Catches of sardine and anchovy around four penguin-breeding colonies, 2009-2012

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INTRODUCTION

Spatial and temporal information on catches of small pelagic fish (anchovy and sardine only) is one of the monitoring indices required for the feasibility study conducted by the Island Closure Task Team (ICTT) to inform on possible future experimental closures to purse-seining around island penguin breeding colonies. The feasibility study was initiated in 2008 and will continue until 2014, with different islands being closed to purse-seine fishing at different times, and closed islands paired with open islands in the same vicinity (Table 1).

Table 1: Timetable of island closures during the feasibility study.

Island	2008	2009	2010	2011	2012	2013	2014
Dassen	X	X					X
Robben				X	X	X	
St Croix		X	X	X			
Bird					X	X	X

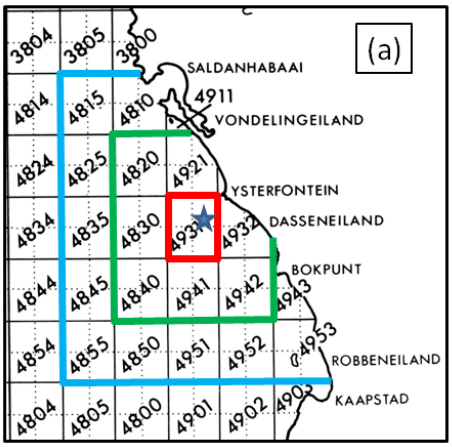
MATERIALS AND METHODS

Catches of small pelagic fish are routinely recorded per 10 x 10 n. mile pelagic fishing block (PFB) by vessel skippers. During closure periods purse-seine fishing is prohibited within a circle of 20 km (ca. 11 n. miles) radius around the island (and also within a circle of 5 km radius around the Riy Bank close to St Croix Island). From 2011 skippers have been required to record the precise location (latitude and longitude) of catches, but capturing and validating these data has proved time-consuming and they are not yet available for analysis.

Catches of anchovy and sardine (by-catch and directed catch combined) from PFBs in the vicinity of each the four islands have been collated to represent the removal of fish at three spatial categories around islands. Catches in the PFB within which the island occurs are taken to represent fish removal within 10 n. miles around the

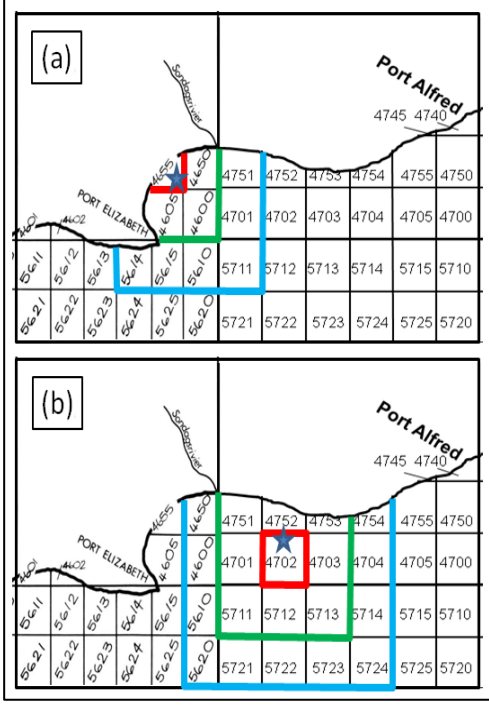
island; catches of fish from immediate neighbouring PFBs around the PFB containing the island, plus catches from the "island-PFB", are taken to represent fish removal within 20 n. miles; and similarly for the 30 n. mile spatial category (Figs 1, 2).

Figure 1: Maps showing the location of penguin breeding islands (blue stars) and surrounding pelagic fishing blocks (PFBs; numbered squares) off the West Coast within which catches of anchovy and sardine were collated to represent three spatial categories (10 [= red], 20 [= green] and 30 [= blue] n.mile radii) around the islands for (a) Dassen Island and (b) Robben Island. The table lists PFB numbers for each spatial category per island.



DASSEN	PFBs	ROBBEN	PFBs
10 n.miles	1 (4931)	10 n.miles	1 (4953)
20 n.miles	8 (4920, 4921, 4830, 4931, 4932, 4840, 4941, 4942)	20 n.miles	6 (4942, 4943, 4952, 4953, 4902, 4903)
30 n.miles	20 (4815, 4810, 4911, 4825, 4820, 4921, 4835, 4830, 4931, 4932, 4845, 4840, 4941. 4942, 4943, 4855, 4850, 4951, 4952, 4953)	30 n.miles	14 (4931, 4932, 4941, 4942, 4943, 4901, 4902, 4903, 5911, 5912, 5913)

Figure 2: Maps showing the location of penguin breeding islands (blue stars) and surrounding pelagic fishing blocks (PFBs; numbered squares) off the South Coast within which catches of anchovy and sardine were collated to represent three spatial categories (10 [= red], 20 [= green] and 30 [= blue] n.mile radii) around the islands for (a) St Croix Island and (b) Bird Island. The table lists PFB numbers for each spatial category per island.



ST CROIX	PFBs
10 n.miles	1 (4655)
20 n.miles	4 (4655, 4650, 4600, 4605)
30 n.miles	10 (4655, 4650, 4600, 4605, 5614, 5615, 5610, 5711, 4701, 4751)

BIRD	PFBs
10 n.miles	1 (4702)
20 n.miles	9 (4702, 4751, 4752, 4753, 4701, 4703, 5711, 5712, 5713)
30 n.miles	20 (4702, 4751, 4752, 4753, 4701, 4703, 5711, 5712, 5713, 4650, 4600, 5610, 5620, 5721, 5722, 5723, 5724, 5714, 4704, 4754)

None of these three spatial scales exactly match the 20 km radius closed areas (Fig. 3), which themselves fall between the PFBs approximating the 10 n.mile and 20 n.mile radii.

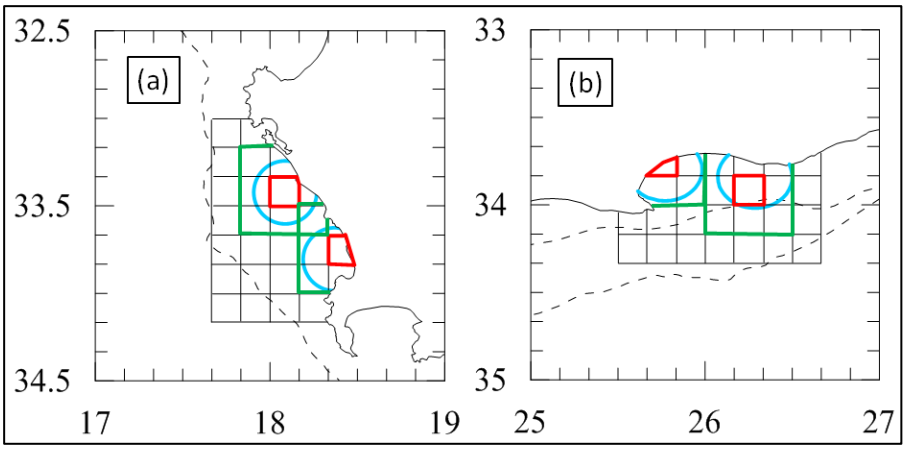


Figure 3: Maps showing the location of areas closed to purse-seine fishing (blue circles) and surrounding pelagic fishing blocks (PFBs; colour coding as for Figs 1 and 2) around penguin island breeding colonies off (a) the West Coast and (b) the South Coast.

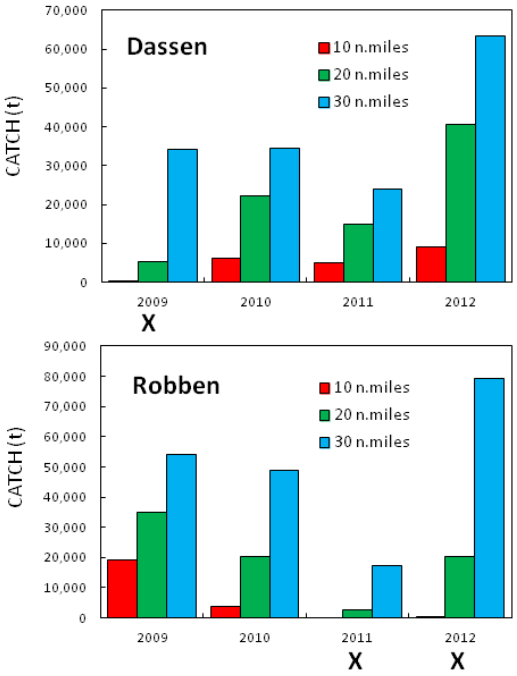
RESULTS

Annual catches of anchovy and sardine (directed and by-catch combined) over the period 2009 to 2012 (up to end-October) for the three spatial categories around each island are presented. Anchovy catches around Dassen and Robben Islands only are shown as virtually no anchovy is caught in Algoa Bay. Negligible anchovy catches were recorded in the PFBs within which the islands are located ("island-PFBs") in closure years, namely 2009 for Dassen and 2011 and 2012 for Robben (Fig. 4). Between 5 000 and 9 000 t of anchovy per year (2010-12) was taken from within 10 n.miles of Dassen Island; between 5 000 and 40 000 t per year (2009-2012) from within 20 n.miles; and between 24 000 and 63 000 t per year (2009-2012) from within 30 n.miles, with the catch for 2012 being roughly double that of the preceding years. Anchovy catches within 30 n.miles around Robben Island were higher than those taken around Dassen Island in all years except 2011.

Anchovy catches around both islands were typically low during the first and last parts of the year and high during winter (June to August), with 10 000 to 14 000 t per month taken within 30 n.miles of Dassen Island and up to 20 000 t per month taken within 30 n.miles of Robben Island (Fig. 5). 2012 was anomalous as catches of

anchovy around both islands were spread over several months (March to September) and showed a bimodal pattern.

Figure 4 (right): Histograms showing annual anchovy catches within (nominally) 10, 20 and 30 n.miles of Dassen (upper) and Robben (lower) Islands from 2009 to 2012 (to end October only). X indicates closure around that island for that year. Note that catches in each spatial category include catches taken at smaller spatial scales, and that the y-axes scales are different.



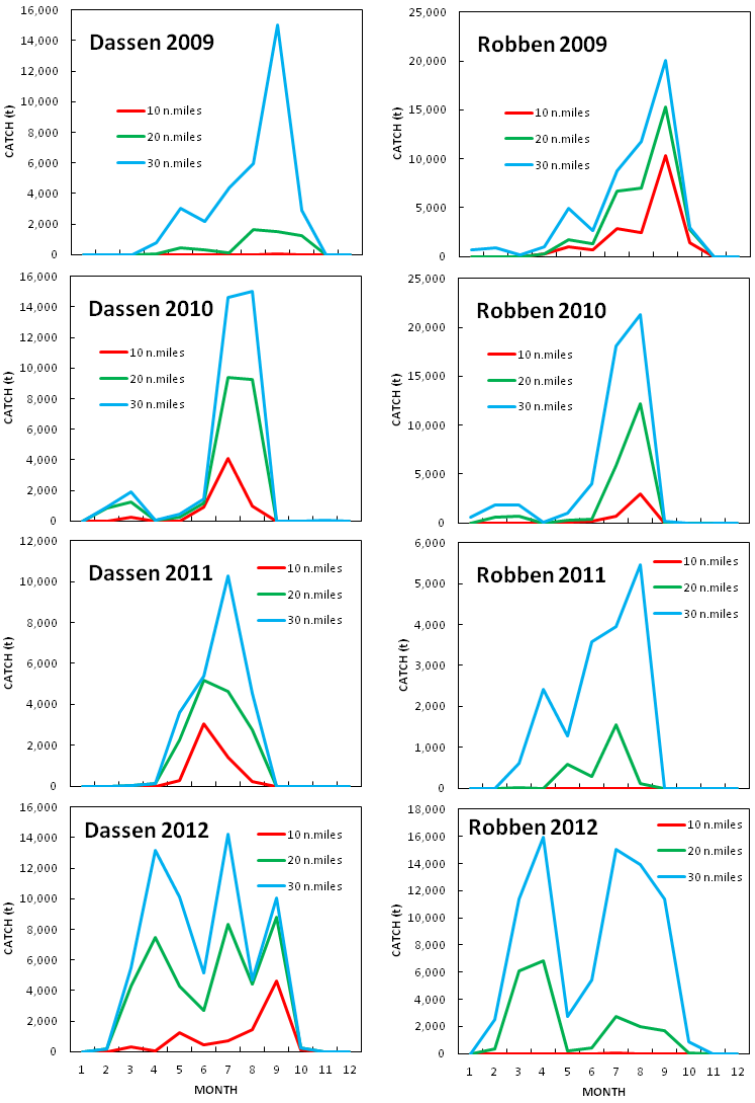


Figure 5 (left): Line plots showing monthly anchovy catches within (nominally) 10, 20 and 30 n.miles of Dassen (left) and Robben (right) Islands from 2009 to 2012 (to end October only). Note that catches in each spatial category include catches taken at smaller spatial scales, and that the y-axes scales are different.

Annual catches of sardine around four islands with penguin breeding colonies are shown in Figure 6. Negligible catches were recorded in the PFBs within which the islands are located in closure years, namely 2009 for Dassen, 2011 and 2012 for Robben, 2009-2011 for St Croix, and 2012 for Bird Islands. Sardine catches within 30 n.miles around Dassen Island were low (± 2 000 t) in 2009 and 2012, and higher

(10 -13 000 t) in 2010 and 2011 with around 1 000 t taken from within 10 n.miles in these years. Sardine catches around Robben were more consistent, with almost no fish caught within 10 n.miles, 1 000 to 2 500 t from within 20 n.miles, and 5 000 to 10 000 t within 30 n.miles over the past four years. Catches of sardine around islands in Algoa Bay were lower than those from around the west coast islands. Catches from within 30 n.miles around St Croix were relatively stable over the past 4 years at 2 000 to 4 000 t, whereas catches around Bird Island showed a marked contrast between 2009/10 and 2011/12, with 3 000 to 5 000 t taken in the former but almost no sardine being caught in the latter.

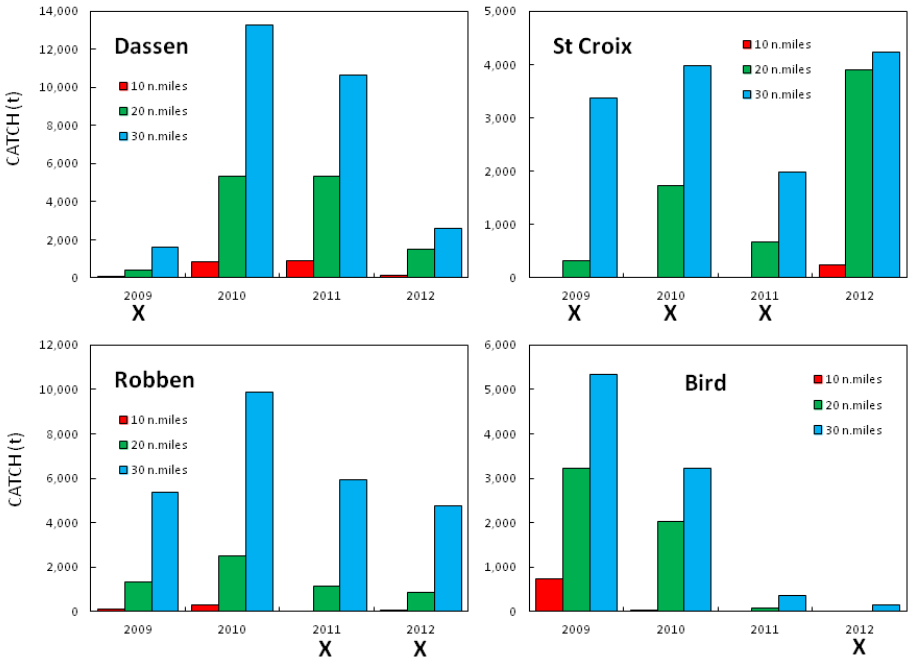


Figure 6: Histograms showing annual sardine catches within (nominally) 10, 20 and 30 n.miles of Dassen, Robben, St Croix and Bird Islands from 2009 to 2012 (to end October only). X indicates closure around that island for that year. Note that catches in each spatial category include catches taken at smaller spatial scales, and that the y-axes scales are different.

Monthly patterns in sardine catches differed between years on the same island, and between islands during the same year, in contrast to patterns observed in anchovy catches. Sardine catches were low and taken mostly during the first half of the year in 2009 around Dassen and Robben islands (Fig. 7). In 2010 the highest monthly catch (4 000 t) around Dassen was taken in November whereas that around Robben in that year was taken in February. For most years on both west coast islands sardine catch was multi-modal. The highest monthly catch of sardine from within 10 n.miles of either island was 630 t (July 2009, Dassen) and catches were mostly substantially smaller than this.

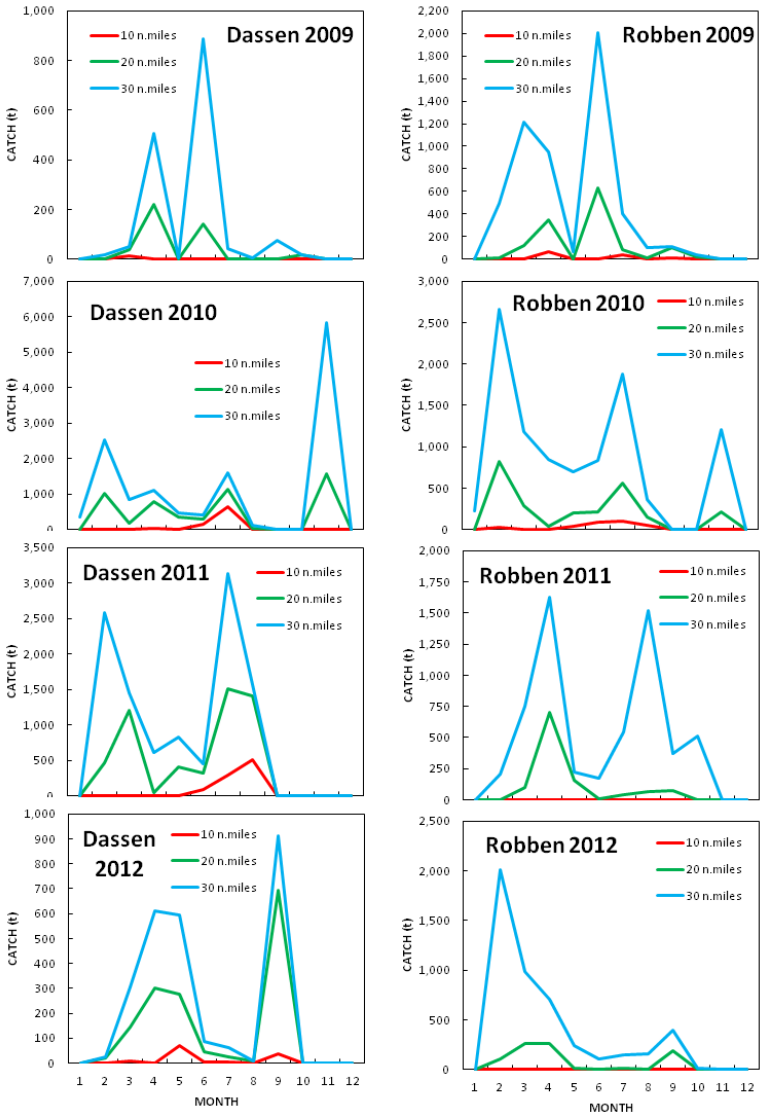


Figure 7: Line plots showing monthly sardine catches within (nominally) 10, 20 and 30 n.miles of Dassen (left) and Robben (right) Islands from 2009 to 2012 (to end October only). Note that catches in each spatial category include catches taken at smaller spatial scales, and that the y-axes scales are different.

Monthly sardine catches from around islands in Algoa Bay are shown in Figure 8, and again differed markedly between years. In 2009 sardine were only caught during the second half of the year; in 2010 most of the catch was taken in March; in 2011 sardine were caught during February/March and again from October to December; and in 2012 fish were caught up to April but not thereafter. Very low catches were taken from around Bird Island in 2011 and 2012 (also see Fig. 6), with the highest monthly sardine catch taken within 30 n.miles in the past two years of only 170 t.

DISCUSSION

Catches of anchovy and sardine from around penguin breeding colonies on Dassen, Robben, St Croix and Bird islands have been collated at three spatial scales (nominally 10, 20 and 30 n.miles around each island) and are available for comparison with penguin data (foraging, breeding success, chick condition, etc) for the island closure feasibility study. Catches reflect the amount of small pelagic fish removed from the available and localised foraging area of breeding penguins, but

these data can also be taken as an indicator of local availability of anchovy and sardine around these islands, with the exception of anchovy abundance around islands in Algoa Bay as these are not targeted there. Strong contrasts are seen in catch data in some cases, notably anchovy catches around Robben Island and sardine catches around Dassen and Bird islands, which should provide a strong signal for comparison with penguin data. The raw data (at both annual and monthly scales) are given in the appendices. Data at the spatial scale (ie PFBs) used here are available for comparison with penguin data from around Dyer Island, and more precise catch location data (latitude and longitude) from 2011 and 2012 for all islands will be available in the next few months.

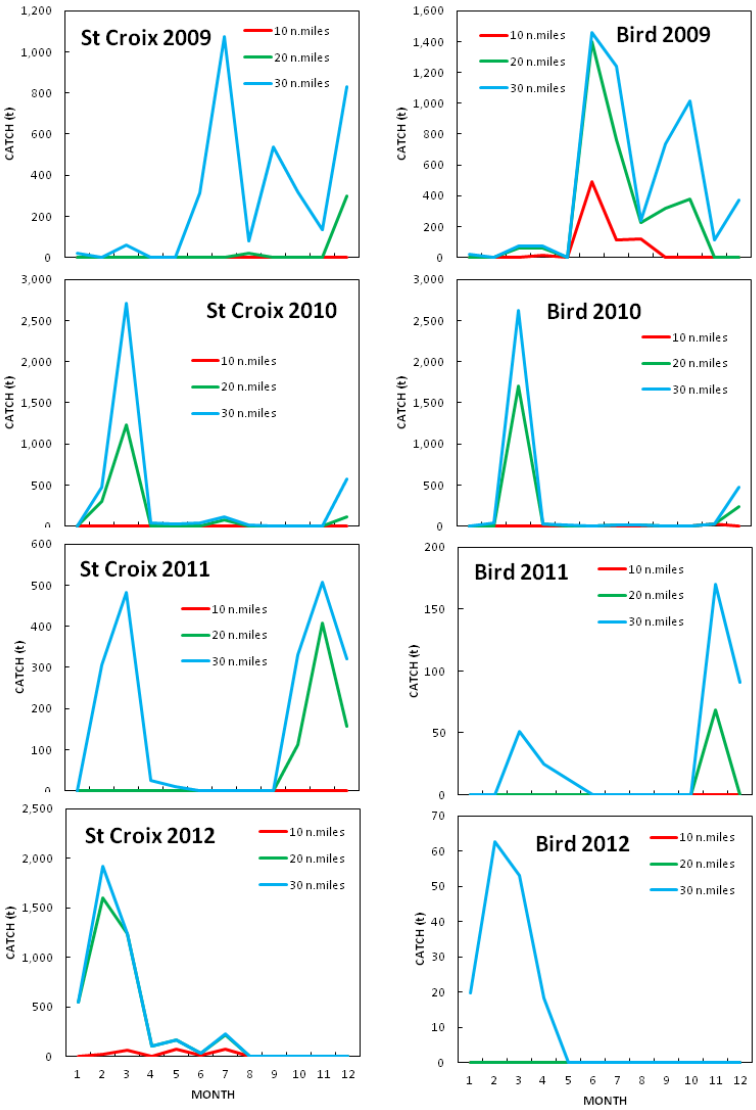


Figure 8: Line plots showing monthly sardine catches within (nominally) 10, 20 and 30 n.miles of St Croix (left) and Bird (right) Islands from 2009 to 2012 (to end October only). Note that catches in each spatial category include catches taken at smaller spatial scales, and that the y-axes scales are different.

Appendix 1: Monthly and annual catches (tons) of **ANCHOVY** at three spatial scales around Dassen and Robben Islands.

Year	Month	Dassen10	Dassen20	Dassen30	Robben10	Robben20	Robben30
2009	1	0.00	0.00	0.00	0.00	0.00	695.06
2009	2	0.00	0.00	2.75	0.00	2.75	857.28
2009	3	0.00	0.00	0.00	0.00	0.00	183.59
2009	4	0.00	16.05	799.40	263.10	284.29	1000.12
2009	5	0.00	444.60	3031.56	992.09	1715.98	4986.00
2009	6	0.00	301.52	2175.93	678.36	1289.23	2611.37
2009	7	0.00	101.07	4383.35	2895.69	6669.97	8808.08
2009	8	0.00	1638.66	5955.78	2453.47	6967.53	11819.97
2009	9	14.80	1493.72	15003.86	10360.19	15276.00	20084.49
2009	10	0.00	1260.50	2927.88	1378.64	2784.84	2963.44
2009	11	0.00	0.00	0.00	0.00	0.00	0.00
2009	12	0.00	0.00	0.00	0.00	0.00	0.00
2009 SUM		**14.80**	**5256.12**	**34280.51**	**19021.54**	**34990.59**	**54009.40**
2010	1	0.00	0.00	0.00	0.00	0.00	552.47
2010	2	0.00	857.57	877.74	0.00	630.21	1844.99
2010	3	220.33	1263.19	1904.15	0.00	719.91	1876.49
2010	4	0.00	38.42	38.42	0.00	0.76	39.15
2010	5	0.00	262.18	434.32	84.43	281.72	956.37
2010	6	902.00	1138.85	1421.14	141.49	366.42	4056.67
2010	7	4064.58	9412.00	14607.46	679.22	5908.05	18121.93
2010	8	978.93	9289.71	15057.10	2984.03	12237.76	21286.64
2010	9	0.00	0.00	0.00	0.00	0.00	195.45
2010	10	0.00	0.00	0.00	0.00	0.00	0.00
2010	11	0.00	2.33	17.14	0.00	0.00	15.89
2010	12	0.00	0.00	0.00	0.00	0.00	0.00
2010 SUM		**6165.84**	**22264.25**	**34357.47**	**3889.17**	**20144.83**	**48946.05**
2011	1	0.00	0.00	0.00	0.00	0.00	0.00
2011	2	0.00	0.00	0.00	0.00	0.00	0.00
2011	3	0.00	7.53	34.66	0.00	14.23	608.13
2011	4	0.00	123.06	123.41	0.00	0.00	2404.13
2011	5	264.20	2238.91	3573.02	0.00	588.73	1269.66
2011	6	3062.90	5157.83	5384.39	0.00	277.35	3581.33
2011	7	1437.52	4615.62	10276.92	0.00	1558.08	3959.66
2011	8	244.06	2744.80	4531.58	0.00	119.51	5467.64
2011	9	0.00	0.00	0.00	0.00	0.00	0.07
2011	10	0.00	0.00	0.00	0.00	0.00	0.00
2011	11	0.00	0.00	0.00	0.00	0.00	0.00
2011	12	0.00	0.00	0.00	0.00	0.00	0.00
2011 SUM		**5008.68**	**14887.75**	**23923.98**	**0.00**	**2557.90**	**17290.62**
2012	1	0.00	0.00	0.00	0.00	0.00	0.00
2012	2	0.00	193.92	205.42	0.00	322.34	2538.56
2012	3	301.38	4282.20	5498.82	0.00	6063.74	11390.54
2012	4	13.02	7441.15	13184.39	0.00	6870.64	15912.81
2012	5	1251.73	4266.19	10113.63	0.00	185.54	2752.76
2012	6	440.77	2668.85	5153.20	0.00	438.41	5420.98
2012	7	733.40	8335.19	14260.37	72.64	2724.45	15069.76
2012	8	1447.44	4398.23	4700.05	0.00	1982.78	13955.36
2012	9	4643.55	8785.00	10022.07	0.00	1671.05	11393.38
2012	10	135.13	218.90	218.90	0.00	58.68	897.21
2012 SUM2Oct		**8966.42**	**40589.63**	**63356.85**	**72.64**	**20317.63**	**79331.36**

Appendix 2: Monthly and annual catches (tons) of **SARDINE** at three spatial scales around Dassen and Robben Islands, January 2009-October 2012.

Year	Month	Dassen10	Dassen20	Dassen30	Robben10	Robben20	Robben30
2009	1	0.00	0.00	0.00	0.00	0.00	0.00
2009	2	0.00	0.05	15.84	0.00	12.89	490.52
2009	3	13.84	40.03	50.79	0.00	116.66	1215.33
2009	4	0.00	219.79	505.15	65.75	343.44	947.83
2009	5	0.00	0.20	6.09	1.11	3.27	63.65
2009	6	0.00	143.35	886.41	2.08	628.87	2007.00
2009	7	0.00	0.02	43.62	41.21	81.94	404.62
2009	8	0.00	0.00	5.17	4.91	8.51	99.40
2009	9	0.00	0.19	76.20	14.68	101.21	114.10
2009	10	0.00	16.26	18.34	1.84	18.34	37.88
2009	11	0.00	0.00	0.00	0.00	0.00	0.00
2009	12	0.00	0.00	0.00	0.00	0.00	0.00
2009 SUM		**13.84**	**419.89**	**1607.61**	**131.58**	**1315.13**	**5380.33**
2010	1	0.00	0.00	345.83	0.00	0.00	227.90
2010	2	1.20	1012.44	2533.04	29.64	826.87	2656.88
2010	3	13.51	171.33	842.74	0.00	289.19	1176.94
2010	4	32.21	780.33	1105.93	0.00	37.72	846.99
2010	5	0.00	341.70	481.12	36.79	199.65	694.18
2010	6	161.50	281.07	415.53	94.33	209.16	832.40
2010	7	629.72	1128.47	1600.32	106.21	560.93	1873.08
2010	8	7.95	45.66	118.89	47.46	151.69	363.94
2010	9	0.00	0.00	0.00	0.00	0.00	0.00
2010	10	0.00	0.00	0.00	0.00	0.00	0.00
2010	11	0.00	1575.86	5846.55	0.00	211.90	1206.43
2010	12	0.00	0.00	0.00	0.00	0.00	0.00
2010 SUM		**846.09**	**5336.86**	**13289.95**	**314.43**	**2487.11**	**9878.74**
2011	1	0.00	0.00	0.00	0.00	0.00	0.00
2011	2	0.00	468.21	2580.52	0.00	1.66	208.35
2011	3	0.00	1201.93	1454.56	0.00	96.81	747.52
2011	4	0.00	40.97	607.53	0.00	706.20	1629.85
2011	5	1.27	403.91	835.41	0.00	155.68	223.27
2011	6	96.58	325.78	447.69	0.00	6.34	173.60
2011	7	295.73	1504.91	3139.55	0.00	37.96	544.22
2011	8	510.49	1409.75	1574.29	0.00	62.19	1523.75
2011	9	0.00	0.00	0.00	0.00	76.46	374.36
2011	10	0.00	0.00	0.00	0.00	0.00	513.86
2011	11	0.00	0.00	0.00	0.00	0.00	0.00
2011	12	0.00	0.00	0.00	0.00	0.00	0.00
2011 SUM		**904.07**	**5355.46**	**10639.55**	**0.00**	**1143.30**	**5938.78**
2012	1	0.00	0.00	0.00	0.00	0.00	4.58
2012	2	0.09	21.96	25.98	0.00	107.30	2014.28
2012	3	6.83	142.72	306.29	0.00	256.68	989.34
2012	4	1.38	301.52	610.65	0.00	256.27	702.37
2012	5	71.04	275.08	593.08	0.00	15.52	237.03
2012	6	5.54	46.37	87.15	0.00	4.66	105.68
2012	7	3.97	23.11	61.25	0.08	10.17	141.71
2012	8	0.92	7.13	7.13	0.00	2.30	159.17
2012	9	37.31	693.48	914.65	0.00	191.69	390.43
2012	10	0.00	0.00	0.00	0.00	0.00	8.69
2012 SUM to Oct		**127.08**	**1511.37**	**2606.18**	**0.08**	**844.59**	**4753.28**

Appendix 3: Monthly and annual catches (tons) of **SARDINE** at three spatial scales around St Croix and Bird Islands, January 2009-October 2012.

Year	Month	St Croix10	St Croix20	St Croix30	Bird10	Bird20	Bird30
2009	1	0.00	0.00	20.49	0.00	0.00	20.49
2009	2	0.00	0.00	0.00	0.00	0.00	0.00
2009	3	0.00	0.00	59.90	0.00	59.90	73.26
2009	4	0.00	0.00	0.00	16.00	61.59	75.77
2009	5	0.00	0.00	0.00	0.00	0.00	0.00
2009	6	0.00	0.00	312.17	490.94	1397.66	1457.52
2009	7	0.00	0.00	1075.08	113.07	766.06	1238.52
2009	8	0.00	19.70	81.44	122.12	225.02	242.14
2009	9	0.00	0.00	535.51	0.00	321.15	738.62
2009	10	0.00	0.00	316.93	0.00	382.29	1017.26
2009	11	0.00	0.00	135.43	0.00	0.00	113.35
2009	12	0.00	300.50	829.42	0.00	0.00	369.35
2009 SUM		**0.00**	**320.20**	**3366.37**	**742.13**	**3213.67**	**5346.28**
2010	1	0.00	0.00	0.00	0.00	0.00	0.00
2010	2	0.00	299.94	476.98	0.00	0.00	42.28
2010	3	0.00	1228.39	2708.90	0.00	1707.58	2624.35
2010	4	0.00	6.04	35.61	0.00	29.57	29.57
2010	5	0.00	0.00	22.94	0.00	0.00	13.29
2010	6	0.00	0.00	36.98	0.00	0.00	0.00
2010	7	0.00	83.00	112.30	0.00	13.22	13.22
2010	8	0.00	0.00	10.09	0.00	10.09	10.09
2010	9	0.00	0.00	0.00	0.00	0.00	0.00
2010	10	0.00	0.00	0.00	0.00	0.00	0.00
2010	11	0.00	0.00	0.00	31.83	31.83	31.83
2010	12	0.00	118.85	569.93	0.00	236.04	470.74
2010 SUM		**0.00**	**1736.22**	**3973.73**	**31.83**	**2028.33**	**3235.37**
2011	1	0.00	0.00	0.00	0.00	0.00	0.00
2011	2	0.00	0.00	306.36	0.00	0.00	0.00
2011	3	0.00	0.00	482.65	0.00	0.00	51.56
2011	4	0.00	0.00	25.06	0.00	0.00	25.06
2011	5	0.00	0.00	9.45	0.00	0.00	12.65
2011	6	0.00	0.00	0.00	0.00	0.00	0.00
2011	7	0.00	0.00	0.00	0.00	0.00	0.00
2011	8	0.00	0.00	0.00	0.00	0.00	0.00
2011	9	0.00	0.00	0.00	0.00	0.00	0.00
2011	10	0.00	112.51	331.45	0.00	0.00	0.00
2011	11	0.00	407.31	507.00	0.00	68.38	170.36
2011	12	0.00	157.69	319.98	0.00	0.00	90.54
2011 SUM		**0.00**	**677.51**	**1981.95**	**0.00**	**68.38**	**350.17**
2012	1	0.00	544.96	544.96	0.00	0.00	19.74
2012	2	24.25	1597.96	1917.53	0.00	0.00	62.70
2012	3	58.03	1238.68	1241.17	0.00	0.00	53.07
2012	4	0.00	100.36	100.36	0.00	0.00	18.37
2012	5	74.97	170.36	170.36	0.00	0.00	0.00
2012	6	11.91	32.72	32.72	0.00	0.00	0.00
2012	7	70.68	220.83	223.33	0.00	0.00	0.00
2012	8	0.00	0.00	0.00	0.00	0.00	0.00
2012	9	0.00	0.00	0.00	0.00	0.00	0.00
2012	10	0.00	0.00	0.00	0.00	0.00	0.00
2012 SUM to Oct		**239.84**	**3905.87**	**4230.43**	**0.00**	**0.00**	**153.88**