SECTION C - SPECIALIST STUDIES

C3.2 Fisheries Biomass and Stock Assessment

NAMIBIAN MARINE PHOSPHATE

VERIFICATION SURVEY

BIOMASS AND STOCK ESTIMATES OF HAKE AND MONK IN THE MINING LEASE AREA ML 170 OF NAMIBIAN PHOSPHATE

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SUMMARY

Namibian Marine Phosphate (Pty) Ltd has identified the existence of a high grade phosphate deposit on the Namibian continental shelf. This deposit lies approximately 40-60 km offshore from Conception Bay in water depths of 190 to 300 m. A specialist study was undertaken by Japp (in Midgley 2012) to assess the possible impacts of the proposed mining of the phosphate resource on fish, fisheries, seabirds and marine mammals. The Mining Lease Area (MLA 170) lies between latitudes 23.9°S and 24.9°S. MLA 170 contains three proposed Sandpiper dredging sites. The plan is to initially dredge within the Sandpiper-1 (SP-1) area only. Figures S1 and S2 below show the location of the MLA relative to the demersal fishery (represented here by survey stations) and the position of the Sandpiper sites within the MLA.

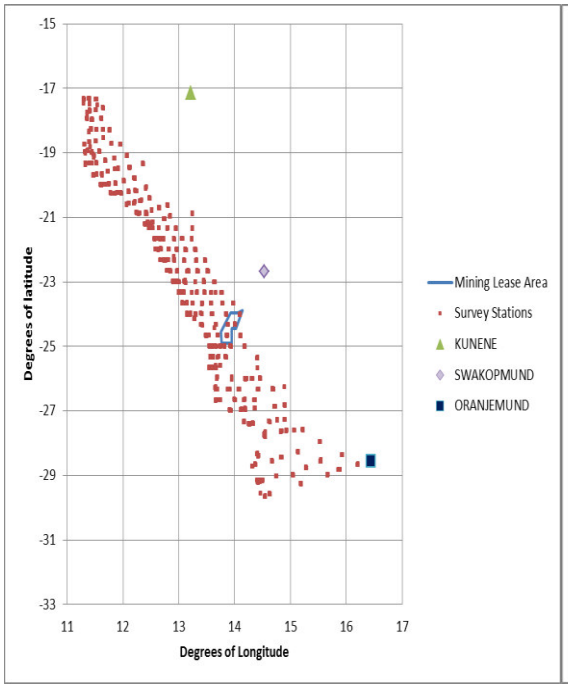

Figure S1. Position of demersal Survey Trawls relative to the Mining Lease Area (MLA) and landmark Reference points.

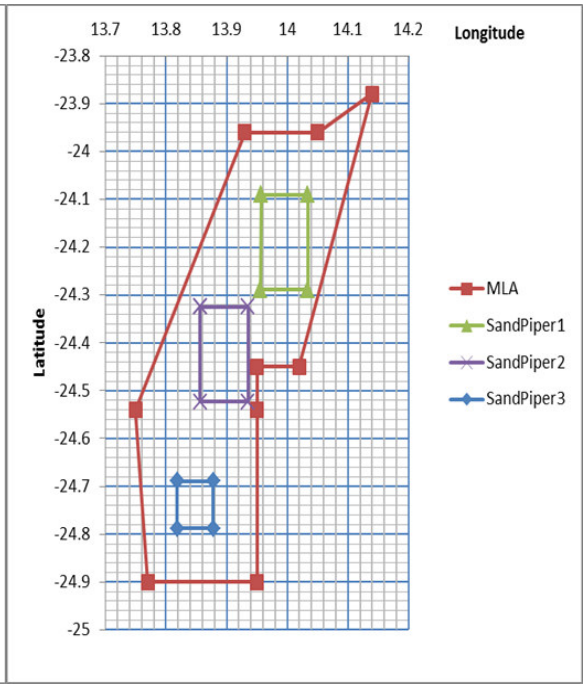

Figure S2. MLA and the Sandpiper dredging sites, SP-1 & (SP-2 & SP-3).

The present study acts as a supplement to Japp (in Midgley 2012), in which we focus on estimating the contribution of the MLA and surrounding areas to biomass for three commercially exploited finfish:

- *Merluccius capensis* (Cape hake)
- *Merluccius paradoxus* (Deep-water Cape hake)
- *Lophius vomerinus* (Cape monk)

For each of these we considered 4 size categories: juveniles, recruits, maturing stock and mature stock. Demersal survey data for 2007 through 2012 provided by NatMIRC were used to estimate biomass in 28 spatial strata (7 depth divisions by 4 latitude divisions) within the Namibian fishery. Densities within these strata were appropriately weighted up in proportion to the area contributions of these strata to the MLA in general and to the Sandpiper-1 dredge site in particular. These calculations resulted in the following estimates of the contribution of the MLA and the SP-1 site to the various components of the fisheries resources under consideration:

	MLA	95% Confidence Interval	SP-1	95% Confidence Interval
% of Area	1.3%		0.11%	
% of Biomass *M. capensis*	1.6%	(1.3% , 2%)	0.14%	(0.1% , 0.18%)
% of Mature Stock *M.capensis*	1.6%	(1.1% , 2%)	0.11%	(0.07% , 0.16%)
% of Recruits *M. capensis (b*y number)	1.6%	(1.1% , 2.2%)	0.20%	(0.12% , 0.28%)
% of Biomass *M. paradoxus*	0.01%	(0% , 0.035%)	0.00%	(0% , 0.01%)
% of Mature Stock *M. paradoxus*	0.001%	(0% , 0.003%)	0.00%	(0% , 0.001%)
% of Recruits *M. paradoxus* (by number)	0.07%	(0% , 0.197%)	0.00%	(0% , 0.01%)
% of Biomass *L. vomerimus*	2.0%	(0.9% , 3.1%)	0.06%	(0.04% , 0.08%)
% of Mature Stock *L. vomerimus*	0.8%	(0.4% , 1.2%)	0.03%	(0.01% , 0.04%)
% of Recruits *L. vomerimus* (by number)	7.0%	(1.8% , 12.3%)	0.20%	(0.07% , 0.34%)

The MLA is estimated to contain less than 1.6% of the Namibian biomass for *M. capensis*, which reduces to 0.14% if the SP-1 dredge site only is considered. These estimated biomasses approximate the relative proportions of each area. No notable departure from these proportions is estimated for either the recruits or the spawning adults. The 23^0 to 26^0 latitude band is a breeding ground for *M. capensis*, containing a large proportion of juveniles, however the overwhelming majority of these are at depths less than 200 m, whereas most of the MLA lies in deeper waters.

M. paradoxus adults are scarce in depths of less than 300 m, and the younger fish (less than 27 cm) are predominantly found south of 26^0 S. Thus the MLA and in particular the SP-1 site have very little interaction with *M. paradoxus* (less than 0.2% of biomass in entire MLA.

For monk, the MLA is estimated to contribute about 2% to overall biomass. This is less (0.8%) among the mature stock which tend to lie in deeper water and further South. The monk recruits however are more prevalent in the MLA than for hake, with an estimated 7% of recruits in the MLA (Table 7c). Most of this contribution to recruitment however is in the 250 to 300 m depth range and is not in the area to be dredged (SP-1). The SP-1 site is shallower than 250 m, and so this is estimated to contribute only 0.2% of recruitment to the fishery. We stress also that recruitment will be affected by many factors, including fishing pressure and variability in environmental and oceanographic conditions and will not necessarily remain constant from year to year.

In conclusion, less than 0.2% of each species considered lies directly within the proposed SP-1 mining site. The SP-1 site also makes no significant contribution to recruitment or spawner stock biomass for any of the species considered in this assessment. Outside of SP-1 and within the larger MLA, the biomass of monk expected to contribute to the recruitment to the fishery is estimated to be 7%. This assessment makes no judgement on the possible impact on recruitment of dredging only in SP-1 on the area outside of SP-1 and within the total MLA. It is emphasized that, as the proportion of the potential biomass in SP-1 and recruiting to the commercial fisheries in the adjacent areas is extremely small, the broader impact, if scaled outside of the dredged area, is likely to be minimal.

1 INTRODUCTION

Namibian Marine Phosphate (Pty) Ltd has identified the existence of a high grade phosphate deposit on the Namibian continental shelf. This deposit lies approximately 60 km offshore from Conception Bay in water depths of 190 to 300 m. A specialist fishery study was undertaken by Japp (in Midgley 2012) to assess the possible impacts of the proposed dredging of the phosphate resource on fish, fisheries, seabirds and marine mammals. For a broader background, refer to Japp and Smith (2012).

The Mining Lease Area (MLA 170) has been demarcated between latitudes 23.9 ^{o}S and 24.9^{o}S. The MLA contains three proposed dredging sites (SP-1, SP-2, SP-3). This is illustrated in Figures 1 and 2 below. Also shown in Figure.1 is the distribution of trawls in the annual demersal surveys conducted by the Namibian National Marine Information and Research Centre (NatMIRC), which serves as a good representation of the extent of the demersal fishery off the Namibian coast.

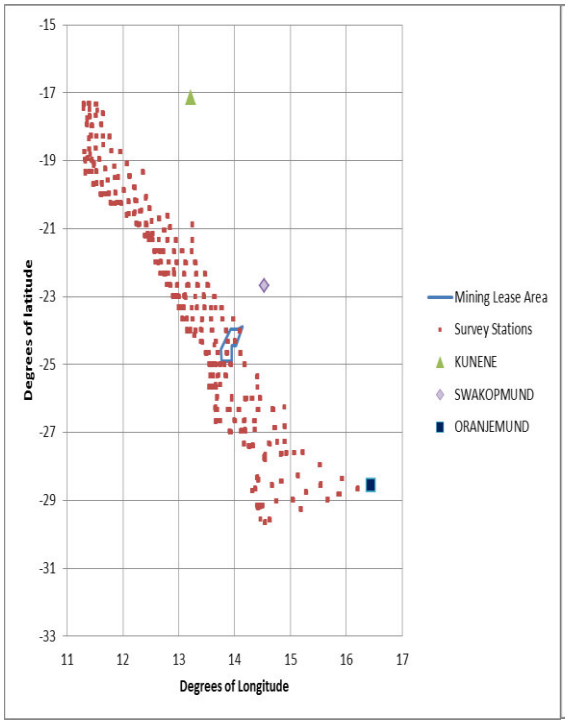

Figure 1. Position of demersal Survey Trawls relative to the Mining Lease Area (MLA) and landmark reference points.

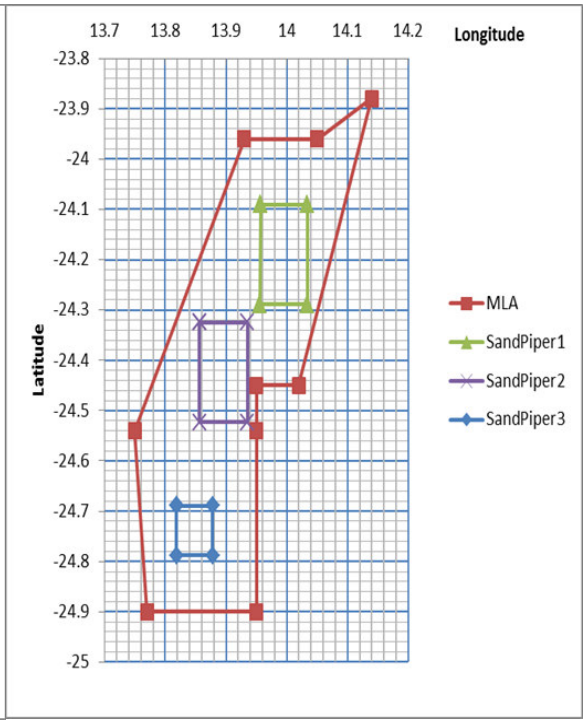

Figure 2. MLA 170 and the Sandpiper sites.

The present study acts to augment the EIA assessment of Japp (in Midgley 2012), in which I focus on estimating the contribution of the MLA and surrounding areas to biomass for three commercially exploited finfish:

- *Merluccius capensis* (Cape hake)
- *Merluccius paradoxus* (Deep-water Cape hake)
- *Lophius vomerinus* (Cape monk)

I estimate for each of these four species:

- The contribution of the MLA and the SP-1 dredging site to total resource biomass
- The contribution to recruitment
- The contribution to spawner stock

2 DATA

Data used in this part of the study are:

1. Demersal Survey data for 2007 through 2012, provided by NatMIRC. Data used include the following for each trawl station:

    a. Catch weight by species,
    b. Sample weight by species,
    c. Frequencies by species and 1cm length class.
    d. Depth
    e. Latitude
    f. Longitude
    g. Trawl speed
    h. Wing spread
    i. Trawl distance

Table 1. Demersal surveys used in this study

Survey	Number of Stations	Date of first Trawl
2007502	213	11 January 2007
2008501	212	12 January 2008
2009501	222	12 January 2009
2010501	217	14 January 2010
2011501	217	14 January 2011
2012501	217	13 January 2012
TOTAL	**1298**	

2. Monk Survey data 2007 through 2010

3. Details of the geography of the Sandpiper sites and the mining lease area

3 METHODS

3.1 BIOMASS ESTIMATES: GENERAL APPROACH

Annual biomass estimates conducted by NatMIRC, using the demersal surveys, are calculated using 100 m depth bands, with no further stratification performed by latitude or other dimensions (Kainge 2011).

Given that our focus in this study is to estimate biomass in a particular (and relatively small) component of the habitat, it was felt that a finer-scale stratification was needed in order to adequately capture local effects which may differ from the norm, for example the possibility of a greater than average density of juveniles in and around the MLA.

Two approaches were considered:

- *Approach 1:* To use observations from within the region of interest itself to directly estimate densities in the SP-1 dredging site and surrounding MLA.
- *Approach 2:* To estimate biomass in appropriate strata in a larger area surrounding the region of interest, and to infer densities inside the MLA by appropriate weighting of strata in proportion to the areas represented by those strata.

Only 24 survey trawls were conducted in the MLA between 2007 and 2012, and these are clustered in four specific locations (see Figure 3) so that Approach 1 was considered too unreliable an estimator. We have thus adopted Approach 2 as the principal method, but have performed the calculations for Approach 1 as well for comparison.

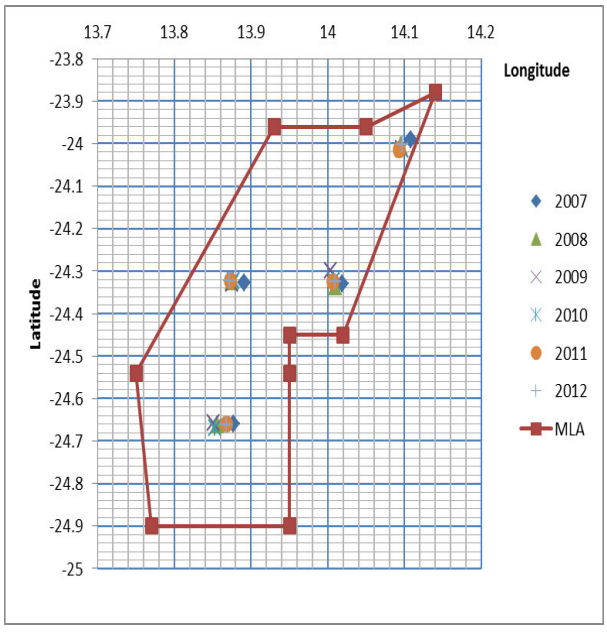

Figure 3. Position of survey stations inside the MLA for the demersal surveys in years 2007 through 2012, by longitude and latitude.

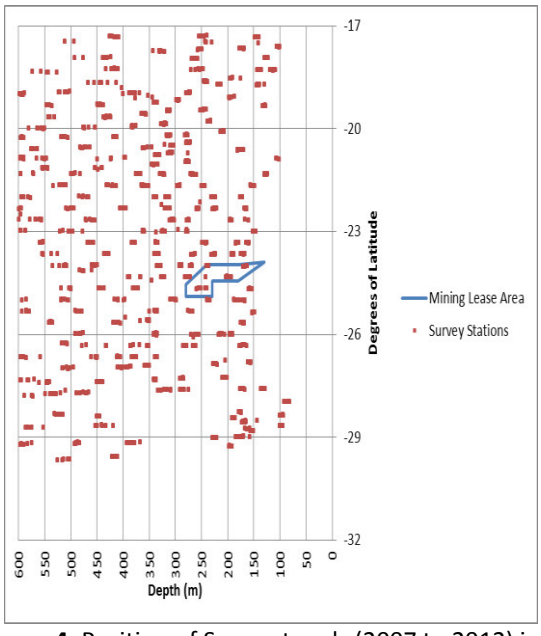

Figure 4. Position of Survey trawls (2007 to 2012) in the MLA by depth and latitude. (Note that due to the scaling used in this figure, the MLA appears distorted and does not reflect the exact geographical shape as in Figure 3).

3.2 STRATIFICATION

Because the objective is to estimate an average expected biomass in the MLA over an extended period of time, rather than an annual index, we have aggregated the data over the 6 years (2007 to 2012) for which data were available for this study.

Strata defined for the purposes of this study are 4 latitude divisions by 7 depth divisions as illustrated in Table 2 below. Thus 28 strata are defined in all, which is comparable to the 30 effective strata used in the annual resource biomass estimates over the same period (5 depth divisions by 6 years).

Table 2. Stratification with sample sizes (number of survey trawls) per stratum.

Latitude (^{0}S)	500 to 600 m	400 to 500 m	300 to 400 m	250 to 300 m	200 to 250 m	150 to 200 m	100 to 150 m	Total
17 to 20	35	45	45	31	33	18	43	250
20 to 23	73	54	97	51	22	29	17	343
23 to 26	43	50	66	36	35	66	3	299
26 to 30	59	61	55	24	19	71	11	300
Total	**210**	**210**	**263**	**142**	**109**	**184**	**74**	**1192**

3.3 LENGTH CLASSES

In order to develop separately contributions of the MLA to recruitment, spawning stock etc. I have conducted calculations on four size classes for each species, which we define as follows:

Table 3. Length Classes by Species

Juveniles	1 to 16 cm
Recruits	17 to 27 cm
Maturing Stock	28 to 36 cm
Mature Spawning Stock	37 cm +

Note that for *M. capensis* the first two classes defined above are consistent with Kainge et al (Kainge 2011), who omit the "juvenile" class from biomass estimates (on the grounds that escape from the gear is both large and inconsistent. NatMIRC (Kainge 2011) also produce an annual recruitment index for *M. capensis* using the "recruit" class, but on a numbers rather than mass basis. The 37cm cut-off for "mature spawning stock" is the estimated length at 95% maturity (Kirchner 2012)[1]. (See Figure 5 below). An alternative here would be to produce a maturity weighted biomass estimate summed across all length classes, but it is felt that the current method makes for simpler categorisation and is sufficient to estimate the contribution of the MLA to this component of the fishery. For the other two species, *M. paradoxus* and *L. vomerinus*, I adopt the same length classes for consistency.

[1] This refers to the ogive in Figure 5 which estimates the relative proportion of fish that are estimated to have obtained maturity at a particular length interval

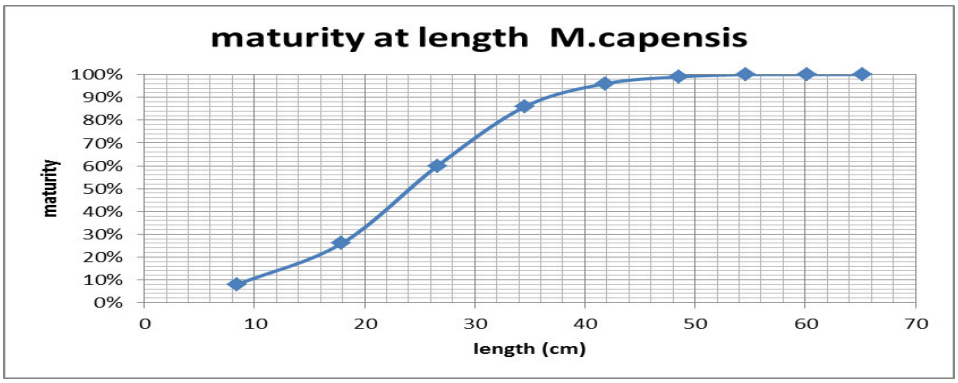

Figure 5. Maturity at length for *M. capensis*

3.4 CALCULATIONS: MASS AND DENSITY PER STATION.

In the notation below, dependence on species is taken as understood and omitted for simplicity. The calculations are in effect repeated independently for each of the four species considered in the study.

The mass of fish of length l in the trawl catch at station *i* is calculated as

$$w_{i,l} = a.l^b.n_{i,l}.f_i \quad (1)$$

where:

$n_{i,l}$ is the number of fish of length l in the sample at station *i*

a and b are parameters of the length : weight function for each species, the values of which can be found in Table 4 below.

$$f_i = \frac{W_i}{\sum_{l=1}^{150} a.l^b.n_{i,l}} \quad (2)$$

is a normalising factor, ensuring that

$$W_i = \sum_{l=1}^{150} w_{i,l} \quad (3)$$

where

W_i is the total catch of species in the trawl *i*, recorded in the data provided.

Mass within each of 4 length classes are calculated as

$$W_{J,i} = \sum_{l=1}^{16} w_{i,l} \quad \text{(Juveniles)} \quad (4)$$

$$W_{R,i} = \sum_{l=17}^{27} w_{i,l} \quad \text{(Recruits)} \quad (5)$$

$$W_{M,i} = \sum_{l=28}^{36} w_{i,l} \quad \text{(Maturing)} \tag{6}$$

$$W_{S,i} = \sum_{l=36}^{150} w_{i,l} \quad \text{(Mature spawning stock)} \tag{7}$$

Density per station (kg per square mile) is calculated as

$$\partial_i = \frac{W_i}{d_i.\Omega/1852} \quad ^2 \tag{8}$$

where:

d_i is the distance (miles) trawled at station *i*, which is provided in the data
Ω = 18.5 is the gear wingspread in metres
1852 is the conversion factor from metres to miles.

Similarly, for each of the 4 length classes L ε {J; R; M; S}:

$$\partial_{L,i} = \frac{W_{L,i}}{d_i.\Omega/1852} \tag{9}$$

Table 4. Parameters of the Length: Weight Function (Source: Kainge 2011)[3]

	a	b
M. capensis	0.006	3.007
M. paradoxus	0.005	3.096
L. vomerinus	0.013	3.012

3.5 CALCULATIONS: STRATIFIED MEAN AND VARIANCE

For each stratum s, the mean density is calculated as:

$$\partial_s = \frac{1}{m_s} \sum_{i\,\varepsilon\,s} \partial_i \tag{10}$$

with error variance:

$$V_s = \frac{1}{m_s(m_s-1)} \sum_{i\,\varepsilon\,s} (\partial_i - \partial_s)^2 \tag{11}$$

where:

m_s is the number of stations trawled in stratum s.

[2] This assumes a swept area which is the product of distance trawled and wingspread, an assumption which is consistent with the methods of Kainge(201l)
[3] Where applicable, parameters for males and females have been averaged.

I calculate stratified biomass estimates for three regions R = H (entire resource habitat), M (mining lease area) or D (SP-1 Dredging site) as

$$B^R = \ {}_S A_S^R . \partial_s \quad (12)$$

with error variance:

$$V = \ {}_S A_S^{R\,2} . V_s \quad (13)$$

and coefficient of variation:

$$\mathrm{CV} = \frac{\overline{\mathrm{V}}}{\mathrm{B}} \quad (14)$$

where:

$\mathrm{A_S^R}$ is the area, in square miles, represented by stratum S, in region R. These areas are given in Section 6, Table 5.

Whereas Equations (11) to (14) are for the species as a whole, we conduct similar calculations for each length class L, as follows:

$$\partial_{s,L} = \frac{1}{m_s} \quad i \ \varepsilon \ \mathrm{s} \ \partial_{i,L} \quad (15)$$

$$V_{s,L} = \frac{1}{m_s(m_s-1)} \quad i \ \varepsilon \ \mathrm{s} \ (\partial_{iL} - \partial_{s,L})^2 \quad (16)$$

$$B_L{}^R = \ {}_S A_S^R . \partial_{s,L} \quad (17)$$

with error variance:

$$V_L = \ {}_S A_S^{R\,2} . V_{s,L} \quad (18)$$

and coefficient of variation:

$$\mathrm{CV}_L = \frac{\overline{\mathrm{V}_L}}{\mathrm{B}} \quad (19)$$

3.6 CALCULATIONS: CONTRIBUTION OF MLA AND S-1 SITE TO THE RESOURCE.

1000 Random draws[4] were taken from each of the estimates of B_L^H , B_L^M and B_L^D assuming normal distributions with mean and variances as estimated a in part 4.5 (see Tables 6.) The ratios $\frac{B_L^D}{B_L^H}$ and $\frac{B_L^B}{B_L^H}$ were calculated for each iterate. The median, 2.5th and 97.5th percentiles were captured to constitute estimates and 95% confidence intervals respectively.

4 RESULTS

Table 6(a) shows the biomass estimates by length class and estimates of recruitment for the Resource, MLA 170 and SP-1 site, using Approach 2, which is the preferred method. Table 6(b) shows comparative results for Approaches 1 and 2. All further results reflect Approach 2 only.

Tables 7(a) to (c) provide the estimates of the contributions of the MLA and SP-1 site as a proportion of the resource. Tables 8(a) to 10(e) provide detailed density and biomass estimates by stratum, species and size class. These are also plotted in Figs 6(a) to (d).

The MLA is estimated to contain less than 2% of the Namibian biomass of *M. capensis*, which reduces to 0.2% if the SP-1 mining site only is considered. This is roughly in line with the area contribution as seen in Table 7(a). No notable departures from this proportion is estimated for either the recruits or the spawning adults. We note that the 23 to 26 degree latitude band is a breeding ground for *M. capensis*, containing a large proportion of juveniles, however the overwhelming majority of these are at depths less than 200 m, whereas most of the MLA lies in deeper waters.

M. paradoxus adults are scarce in depths of less than 300 m, and the younger fish (less than 27 cm) are predominantly found south of 26 degrees. Thus the MLA and in particular the SP-1 site have very little interaction with *M. paradoxus* (less than 0.2% of biomass in entire MLA). See Figure 6(b) and Table 9.

For monk, the MLA is estimated to contribute about 2% to overall biomass. This is less (0.7%) among the mature stock which tend to lie in deeper water and further south (Table 9(e)). The recruits however are more prevalent in the MLA, with an estimated 7% of recruits in the MLA (Table 7(c)). Note that most of this contribution is in the 250 to 300 m depth range (Table 10b). The SP-1 site is shallower than 250 m, and so this is estimated to contribute only 0.2% of recruits.

[4] The implicit assumption here is that error in the estimates of Biomass in the resource, MLA and SP-1 site respectively are uncorrelated. This is in effect a conservative assumption as there is likely to be some positive correlation so that the resulting margins of error are likely in fact to be over-estimated.

5 CONCLUSIONS

In conclusion, less than 0.2 % of each species considered lies directly within the proposed SP-1 dredging site. The SP-1 site also makes no significant contribution to recruitment or spawner stock biomass for any of the species considered in this assessment. Outside of SP-1 and within the larger MLA, the biomass of monk expected to contribute to the recruitment to the fishery is estimated to be 7%. This assessment makes no judgement on the possible impact on recruitment of dredging only in SP-1 on the area outside of SP-1 and within the total MLA. It is emphasized however that as, the proportion of the potential biomass in SP-1 and recruiting to the commercial fisheries in the adjacent areas is extremely small, the broader impact, if scaled outside of the mined area, is likely to be minimal.

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7 ADDITIONAL TABLES AND FIGURES.

Table 5. Area by stratum, for the resource, the MLA and the dredging site SP-1.[5]

Latitude (°S)	Depth (m)	Resource Area	MLA Area	SP-1
26 to 30	100 to 150	892		
	150 to 200	5757		
	200 to 250	753		
	250 to 300	951		
	300 to 400	1781		
	400 to 500	984		
	500 to 600	638		
23 to 26	100 to 150	243	3	
	150 to 200	5352	127	18
	200 to 250	1386	227	33
	250 to 300	1426	286	
	300 to 400	2138		
	400 to 500	806		
	500 to 600	465		
20 to 23	100 to 150	1379		
	150 to 200	2352		
	200 to 250	871		
	250 to 300	2020		
	300 to 400	3142		
	400 to 500	871		
	500 to 600	790		
17 to 20	100 to 150	3487		
	150 to 200	1460		
	200 to 250	1307		
	250 to 300	1228		
	300 to 400	1457		
	400 to 500	726		
	500 to 600	379		
	TOTAL	**45040.18**	**643**	**51**

[5] Detailed calculations can be found in Annexure 1.

Table 6(a). Summary of biomass and recruitment Estimates, Average 2007 to 2012 (Approach 2)

		Resource	s.e.	MLA	s.e.	SP-1	s.e.
Area (Sq Miles)	100m to 600m depth range	45 040		643		51	
M. capensis	Biomass Juvenile	35 673	28277	826	670	114	94
	Biomass Recruits	247 144	30955	3 869	733	488	112
	Biomass Maturing Stock	167 422	26440	2 886	499	279	64
	Biomass Mature Stock	360 456	26142	5 602	750	408	77
	Biomass Total	896 634	70888	14 579	1461	1 289	177
	Biomass Total Excluding Juveniles	858 910	65622	13 873	1364	1 176	150
	Number of Recruits (millions)	3 417	402	56	9	7	1
M. paradoxus	Biomass Juvenile	635	182	0	0	0.0	0.0
	Biomass Recruits	25 341	4201	16	15	0.0	0.0
	Biomass Maturing Stock	44 888	4830	5	3	0.0	0.0
	Biomass Mature Stock	80 332	6051	1	1	0.0	0.0
	Biomass Total	151 337	11064	21	16	0.0	0.0
	Biomass Total Excluding Juveniles	150 561	11042	21	16	0.0	0.0
	Number of Recruits (millions)	269	44	0.19	0	0.0	0.0
L. vomerinus	Biomass Juvenile	160	50	4	2	0.3	0.1
	Biomass Recruits	2 232	410	166	62	4.7	1.6
	Biomass Maturing Stock	3 290	519	119	39	3.2	1.0
	Biomass Mature Stock	13 706	1175	107	27	3.5	1.1
	Biomass Total	19 431	1644	398	107	11.7	2.2
	Biomass Total Excluding Juveniles	19 229	1629	393	106	11.5	2.2
	Number of Recruits (millions)	10	2	0.72	0	0.02	0.01

Table 6(b). Biomass and recruitment estimates, Comparison of Approach 1 and Approach 2.

				Approach 1		Approach 2	
		Resource	s.e.	MLA	s.e.	MLA	s.e.
Area (Sq Miles)	100m to 600m depth range	45 040		643		643	
M. capensis	Biomass Juvenile	35 673	28277	115	59	826	670
	Biomass Recruits	247 144	30955	15410	6307	3 869	733
	Biomass Maturing Stock	167 422	26440	10645	8157	2 886	499
	Biomass Mature Stock	360 456	26142	5030	2065	5 602	750
	Biomass Total	896 634	70888	31208	13587	14 579	1461
	Biomass Total Excluding Juveniles	858 910	65622	26178	13587	13 873	1364
	Number of Recruits (millions)	3 417	402	150	55	56	9
M. paradoxus	Biomass Juvenile	635	182	0.0	-	0	-
	Biomass Recruits	25 341	4201	0.0	-	16	15
	Biomass Maturing Stock	44 888	4830	0.0	-	5	3
	Biomass Mature Stock	80 332	6051	0.0	-	1	1
	Biomass Total	151 337	11064	0.0	-	21	16
	Biomass Total Excluding Juveniles	150 561	11042	0.0	-	21	16
	Number of Recruits (millions)	269	44	0.0	-	0.19	0.2
L. vomerinus	Biomass Juvenile	160	50	9	9	4	2
	Biomass Recruits	2 232	410	212	190	166	62
	Biomass Maturing Stock	3 290	519	22	12	119	39
	Biomass Mature Stock	13 706	1175	30	16	107	27
	Biomass Total	19 431	1644	277	209	398	107
	Biomass Total Excluding Juveniles	19 229	1629	248	209	393	106
	Number of Recruits (millions)	10	2	0.90	0.80	0.72	0.3

Table 7(a). Estimated percentage contribution of the MLA and the SP-1 dredging site to the *M. capensis* resource

	MLA	95% Confidence Interval	SandPiper-1	95% Confidence Interval
% of Area	1.3%		0.11%	
% of Biomass	1.6%	(1.3% , 2%)	0.14%	(0.1% , 0.18%)
% of Mature Stock	1.6%	(1.1% , 2%)	0.11%	(0.07% , 0.16%)
% of Recruits	1.6%	(1.1% , 2.2%)	0.20%	(0.12% , 0.28%)

Table 7(b). Estimated percentage contribution of the MLA and the SP-1 site to the *M. paradoxus* resource

	MLA	95% Confidence Interval95% CI	SandPiper-1	95% Confidence Interval95% CI
% of Area	1.3%		6.9%	
% of Biomass	0.01%	(0% , 0.035%)	0.00%	(0% , 0.01%)
% of Mature Stock	0.001%	(0% , 0.003%)	0.00%	(0% , 0.001%)
% of Recruits	0.07%	(0% , 0.197%)	0.00%	(0% , 0.01%)

Table 7(c). Estimated percentage contribution of the MLA and the SP-1 site to the *L.vomerinus* resource

	MLA	95% Confidence Interval	SandPiper-1	95% Confidence Interval
% of Area	1.3%		0.11%	
% of Biomass	2.0%	(0.9% , 3.1%)	0.06%	(0.04% , 0.08%)
% of Mature Stock	0.8%	(0.4% , 1.2%)	0.03%	(0.01% , 0.04%)
% of Recruits	7.0%	(1.8% , 12.3%)	0.20%	(0.07% , 0.34%)

Table 8(a). Density and biomass estimates by stratum, *M. capensis* juveniles (0 to 16 cm)

Latitude (°S)	Depth (m)	mean density	s.e.	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	181.3	0.4	162	67	0	0	0	0
	150 to 200	116.7	43.1	672	248	0	0	0	0
	200 to 250	348.8	316.9	263	238	0	0	0	0
	250 to 300	9.3	6.7	9	6	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	1329.1	1226.0	323	298	5	4	0	0
	150 to 200	5921.8	5282.1	31693	28269	751	670	106	43
	200 to 250	245.0	90.3	340	125	56	20	8	8
	250 to 300	51.9	23.8	74	34	15	7	0	9
	300 to 400	0.2	0.2	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	124.8	44.0	172	61	0	0	0	0
	150 to 200	549.1	156.1	1291	367	0	0	0	0
	200 to 250	392.8	226.3	342	197	0	0	0	0
	250 to 300	105.0	29.7	212	60	0	0	0	0
	300 to 400	9.5	4.2	30	13	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	10.4	5.0	36	18	0	0	0	0
	150 to 200	6.4	3.1	9	4	0	0	0	0
	200 to 250	31.9	17.1	42	22	0	0	0	0
	250 to 300	0.7	0.5	1	1	0	0	0	0
	300 to 400	1.6	1.1	2	2	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**35673**	**28277**	**826**	**670**	**114**	**94**

Table 8(b). Density and biomass estimates by stratum, *M. capensis* recruits (17 to 27 cm)

Latitude (°S)	Depth (m)	mean density	s.e.	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	6966.3	0.2	6214	1504	0	0	0	0
	150 to 200	5207.5	1741.7	29981	10028	0	0	0	0
	200 to 250	10054.7	4514.2	7567	3397	0	0	0	0
	250 to 300	4097.6	2146.1	3895	2040	0	0	0	0
	300 to 400	0.8	0.5	1	1	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	408.7	465.0	99	113	1	2	0	0
	150 to 200	13549.4	3768.0	72515	20166	1411	393	241	43
	200 to 250	7451.9	2693.7	10331	3734	1551	561	247	8
	250 to 300	3165.8	914.0	4514	1303	905	261	0	9
	300 to 400	45.0	19.6	96	42	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	10528.8	6636.1	14514	9148	0	0	0	0
	150 to 200	14451.6	3830.0	33984	9007	0	0	0	0
	200 to 250	13556.8	4625.6	11814	4031	0	0	0	0
	250 to 300	2781.6	814.0	5619	1644	0	0	0	0
	300 to 400	186.0	65.7	584	206	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	3714.2	1056.2	12951	3683	0	0	0	0
	150 to 200	4063.3	1884.8	5931	2751	0	0	0	0
	200 to 250	6115.0	2768.6	7993	3619	0	0	0	0
	250 to 300	15091.1	11499.1	18530	14120	0	0	0	0
	300 to 400	6.9	3.0	10	4	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**247144**	**30955**	**3869**	**733**	**488**	**112**

Table 8(c). Density and biomass estimates by stratum, *M. capensis* maturing stock (28 to 36 cm)

Latitude (°S)	Depth (m)	mean density	s.e.	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	2102.8	0.3	1876	580	0	0	0	0
	150 to 200	2159.8	734.3	12435	4228	0	0	0	0
	200 to 250	7804.0	3518.1	5873	2648	0	0	0	0
	250 to 300	9558.1	2782.9	9086	2646	0	0	0	0
	300 to 400	266.4	108.9	475	194	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	5602.3	3054.0	29983	16344	584	318	100	43
	200 to 250	5421.2	1018.4	7516	1412	1128	212	179	8
	250 to 300	4106.7	1123.0	5856	1601	1174	321	0	9
	300 to 400	426.0	189.9	911	406	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	1480.3	812.2	2041	1120	0	0	0	0
	150 to 200	3083.9	761.5	7252	1791	0	0	0	0
	200 to 250	4454.3	1242.0	3882	1082	0	0	0	0
	250 to 300	4093.6	1184.1	8269	2392	0	0	0	0
	300 to 400	1031.8	225.6	3242	709	0	0	0	0
	400 to 500	2.0	1.4	2	1	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	3160.6	1235.6	11020	4308	0	0	0	0
	150 to 200	5071.1	1014.4	7402	1481	0	0	0	0
	200 to 250	20615.0	13861.2	26946	18118	0	0	0	0
	250 to 300	17943.0	4728.5	22032	5806	0	0	0	0
	300 to 400	901.5	419.1	1314	611	0	0	0	0
	400 to 500	15.4	10.0	11	7	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**167422**	**26440**	**2886**	**499**	**279**	**64**

Table 8(d). Density and biomass estimates by stratum, *M. capensis* mature stock (37 cm +)

Latitude (°S)	Depth (m)	mean density	s.e.	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	408.8	1.0	365	363	0	0	0	0
	150 to 200	4488.5	873.1	25842	5027	0	0	0	0
	200 to 250	4243.5	1765.7	3194	1329	0	0	0	0
	250 to 300	11075.4	3537.7	10529	3363	0	0	0	0
	300 to 400	5842.2	2074.3	10407	3695	0	0	0	0
	400 to 500	33.9	19.0	33	19	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	3880.9	974.0	20770	5213	404	101	69	43
	200 to 250	10251.3	2260.8	14212	3134	2134	471	339	8
	250 to 300	10717.8	2013.9	15283	2872	3064	576	0	9
	300 to 400	5814.1	1055.4	12428	2256	0	0	0	0
	400 to 500	7.7	6.0	6	5	0	0	0	0
	500 to 600	6.9	6.9	3	3	0	0	0	0
20 to 23	100 to 150	5838.9	2901.4	8049	4000	0	0	0	0
	150 to 200	7717.6	2881.3	18149	6776	0	0	0	0
	200 to 250	12626.7	5338.3	11003	4652	0	0	0	0
	250 to 300	12428.6	3033.1	25107	6127	0	0	0	0
	300 to 400	13084.7	1804.5	41107	5669	0	0	0	0
	400 to 500	259.7	137.4	226	120	0	0	0	0
	500 to 600	1.5	1.5	1	1	0	0	0	0
17 to 20	100 to 150	679.9	269.2	2371	939	0	0	0	0
	150 to 200	10024.3	4156.5	14631	6067	0	0	0	0
	200 to 250	30547.0	9215.2	39928	12045	0	0	0	0
	250 to 300	42433.8	10163.5	52104	12480	0	0	0	0
	300 to 400	21746.5	6436.7	31694	9381	0	0	0	0
	400 to 500	4151.7	1513.1	3013	1098	0	0	0	0
	500 to 600	1.2	1.2	0	0	0	0	0	0
TOTAL				**360456**	**26142**	**5602**	**750**	**408**	**77**

Table 8(e). Recruits (numbers) by stratum, *M. capensis* recruits (17 to 27 cm)

Latitude (°S)	Depth (m)	numbers per sq. mile	s.e.	Recruits (millions)	s.e.	Recruits (millions) in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	110500.6	0.2	99	24	0	0	0	0
	150 to 200	71175.4	24323.2	410	140	0	0	0	0
	200 to 250	167292.4	72114.0	126	54	0	0	0	0
	250 to 300	68120.1	30326.4	65	29	0	0	0	0
	300 to 400	42.7	18.9	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	2420.3	2964.2	1	1	0	0	0	0
	150 to 200	183356.0	45289.8	981	242	19	5	3	1
	200 to 250	108527.0	34841.3	150	48	23	7	4	1
	250 to 300	49412.0	13044.5	70	19	14	4	0	0
	300 to 400	831.0	326.6	2	1	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	133395.3	83812.5	184	116	0	0	0	0
	150 to 200	186091.2	48516.1	438	114	0	0	0	0
	200 to 250	183373.7	62465.0	160	54	0	0	0	0
	250 to 300	40067.9	10715.6	81	22	0	0	0	0
	300 to 400	3209.3	946.7	10	3	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	52914.5	14004.1	185	49	0	0	0	0
	150 to 200	56726.7	24499.0	83	36	0	0	0	0
	200 to 250	82713.5	33317.1	108	44	0	0	0	0
	250 to 300	216227.3	164311.3	266	202	0	0	0	0
	300 to 400	170.0	61.5	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**3417**	**402**	**56**	**9**	**7**	**1**

Table 9(a). Density and biomass estimates by stratum, *M. paradoxus* juveniles (0 to 16 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	17.8	1.0	16	17	0	0	0	0
	150 to 200	94.0	29.2	541	168	0	0	0	0
	200 to 250	100.8	90.4	76	68	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	1.3	1.2	2	2	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**635**	**182**	**0**	**0**	**0**	**0**

Table 9(b). Density and biomass estimates by stratum, *M. paradoxus* recruits (17 to 27 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	135.6	1.0	121	127	0	0	0	0
	150 to 200	1136.5	304.9	6543	1755	0	0	0	0
	200 to 250	2369.9	1107.8	1784	834	0	0	0	0
	250 to 300	3481.0	2834.8	3309	2695	0	0	0	0
	300 to 400	5358.8	1387.3	9546	2471	0	0	0	0
	400 to 500	1702.6	648.5	1675	638	0	0	0	0
	500 to 600	175.3	108.3	112	69	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	55.7	50.8	79	72	16	15	0	0
	300 to 400	625.2	100.8	1336	215	0	0	0	0
	400 to 500	89.9	24.0	73	19	0	0	0	0
	500 to 600	10.7	6.0	5	3	0	0	0	0
20 to 23	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	2.4	2.4	5	5	0	0	0	0
	300 to 400	222.5	51.1	699	161	0	0	0	0
	400 to 500	24.6	8.8	21	8	0	0	0	0
	500 to 600	0.4	0.3	0	0	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	1.9	0.9	3	1	0	0	0	0
	400 to 500	38.2	28.4	28	21	0	0	0	0
	500 to 600	4.2	2.7	2	1	0	0	0	0
TOTAL				**25341**	**4201**	**16**	**15**	**0**	**0**

Table 9(c). Density and biomass estimates by stratum, *M. paradoxus* maturing stock (28 to 35 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	#DIV/0!	0	0	0	0	0	0
	150 to 200	91.2	48.2	525	278	0	0	0	0
	200 to 250	148.0	69.0	111	52	0	0	0	0
	250 to 300	3048.7	2218.9	2898	2109	0	0	0	0
	300 to 400	11299.4	2132.6	20128	3799	0	0	0	0
	400 to 500	6098.2	1488.0	6000	1464	0	0	0	0
	500 to 600	476.6	306.3	304	196	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	15.8	11.5	23	16	5	3	0	0
	300 to 400	3038.6	480.8	6495	1028	0	0	0	0
	400 to 500	1170.3	374.5	944	302	0	0	0	0
	500 to 600	111.0	46.7	52	22	0	0	0	0
20 to 23	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	46.0	46.5	93	94	0	0	0	0
	300 to 400	1648.2	294.8	5178	926	0	0	0	0
	400 to 500	925.9	277.0	806	241	0	0	0	0
	500 to 600	41.2	13.9	33	11	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	6.0	6.1	7	8	0	0	0	0
	300 to 400	235.1	118.8	343	173	0	0	0	0
	400 to 500	1077.9	388.3	782	282	0	0	0	0
	500 to 600	436.9	239.0	165	91	0	0	0	0
TOTAL				**44888**	**4830**	**5**	**3**	**0**	**0**

Table 9(d). Density and biomass estimates by stratum, *M. paradoxus* mature stock (36 cm+).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	#DIV/0!	0	0	0	0	0	0
	150 to 200	14.8	9.3	85	54	0	0	0	0
	200 to 250	73.1	40.1	55	30	0	0	0	0
	250 to 300	682.1	443.5	648	422	0	0	0	0
	300 to 400	11846.6	2634.9	21103	4694	0	0	0	0
	400 to 500	12903.7	1914.9	12695	1884	0	0	0	0
	500 to 600	4080.0	833.6	2605	532	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	2.5	2.5	4	4	1	1	0	0
	300 to 400	4489.1	881.1	9596	1883	0	0	0	0
	400 to 500	6682.8	1403.1	5389	1132	0	0	0	0
	500 to 600	4512.0	502.9	2099	234	0	0	0	0
20 to 23	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	32.0	32.3	65	65	0	0	0	0
	300 to 400	2687.5	534.0	8443	1678	0	0	0	0
	400 to 500	5708.2	1133.0	4971	987	0	0	0	0
	500 to 600	5762.8	878.4	4552	694	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	13.9	14.2	17	17	0	0	0	0
	300 to 400	905.1	386.1	1319	563	0	0	0	0
	400 to 500	3297.5	702.3	2393	510	0	0	0	0
	500 to 600	11336.5	2422.3	4293	917	0	0	0	0
TOTAL				**80332**	**6051**	**1**	**1**	**0**	**0**

Table 9(e). Recruits (numbers) by stratum, *M. paradoxus* recruits (17 to 27 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Recruits (millions)	s.e.	Recruits (millions) in MLA	s.e.	Recruits (millions) in SP-1	s.e.
26 to 30	100 to 150	2123.7	1.0	2	2	0	0	0	0
	150 to 200	15130.5	4141.1	87	24	0	0	0	0
	200 to 250	28974.9	13641.6	22	10	0	0	0	0
	250 to 300	30038.0	23629.1	29	22	0	0	0	0
	300 to 400	53875.6	15271.3	96	27	0	0	0	0
	400 to 500	14108.1	4984.9	14	5	0	0	0	0
	500 to 600	1408.6	937.4	1	1	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	648.6	600.2	1	1	0	0	0	0
	300 to 400	5245.8	828.2	11	2	0	0	0	0
	400 to 500	755.3	200.9	1	0	0	0	0	0
	500 to 600	84.4	47.7	0	0	0	0	0	0
20 to 23	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	15.6	15.8	0	0	0	0	0	0
	300 to 400	1714.5	367.4	5	1	0	0	0	0
	400 to 500	191.6	68.4	0	0	0	0	0	0
	500 to 600	3.6	2.6	0	0	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	15.1	7.0	0	0	0	0	0	0
	400 to 500	309.3	232.8	0	0	0	0	0	0
	500 to 600	32.6	21.6	0	0	0	0	0	0
TOTAL				**269**	**44**	**0**	**0**	**0**	**0**

Table 10(a). Density and biomass estimates by stratum, *L. vomerinus* juveniles (0 to 16 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	3.6	2.3	21	13	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.0	0.0	0	0	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	10.2	7.8	54	42	1	1	0	0
	200 to 250	3.2	1.5	4	2	1	0	0	0
	250 to 300	8.1	6.3	12	9	2	2	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
20 to 23	100 to 150	6.2	6.1	9	8	0	0	0	0
	150 to 200	6.2	4.5	15	11	0	0	0	0
	200 to 250	7.9	4.5	7	4	0	0	0	0
	250 to 300	14.5	8.0	29	16	0	0	0	0
	300 to 400	1.7	1.0	5	3	0	0	0	0
	400 to 500	0.7	0.7	1	1	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	0.7	0.5	1	1	0	0	0	0
	300 to 400	2.3	1.5	3	2	0	0	0	0
	400 to 500	0.0	0.0	0	0	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**160**	**50**	**4**	**2**	**0**	**0**

Table 10(b). Density and biomass estimates by stratum, *L. vomerinus* recruits (17 to 27 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomass	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	0	0	0	0	0	0	0
	150 to 200	51.2	16.9	295	97	0	0	0	0
	200 to 250	11.8	9.8	9	7	0	0	0	0
	250 to 300	27.0	17.2	26	16	0	0	0	0
	300 to 400	0.0	0.0	0	0	0	0	0	0
	400 to 500	1.0	0.5	1	1	0	0	0	0
	500 to 600	0.4	0.3	0	0	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	53.7	38.9	288	208	6	4	1	1
	200 to 250	114.2	43.5	158	60	24	9	4	1
	250 to 300	477.5	214.4	681	306	137	61	0	0
	300 to 400	18.8	5.7	40	12	0	0	0	0
	400 to 500	3.0	1.5	2	1	0	0	0	0
	500 to 600	0.8	0.5	0	0	0	0	0	0
20 to 23	100 to 150	72.7	47.8	100	66	0	0	0	0
	150 to 200	64.8	40.5	152	95	0	0	0	0
	200 to 250	101.5	42.6	88	37	0	0	0	0
	250 to 300	82.1	22.1	166	45	0	0	0	0
	300 to 400	52.2	9.1	164	29	0	0	0	0
	400 to 500	4.2	1.3	4	1	0	0	0	0
	500 to 600	0.8	0.6	1	0	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	3.2	2.6	4	3	0	0	0	0
	250 to 300	16.2	12.1	20	15	0	0	0	0
	300 to 400	22.3	6.3	32	9	0	0	0	0
	400 to 500	0.7	0.8	1	1	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**2232**	**410**	**166**	**62**	**5**	**2**

Table 10(c). Density and biomass estimates by stratum, *L. vomerinus* maturing stock (28 to 35 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomas	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	#DIV/0!	0	0	0	0	0	0
	150 to 200	137.6	32.6	792	188	0	0	0	0
	200 to 250	32.5	14.9	24	11	0	0	0	0
	250 to 300	454.9	413.1	432	393	0	0	0	0
	300 to 400	26.7	9.1	48	16	0	0	0	0
	400 to 500	5.4	2.1	5	2	0	0	0	0
	500 to 600	2.7	1.9	2	1	0	0	0	0
23 to 26	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	36.3	31.7	194	170	4	3	1	1
	200 to 250	76.6	25.2	106	35	16	5	3	1
	250 to 300	348.4	133.3	497	190	100	38	0	0
	300 to 400	109.4	23.2	234	50	0	0	0	0
	400 to 500	34.0	11.7	27	9	0	0	0	0
	500 to 600	4.6	2.1	2	1	0	0	0	0
20 to 23	100 to 150	37.3	31.0	51	43	0	0	0	0
	150 to 200	21.2	11.6	50	27	0	0	0	0
	200 to 250	73.2	31.6	64	28	0	0	0	0
	250 to 300	122.9	28.9	248	58	0	0	0	0
	300 to 400	125.0	18.9	393	59	0	0	0	0
	400 to 500	12.3	4.2	11	4	0	0	0	0
	500 to 600	6.6	3.7	5	3	0	0	0	0
17 to 20	100 to 150	0.0	0.0	0	0	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	0.0	0.0	0	0	0	0	0	0
	250 to 300	8.3	7.0	10	9	0	0	0	0
	300 to 400	58.8	18.5	86	27	0	0	0	0
	400 to 500	10.8	4.3	8	3	0	0	0	0
	500 to 600	0.0	0.0	0	0	0	0	0	0
TOTAL				**3290**	**519**	**119**	**39**	**3**	**1**

Table 10(d). Density and biomass estimates by stratum, *L. vomerinus* mature stock (36 cm +).

Latitude (°S)	Depth (m)	mean density	s.e	Resource Biomas	s.e.	Biomass in MLA	s.e.	Biomass in SP-1	s.e.
26 to 30	100 to 150	0.0	#DIV/0!	0	0	0	0	0	0
	150 to 200	331.2	90.8	1907	523	0	0	0	0
	200 to 250	1196.0	565.8	900	426	0	0	0	0
	250 to 300	1167.2	555.5	1110	528	0	0	0	0
	300 to 400	1321.7	234.9	2354	418	0	0	0	0
	400 to 500	546.1	86.6	537	85	0	0	0	0
	500 to 600	181.7	46.1	116	29	0	0	0	0
23 to 26	100 to 150	1026.2	1256.9	250	306	4	4	0	0
	150 to 200	13.9	6.3	74	34	1	1	0	0
	200 to 250	99.7	32.3	138	45	21	7	3	1
	250 to 300	285.4	88.6	407	126	82	25	0	0
	300 to 400	868.1	212.0	1856	453	0	0	0	0
	400 to 500	535.4	126.0	432	102	0	0	0	0
	500 to 600	790.6	175.2	368	82	0	0	0	0
20 to 23	100 to 150	23.8	20.9	33	29	0	0	0	0
	150 to 200	111.9	63.2	263	149	0	0	0	0
	200 to 250	122.6	90.3	107	79	0	0	0	0
	250 to 300	312.0	77.2	630	156	0	0	0	0
	300 to 400	336.8	51.2	1058	161	0	0	0	0
	400 to 500	73.6	18.9	64	16	0	0	0	0
	500 to 600	303.8	64.4	240	51	0	0	0	0
17 to 20	100 to 150	1.9	1.9	7	7	0	0	0	0
	150 to 200	0.0	0.0	0	0	0	0	0	0
	200 to 250	1.8	1.9	2	2	0	0	0	0
	250 to 300	136.8	101.4	168	124	0	0	0	0
	300 to 400	318.5	112.8	464	164	0	0	0	0
	400 to 500	211.8	73.3	154	53	0	0	0	0
	500 to 600	177.9	67.2	67	25	0	0	0	0
TOTAL				**13706**	**1175**	**107**	**27**	**4**	**1**

Table 10(e). Recruits (numbers) by stratum, *L. vomerinus* recruits (17 to 27 cm).

Latitude (°S)	Depth (m)	mean density	s.e	Recruits (millions)	s.e.	Recruits (millions) MLA	s.e.	Recruits (millions) SP-1	s.e.
26 to 30	100 to 150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	150 to 200	206.3	93.6	1.2	0.5	0.0	0.0	0.0	0.0
	200 to 250	44.8	35.6	0.0	0.0	0.0	0.0	0.0	0.0
	250 to 300	95.9	55.2	0.1	0.1	0.0	0.0	0.0	0.0
	300 to 400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	400 to 500	4.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0
	500 to 600	2.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0
23 to 26	100 to 150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	150 to 200	288.3	204.2	1.5	1.1	0.0	0.0	0.0	0.0
	200 to 250	475.9	178.1	0.7	0.2	0.1	0.0	0.0	0.0
	250 to 300	2057.1	922.6	2.9	1.3	0.6	0.3	0.0	0.0
	300 to 400	72.6	22.4	0.2	0.0	0.0	0.0	0.0	0.0
	400 to 500	10.5	5.2	0.0	0.0	0.0	0.0	0.0	0.0
	500 to 600	3.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0
20 to 23	100 to 150	437.5	288.4	0.6	0.4	0.0	0.0	0.0	0.0
	150 to 200	275.3	164.9	0.6	0.4	0.0	0.0	0.0	0.0
	200 to 250	524.8	234.9	0.5	0.2	0.0	0.0	0.0	0.0
	250 to 300	365.8	103.6	0.7	0.2	0.0	0.0	0.0	0.0
	300 to 400	256.4	53.5	0.8	0.2	0.0	0.0	0.0	0.0
	400 to 500	19.1	6.3	0.0	0.0	0.0	0.0	0.0	0.0
	500 to 600	1.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0
17 to 20	100 to 150	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	150 to 200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	200 to 250	23.6	21.1	0.0	0.0	0.0	0.0	0.0	0.0
	250 to 300	73.9	57.1	0.1	0.1	0.0	0.0	0.0	0.0
	300 to 400	127.7	40.0	0.2	0.1	0.0	0.0	0.0	0.0
	400 to 500	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0
	500 to 600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL				**10.2**	**1.9**	**0.7**	**0.3**	**0.02**	**0.01**

Table 11. *L. vomerinus* catch per depth range from the November Monk surveys 2007 to 2010 between 23 and 26 degrees latitude.

Depth (m)	Mean catch (kg) per 30 minute trawl	Number of trawls	std error
100	1.1	2	0.2
150	16.4	22	6.4
200	25.6	21	5.5
250	26.5	8	8.5
300	24.9	23	3.6
400	16.2	8	6.0
500	13.8	7	7.6

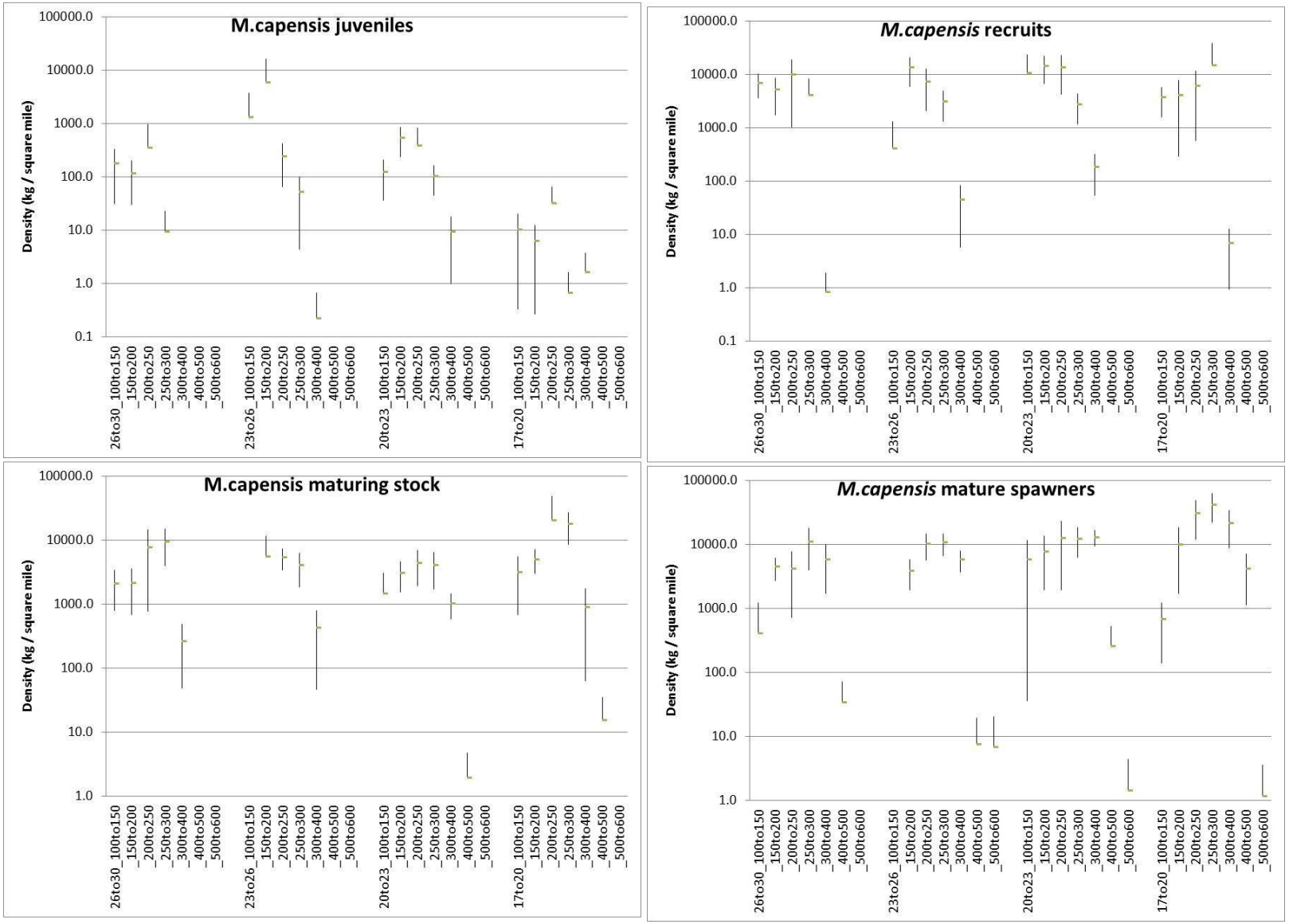

Figure 6(a) *M. capensis* Density estimates (log scale) by latitude and depth division, panelled by length class.
Error bars represent 2 standard errors either side of the mean.

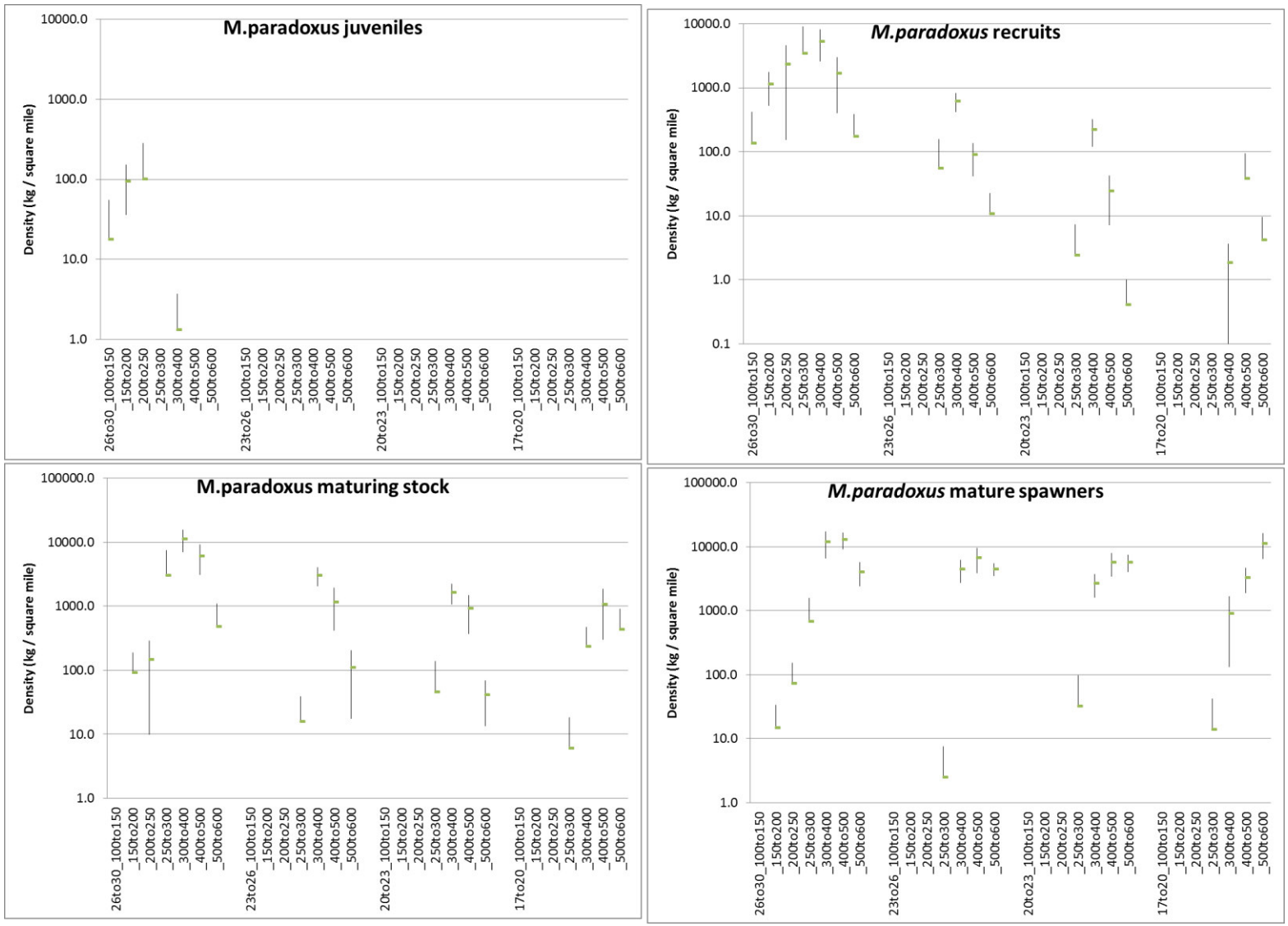

Figure 6(b) *M. paradoxus* Density estimates (log scale) by latitude and depth division, panelled by length class.
Error bars represent 2 standard errors either side of the mean.

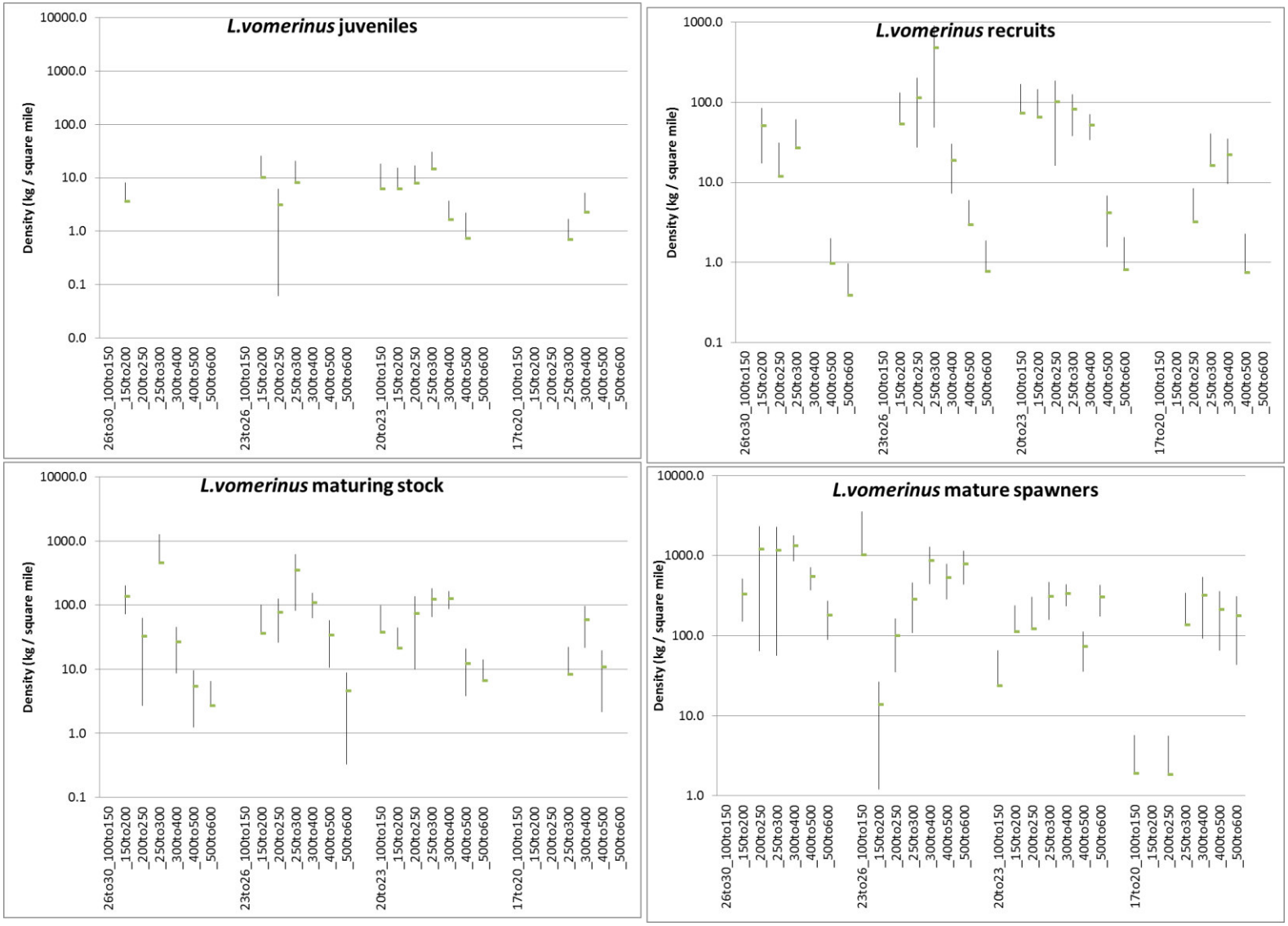

Figure 6(c) *L. vomerinus* Density estimates (log scale) by latitude and depth division, panelled by length class.
Error bars represent 2 standard errors either side of the mean.

ANNEXURE A: AREA CALCULATIONS

The stratification adopted for this study and resulting biomass calculations require area estimates for each of 28 strata intersecting with (a) the MLA (b) the Sandpiper 1 mining site and (c) the resource habitat as a whole.

MLA Area

Areas were calculated by decomposition of the MLA into trapezia.

For each trapezium, let X and Y denote longitude and latitude respectively, with subscripts T, B, TL, TR, BL, BR denoting top, bottom, top left, top right, bottom left and bottom right.

The length (North to South) in miles of each trapezium is calculated as:

$$L = (Y_T - Y_B)*60 \qquad (A1)$$

The widths (East to West) of the North and South boundaries are, respectively

$$W_T = (X_{TR} - X_{TL}).\cos(Y_T)*60 \qquad (A2)$$

$$W_B = (X_{BR} - X_{BL}).\cos(Y_B)*60 \qquad (A3)$$

The area of the trapezium in square miles is then approximately

$$A = L.(W_T + W_B)/2 \qquad (A4)$$

In each Trapezium the proportions by 50m depth zone are estimated using the contours illustrated in Figure A1. Figure A2 and Table A1 show the coordinates used in the calculations. Table A2 shows detailed outputs of these area calculations.

Resource Habitat Area

Areas by 100 m depth range (100 m to 600 m) are given in Kainge (2011). Subdivision of these areas into the strata used in this study is done by assuming area is proportional to number of survey stations. Details of these calculations are shown in Table A3.

Table A1. Coordinates of the vertices of the polygons defining the MLA and the SP-1 dredging site.

	Longitude	Latitude
	14.05	-23.96
	14.14	-23.88
	14.02	-24.45
	13.95	-24.45
	13.95	-24.54
	13.95	-24.90
	13.77	-24.90
	13.75	-24.54
MLA	13.93	-23.96
	13.96	-24.09
	14.03	-24.09
	14.03	-24.29
SP-1	13.96	-24.29
	13.86	-24.32
	13.94	-24.32
	13.94	-24.52
SP-2	13.86	-24.52
	13.82	-24.69
	13.82	-24.79
	13.88	-24.79
SP-3	13.88	-24.69

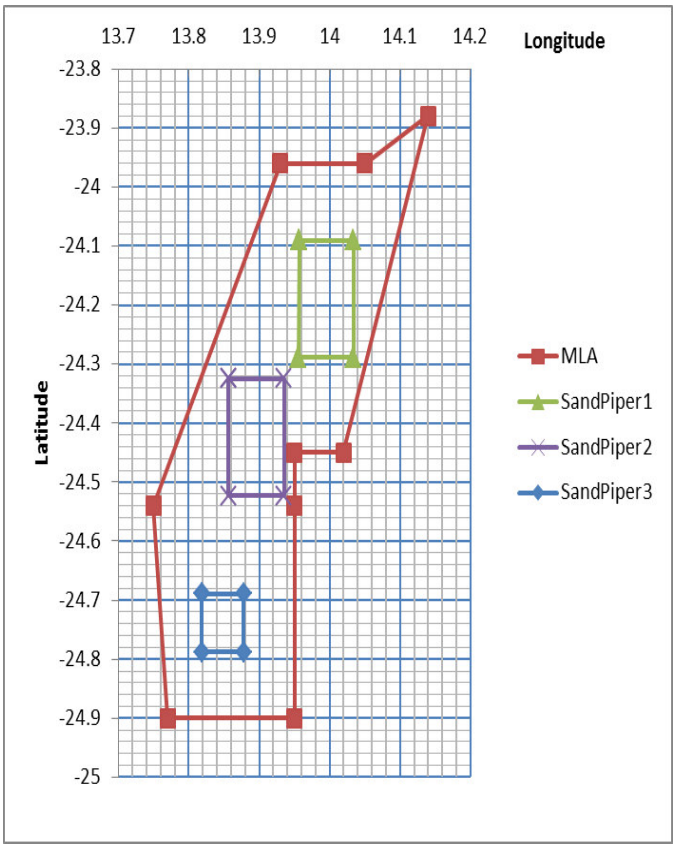

Figure A1. Schematic plot of the MLA and Sandpiper sites (SP-1, SP-2 and SP-3).

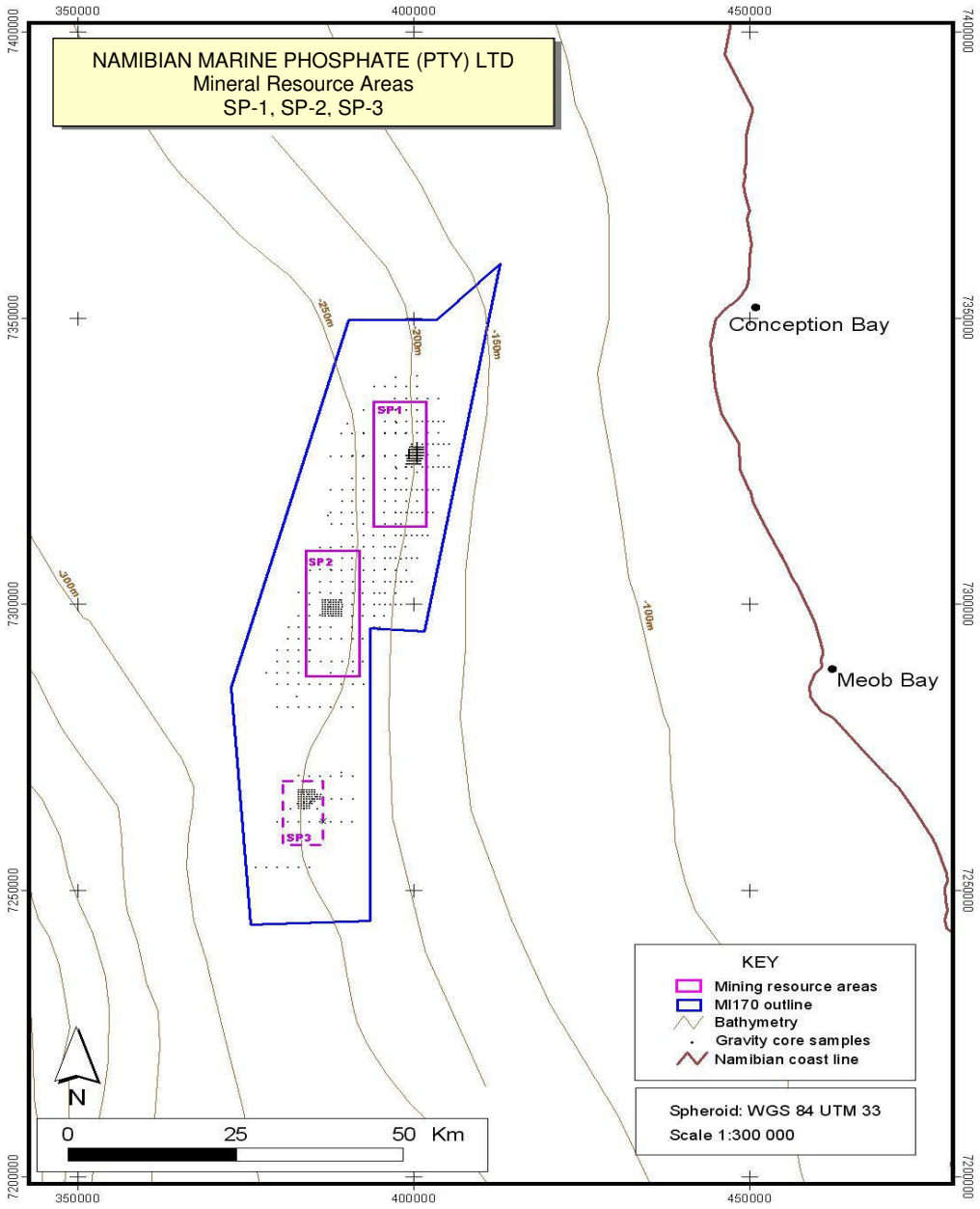

Figure A2. 50 m depth contours in the Sandpiper areas (SP-1, SP-2 and SP-3) and the surrounding area.

Table A2. Calculations of Area of the MLA and decomposition by Depth Range

	proportions by depth range				Dimensions						Area	
	100-150 m	150-200 m	200-250 m	250-300 m	Top Width Degrees	Bottom Width Degrees	Height Deg	Top Width miles	Bottom Width miles	Height miles	Sq miles	Sq km
Upper Triangle	35%	65%			0.0000	0.0750	0.0800	0.000	4.112	4.800	9.9	32.6
Triangle to SP-1		46%	50%	4%	0.1950	0.2100	0.1306	10.692	11.503	7.833	86.9	287.4
SP-1		35%	65%		0.0772	0.0789	0.1986	4.230	4.314	11.917	50.9	168.3
left of SP-1			25%	75%	0.0669	0.1253	0.1986	3.667	6.851	11.917	62.7	207.2
Right of SP-1		100%			0.0658	0.0258	0.1986	3.606	1.413	11.917	29.9	98.9
SP-1 to SP-2		26%	28%	46%	0.2300	0.2300	0.0348	12.578	12.575	2.090	26.3	86.9
SP-2			13%	87%	0.0789	0.0789	0.1990	4.313	4.306	11.940	51.5	170.1
Left of SP-2				100%	0.0367	0.1067	0.1990	2.005	5.823	11.940	46.7	154.5
Right of SP-2 Upper		55%	45%		0.1144	0.0844	0.1260	6.257	4.612	7.560	41.1	135.8
Right of SP-2 Lower		100%			0.0144	0.0144	0.0730	0.789	0.788	4.380	3.5	11.4
SP-2 to SP-3			35%	65%	0.2000	0.1900	0.1670	10.918	10.358	10.020	106.6	352.4
SP-3			60%	40%	0.0594	0.0594	0.0980	3.241	3.238	5.880	19.0	63.0
Left of SP-3				100%	0.0586	0.0536	0.0980	3.195	2.920	5.880	18.0	59.4
Right ofSP-3			100%		0.0719	0.0719	0.0980	3.922	3.919	5.880	23.1	76.2
SP-3 to bottom			45%	55%	0.1850	0.1800	0.1120	10.077	9.796	6.720	66.8	220.7
Total MLA Area Sq miles	**3.5**	**126.8**	**226.7**	**285.9**							**642.7**	
Total MLA Area Sq km	**11.4**	**419.1**	**749.3**	**945.0**								**2124.8**
SP-1 Area Sq miles	**0**	**17.8**	**33.1**								**50.9**	
SP-1 Area Sq km	**0**	**58.9**	**109.4**									**168.3**

Table A3. Calculations of area of resource habitat by stratum

100 m Depth Division	Area of 100 m Depth Division [Kainge (2011)] (km^2)	Depth Subdivision	Latitude	Number of Trawls	% of Depth Division	Stratum Area
100 to 200	20921	100 to 150	17to20	43	16.7%	3486.8
			20to23	17	6.6%	1378.5
			23to26	3	1.2%	243.3
			26to30	11	4.3%	892.0
		150 to 200	17to20	18	7.0%	1459.6
			20to23	29	11.2%	2351.6
			23to26	66	25.6%	5351.9
			26to30	71	27.5%	5757.3
100 to 200	9942	200 to 250	17to20	33	13.1%	1307.1
			20to23	22	8.8%	871.4
			23to26	35	13.9%	1386.3
			26to30	19	7.6%	752.6
		250 to 300	17to20	31	12.4%	1227.9
			20to23	51	20.3%	2020.1
			23to26	36	14.3%	1425.9
			26to30	24	9.6%	950.6
300 to 400	8518	300 to 400	17to20	45	17.1%	1457.5
			20to23	97	36.9%	3141.6
			23to26	66	25.1%	2137.6
			26to30	55	20.9%	1781.3
400 to 500	3387	400 to 500	17to20	45	21.4%	725.8
			20to23	54	25.7%	870.9
			23to26	50	23.8%	806.4
			26to30	61	29.0%	983.8
500 to 600	2283	500 to 600	17to20	35	16.6%	378.7
			20to23	73	34.6%	789.9
			23to26	43	20.4%	465.3
			26to30	59	28.0%	638.4