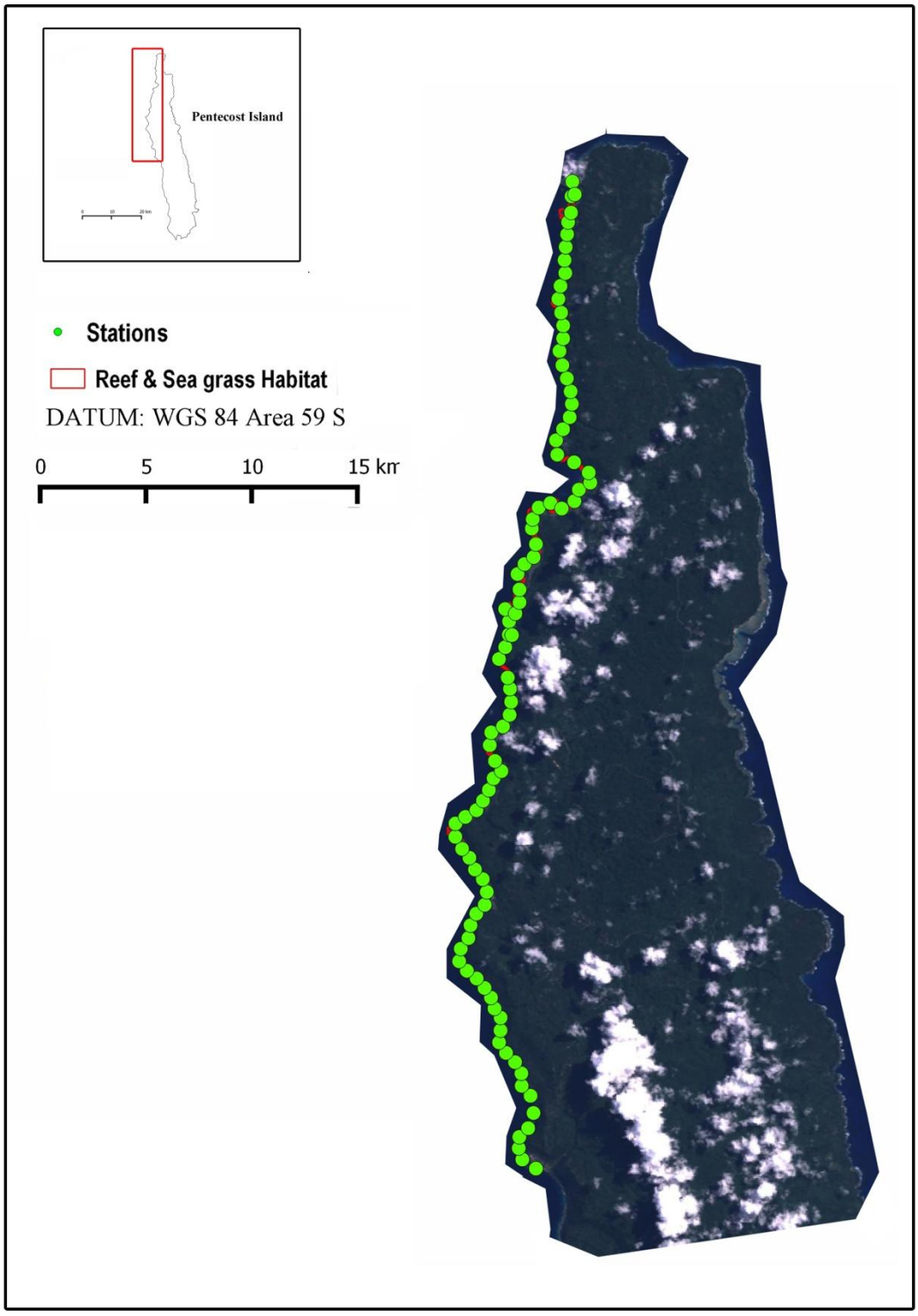




Size distribution of observed sea cucumbers (n=155)



7. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Pentecost island.



Bohadschia argus - PENTECOST_2013-09

The selected data includes **13 habitat zone(s)** of the study area (**4.3 km²**). The field census occurred from 10/09/2013 to 12/09/2013. **78 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z008 ; Z009 ; Z010 ; Z011 ; Z012 ; Z014 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **9278 kg** (wet) and the conservative total abundance is **7073 individual(s)**. This wet biomass is equivalent to **4639 kg** of gutted and salted products, and **371 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **17 individual/ha** and **21.6 kg/ha** over the selected habitat zones .

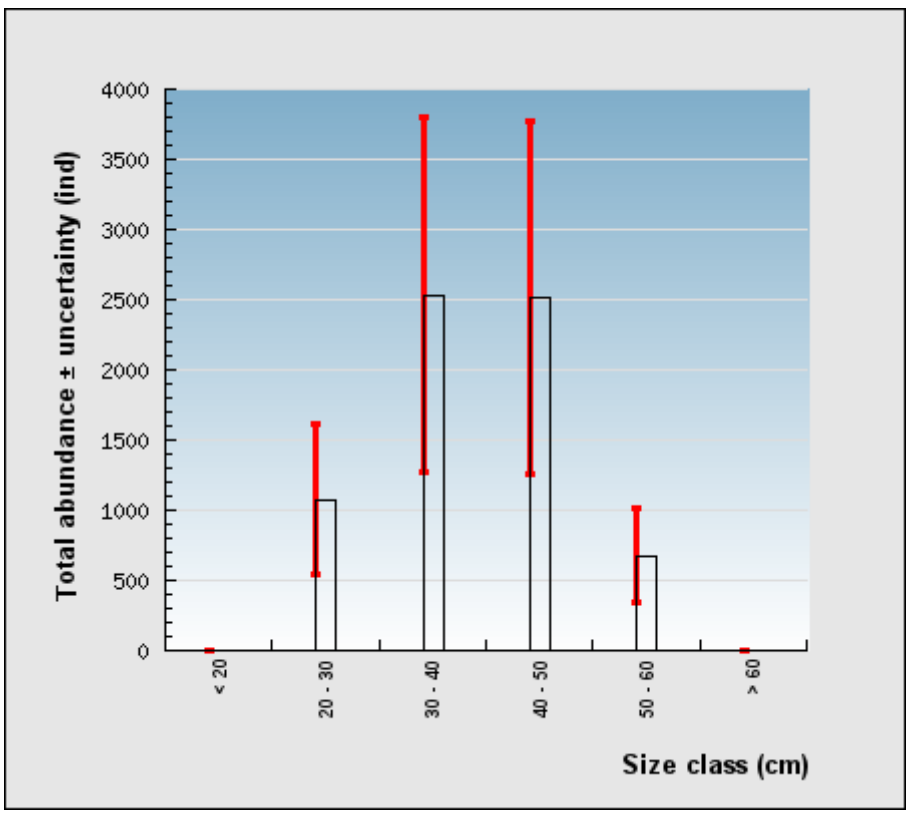
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

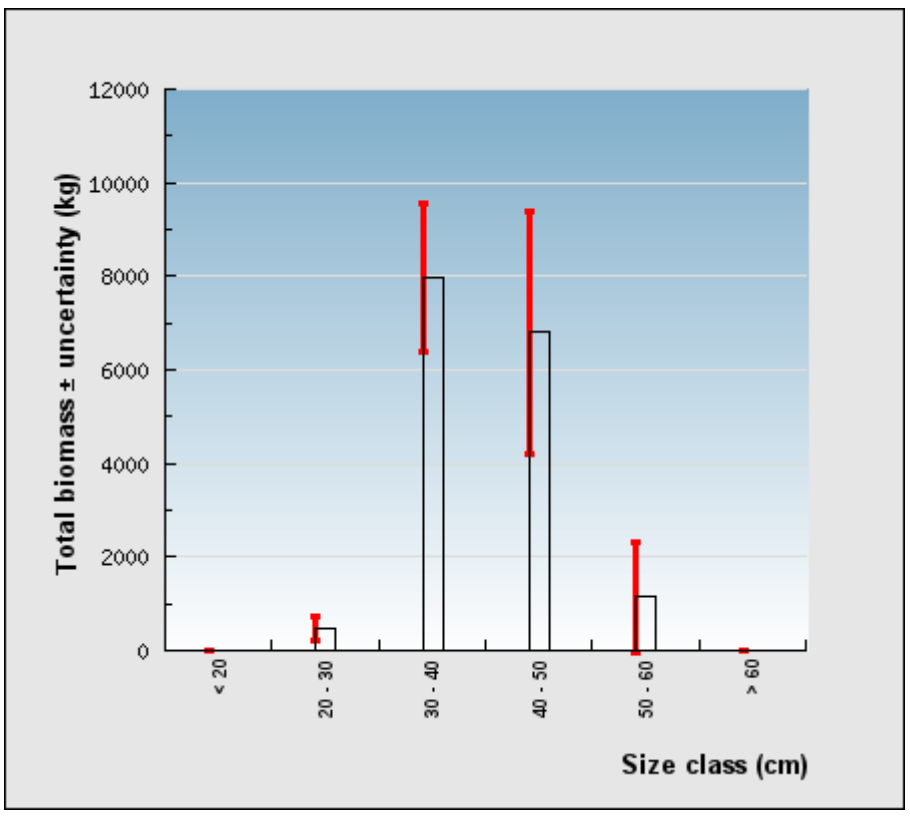
Biological interpretation

Legal-sized individuals (300 mm) represent **95 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 21.05 % and 31.58 % of the estimated TAC (see table) as a precautionary approach.**

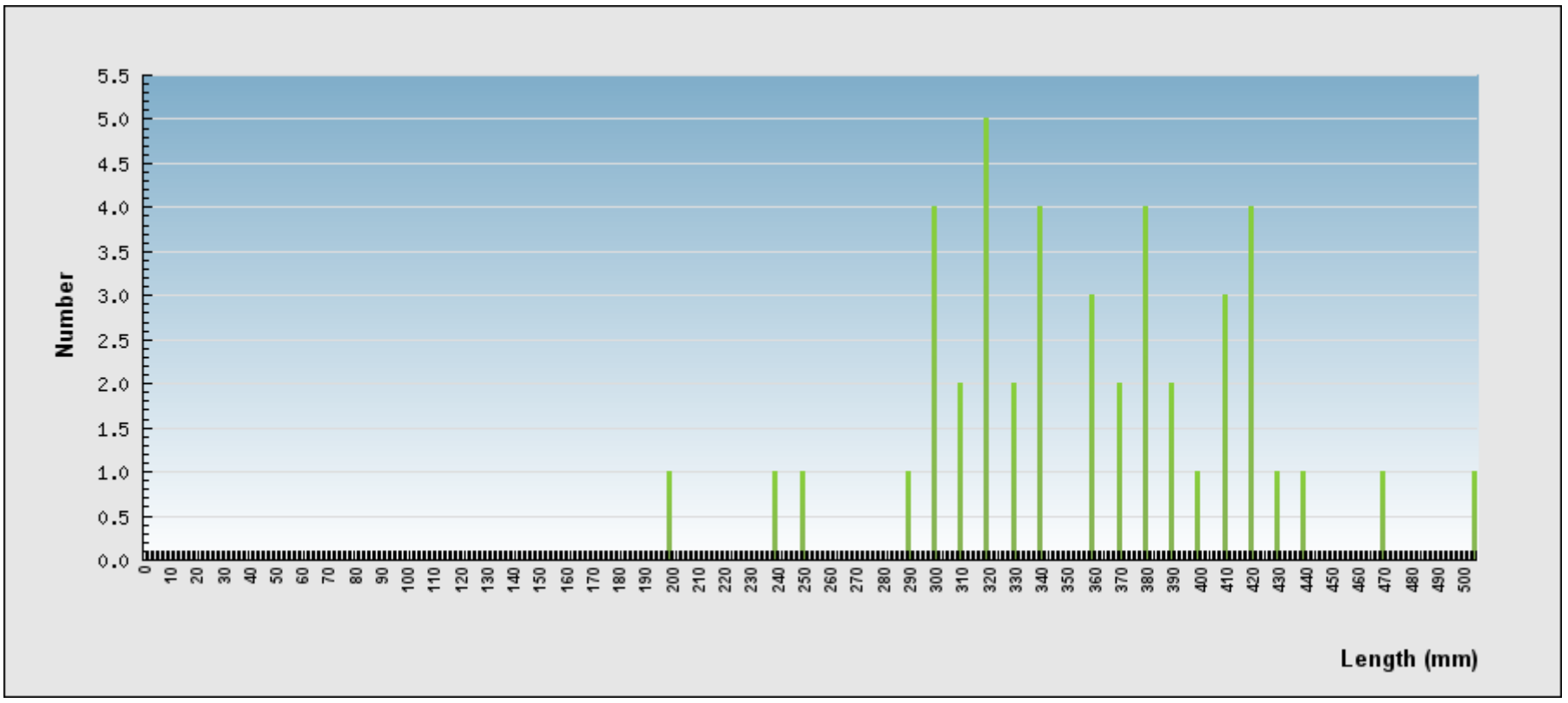
Total stock estimates for Bohadschia argus	
(all sizes)	16.367 t ± 7.09 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (300 mm) :	
Fresh/wet products	8.858 t
Salted and gutted products	4.429 t
Dried products (bêche-de-mer)	0.354 t

Size structure of the whole stock of Bohadschia argus





Size distribution of observed sea cucumbers (n=44)



Holothuria atra - PENTECOST_2013-09

The selected data includes **10 habitat zone(s)** of the study area (**3.78 km²**). The field census occurred from 10/09/2013 to 12/09/2013. **63 transects** are considered in the results below.

Zones : Z001 ; Z002 ; Z003 ; Z004 ; Z005 ; Z006 ; Z007 ; Z008 ; Z012 ; Z013 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **2769 kg** (wet) and the conservative total abundance is **3766 individual(s)**. This wet biomass is equivalent to **1385 kg** of gutted and salted products, and **138 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **10 individual/ha** and **7.3 kg/ha** over the selected habitat zones .

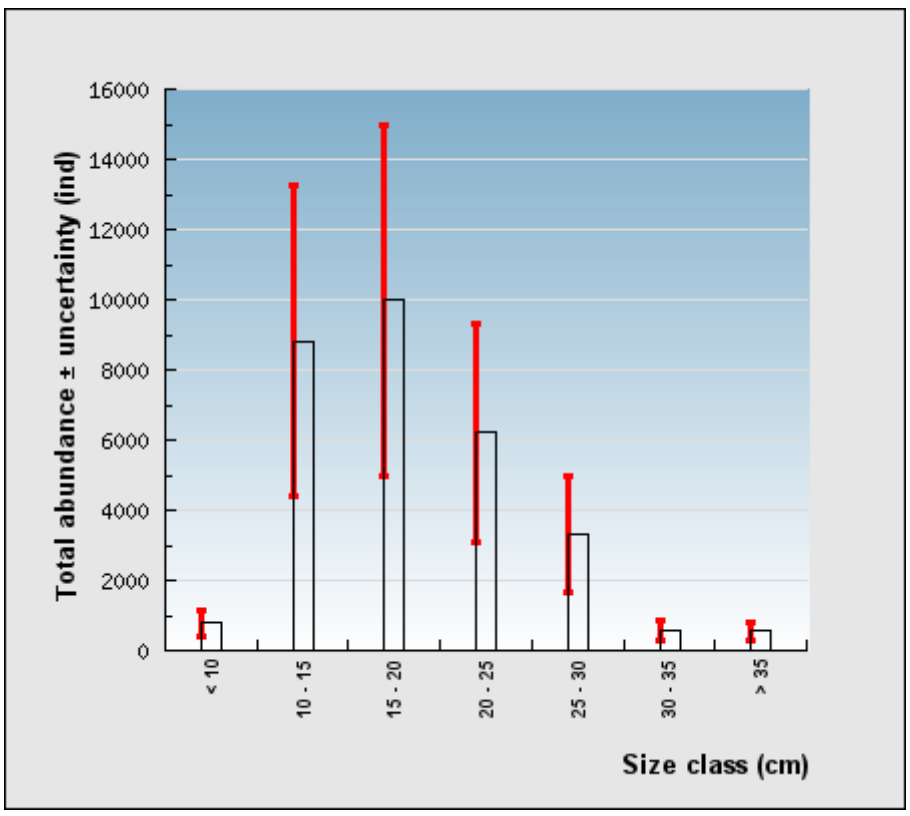
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

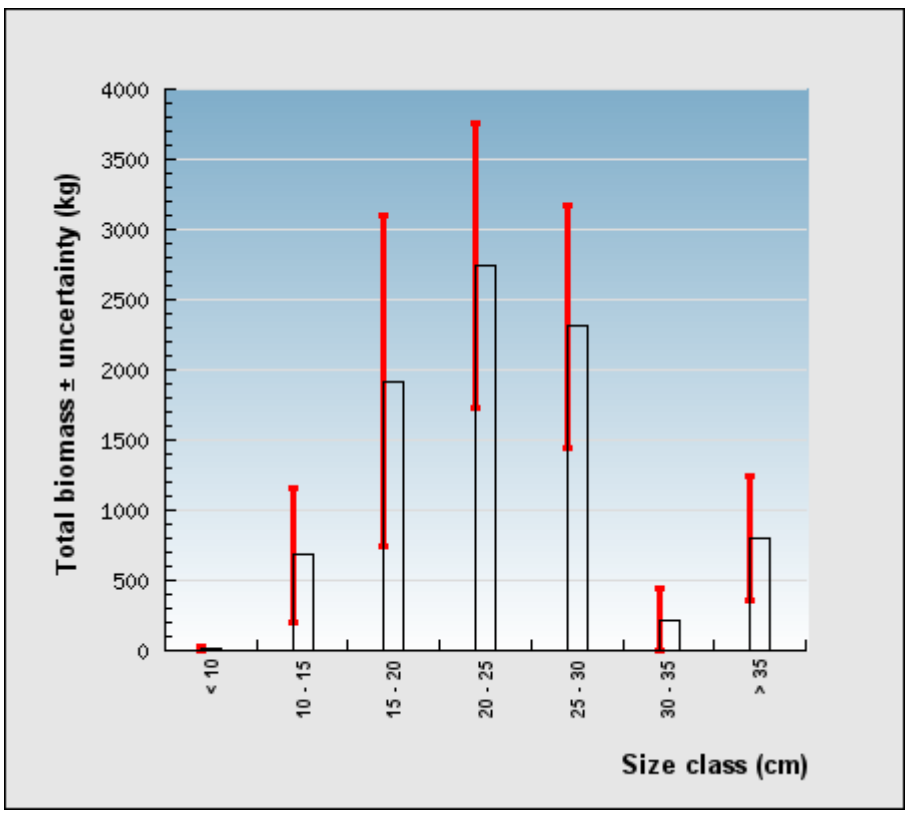
Biological interpretation

Legal-sized individuals (200 mm) represent **102 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 19.61 % and 29.42 % of the estimated TAC (see table) as a precautionary approach.**

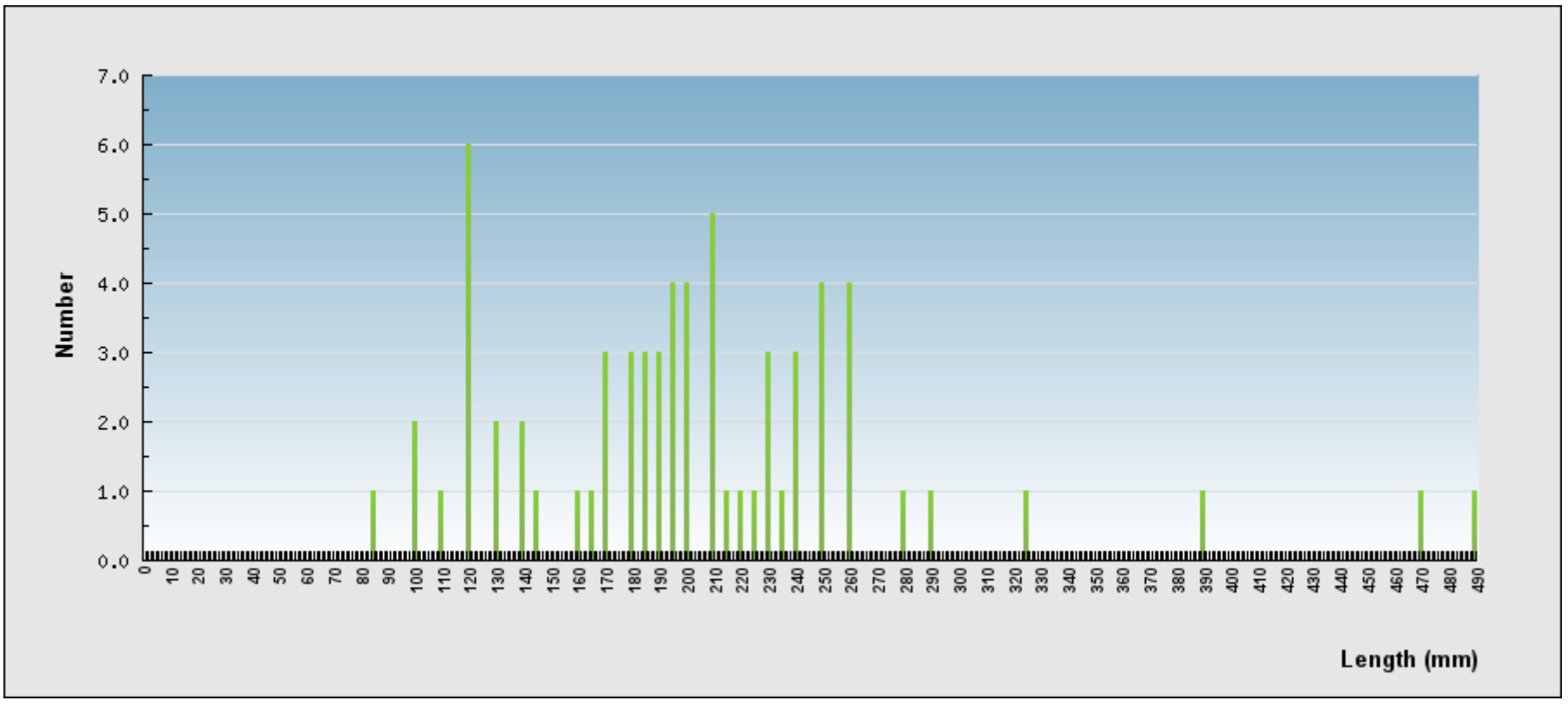
Total stock estimates for Holothuria atra	
(all sizes)	8.699 t ± 5.93 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	2.813 t
Salted and gutted products	1.406 t
Dried products (bêche-de-mer)	0.141 t

Size structure of the whole stock of Holothuria atra

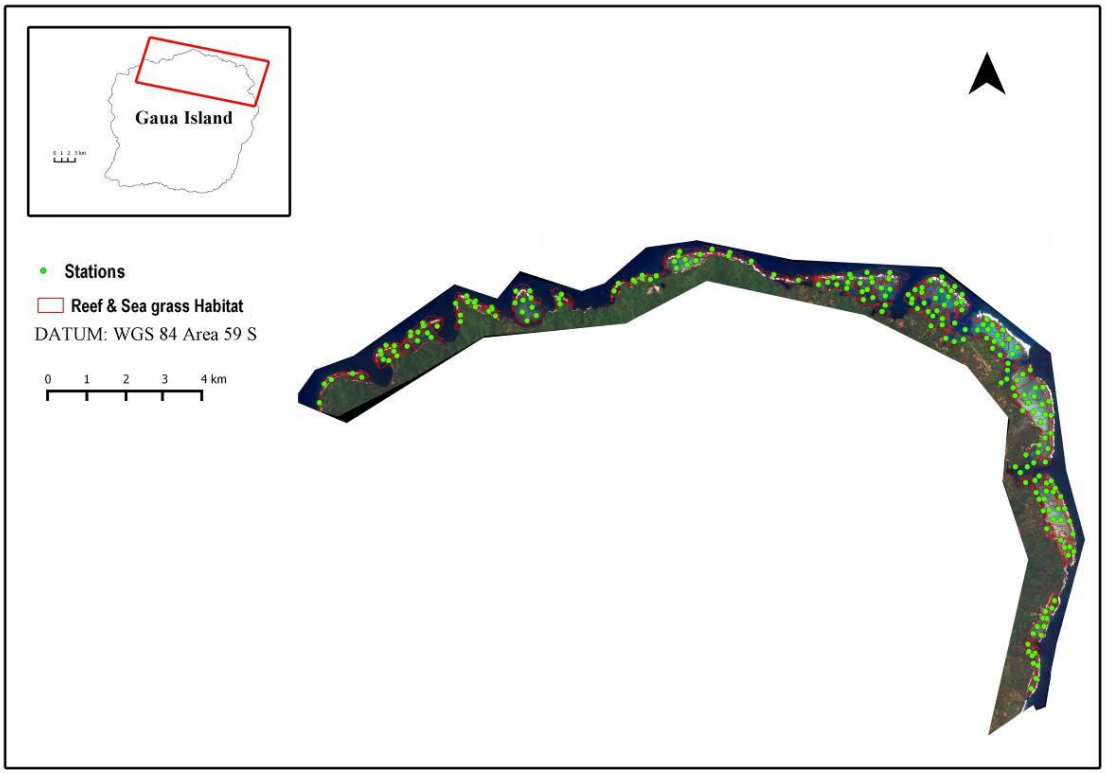




Size distribution of observed sea cucumbers (n=66)



8. Map of survey site, sampling design and stock estimates of most abundant sea cucumber species in Gaua island.



Holothuria atra - GAUA_2014-08

The selected data includes **33 habitat zone(s)** of the study area (**7.66 km²**). The field census occurred from 26/08/2014 to 31/08/2014. **128 transects** are considered in the results below.

Zones : Z001 ; Z003 ; Z006 ; Z007 ; Z009 ; Z010 ; Z011 ; Z012 ; Z013 ; Z014 ; Z017 ; Z019 ; Z021 ; Z022 ; Z023 ; Z027 ; Z029 ; Z031 ; Z032 ; Z035 ; Z037 ; Z039 ; Z042 ; Z043 ; Z044 ; Z045 ; Z046 ; Z049 ; Z052 ; Z053 ; Z054 ; Z055 ; Z057 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **33365 kg** (wet) and the conservative total abundance is **80123 individual(s)**. This wet biomass is equivalent to **16683 kg** of gutted and salted products, and **1668 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **105 individual/ha** and **43.6 kg/ha** over the selected habitat zones .

The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

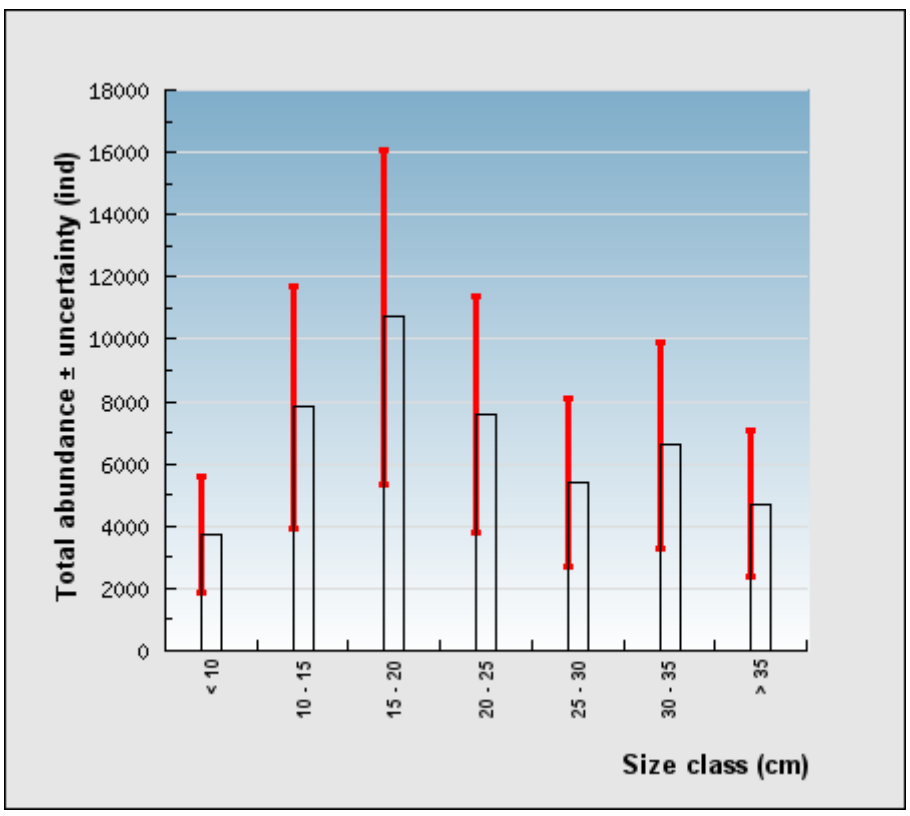
Biological interpretation

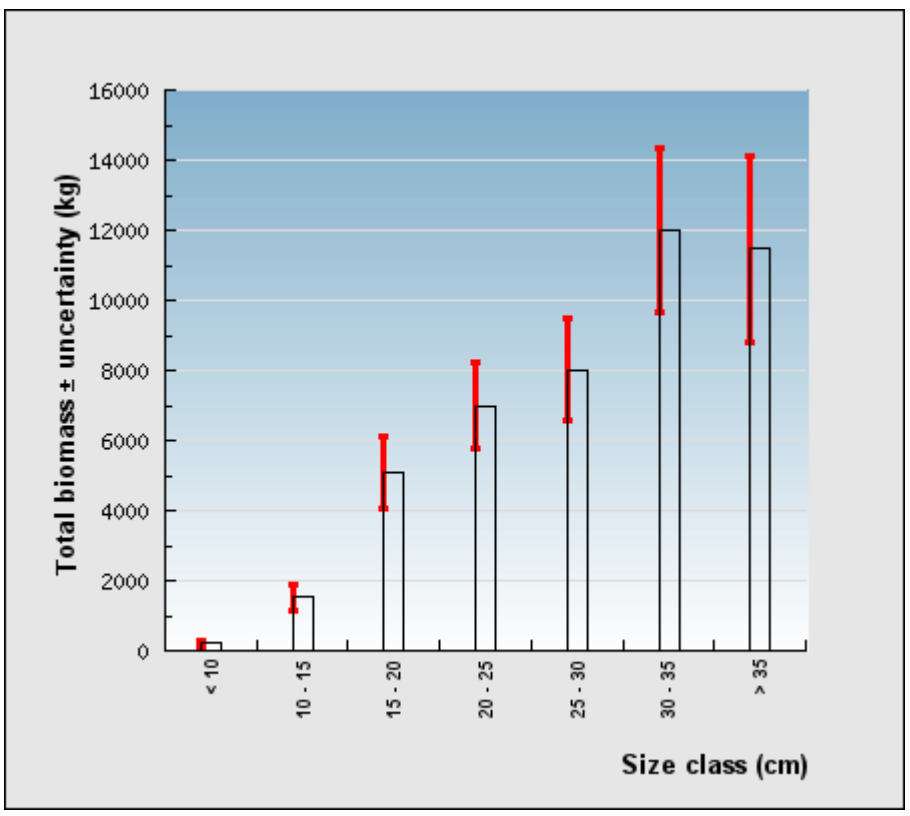
Legal-sized individuals (200 mm) represent **82 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 24.39 % and 36.59 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for *Holothuria atra*	
(all sizes)	45.321 t ± 11.955 t

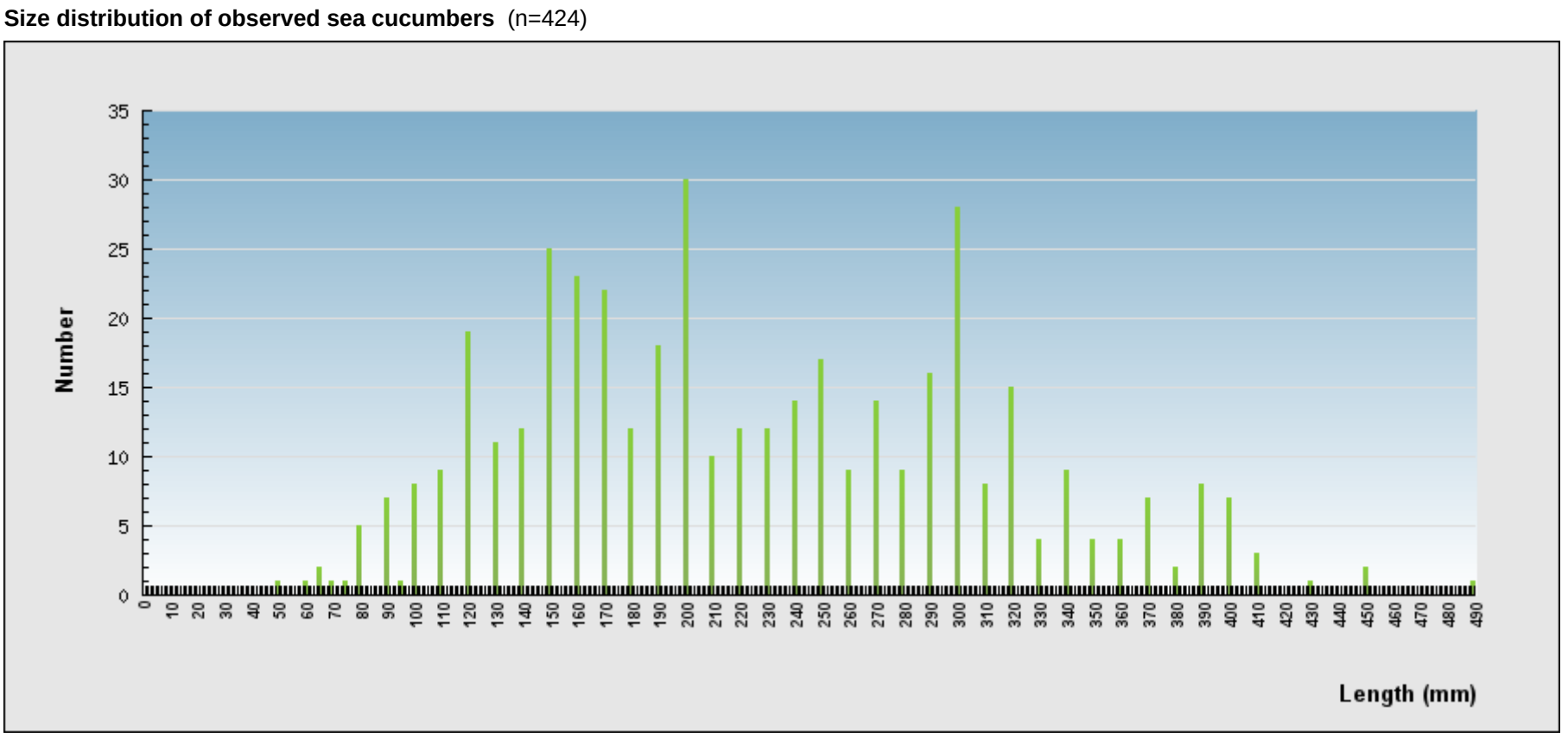
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	27.398 t
Salted and gutted products	13.699 t
Dried products (bêche-de-mer)	1.37 t

Size structure of the whole stock of Holothuria atra





Size distribution of observed sea cucumbers (n=424)



Stichopus chloronotus - GAUA_2014-08

The selected data includes **18 habitat zone(s)** of the study area (**4.56 km²**). The field census occurred from 26/08/2014 to 31/08/2014. **75 transects** are considered in the results below.

Zones : Z001 ; Z007 ; Z008 ; Z009 ; Z011 ; Z012 ; Z013 ; Z014 ; Z020 ; Z021 ; Z022 ; Z027 ; Z031 ; Z035 ; Z039 ; Z046 ; Z051 ; Z056 ;

Reference indicators for all individuals

Reference indicators include biomass, abundance and density estimates.

The conservative stock biomass of all individuals is **3911 kg** (wet) and the conservative total abundance is **18826 individual(s)**. This wet biomass is equivalent to **1955 kg** of gutted and salted products, and **117 kg** of of dried products (bêche-de-mer).

The conservative mean density estimate of all individuals is **41 individual/ha** and **8.6 kg/ha** over the selected habitat zones .

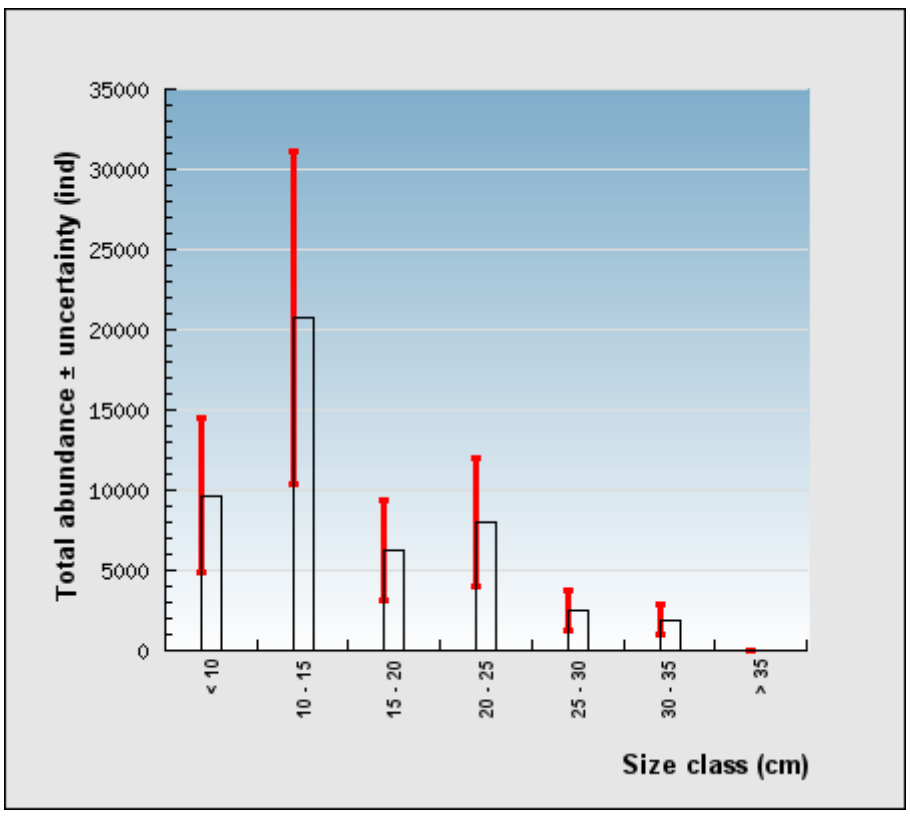
The above estimates incorporate measure uncertainty that is attributable to survey method and heterogeneous resource distribution over the survey site.

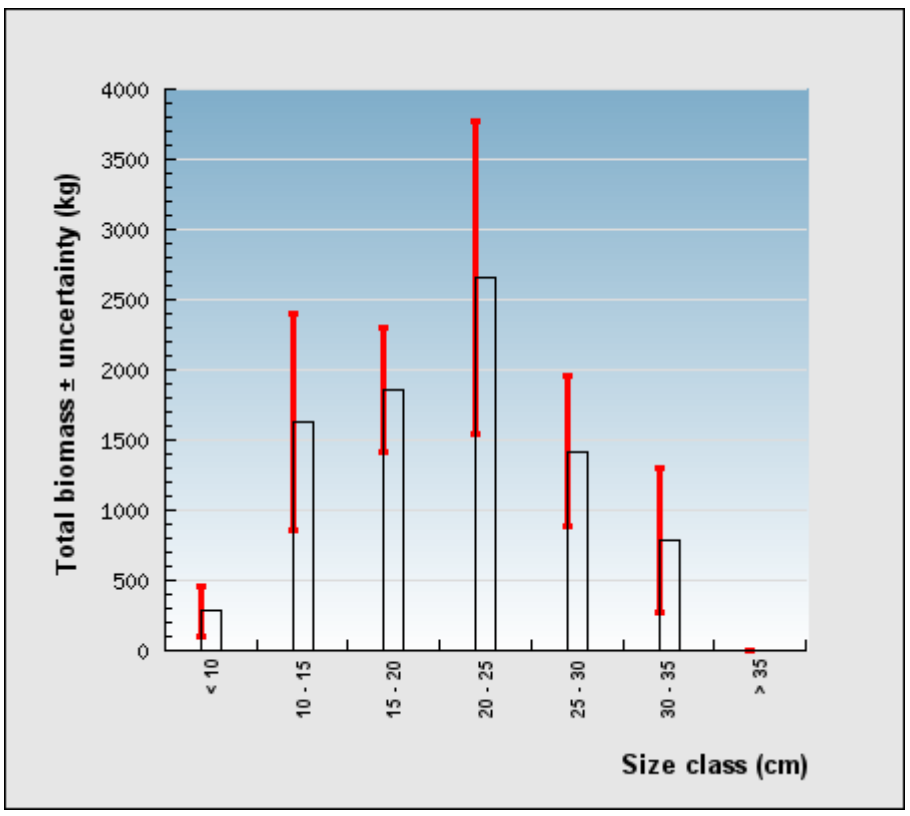
Biological interpretation

Legal-sized individuals (200 mm) represent **38 % of the total stock biomass**. This high proportion means that small individuals were rarely observed during survey compared to large individuals, and may be indicative of recruitment failure. **Consequently, the recommended TAC must range between 52.63 % and 78.95 % of the estimated TAC (see table) as a precautionary approach.**

Total stock estimates for *Stichopus chloronotus*	
(all sizes)	8.625 t ± 4.714 t
Recommended TAC (Total Allowable Catch, or quota) of legal-sized individuals (200 mm) :	
Fresh/wet products	1.494 t
Salted and gutted products	0.747 t
Dried products (bêche-de-mer)	0.045 t

Size structure of the whole stock of Stichopus chloronotus





Size distribution of observed sea cucumbers (n=224)