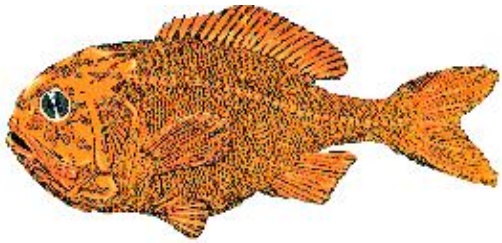
REPUBLIC OF NAMIBIA

MINISTRY OF FISHERIES & MARINE RESOURCES

Report on the

Orange roughy survey



17 – 31 July 2007

National Marine Information and Research Centre,
P.O.Box 912, Swakopmund, Namibia

Directorate of Resource Management

Orange roughy survey
17– 31 July 2006

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1 INTRODUCTION

1.1 Survey Objectives

Surveys of Namibian orange roughy have been conducted annually since 1997 using swept-area trawling and acoustics supported by targeted trawling. The indices of these surveys are used as inputs to stock assessment models used for management purposes.

Orange roughy occur in dense aggregations close to the seabed between the 600 and 850m isobaths, as well as dispersed at varying densities in regions adjacent to the aggregations. This, combined with the low target strength of orange roughy compared to other species, results in the acoustic abundance estimation technique being engaged to its limit. Current estimates are intended for use only as relative estimates.

Similarly, swept-area estimates rely on several critical assumptions regarding in particular the catchability of orange roughy and distribution and density of aggregations and dispersed orange roughy. Until these are known, these estimates must also be used as relative indices.

For 2007 an acoustic survey was planned for the fishing grounds Hotspot, Rix and Frankies and a swept area survey for Johnies. Johnies has been monitored every winter since 1997, and the swept area survey is seen as a valuable fishery independent biomass estimate of orange roughy abundance.

As mentioned above, the survey estimates should be seen as relative abundance indices, and therefore a time-series of survey data is of high importance for reliable stock assessment.

The survey therefore had a number of objectives, of which the first was considered of primary importance:

1. To assess the spawning (present) biomass of orange roughy on Hotspot, Rix, Frankies and Johnies.
2. To determine length-frequency, length-weight relationship and maturity parameters of orange roughy from the surveyed QMAs.
3. To monitor the oceanographic conditions on the QMAs, specifically of profiles of temperature, dissolved oxygen and salinity.

For 2007 the *F.V. Southern Aquarius* was used for both the acoustic and swept area survey, while the *R.V. Welwitchia* was collecting the oceanographic data.

1.2 Participation

The Scientific staff from the National Marine Information and Research Centre (NatMIRC), Swakopmund, Namibia were:

Rudi Cloete	Cruise leader	Southern Aquarius
Stefanus Voges	Acoustics	Southern Aquarius
Theo Kairua	Acoustics /Biology	Southern Aquarius
Mathew Hanghome	Biological sampling	Southern Aquarius
Renate Lemke	Biological sampling	Southern Aquarius
Johnny Gamatham	Biological sampling	Southern Aquarius
Malakia Shimanda	Biological sampling	Southern Aquarius
Ernesto Kangombe	Biological sampling	Southern Aquarius
Toini Mweenda	Biological sampling	Southern Aquarius
Allie Gumbo	Biological sampling	Southern Aquarius
Gideon Hengari	CTD	Welwitchia
Suzi Christoff	CTD	Welwitchia
Stefan Oesterle	CTD	Welwitchia

1.3 Cruise schedule

The *F.V. Southern Aquarius* left the Gendor jetty at 12h00 on Tuesday 17th July 2007. The vessel was then anchored outside Walvis Bay harbour in order to conduct calibration exercises of the acoustic system. The *F.V. Southern Aquarius* then departed for Hotspot on Wednesday at 14h00. The vessel arrived at Hotspot at 17h00 on Thursday the 19th and started with the first survey of the area. The weather was calm but there was still a lot of interference with the echosounder picture. Vessel speed was therefore reduced to six knots. Two acoustic coverages were conducted and a total of 13 trawls were made.

The vessel departed from Hotspot at 00h00 on Friday night and steamed south to Rix. On arrival at Rix the weather was too rough to conduct an acoustic survey and it was decided to continue southwards to Frankies. The vessel arrived at Frankies on Sunday the 22nd and we started with the first coverage on Frankies Flats. After the second coverage the vessel steamed to 3 Sisters. A total of three acoustic coverages were conducted on both Frankies Flats and 3 Sisters.

The vessel arrived on Tuesday the 25th of July on Johnies where we conducted a swept area trawl survey on random stations. On the 27th the *F.V. Southern Aquarius* steamed further south to Pavs (South Johnies) to conduct three trawls in the area.

On the 28th of July one trawl each was conducted on Frankies Flats and 3 Sisters. On 29 July the vessel conducted 3 commercial trawls in South Johnies.

On Monday the 30th of July we started with the first acoustic coverage of Rix and we finished the third coverage at around 20h00 on Tuesday evening where after we departed for Walvis Bay. The vessel arrived back in Walvis Bay harbour on the 1st of August.

2 MATERIALS AND METHODS

2.1 Hydrography and Meteorology

A Seabird SBE19*plus* CTD with an SBE43 oxygen sensor was used to measure the temperature, salinity and dissolved oxygen within the water column. Water samples were collected at selected depths (including near surface and just above the bottom) for each station. These samples were used for calibration of the oxygen measurements by the standard Winkler method using a Metrohm Dosimat. A total of 248 water samples were titrated for the oxygen data correction of which 11, 12 and 11 CTD-O stations were carried out on Rix, Frankies and Johnies respectively and an additional of 6 samples were also sampled between the three Orange roughly grounds.

Three transects of three to five stations were done for each of the surveyed Orange roughy grounds. Transects were taken along the east-west axis, thereby covering different bottom depths (Appendix 9, Figure 1). Transects were visualized by means of the Ocean Data View Software and selected station profiles at each ground were compared to the profiles of previous July surveys using the Grapher software. Selected daily SST imagery for the last two weeks of July 2007 was used to discuss the surface temperature conditions during the survey period.

2.2 Trawl sampling

2.2.1 Vessels and gear

The *Southern Aquarius* carried out all trawling operations. This vessel is a 54.6 m factory stern trawler, with 1154 GRT (net tonnage 391 tonnes), 3300 HP, operated by Gendor Fishing Ltd. She deployed a standard commercial deep water net and gear. The net is based on the standard New Zealand 'Arrow' rough bottom trawl, with cut-away lower wings. Sweep and bridle lengths were 100 m and 50 m respectively. A 'rock-hopper' footrope was used with 21" rock-hoppers. The net had a 5-6 m headline height when towed at a average speed of about 3.5 knots. Wingspread is estimated at 15 m.

Trawling on aggregations was generally only carried out after acoustic surveys had been completed. This was done to allow the aggregations to distribute on the ground, with minimal disturbance from trawling activities.

2.2.2 Trawl catch sampling

A summary of trawls performed during the survey is listed in Appendix 8. Catches were sorted by species. Length, weight, sex and gonad maturity stage data were collected for orange roughy. Between 100 and 200 orange roughy were sampled at each tow station. When a catch was large, several samples were taken at intervals to ensure that a representative sample was obtained. Length frequency and individual weight data were collected for by-catch species such as hake (*Merluccius sp.*), rattails (*Macrouridae sp.*), oreos (*Oreosomatidae sp.*) and shark species. The total sample number, sample weight and total weight for each species caught were recorded. If the catch was big (e.g. >5tonnes), the estimate of the captain was used.

2.3 Biological analysis

The methodology followed during biological sampling was the same as in previous years.

2.3.1 Length frequency distribution

Standard length was measured for orange roughy, while total length was recorded for rattails (*Macrouridae sp)*, oreos, hakes, and sharks. Length frequency data were not raised to the total catch. Each trawl sampled was seen as representative of the surveyed population.

2.3.2 Reproductive stages

Gonad staging was done following the description commonly used in New Zealand and Australia after Pankhurst *et al.* (1987) (Table 1).

Table 1: Maturity stages for female and male orange roughy

Stage	Female	Male
1	Immature/resting	Immature/resting
2	Early maturation	Early maturation
3	Maturation	Maturation
4	Ripe	Ripe/running ripe
5	Running ripe	Spent
6	Spent	

The length at 50% maturity was estimated by QMA and per sex by calculating the proportion of mature fish (>stage 3) for all 1cm length classes of orange roughy, and determining at which length 50% of the sampled fish were mature.

2.4 Acoustics

2.4.1 Survey grids

Acoustic surveying was conducted on Hotspot, Frankies and Rix, weather permitting. Multiple coverages of each ground were run on equally spaced east west transects. Transect spacing was 1 nautical mile for all coverages. Survey depths ranged between 400 and 1000 meters.

A summary of the various surveys that were conducted during this cruise is presented in Table 2. The vessels speed at which surveying was carried out depended on surveying direction and weather conditions. During good weather conditions the average surveying speed was 7.5 to 8.5 knots and was reduced to as low as 5 knots during bad weather.

Table 2: Summary of acoustic surveys done during the 2007 orange roughy survey.

QMA	Coverage	Date & Time	Transect interval	Depth range (m)	Latitudinal range (S °)	# of transects
Hotspot	1	19/07 16h47 – 19/07 21h51	1 nm	700-1100	19°19' –19°26'	8
Hotspot	2	19/07 21h54 –20/07 02:15	1 nm	700-1100	19°19' –19°26'	7
3 Sisters	1	22/07 17h42 –22/07 22h55	1 nm	600 - 900	24°42' –24°36'	6
3 Sisters	2	23/07 05h46 – 23/07 09h21	1 nm	600-900	24°42' –24°38'	4
3 Sisters	3	23/07 09h28 – 23/07 14h57	1 nm	600-900	24°42' –24°37'	6
Frankies Flats	1	22/07 09h38 – 22/07 13h36	1 nm	500-750	24°34' - 24°30'	5
Frankies Flats	2	22/07 13h42 – 22/07 16h46	1 nm	500-750	24°34' - 24°30'	4
Frankies Flats	3	23/07 00h41 –23/07 04h49	1 nm	500-750	24°34' - 24°30'	5
Rix	1	30/07 09h10 – 30/07 21h11	1 nm	500-1000	22°38' – 22°26'	13
Rix	2	30/07 21h11 – 31/07 07h56	1 nm	500-1000	22°36' – 22°26'	11
Rix	3	31/07 15h50 – 31/07 20h31	1 nm	500-1000	22°32' – 22°27'	6

2.4.2 Target identification

Attempts were made to identify all marks possibly containing orange roughy, taking into consideration appearance (definition), bottom depth, sea floor structure (features), bottom type, and location. Some targets could not be identified due to the ground being unsuitable for trawling, and were identified by using the known identity of similar targets in the same vicinity.

When analysing the data, targets were classified as **A)** Definitely identified, and

B) Possibly orange roughy, where identification was uncertain. Category A targets tended to be those that had characteristic orange roughy aggregation shapes with distinct boundaries, and were in depths and areas where relatively clean orange roughy catches were made during the survey. Often they were associated with irregular bottom features on known fishing grounds. The biomass of these targets was estimated using the species composition of the trawl(s) allocated to them.

Most trawls caught a mixture of orange roughy and a number of by-catch species. However in some instances it was clear that the trawl had not only caught fish from the aggregation targeted, but also from the surrounding area. In these cases, if a large amount of orange roughy was caught, the aggregations were assumed to be 100% orange roughy regardless of the catch of other species.

2.4.3 Acoustic hardware and setup

The *F.V. Southern Aquarius* is equipped with a Simrad EK60 (MK II) split beam echo sounder, operating at 38 kHz. Echo sounder settings were kept the same as during previous surveys. The sounder and network IP settings are listed in Appendix 1.

The sounder on the *F.V. Southern Aquarius* was interfaced to ECHOLOG for data logging and processing. ECHOVIEW was used for the acoustic data processing.

2.4.4 Biomass estimation

The mean S_a value for each survey considered valid for biomass estimation, and the coefficient of variation of this estimate, was calculated according to expressions given in Appendix 3. For each area the number of orange roughy in length class *j* in that area was estimated from the expression:

$$n_j = F_j \overline{S_a} A / \overline{\sigma_j} = F_j \overline{S_a} A.10^{7.1} L_j^{-2} \qquad 3.$$

where A is the area surveyed, $\overline{S_a}$ the mean S_a attributed to orange roughy for the survey, L_j is the length of length class j, and F_j is the proportion by number of orange roughy in length class j in a pooled length frequency distribution for the ground. $\overline{\sigma_j}$ is the mean back-scattering cross-section of orange roughy in length class j. The expression for σ_j, viz:

$$\sigma_j = 10^{-7.1} L_j^2 \qquad 4.$$

was obtained from the orange roughy Target Strength/length relationship:

$$TS = 10 \, Log \, (\sigma/4\pi) = 20 \, Log \, L - 82 \qquad \text{[dB]} \qquad 5.$$

The above expression is that used in Tasmania (Kloser et al., 1997) and was revised in 1998. The total number of orange roughy in each area was estimated by summing the n_j estimates. Multiplication by the mean weight of orange roughy in the pooled sample for that ground gave the biomass in the area. Single survey c.v.'s were calculated by taking the square root of the sum of variances, and dividing it by the sum of weighted S_a values.

2.5 Swept area

2.5.1 Random trawl survey design

The principle of a two-phase random survey design (Francis 1981) was applied on Johnies for selected strata. The selected strata were kept the same for the last three years for comparative purposes.

Between two to six stations were randomly chosen for each selected stratum. The random position was designated as the approximate vessel position at the start of the tow when the trawl started fishing on the bottom and the direction of the tow was along the depth contour in a south-north orientation. The default was to trawl in a northern direction, but if the stratum border was crossed during the towing by doing this, the towing course was selected to be south. The duration of each trawl was about 30 minutes on the bottom.

2.5.2 Trawl survey stratification

Stratification of the survey areas and the allocation of the stations on Johnies are shown in Appendix 4, based on the survey design from 1998. A core region (stratum 1) was originally identified, where high catch rates by commercial vessels and during previous surveys had been recorded. This stratum was designed to cover the area of main aggregations, but was combined with stratum 2 in 2003, since no high-density area could since be identified.

2.5.3 Abundance estimation

Biomass indices were calculated for the survey area from random trawl data using standard area-swept methodology (after Francis 1981). Biomass, and its standard error, was calculated from the following formulae:

$$B = \sum (X_i a_i) / cb \qquad 6.$$

$$S_B = \sqrt{(\sum s_i^2 \, a_i^2)} / c^2 b^2 \qquad 7.$$

where B is biomass (tonnes), X_i is the mean catch rate (kg*nm^{-1}) in stratum i, a_i is the area of stratum i (km^2), b is the width swept by the trawl gear (0.0081 nm), c is the catchability coefficient (an estimate of the proportion of fish available to be caught by the net), S_B is the standard error of the biomass, s_i is the standard error of X_i.

The coefficient of variation (*c.v. in %*) is a measure of the precision of the biomass estimate, and is calculated by:

$$c.v. = S_B / B * 100 \qquad 8.$$

No correction is made for possible herding by the trawl gear, or escapement of fish from the path of the trawl. It is assumed that all fish in the water column above the trawl path are caught by the gear (i.e. c = 1) The effective area of bottom swept by the trawl (b) has been taken as the distance between the wing-ends (15 meters) times tow distance.

3. RESULTS

3.1 Hydrography

Temperature, salinity and oxygen profiles were drawn for the three Orange roughy grounds that were assessed (Appendix 8, Figures 2-11). Below 600 m depth temperatures were less than 6 °C, while the surface temperature ranged between 15-16°C at all the Orange roughy grounds, while relatively cooler SST of 14°C was recorded at the additional stations. At the surface, salinity ranged between 35.1 to 35.3 psu, while the bottom water salinity was 34.8psu.

Dissolved oxygen levels in the upper 200m at Rix and Frankies ranged between 3 to 5 ml/l, while at the additional stations and Johnies ranged between 4 to 6 ml/l. The oxygen levels at Rix and Frankies generally decreased from the sea surface (5ml/l) down to (2ml/l) at 600m and thereafter slowly started increasing downward. However, at the additional transect at Johnies the oxygen levels decreased from the surface to 400m and below that oxygen level of 3ml/l was maintained.

The SST imagery shows that upwelling was taking place along the Namibian coast during the two weeks of the survey period (Appendix 8, Figure 16), where cooler surface temperatures in the range of 12-13°C were observed along the Namibian coast, particularly in the southern region.

The temperature and oxygen profiles of selected stations from the main aggregations were compared to those of eight to ten previous July surveys (Appendix 8, Figures 13-15). Most temperature variation occurred in the upper 50 to 80 metres of the water column, although there are also noticeable deviations between 300 to 600 m depth. The temperature profile of July 2007 seems to fit in very well with the other profiles.

The dissolved oxygen profiles indicate that high oxygen water was present is the sampling area with the upper 100m zone shows concentrations ranged between 3-7ml/l, while the bottom oxygen levels ranged between 2-3ml/l. Oxygen levels varied mainly in the upper 170 to 500 meters and less variable below 200m depth. However, during the July 2007 oxygen concentration were relatively higher and less variable in the 170 to 500 meters depth

compared to other years. Overall there are no significant differences in the vertical oxygen distribution during the nine to eleven years that were plotted.

3.2 Trawl sampling

3.2.1 Catch composition

A total number of 59 bottom trawls were made during the survey. Thirteen trawl were made on Hotspot, five on Frankies, three on Rix and a total of 35 trawls were made on Johnies. Trawl positions are shown in Appendices 4 – 7, while station and catch details for each tow are presented in Appendix 8. Table 3 shows the amount of orange roughy and bycatch that were caught in each area. A total of 70 tonnes of orange roughy were caught during the survey. The most frequent by-catch species were hake, rat-tails, sharks and dories.

Table 3. Catch statistics for orange roughy and its bycatch per QMA covered during the 2006 survey.

Area	Catch (kg)	
	Orange Roughy	**Bycatch**
Hotspot	14 507	1 329
Rix	601	455
Frankies	1 838	174
Johnies	52 511	4 462

3.2.2 Distribution

Hotspot

Orange roughy was mainly found in the southern and central parts of Hotspot. The trawls were distributed in a southwest to northwest direction (Appendix 4).

Rix

Few orange roughy were found on Rix and only in the central part (Appendix 5).

Frankies

Acoustic target identification and commercial tows were conducted on ‘Frankies Flats’ and ‘Three Sisters’. Not many fish were found on Three Sisters and on Frankies Flats the orange roughy were distributed in the central parts (Appendix 6).

Johnies

The strata surveyed on Johnies were similar to previous surveys since 2004 . Strata covered were 2, 4, 6, 8, 9c, 9s and 11. In general orange roughy catches were low except for area 2 which had the highest catch of 8372 kg (Appendix 7). Catches in the other strata ranged between 0 and 170 kg in size.

3.3 Biology

3.3.1 Length frequencies

In general, the length of orange roughy caught during the 2007 survey ranged between 10 - 46 cm, with the mean length for females and males being 26.3 and 24.4 cm, respectively. The mean lengths were similar to those of the 2006 survey. Orange roughy caught on Hotspot were the largest with a bimodal distribution. The smallest fish were once again found on Johnies. The male to female ratio for all orange roughy caught were 57.7 vs. 42.3 % .

Hotspot

Length distributions on Hotspot were bi-modal with fish sizes ranging from 19 - 46 cm (Fig. 1). Male orange roughy peaked at 28 cm while the females had a peak at 38 cm. The average size for males were also smaller than females, 29.5 cm compared to 32.1 cm for females.

Rix

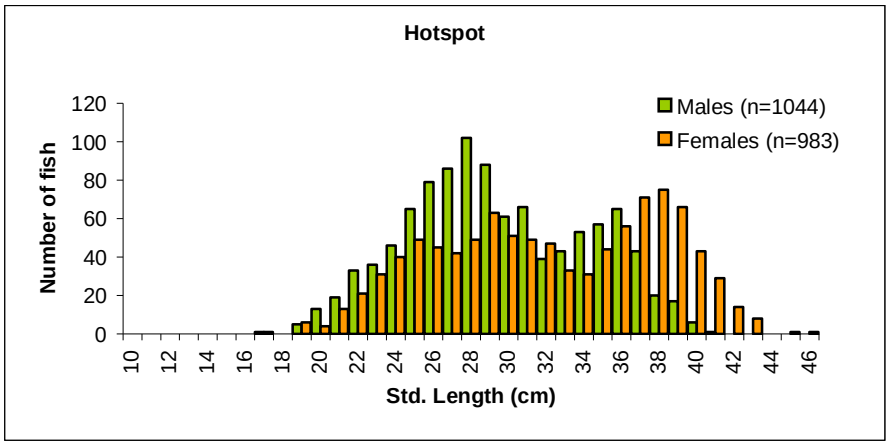
Length distributions on Rix were uni-modal with fish sizes ranging from 18 - 34 cm (Fig. 1). Again, females were larger than males with the mean lengths for females and males being 27 and 25.4 cm, respectively. On Rix, more females than males were caught with a ratio of 55.3 to 44. 7 %.

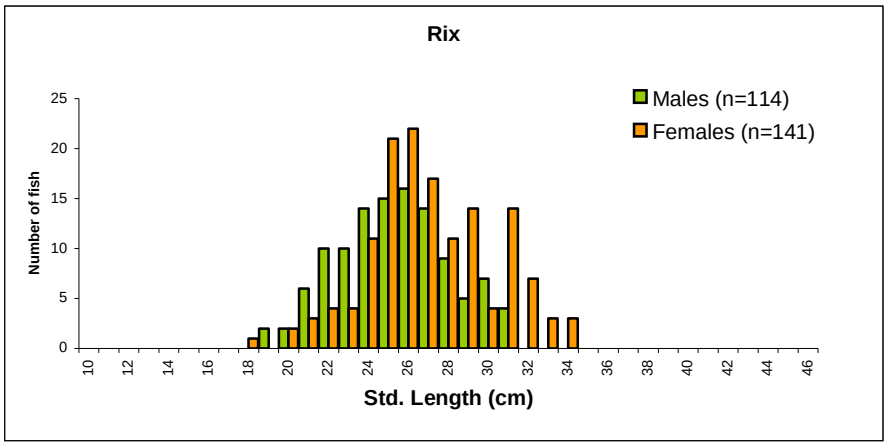
Frankies

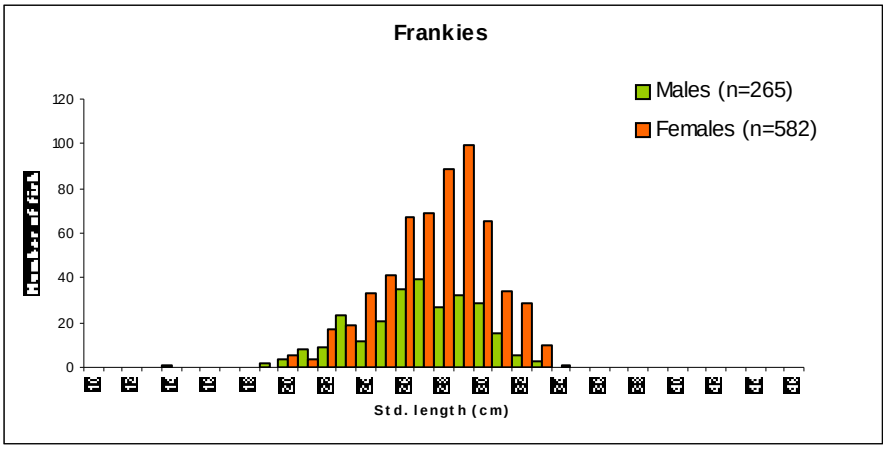
Length distributions on Frankies were also uni-modal with fish sizes ranging from 19 – 34 cm (Fig. 1). Females were slightly larger in size with a mean length of 27.6 cm compared to 26.7 cm for males. Females constituted 68.7% of the total number of fish caught on Frankies, while males constituted only 31.3 %.

Johnies

The size of orange roughy caught during the 2007 survey was similar to the 2006 survey ranging from 10 to 34 cm. Females were larger than male fish, with mean lengths measured for females and males being 24 and 23.1 cm, respectively. About one third (34 %) of orange roughy caught on Johnies were females, while two thirds (66 %) were males.







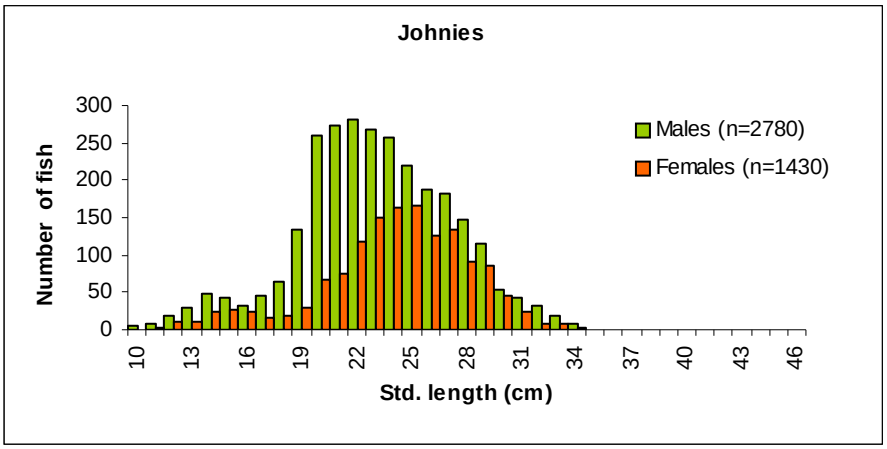


Fig. 1. Length-frequency distribution of male and female orange roughy for the grounds, Hotspot, Rix Frankies and Johnies. The number of fish (n) sampled is given in brackets.

3.3.2 Length-weight relationship

Table 4 shows length-weight relationship parameters of orange roughy for females and males for each ground. Females were generally heavier than males in corresponding length classes.

Table 4: Length-weight relationship of orange roughy by sex and QMA.

Area	**Sex**	**No. fish sampled**	**W-L relationship**	**R^2**
Hotspot	Male	966	$W=0.1344L^{2.56}$	0.88
	Female	1032	$W=0.1282L^{2.57}$	0.87
Rix	Male	115	$W=0.1957L^{2.45}$	0.92
	Female	140	$W=0.1316L^{2.58}$	0.94
Frankies	Male	220	$W=0.0978L^{2.66}$	0.92
	Female	425	$W=0.0747L^{2.78}$	0.90
Johnies	Male	1814	$W=0.1475L^{2.52}$	0.93
	Female	1387	$W=0.1559L^{2.52}$	0.94

3.3.3 Reproduction

On Hotspot 66 % of females were mature while only 42 % of the males have reached maturity. On Johnies about 80 % of the females and 40 % of the males were mature (Table 5). On Hotspot about 26 % of females and 20 % of males were spent, while on the other QMA's it was less than 10 percent (Fig. 2). The low percentage of spent fish indicates that the major spawning event still had to take place.

Table 5. Proportions (%) of immature and mature orange roughy by sex and ground.

Area	Sex	% Immature	% Mature	Sample size (n)
Hotspot	Males	64.7	42.13	966
	Females	27.03	66.57	1032
Rix	Males	71.3	28.7	115
	Females	56.43	43.57	140
Frankies	Males	49.55	50.45	220
	Females	7.76	92.24	425
Johnies	Males	60.2	39.8	1814
	Females	19.83	80.25	1387

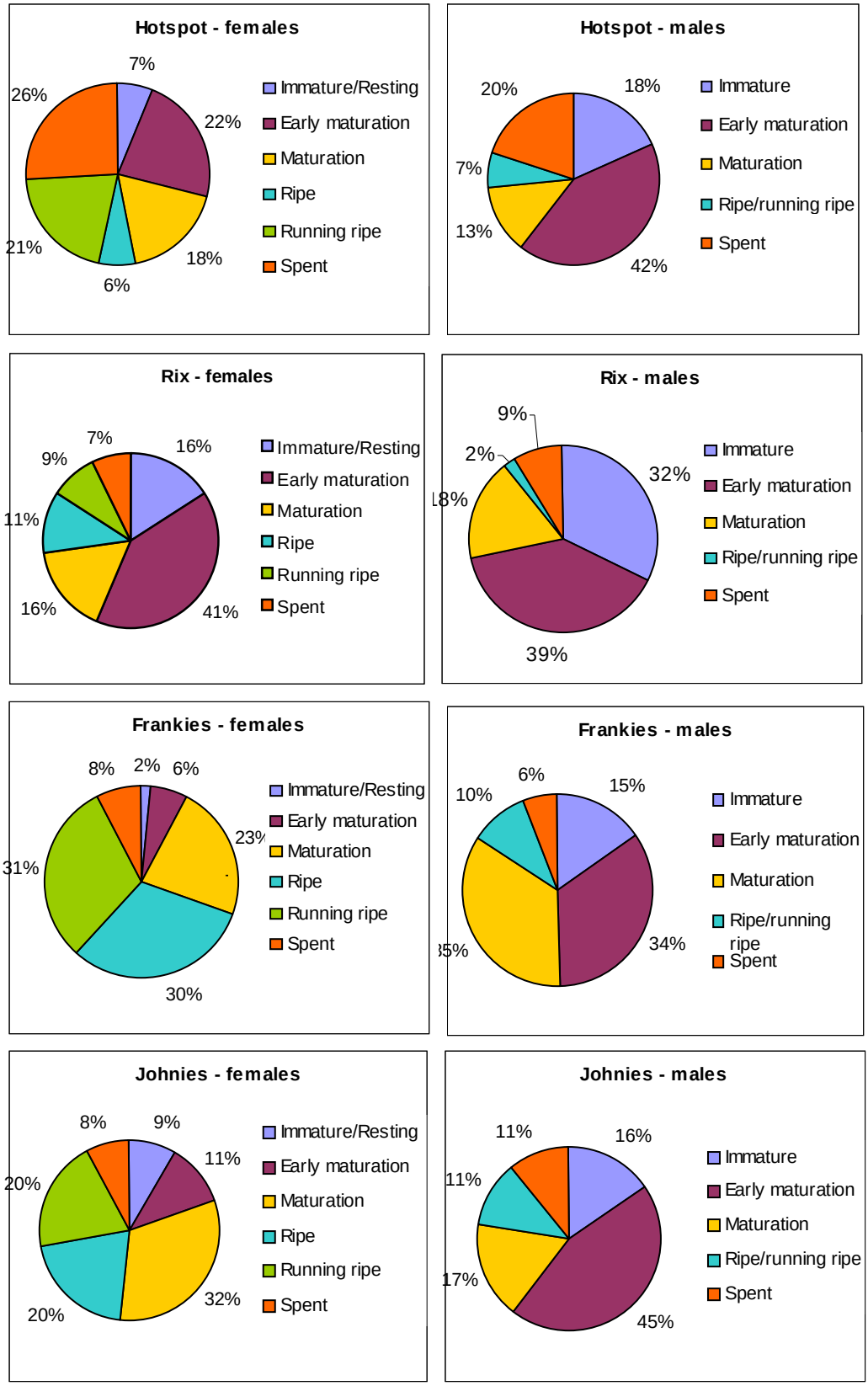


Fig. 2. Gonad maturity stages for orange roughy females and males on each QMA.

On Hotspot, L_{50} calculated at 27.6 and 31.2 cm for female and male orange roughy, respectively (Fig. 3, Table 6). On Frankies and Johnies L_{50} was the lowest with only 19 cm for females and 26.1 and 23.8 cm for males.

Table 6. L_{50} (cm) for female and male orange roughy on each QMA.

QMA	L_{50}	
	Females	Males
Hotspot	27.6	31.2
Rix	27.1	27.6
Frankies	19	26.1
Johnies	19.1	23.8

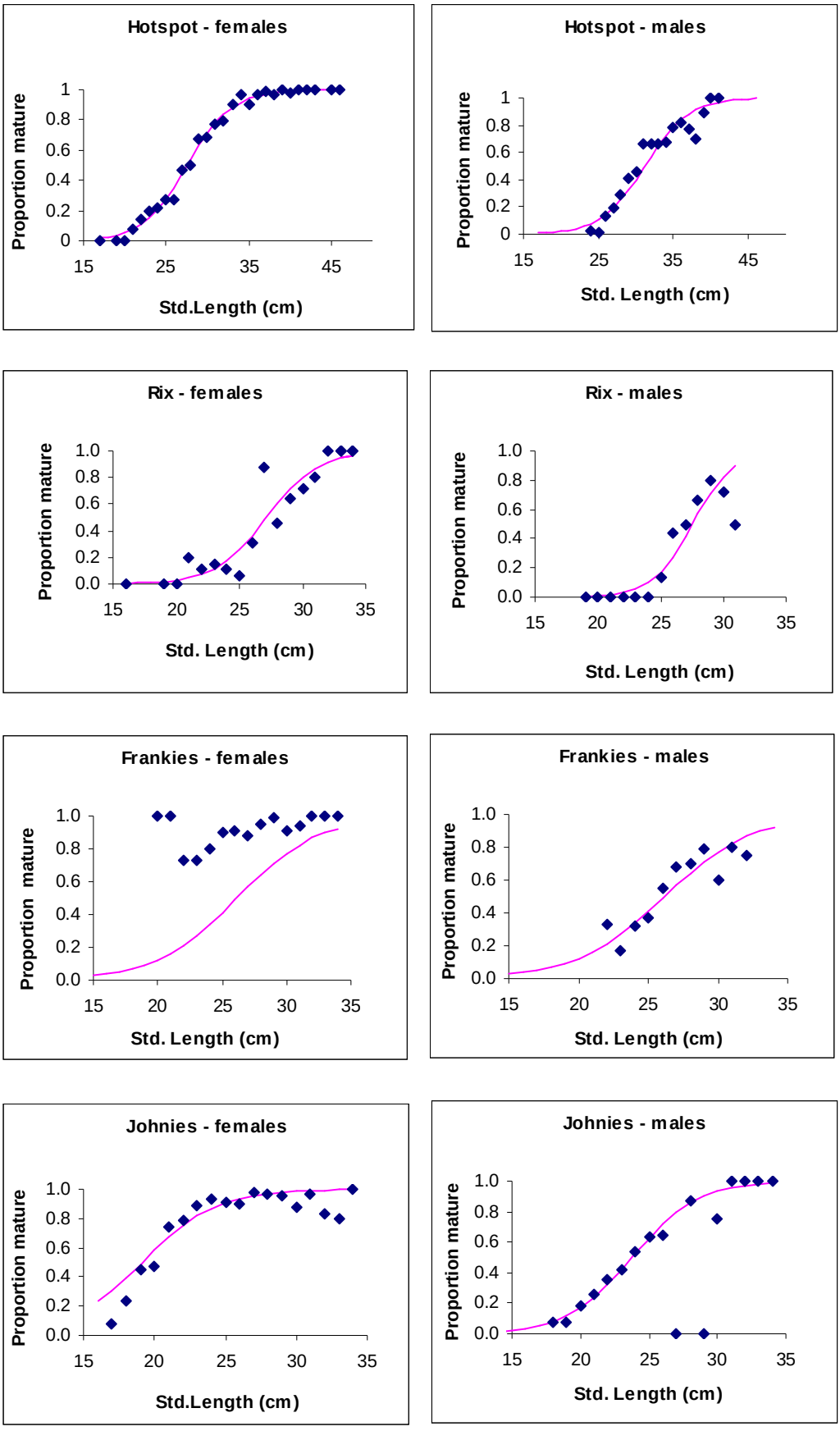


Fig. 3. Maturity ogives for female and male orange roughy per QMA (diamonds represent proportion mature, line indicates estimated proportion mature).

3.4 Biomass assessment

3.4.1 Swept area estimates on Johnies

The gear performed well during all the tows and none of the tows were excluded because of gear getting stuck on the seabed. The distribution of the random tows is given in Appendix 4. Catch rates have been mentioned in section 3.2.1 and 3.2.2. A summary of catch-rates and biomass per strata is given in Table 7. The highest mean catch rate of 1451 kg/nm was recorded in stratum 2. With an area of 13.36 nm^2, this stratum contributed 2397 tonnes, or 82 %, to the total biomass estimate of 2910 tonnes. However the coefficient of variance of was very high at 79 percent.

Table 7: Number of tows, area, CPUE, Standard deviation and estimated abundance by stratum on Johnies.

			c =	1.0		Sb	2299.49		
			b =	0.0081		CV	79.03		
Stratum	#Tows	Mean CPUE kg/nm	Area of strat nm^2 (a)	Biomass/str. tons	Std.Dev CPUE	Std Error (biomass)	s^2*a^2	Sb	cv
2	6	1451.6	13.36	2397.3	3390.50	1384.16	342067639	2286.0	0.95
4	3	2.21	9.933	2.714	2.632	1.520	227.876	1.87	0.69
6	2	91.8	25.81	292.9	107.5	76.0	3848075.4	242.46	0.83
8	3	26	20	64	21	12	58219	29.82	0.46
9c	3	25	14	45	25	14	41960	25.32	0.56
9s	3	37	16	73	31	18	85212	36.08	0.49
11	3	11	25	34	0	5	17060	16.14	0.47
	23		124.54	2909.5			346118393		

3.4.2 Acoustic biomass assessment

The biomass estimates for Hotspot, Rix and Frankies are summarized in Table 8. These estimates use targets identified positively and with a fair degree of certainty .

Table 8: Acoustic biomass estimates of QMA's

Area	Survey	Transect Spacing	Area (nm2)	Biomass (tonnes)	Transects no.	CV
Hotspot	1	1	27.6	6991	8	1
	2	1	22	2939	7	0.75
Three Sisters	1	1	34.3	2385	6	0.64
	2	1	21.4	1196	4	0.72
	3	1	32.5	1689	6	0.81
Frankies Flats	1	1	23.1	0	5	/
	2	1	20.1	149	4	0.36
	3	1	23.1	867	5	0.65
Rix	1	1	65.6	130	13	1
	2	1	56.4	5580	11	1
	3	1	26.6	1608	6	1

Hotspot

This was the first time since the start of the orange roughy fisheries that an acoustic assessment was done on Hotspot. Two coverages were conducted which resulted in an average biomass of 4965 tonnes.

Frankies (Three Sisters)

Three acoustic surveys were conducted on Three Sisters, which resulted in an average biomass of 1756 tonnes.

Frankies (Flats)

Three coverages were also conducted on Frankies Flats. During the first coverage no orange roughy were found. The average of the second and third coverages resulted in a biomass of 508 tonnes.

Rix

Three coverages were also conducted on Rix. Weather conditions were not favourable which gave poor acoustic data, resulting in biomass estimates (2439 tonnes) with high CV values.

DISCUSSION

The 2007 orange roughy survey was conducted from 20 to 31 July. The timing of the survey was similar to previous surveys conducted since 2000. A swept area survey was conducted on Johnies while multiple acoustic coverages were done of Hotspot, Frankies and Rix. The survey was combined with commercial trawling. The fishing vessel *Southern Aquarius* conducted the survey without any major technical or mechanical interruptions.

4.1 Meteorology and Hydrography

Weather conditions were not always favourable resulting sometimes in the assembling of poor quality acoustic data. Temperature and oxygen profiles compared well with the data collected during the last decade.

4.2 Biology

Biological data was compared to previous surveys excluding the 2000 survey, as the analysis used during that survey was different and hence not comparable.

4.2.1 Length frequency

Both male and female length frequencies were similar to last year. The average length of orange roughy was again the smallest on Johnies. On Hotspot, the average length of both males and females was the greatest of all the grounds.

Table 9: Average length of orange roughy during the period 1997-2007.

Year	Johnies		Frankies		Rix	
	Male	Female	Male	Female	Male	Female
1997	26.5		27.9		27.9	
1998	26.0		27.3		28.1	
1999	24.8	26.3	26.4	27.1	25.1	25.9
2000	23.6	25.9	26.7	27.3	*	*
2001	24.0	25.3	27.1	28.0	**	**
2002	23.4	25.1	26.8	28.0	*	*
2003	23.3	24.5	27.5	28.5	26.8	27.5
2004	23.2	25.0	26.9	28.6	*	*
2005	24.2	25.8	26.4	27.1	*	*
2006	22.7	24.4	26.3	27.7	25.8	26.8
2007	23.1	24.0	26.7	27.6	25.4	27.0

* Insufficient data , ** No survey

4.2.2 Reproduction

On Hotspot about 26 % of females and 20 % of males were spent, while on the other QMA's it was less than 10 percent. The low percentage of spent fish indicates that the major spawning event still had to take place.

4.3 Swept area estimates

The biomass estimate of the 2007 survey on Johnies showed an increase compared to the 2005 and 2006 surveys. The increase was due to the high biomass that was found in stratum (1&2). Catch rates in the other areas were generally similar to last year. (Table 10)

Table 10: Swept-area comparison of mean catch rates (kg/nm) on Johnies from 1997 to 2006.

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
1	29 638	24 904	2 304	4765	294	382	128.5	3285	1014	20.4	1452
2	11 802	440	517	106	560	1083					
4	3	1	1	4	-	5	4.5	0.2	0.14	14.36	2.21
5	1	1	0	-	-	-	-				
6	9 701	1315	52	396	2483	2053	62.5	20	115	109	91.8
7	8	3151	6	14	-	-	-				
8	4	189	34	3	-	299	63.5	85	14	225	26
9n	-	189	40	3	-	36	15.1				
9c	-		70	78	686	304	38.7	10	13	26	25
9s	-		36	205	344	313	55.6	20	9	11	37
10	-	21	52	4	-		-				
11							52.6	36	5	31	11

4.4 Acoustic estimates

The 2007 survey attempted to follow as closely as possible the methodology developed in previous years for the assessment of orange roughy aggregations and is believed to be comparable to previous estimates. Unfortunately the acoustic system of the *Southern Aquarius* suffered from signal attenuation during poor weather and some degree of signal interference.

4.4.1 Target Identification

A similar approach as last year was followed by first completing an acoustic coverage before trawling was conducted. The main reason was to have a complete coverage of an area, before bad weather conditions would make acoustic data collection impossible. The downside of this

method was that trawling was often conducted several hours after an aggregation had been assessed and the form of the aggregation had changed. Therefore it was not always straightforward to match catch results with acoustic targets.

4.4.2 Biomass estimates

This was the first time since the start of the orange roughy fisheries in Namibia that an acoustic assessment was done on Hotspot. Two coverages were conducted which resulted in an average biomass of 4 965 tonnes. The biomass on Frankies was about halve of last year's estimate. The biomass estimate on Rix was similar to last year this year at 2 439 tonnes. (Table 11)

Table 11: Acoustic and swept-area estimates (tonnes) of orange roughy biomass in the respective QMAs. **C**.V.'s (in %)

Year	Johnies	Frankies	Rix	Total
1997	34 178 (21)	17 925 (25)	21 579 (15)	73 683 (12)
1998	3 570 (43)	4 940 (38)	7 572 (19)	16 082 (17)
1999	No estimate	1 782 (25)	No estimate	/
2000	No estimate	4 000-4 600 (30)	No estimate	/
2001	No estimate	4 820 (16)	/	/
2002	/	15 802 (21)	/	/
2003	/	6 133 (27)	1 174 (51)	7307
2004	5 865	3 727 (26)	/	9 592
2005	2 132	7 734 (47)	/	9 866
2006	1 117 (16)	4 914 (27)	2 422 (64)	8 453
2007	2910 (79)	2264 (35)	2439 (73)	7613

Appendix 1: Echosounder settings:

ES 60 on F.V.Southern Aquarius *(EK 60 Program vers. 1.3.0.54)*

Transceiver installation dialog

Frequency channel selection	GPT 38kHz 009072017192 1 ES38D

Operation dialog

Mode	Normal
Ping rate	Maximum

Transceiver settings dialog

Mode	active
Transducer	ES38D
Transducer depth	4.5 m
Transit power	Max. (2000 W)
Pulse length	Medium (1.024 m/s)

Advanced tranceiver dialog

Transducer type	Splitbeam
Absorption coeff.	9.75 db/km
Bandwidth	2425 Hz
Sample interval	0.1920 m
2-way Beam Angle	-20.6 dB
Gain	26.50 dB
Angle Sens. Along	21.9°
Angle Sens. Athw.	21.9°
3 dB Beamw. Along	7.1°
3db Beamw. Athw.	7.1°
Alongship Offset	-0.00°
Athw. Ship Offset	-0.10°

Echogram dialog

Echogram	surface manual
TVG	20 log

Color scale dialog

20 TVG	–75 dB

Environment dialog

Saltwater	35 ppt
Sound Velocity	1500 m/s
Temperature	8°C

BI 500 Dialog

Echogram	On
Echotrace	On
No.of surface values	500
No. of bottom values	150
Surface range	Normally 400-900 m, but scaled to actual depth
Bottom range	5-15 m
Navigation	On
Vessel Log	On

PORT	2020
IP address	157 237 15 222

Appendix 2: Partitioning of back-scattered energy between species

In a mixture of species, $(S_a)_j$, the contribution of species j to the S_a value is:

$$(S_a)_j = F_j S_a \quad .$$

F_j is the fraction of the total S_a attributable to species j , given by:

$$F_j = \frac{n_j \overline{\sigma_j}}{\sum n_j \overline{\sigma_j}} \qquad (1)$$

where n_j is the number of fish of species j contributing to the echo, and $\overline{\sigma_j}$ is the mean back-scattering cross-section of species j. $\overline{\sigma_j}$ is given approximately by the expression:

$$\overline{\sigma_j} = 4\pi 10^{C_j/10} (\overline{L_j})^2$$

(see 1998 Orange Roughy Survey Report). $\overline{L_j}$ is the mean length of species j and C is the constant in the Target Strength/Length relationship:

$$\text{TS} = 20 \text{ Log L} + \text{C} \quad .$$

For orange roughy, Eqn. 1 becomes:

$$F_{ORH} = \frac{n_{ORH} 10^{C_{ORH}/10} (\overline{L_{ORH}})^2}{\sum n_j 10^{C_j/10} (\overline{L_j})^2} \quad . \qquad (2)$$

Since $n_{ORH} = \frac{W_{ORH}}{\overline{w_{ORH}}}$ and $n_j = \frac{W_j}{\overline{w_j}}$, where W_j is the total weight of species j in the sample, and $\overline{w_j}$ is the mean weight of species j ;

$$F_{ORH} = \frac{(W_{ORH} / \overline{w_{ORH}}) 10^{C_{ORH}/10} (\overline{L_{ORH}})^2}{\sum (W_j / \overline{w_j}) 10^{C_j/10} (\overline{L_j})^2} \quad . \qquad (3)$$

The following C_j constants (in dB) were used in the above equation (from Table 8, 1997 Orange Roughy Survey Report):

Orange roughy	-82	Oreos	-68
Hake	-68	Rat-tails	-73

Appendix 3: Estimation of mean S_a and sampling variance

The mean S_a for each survey was estimated from the expression:

$$\overline{S_a} = \frac{\sum_{i=1}^{n} (\overline{S}_a)_i L_i}{\sum_{i=1}^{n} L_i} \quad , \qquad (1)$$

where $(\overline{S}_a)_i$ is the mean S_a for transect i, L_i the length of transect i and n the number of transects in the survey.

The sampling variance of $(\overline{S}_a)_i$ was estimated from the following expression, based on Jolly and Hampton (1990):

$$Var(\overline{S}_a) = \frac{1}{n(n-1)} \sum_{i=1}^{n} w_i^{\,2} [(\overline{S}_a)_i - \overline{S}_a]^2 \quad ,$$

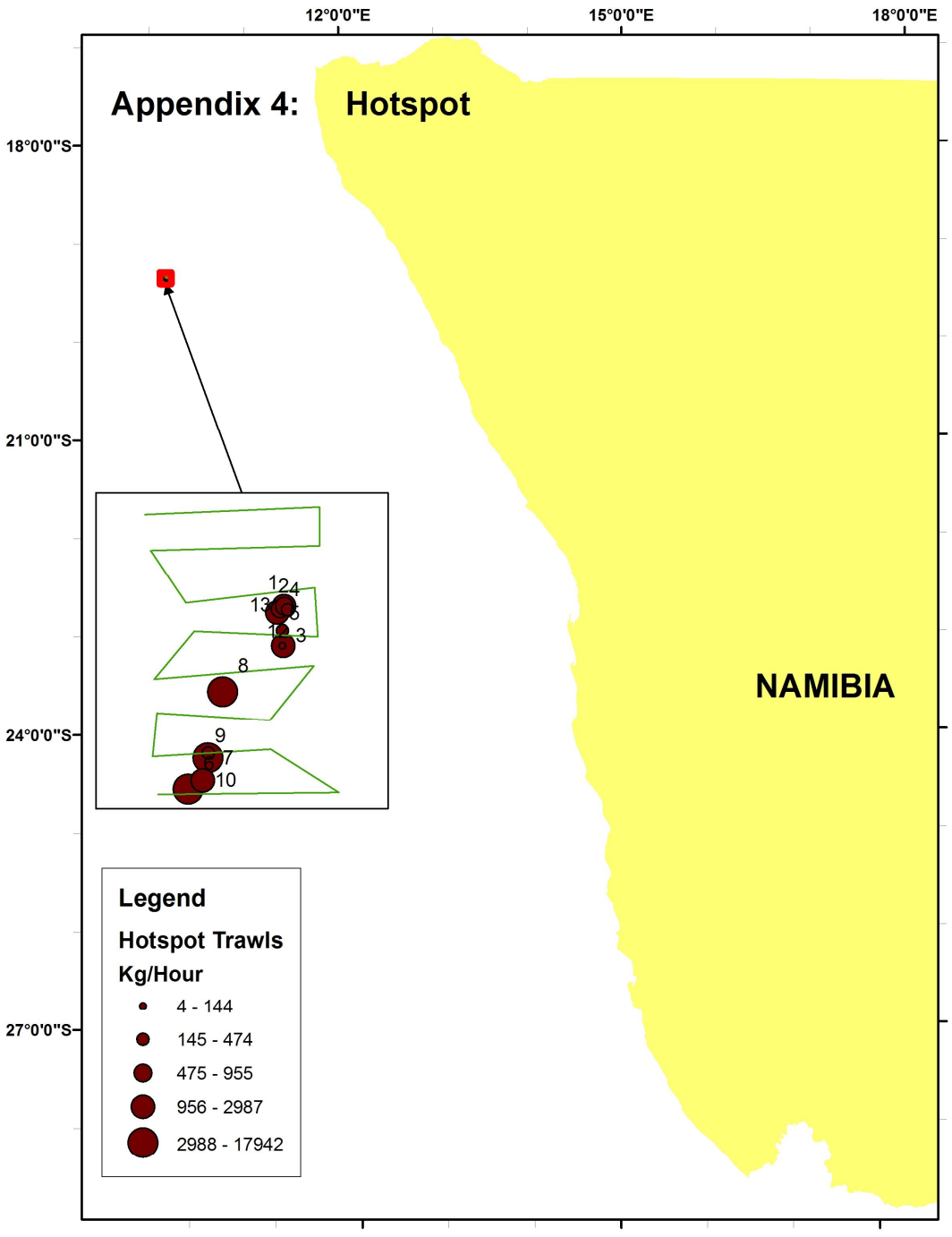
where w_i is a weighting factor for transect length, given by $L_i / \overline{L}$, where $\overline{L}$ is the mean length of the transects in the survey. Since $\overline{L} = \sum L / n$, Eqn. 1 can be written:

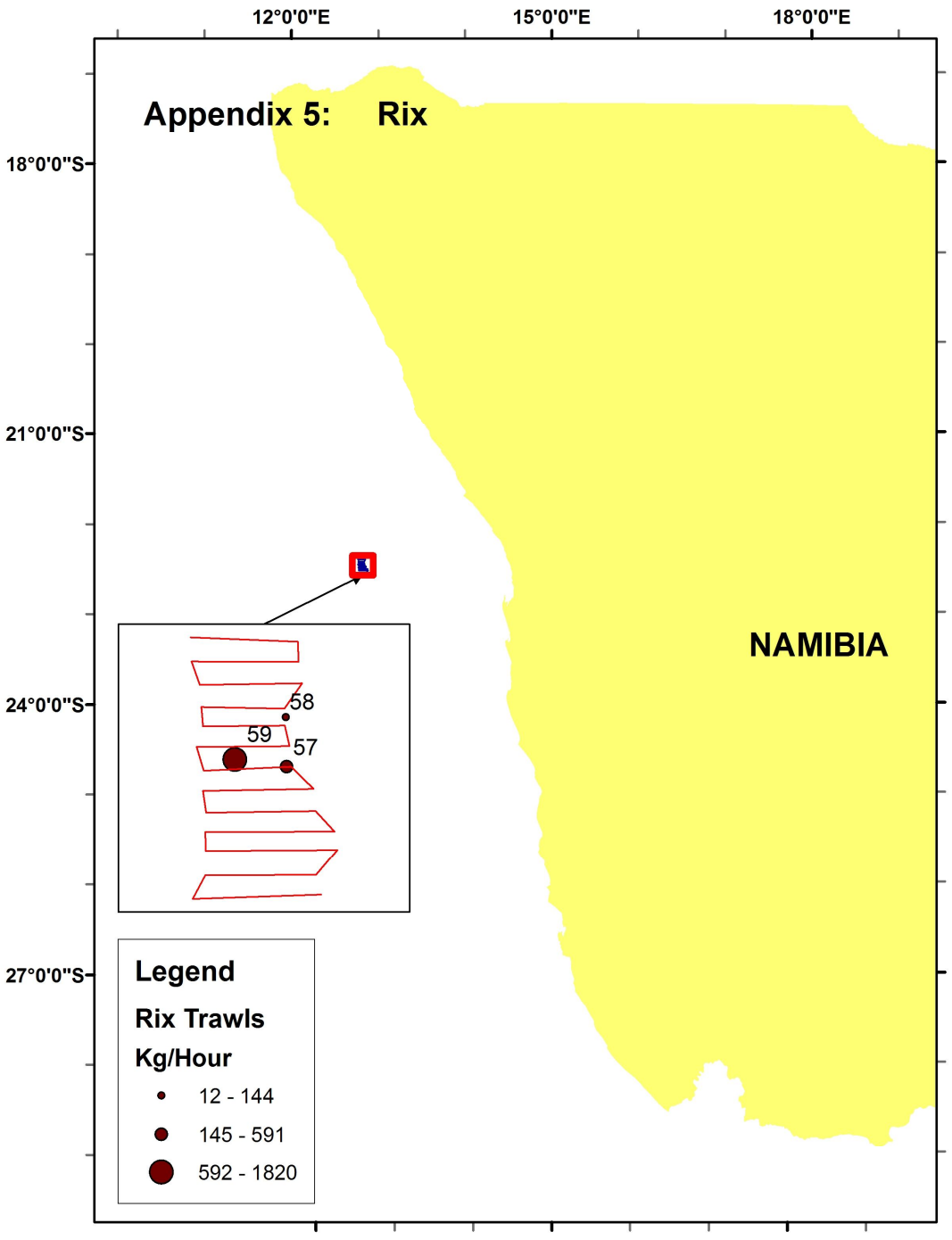
$$Var(\overline{S}_a) = \frac{n}{(n-1)} \frac{\sum_{i=1}^{n} L_i^{\,2} [(\overline{S}_a)_i - \overline{S}_a]^2}{(\sum_{i=1}^{n} L_i)^2} \quad . \qquad (2)$$

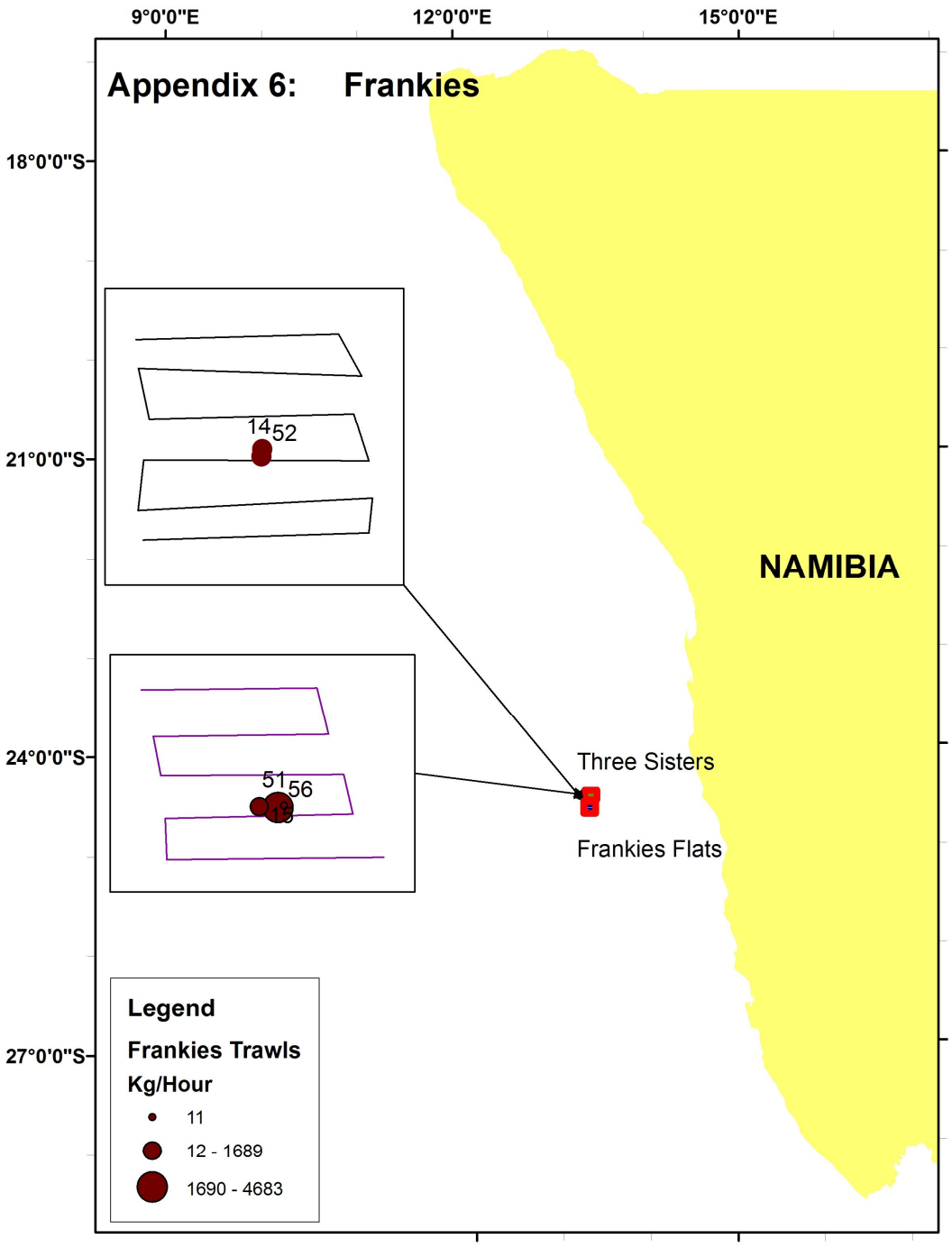
This form of the expression was used for all sampling variance calculations.

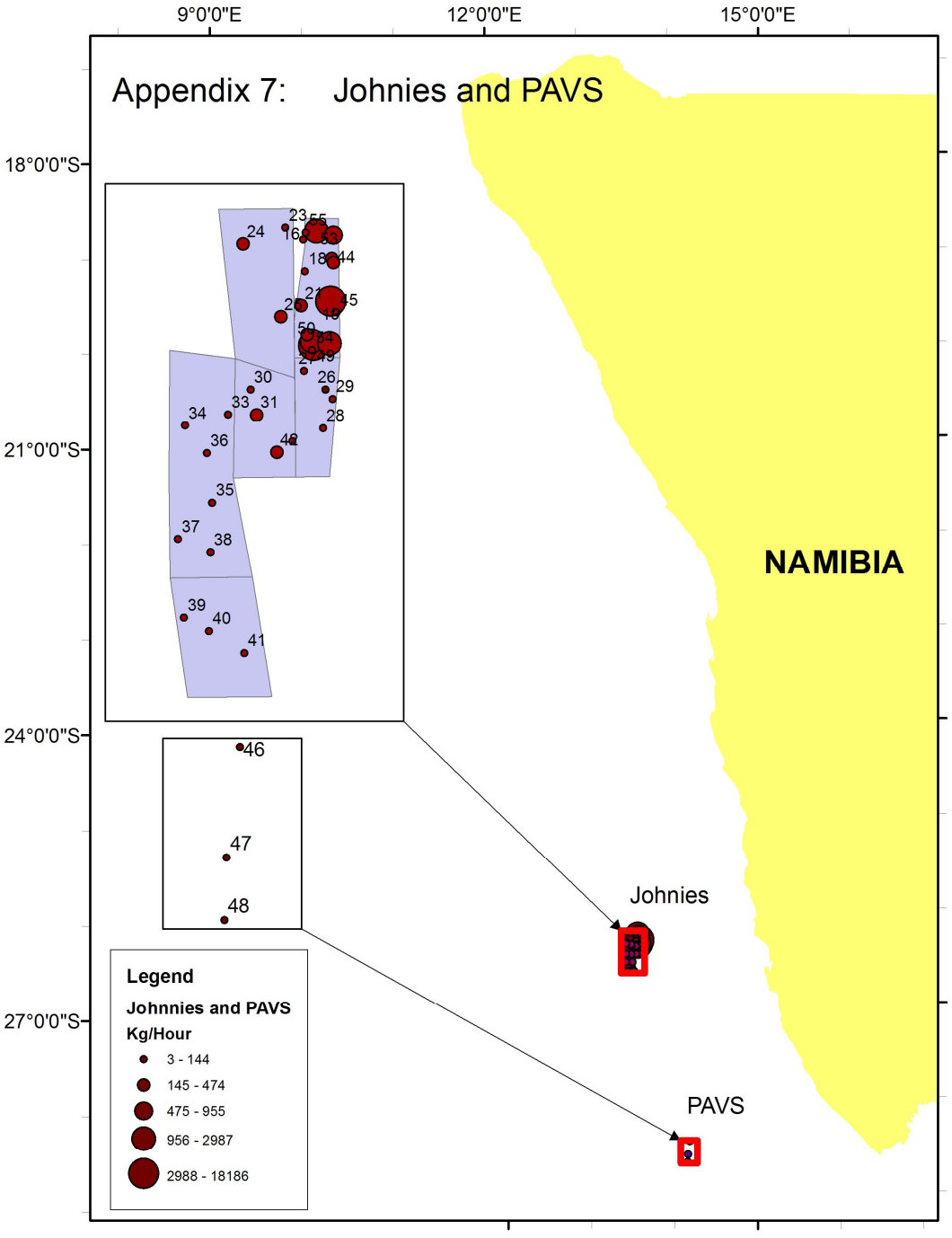
Reference

Jolly, G. M. and I. Hampton 1990 – A stratified random transect design for acoustic surveys of fish stocks. *Can. J. Fish. Aquat. Sci.* **47**(7): 1282 – 1291.


Appendix 4: Hotspot
12°0'0"E
15°0'0"E
18°0'0"E
18°0'0"S
21°0'0"S
24°0'0"S
27°0'0"S
NAMIBIA
12
4
13
6
3
8
9
7
10
Legend
Hotspot Trawls
Kg/Hour
4 - 144
145 - 474
475 - 955
956 - 2987
2988 - 17942


Appendix 5: Rix
12°0'0"E
15°0'0"E
18°0'0"E
18°0'0"S
21°0'0"S
24°0'0"S
27°0'0"S
NAMIBIA
58
59
57
Legend
Rix Trawls
Kg/Hour
12 - 144
145 - 591
592 - 1820


Appendix 6: Frankies
9°0'0"E
12°0'0"E
15°0'0"E
18°0'0"S
21°0'0"S
24°0'0"S
27°0'0"S
NAMIBIA
14
52
51
56
Three Sisters
Frankies Flats
Legend
Frankies Trawls
Kg/Hour
11
12 - 1689
1690 - 4683


Appendix 7: Johnies and PAVS
9°0'0"E
12°0'0"E
15°0'0"E
18°0'0"S
21°0'0"S
24°0'0"S
27°0'0"S
NAMIBIA
Johnies
PAVS
Legend
Johnnies and PAVS
Kg/Hour
3 - 144
145 - 474
475 - 955
956 - 2987
2988 - 18186

Appendix 8: Station and Catch Information

				Start				Finish				Depth		Time			Distance	Catch		
Area	Stn no	Stratum	Date	Lat	min	Lon	min	Lat	min	Lon	min	Start	End	Set	Haul	Course	nm	Total kg	ORH (kg)	OTH
Hotspot	**1**		07/20/07	19	21	10	7	19	19	10	7	610	610	03:01	03:32	0	2.00	1148.09	1038.1	109.99
Hotspot	**2**		07/20/07	19	21	10	7	19	19	10	7	608	1008	04:50	05:25		2.00	511.78	407.4	104.35
Hotspot	**3**		07/20/07	19	22	10	7	19	24	10	7	634	957	06:30	07:05	194	2.00	1426.96	1282.0	144.96
Hotspot	**4**		07/20/07	19	21	10	7	19	19	10	7	600	985	08:08	08:44	0	2.00	866.18	730.7	135.51
Hotspot	**5**		07/20/07	19	22	10	7	19	23	10	7	565	763	09:42	10:20		1.00	294.16	220.9	73.22
Hotspot	**6**		07/20/07	19	25	10	4	19	26	10	4	732	916	11:30	11:46	25	1.00	1140.02	1099.3	40.74
Hotspot	**7**		07/20/07	19	25	10	5	19	24	10	5	606	680	13:08	13:29	30	1.00	1974.16	1811.2	163.00
Hotspot	**8**		07/20/07	19	23	10	5	19	26	10	4	685	890	14:37	14:58	190	3.12	6365.63	6279.8	85.86
Hotspot	**9**		07/20/07	19	25	10	5	19	23	10	5	628	669	15:58	16:22	25	2.00	186.98	141.6	45.39
Hotspot	**10**		07/20/07	19	25	10	5	19	26	10	5	588	919	17:31	17:53	194	1.00	1147.58	894.9	252.73
Hotspot	**11**		07/20/07	19	21	10	7	19	21	10	8	623	1032	19:41	20:11	11	0.88	285.66	208.9	76.81
Hotspot	**12**		07/20/07	19	22	10	7	19	24	10	7	627	934	21:10	21:41	242	2.00	65.41	2.2	63.18
Hotspot	**13**		07/20/07	19	22	10	7	19	19	10	7	596	988	22:50	23:23	321	3.00	423.63	390.7	32.94
Frankies	**14**		07/23/07	24	39	13	21	24	39	13	21	790	727	16:05	16:12	340	0.00	168.37	160.0	8.39
Frankies	**15**		07/23/07	24	32	13	22	24	32	13	22	611	635	17:24	17:35	330	0.00	363.17	309.6	53.55
Johnies	**16**	2B	07/24/07	26	18	13	35	26	19	13	35	690	652	04:07	04:38	180	1.00	159.70	43.1	116.59
Johnies	**17**	2A	07/24/07	26	19	13	36	26	17	13	36	621	617	05:57	06:27	10	2.00	326.22	176.1	150.17
Johnies	**18**	2E	07/24/07	26	19	13	35	26	21	13	25	693	687	07:29	07:59	200	4.13	180.00	42.2	137.79
Johnies	**19**	2C	07/24/07	26	21	13	36	26	22	13	36	615	605	09:25	09:57	181	1.00	8445.21	8371.9	73.30
Johnies	**20**	2D	07/24/07	26	22	13	35	26	21	13	35	675	649	11:14	11:44	20	1.00	239.43	132.7	106.76
Johnies	**21**	2F	07/24/07	26	21	13	24	26	22	13	35	1086	1086	12:53	13:24	180	3.85	255.94	244.8	11.19
Johnies	**22**		07/24/07	26	23	13	36	26	20	13	36	608	620	14:19	15:15	0	3.00	2303.60	2303.6	0.05
Johnies	**23**	6B	07/24/07	26	17	13	34	26	18	13	34	747	733	16:33	17:03	180	1.00	155.94	15.8	140.18
Johnies	**24**		07/24/07	26	18	13	31	26	19	13	31	855	852	18:40	19:09	180	1.00	172.56	94.5	78.02
Johnies	**25**	6A	07/24/07	26	21	13	33	26	20	13	33	753	741	20:29	20:58	7	1.00	273.92	167.8	106.15
Johnies	**26**	4C	07/24/07	26	25	13	36	26	24	13	26	614	614	22:25	23:06	360	3.08	129.83	2.1	127.73
Johnies	**27**	4B	07/25/07	26	24	13	35	26	26	13	35	618	674	00:03	00:32	180	2.00	21.16	10.5	10.62
Johnies	**28**	4A	07/25/07	26	27	13	36	26	29	13	36	617	612	01:25	01:54	180	2.00	32.62	1.4	31.20
Johnies	**29**		07/25/07	26	26	13	36	26	19	13	36	595	615	02:53	04:54	0	7.00	81.02	45.0	36.01
Johnies	**30**	8C	07/25/07	26	25	13	32	26	27	13	31	838	862	06:17	06:47	195	2.02	122.51	52.6	69.95
Johnies	**31**	8A	07/25/07	26	26	13	32	26	28	13	32	818	816	07:56	08:28	180	2.00	181.55	94.5	87.07
Johnies	**32**	8B	07/25/07	26	28	13	34	26	26	13	24	711	709	09:36	10:06	0	3.21	105.50	16.6	88.89
Johnies	**33**	9A	07/25/07	26	26	13	30	26	25	13	30	903	958	11:14	11:43	332	1.00	93.81	53.6	40.26
Johnies	**34**	9B	07/25/07	26	27	13	28	26	28	13	28	1051	1030	12:58	13:29	170	1.00	90.86	11.9	79.00
Johnies	**35**	9SC	07/25/07	26	31	13	29	26	32	13	29	979	1082	14:45	15:21	180	1.00	63.94	33.2	30.71
Johnies	**36**	9C	07/25/07	26	28	13	29	26	27	13	19	981	988	16:48	17:18	0	2.63	41.60	26.8	14.85
Johnies	**37**	9SB	07/25/07	26	33	13	27	26	34	13	28	1107	1109	18:49	19:19	174	1.01	49.91	7.3	42.61
Johnies	**38**	9SA	07/25/07	26	33	13	29	26	32	13	29	1011	1022	20:45	21:14	341	1.00	171.27	69.6	101.64
Johnies	**39**	11B	07/25/07	26	32	13	28	26	35	13	27	1130	1120	23:21	23:51	354	3.00	15.44	11.4	4.09
Johnies	**40**	11C	07/26/07	26	37	13	29	26	39	13	29	1062	1081	01:14	01:43	209	2.00	29.67	16.4	13.24
Johnies	**41**	11A	07/26/07	26	38	13	31	26	37	13	31	960	963	03:02	03:32	354	1.00	44.88	21.2	23.65
Johnies	**42**		07/26/07	26	28	13	33	26	20	13	33	761	761	05:00	07:38	21	8.00	727.10	511.1	215.99
Johnies	**43**		07/26/07	26	17	13	36	26	19	13	36	610	618	08:49	09:11	174	2.00	493.76	350.2	143.60
Johnies	**44**		07/26/07	26	19	13	36	26	21	13	36	614	614	10:04	10:42	184	2.00	593.99	167.8	426.21
Johnies	**45**		07/26/07	26	21	13	36	26	26	13	36	590	593	11:31	13:00	182	5.00	317.88	34.8	283.12
EFA	**46**		07/27/07	28	29	14	11	28	35	14	11	828	837	00:30	02:29	196	6.00	98.27	81.4	16.88
EFA	**47**		07/27/07	28	37	14	10	28	45	14	11	936	945	03:46	06:12	204	8.05	449.80	289.5	160.27
EFA	**48**		07/27/07	28	42	14	9	28	39	14	9	997	977	07:31	08:31	4	3.00	609.29	157.7	451.61
Johnies	**49**		07/27/07	26	23	13	35	26	18	13	35	653	663	21:01	22:39	359	5.00	31055.03	29704.6	1350.42
Johnies	**50**		07/27/07	26	23	13	35	26	17	13	35	655	669	02:03	03:53	22	6.00	5475.44	5475.4	0.00
Frankies	**51**		07/28/07	24	32	13	22	24	32	13	22	610	610	13:52	14:08	354	0.00	1248.67	1248.7	0.00
Frankies	**52**		07/28/07	24	39	13	21	24	39	13	21	736	743	17:14	17:21	352	0.00	120.02	113.7	6.36
Johnies	**53**		07/29/07	26	17	13	35	26	23	13	35	665	656	03:38	05:20	214	6.00	4098.36	4075.8	22.54
Johnies	**54**		07/29/07	26	23	13	35	26	17	13	35	657	661	06:33	08:29	28	6.00	261.21	107.7	153.51
Johnies	**55**		07/29/07	26	17	13	35	26	21	13	34	696	691	09:20	10:29	187	4.02	161.81	16.8	145.02
Frankies	**56**		07/29/07	24	32	13	22	24	32	13	22	605	630	22:38	22:54	335	0.00	108.43	2.8	105.63
Rix	**57**		07/31/07	22	31	12	45	22	34	12	46	582	671	09:41	10:04	164	3.12	525.50	226.4	299.14
Rix	**58**		07/31/07	22	29	12	45	22	28	12	42	564	936	12:11	13:05	293	2.84	93.08	10.5	82.55
Rix	**59**		07/31/07	22	31	12	42	22	31	12	42	770	776	15:02	15:14	197	0.00	437.92	364.0	73.92

Appendix 9: Temperature, salinity and oxygen profiles

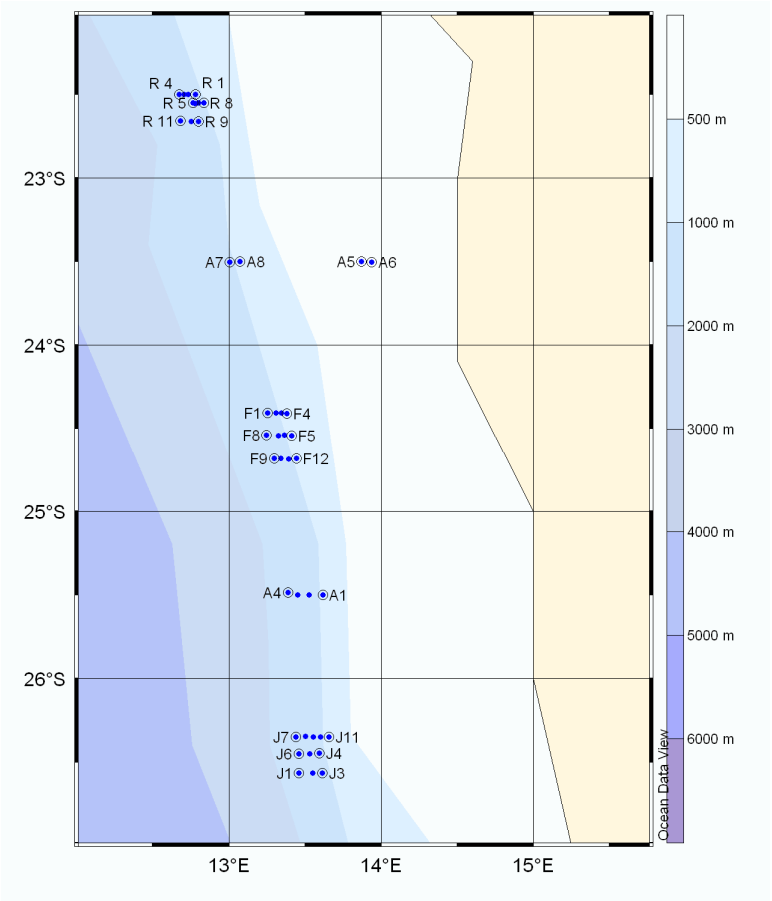


Figure 1: Map showing transects conducted at Johnies, Frankies, Rix and an additional stations, Contoured shade shows bathymetry.

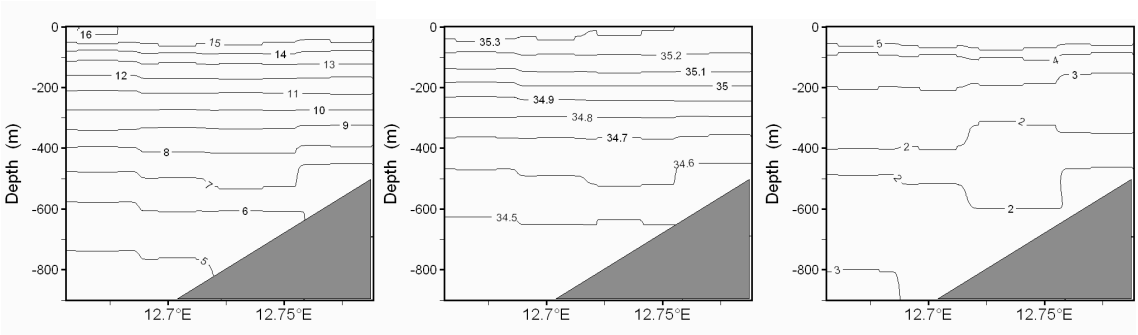


Figure 2: Vertical sections of a) temperature b) salinity and c) oxygen at Rix for stations R1-R4.

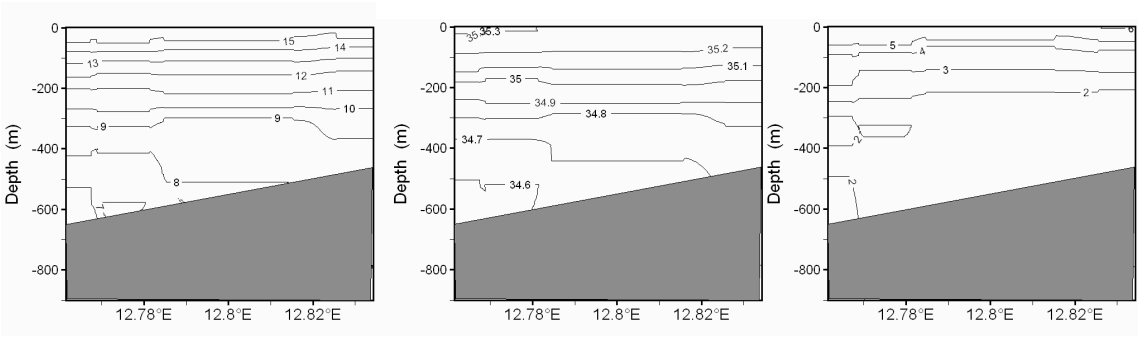


Figure 3: Vertical sections of a) temperature b) salinity and c) oxygen at Rix for stations R5-R8.

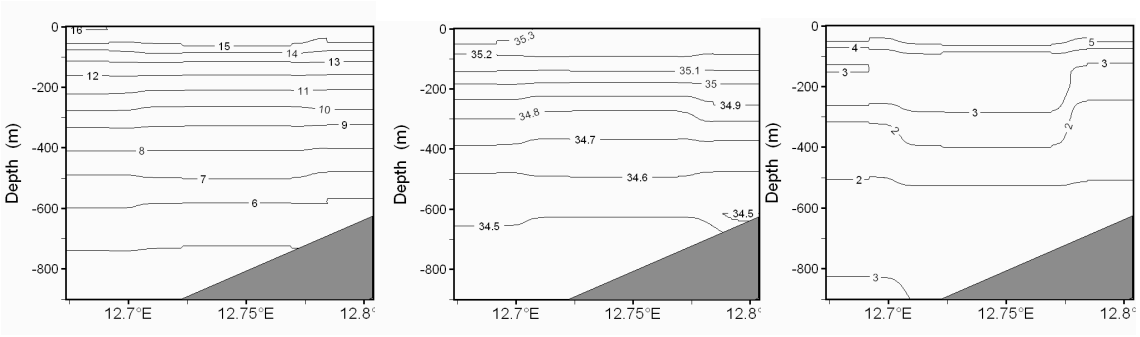


Figure 4: Vertical sections of a) temperature b) salinity and c) oxygen at Rix for stations R9-R11.

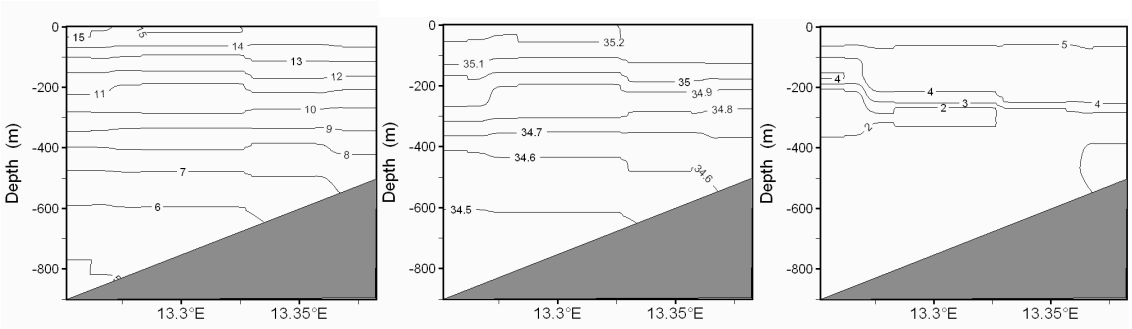


Figure 5: Vertical sections of a) temperature b) salinity and c) oxygen at Frankies for stations F1-F4.

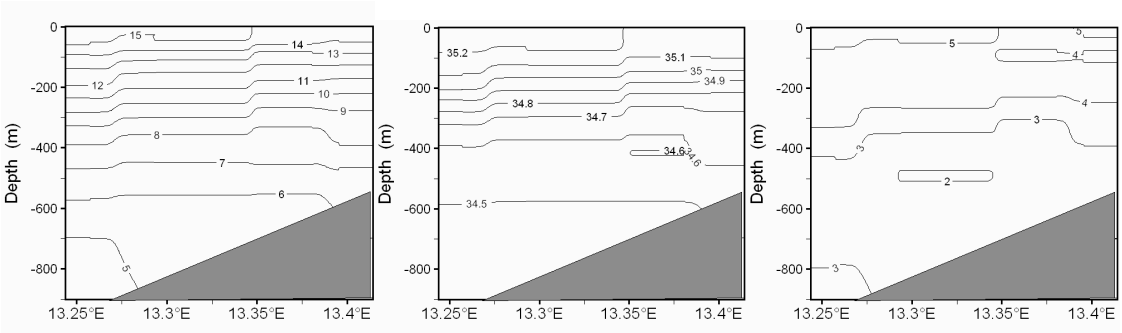


Figure 6: Vertical sections of a) temperature b) salinity and c) oxygen at Frankies for station F5-F8.

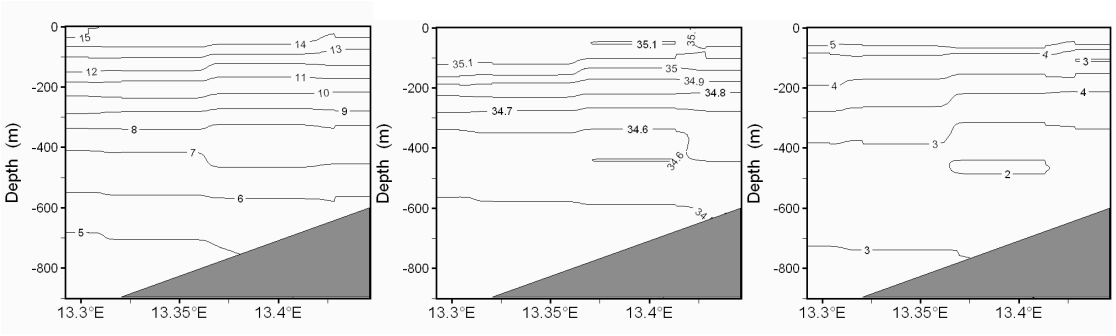


Figure 7: Vertical sections of a) temperature b) salinity and c) oxygen at Frankies for stations F9-F11.

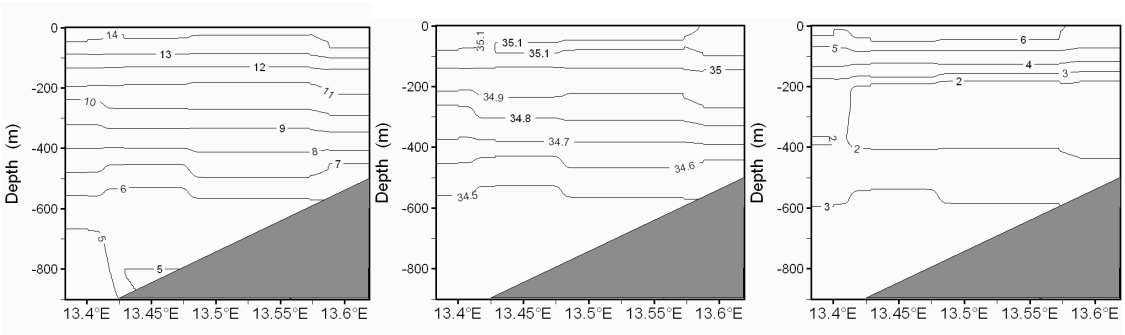


Figure 8: Vertical sections of a) temperature b) salinity and c) oxygen for Additional stations A1-A4.

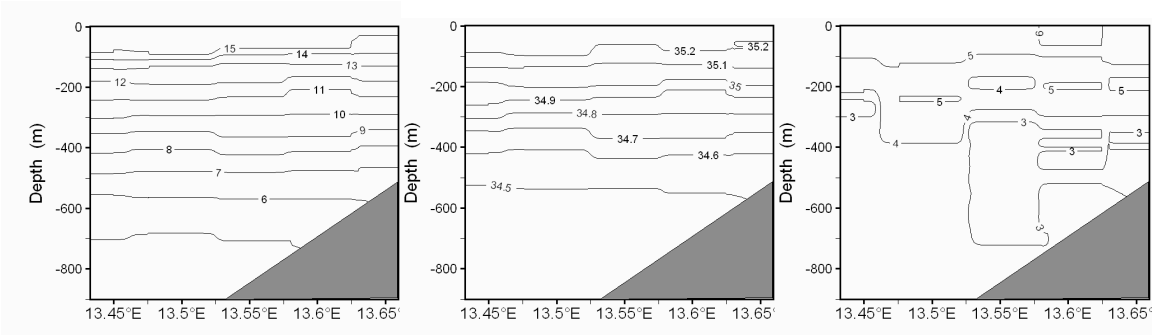


Figure 9: Vertical sections of a) temperature b) salinity and c) oxygen at Johnies for stations J7-J11.

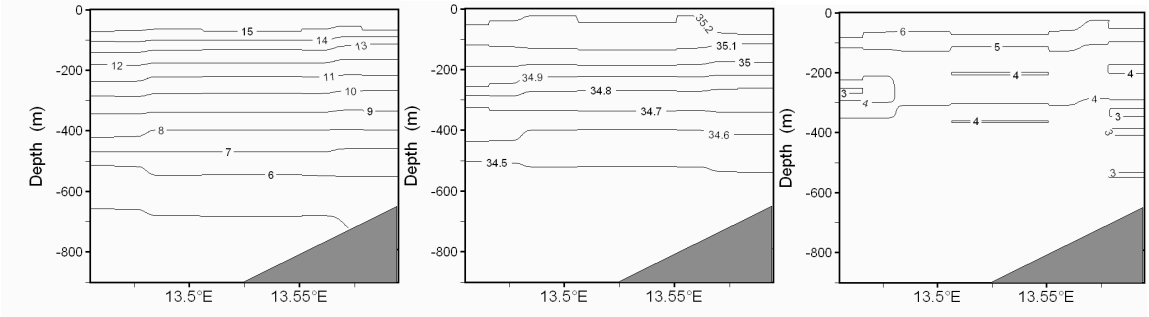


Figure 10: Vertical sections of a) temperature b) salinity and c) oxygen at Johnies for stations J4-J6.

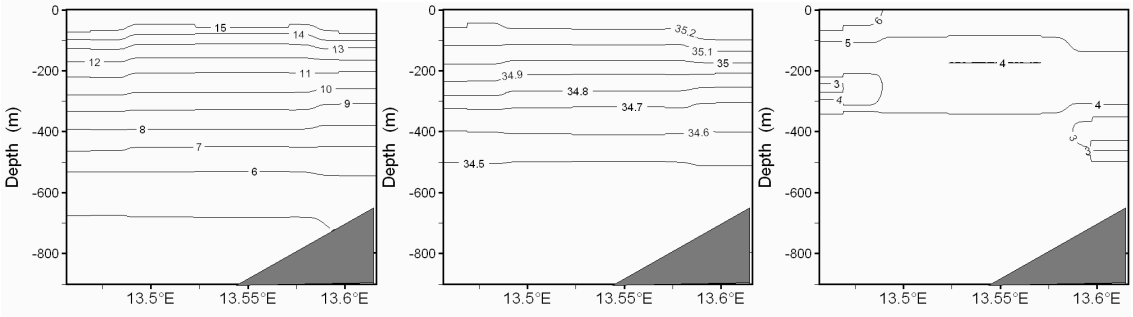


Figure 11: Vertical sections of a) temperature b) salinity and c) oxygen at Johnies for J1-J3.

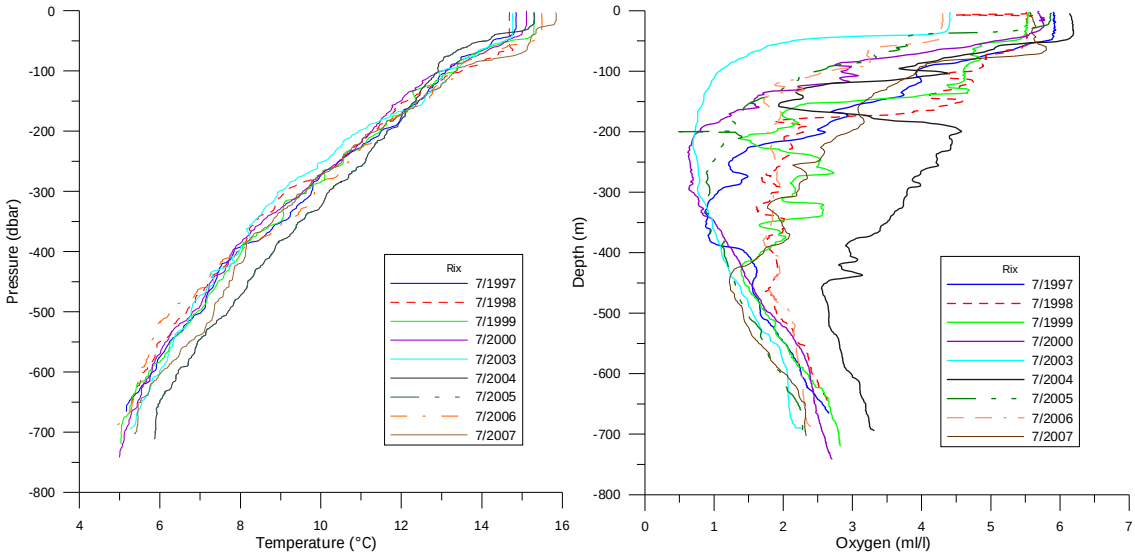


Figure 12: Vertical profiles of a) temperature and b) oxygen at Rix for July 1997-2007.

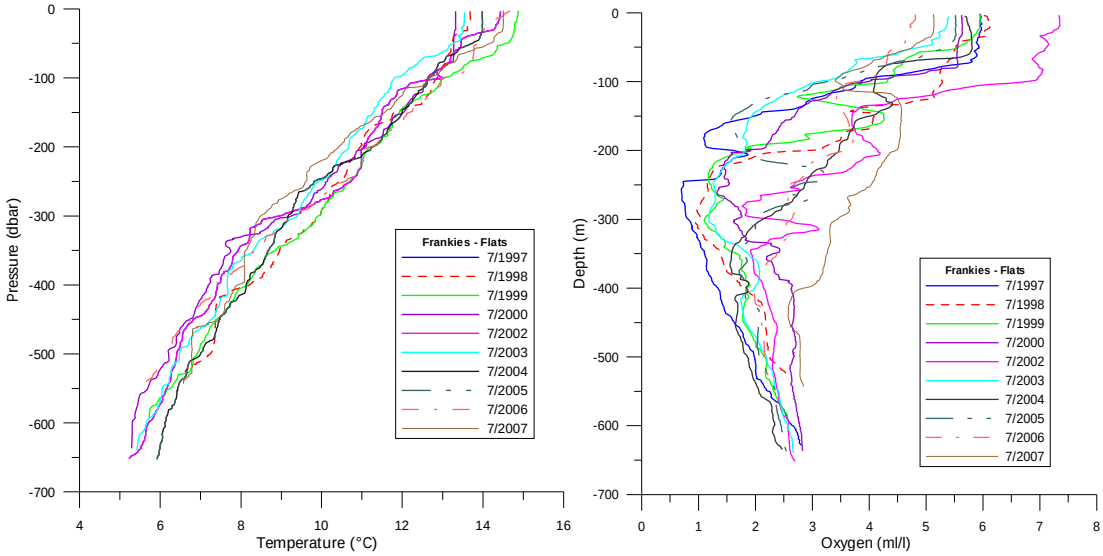


Figure 13: Vertical profiles of a) temperature and b) oxygen at Frankies – Flats for July 1997-2007.

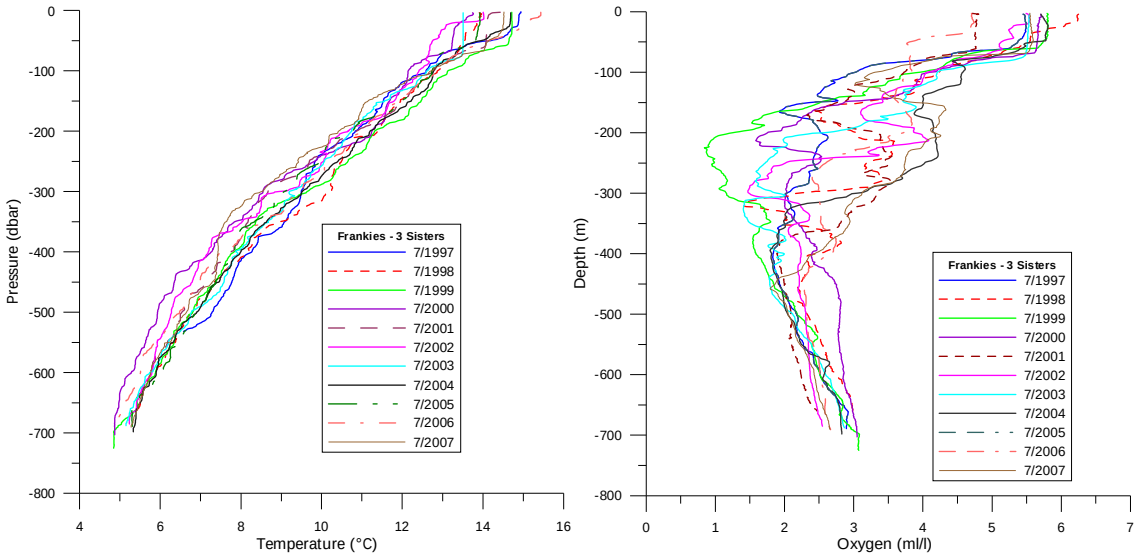


Figure 14: Vertical profiles of a) temperature and b) oxygen at Frankies – 3 Sisters for July 1997-2006.

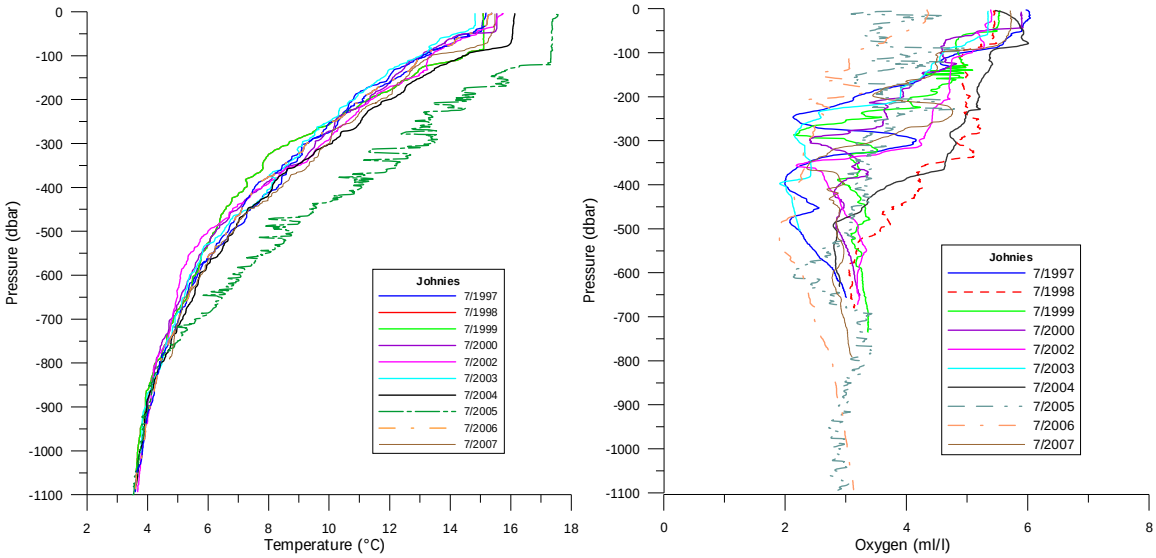


Figure 15: Comparison of Vertical profiles of a) temperature and b) oxygen at Johnies for July 1997-2007.

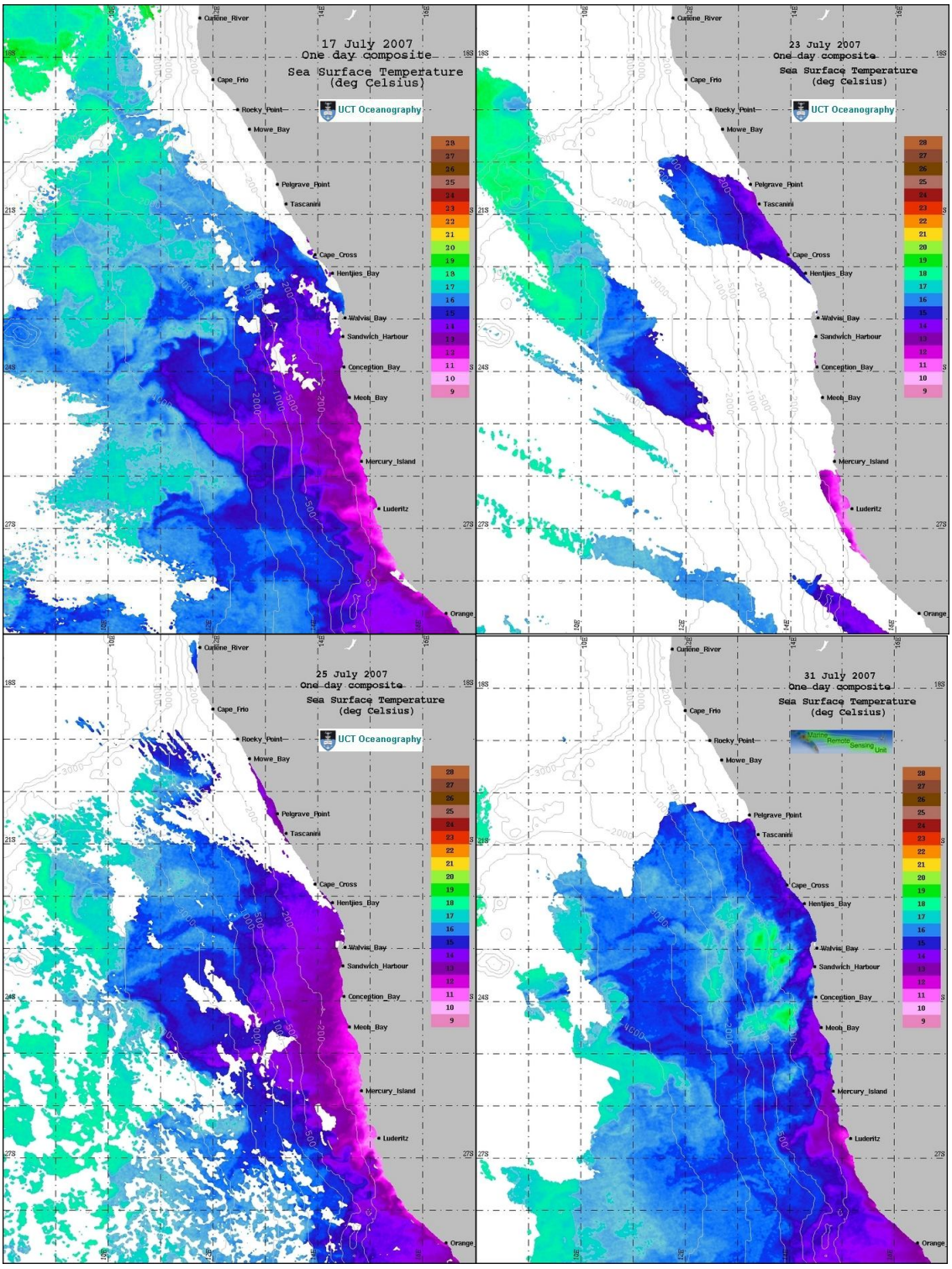


Figure 16: Mean SST daily composites for the weeks 17, 23, 25 and 31 July 2007.

Appendix 10: Gear specifications