

## ***Information used to support orange roughy stock structure assumptions***

### **Introduction**

Innovative Solutions Ltd (ISL) was contracted by SIOFA to provide a stock assessment for orange roughy in the Walter's Shoal region (WSR) and to apply the New Zealand Harvest Control Rule (HCR) to other orange roughy stocks in the SIOFA area. The region WSR was established on the basis of a review of spawning stocks in the SIOFA region initially provided to the SC in SC-01-INFO-16.

There are two major fishing areas for orange roughy in the Southwest Indian Ocean, the Walter's Shoal region to the west, and 300 nautical miles to the southeast, the Southwest Indian Ridge. This ridge extends for over 840 nautical miles.

The four SIOFA Statistical Regions that cover these fishing areas (SIOFA1, SIOFA2, SIOFA3a, SIOFA3b) were not established on the basis of scientific data. Using such regions was considered inappropriate for the stock assessments being undertaken.

To facilitate the contracted stock assessments outside of the South Walter's region, updated biological data were used to produce more realistic spatial areas that could be considered as interim management areas. This review took into account spawning stock data including timing of peak spawning, size composition, habitat type and spatial separation from other spawning aggregations.

This current report provides summary biological data from orange roughy to assist with stock assessments using acoustic data collected by the vessel *Will Watch* from 2004 to 2017 under the flag of the Cook Islands.

### **Materials and Methods**

The full data collection protocols for vessels operating in the Indian Ocean were described in Shotton (2007). This protocol was updated in 2012, and forms part of the vessel permit requirements for vessels registered under the Cook Islands flag.

The biological sampling is as follows:

#### **3. SAMPLING PROCEDURES**

##### **3.1 Selection of a Trawl for Sampling**

Biological samples are to be collected from the catch taken from at least *one* trawl for each day of fishing. One of two options should be used:

- i. randomly selecting a trawl for each day or
- ii. sampling every trawl with a catch greater than 5000 kg.

The trawl catch to be sampled should be selected at random from the fishing undertaken on a given day. Selection is to be determined based on a random time of the day for the time the trawl is on deck (i.e. when it is completed). The first trawl retrieved after the random time for that day is to be chosen for biological sampling. However, if the catch from this trawl is too small for a good sample, i.e. the total catch of either species is less than 500 kg then the catch from the next trawl with a total catch larger than 500 kg should be sampled.

### 3.2 Calculation of Random Time for Trawls

Lists of random times for each day of fishing are provided in **Attachment 1**. For example, for a random time of 04:33 sample the catch from the next trawl landed on deck which has a total catch greater than 500 kg is to be sampled. Remember not to sample the catch from trawls with a catch of less than 500 kg.

For random times later than 2000, it is possible that the next trawl will not be landed on deck until after midnight. However, the next trawl should still be sampled and considered as the sample from the previous day. In such cases where the random time for the next day is early and overlaps with the previous night's sample, select the next random time on the list for the sample from the following day.

### 3.3 Selection of a Sample from the Catch

A sample of 100 fish is to be measured for each species from the catch. The number of fish comprising the sample does not change in relation to the size of the catch.

The sample of fish to be measured must be selected at random from the entire catch. All samples are to be selected from an appropriate sample point on board the vessel. The sample point should be established at a location that enables all fish in the catch to have an equal chance of being selected in the sample. *The sample point should not change from day to day, but remain fixed for the whole trip. It is important that the sampling point chosen allows sampling before any fish are sorted.*

The position of the sample point will vary depending on the size of the vessel and layout of the processing area and/or fish hold. On larger vessels, an appropriate sampling point would be located at the conveyor in front of the fish ponds, while on small vessels it may be necessary to collect a sample directly from the codend of the trawl.

The sub-sample of 100 fish is to be selected from the catch at one time. Individual fish will be drawn from the sampling point by successively selecting the fish with the eyeball nearest the sampling point. In the Indian Ocean the volume of 100 orange roughy will require about 10-12 35-40 kg fish bins.

## ***ACOUSTIC SURVEY BIOLOGICAL DATA***

Acoustic surveys with calibrated Simrad ES60/70 echosounders were carried out from 2004 to 2016, following the protocols described in Shotton (2007), and in Niklitschek and Patchell (2016). In 2017 the protocols were modified following the ABNJ Acoustic Review for SIOFA, to increase the pulse length during surveys.

Overall across the regions there is a complex species mix, which varies considerably between depth, bathymetric feature and area. As well as aggregations of orange roughy and alfonso, there are significant aggregations of black and spiky oreo dories, smooth oreo dory, cardinal fish (*Epigonus spp.*). The difference in species composition between areas is important for acoustic biomass estimation. In the analysis below, there is a species composition in the area at the time of the survey, in the region where the Echoview 'Schools' analysis is undertaken. Where mixed species occur in the water column, they were separately detected in the analysis. In addition, three dimensional plots of schools, were overlaid on 3D bathymetry. This enabled the observation of aggregation integrity, to ensure confidence that the schools which were taken into the acoustic assessment were distinct single species aggregations. This provided an auditing process on the mark

identifications in the regions where more than one species existed, or on steep seamounts and ridges where the fish were known to move around from one side to the other. From the Echoview Scene, further analysis allowed the removal of schools which were not considered part of the aggregation.

In 2014, several multi-frequency tow body acoustic surveys were carried out using the CSIRO developed Acoustic Optical System (Sealord AOS Mk II). This allows verification of the species composition in mixed species aggregations (Ryan et al 2015).

Only where there was uncertainty about the ability to separate out marks, was a species mix applied.

## RESULTS

In total, 66,408 orange roughy were sampled for length, weight, sex and maturation, from 522 target trawls shots between 2004 and 2017. In total, there were 52 known separate spawning aggregations of orange roughy identified in the region, and 123 features that contain orange roughy. Some of these aggregations are separated by only 10 miles, but they remain distinctively separated during the spawning season, as has been established by acoustic surveys, and multiple vessels fishing them at the same time. In many cases, the stocks are separated by waters 2000-5000 metres deep, and there is a difference in the timing of spawning by stocks. Spawning occurs across the region from June to October.

Some biological data are held for at least 54 stocks, including size and weight distribution, maturation and spawning data, and otoliths (Table 1).

Historical information is also available for a number of other stocks, for which we have no biological and catch information available at present for this analysis. In the SIOFA region, there were 123 features where at least 10 kg of Orange Roughy were caught.

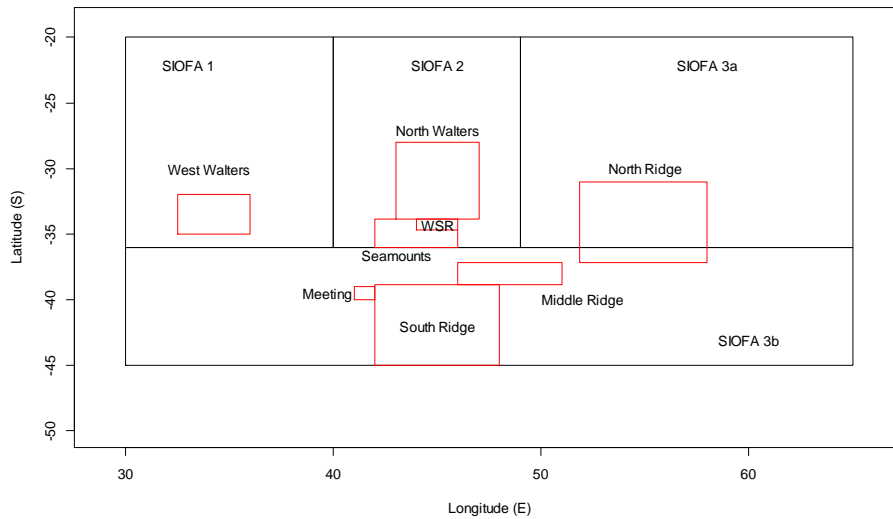
The data used included catch data from 12,702 bottom trawl shots over the region and a total greenweight catch of 28,295 tonnes of orange roughy over 18 years, and a large number of acoustic surveys on individual stocks.

The updated biological data were used to produce more realistic spatial areas that could be considered as interim management areas (Figure 1). This review took into account spawning stock data including timing of peak spawning, size composition, habitat type and spatial separation from other spawning aggregations

**Table 1 Summary Data for Southwest Indian Ocean**

Orange Roughy Spawning Aggregations	52
Features with Catch data (>100 kg)	123
Number of stocks heavily fished	20
Stocks with Acoustic survey biomass estimates available	24
Biological data available	54
Features with Estimated catch available	70

The following tables indicate locations of potential spawning stocks of Orange Roughy in the SIOFA area. This is not a record of all fishable features in the region, but one where records are held of orange roughy presence. Where spawning stocks have been identified, this indicates where gonadosomatic indices of female fish exceed 3% or stage 3 maturation. The full maturation data have not been included in this report.



**Figure 1 Spatial Management Areas for Orange Roughy**

### South Walter's

#### Area Boundaries S 33 50 to S 34 41, E44 to E 46

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Abby Road	34 01	45 36	Yes	Yes	Heavily Fished
Normans	34 14	45 22	Yes	No	Uncertain
Harvey's	34 16	45 23	Yes	Yes	Cannot be fished
Henry's	34 17	45 24	Yes	No	Very Lightly Fished
Lazywire	34 21	45 01	Yes	Yes	Heavily Fished
Split Pin	34 24	45 06	Yes	Yes	Heavily Fished
Boulder	34 35	44 37	Yes	Yes	Moderately Fished
Sleepy Hollows	34 36	44 13	Yes	Yes	Heavily Fished
Coopaville	34 28	44 03	Yes	Yes	Uncertain
Sleeping Beauty	34 24	44 10	Yes	Yes	Moderately Fished

ZZ Top	34 14	44 18	Yes	No	Lightly Fished
OK Coral	34 12	45 15	Yes	No	Lightly Fished
El Paso	34 15	45 05	Yes	Yes	Uncertain
Porky's	34 24	44 15	Yes	Yes	Heavily Fished
Elm St	33 06	43 48	Yes	No	Uncertain
Club 21	34 18	45 28	Yes	No	Very Lightly Fished
Hank	34 18	45 28	Yes	No	Very Lightly Fished
Mini Patch	33 08	45 12	Yes	No	Lightly Fished
Patch's	33 14	45 15	Yes	No	Lightly Fished
Danilo	34 10	45 57	Yes	Yes	Uncertain

Mean Length (cm)	44.68	
Mean Weight (kg)	2.8	
Spawning period	1-14 July	
Habitat type	Banks/knolls linked by depths less than 1800 m	
Number of spawning aggregations	12+	
Distance to next closest region	20 nm	

### Walter's Seamounts

**Area Boundaries S 34 41 to S 36, E42 to E 46 S 34 10 to S 34 41, E42 to E 44**

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Smurf's	35 02	44 12	Yes	Yes	Lightly fished
Novel	34 44	43 44	Yes	Yes	Moderately Fished
Wrongford's	34 32	43 15	Yes	Yes	Moderately Fished
Grover	35 03	43 13	Yes	Yes	Cannot be fished

Mean Length (cm)	46.86	
Mean Weight (kg)	3.4	
Habitat type	Large seamounts separated by >2000 m	
Number of spawning aggregations	4	
Distance to next closest region	280 nm to Meeting	

### Meeting

**Area Boundaries S 39 to S 40, E 41 to E 42**

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Big Flat	40 04	42 59	Yes	Yes	Lightly Fished
Meeting	39 25	41 24	Yes	Yes	Heavily Fished

Mean Length (cm)	41	
Mean Weight (kg)	2.3	
Habitat type	Large Seamount	
Number of spawning aggregations	1	
Distance to next closest region	200 nm to South Ridge	

### Western Walter's

#### Area Boundaries S 32 to S 35, E 32 30 to E 36

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Sin City	34 10	33 23	Yes	Yes	Moderately Fished
Jeanies	32 46	35 21	Yes	Yes	Moderately Fished

Mean Length (cm)	51	
Mean Weight (kg)	4.2	
Habitat type	Very large Plateau with 3 known knolls	
Number of spawning aggregations	2	
Distance to next closest region	250 nm to Northern Walter's	

### Northern Walter's

#### Area Boundaries S 28 to S 32, E 44 to E 47

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
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Da Vinci's	29 52	46 04	Yes	Yes	Moderately Fished
Banana	30 22	45 56	Yes	Yes	BPA
Angelo's	29 34	45 57	Yes	Yes	Moderately Fished

Mean Length (cm)	50	
Mean Weight (kg)	4	
Habitat type	Large Plateau	
Number of spawning aggregations	2	
Distance to next closest region	260 nm to South Walter's	

## Northern Ridge

### Area Boundaries S 31 to S 37 10, E 51 50 E 58

Feature Name	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Atlantis	32 42	57 16	Yes	No	BPA
Big Ted's	33 07	57 12	Yes	Yes	Lightly Fished
Freon	33 55	55 16	Yes	Yes	Lightly Fished
Commodore	34 15	54 30	Yes	No	Lightly Fished
HH	34 22	54 38	Yes	No	Very Lightly Fished
Rainy Day	34 32	55 15	Yes	No	Very Lightly Fished
ITM	35 05	54 24	Yes	Yes	Heavily Fished
Leo's	35 11	54 18	Yes	Yes	Moderately Fished
Rat	35 08	53 43	Yes	Yes	Moderately Fished
The Bus	35 36	53 14	Yes	No	Uncertain
Rainbow	35 17	54 18	Yes	No	Very Lightly Fished
Eric's	35 43	53 37	Yes	Yes	Moderately Fished
Europa	35 47	53 36	Yes	Yes	Very Lightly Fished
Le Big	35 57	53 14	Yes	No	Uncertain
Angries	35 58	53 36	Yes	No	Very Lightly Fished
Grumpy's	36 02	53 35	Yes	Yes	Very Lightly Fished
Pot's	35 52	54 14	Yes	Yes	Heavily Fished
Focus	36 20	53 01	Yes	Yes	Very Lightly Fished
Saddle	36 50	52 05	Yes	Yes	Heavily Fished
Fruitsalad	37 03	51 57	Yes	Yes	Moderately Fished

Mean Length (cm)	46	
Mean Weight (kg)	3.1	
Habitat type	Seamounts and Ridges	
Number of spawning aggregations	12	
Distance to next closest region	500 nm from South Walter's	

**Middle Ridge****Area Boundaries S 37 10 to 38 50, E 46 to E 51**

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Top Knot	38 22	47 44	Yes	No	Very Lightly Fished
M.M	37 26	50 34	Yes	Yes	Moderately Fished
Kettle	37 24	50 26	Yes	Yes	Lightly fished
Harlot	37 21	49 54	Yes	Yes	Lightly Fished
Scud	37 28	49 29	Yes	Yes	Lightly Fished
Bridle	37 52	49 43	No	No	Lightly fished
Portland	37 56	49 46	Yes	No	BPA
Mt Yuk	37 58	49 56	Yes	No	BPA
M.O.W	37 57	50 25	Yes	Yes	Lightly fished
Nuie	38 18	48 55	Yes	No	Lightly fished
Rarotonga	38 13	48 31	Yes	No	Lightly fished
Melville	38 28	46 45	Yes	No	Uncertain
Tonga	38 25	48 23	Yes	Yes	Heavily Fished
Sugarol	38 37	48 20	Yes	Yes	Heavily Fished
Robbs	38 30	47 42	Yes	Yes	Moderately Fished
Fredrick's	38 34	47 32	Yes	Yes	Moderately Fished
Zedric	38 36	47 36	Yes	Yes	Moderately Fished

Mean Length (cm)	47.5	
Mean Weight (kg)	3.3	
Habitat type	Seamounts and Ridges	
Number of spawning aggregations	9	
Distance to next closest region	80 nm to North Ridge, 40 nm to South Ridge and 6000 m depths	



## South Ridge

### Area Boundaries S 38 50 to 45S, E 42 to 48

FEATURE NAME	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Monitor	38 57	47 19	Yes	Yes	Moderately Fished
Boney M	39 02	47 10	Yes	Yes	Lightly Fished
David's	39 02	46 33	Yes	Yes	Moderately Fished
Crayfish	39 17	45 58	Yes	No	Very Lightly Fished
Squidly	39 04	46 04	Yes	No	Very Lightly Fished
McLay's	39 33	47 37	Yes	Yes	Moderately Fished
Clearlight	40 26	45 32	Yes	Yes	Moderately Fished
Seal Shark	40 30	44 30	Yes	No	Uncertain
Coral	41 09	42 57	Yes	No	BPA
Winter	41 55	42 46	Yes	No	Uncertain

Mean Length (cm)	47.35	
Mean Weight (kg)	3.2	
Habitat type	Seamounts and Ridges	
Number of spawning aggregations	6	
Distance to next closest region	40 nm to Middle Ridge, 6000 m water depth	

## Broken Ridge and Ninety-East

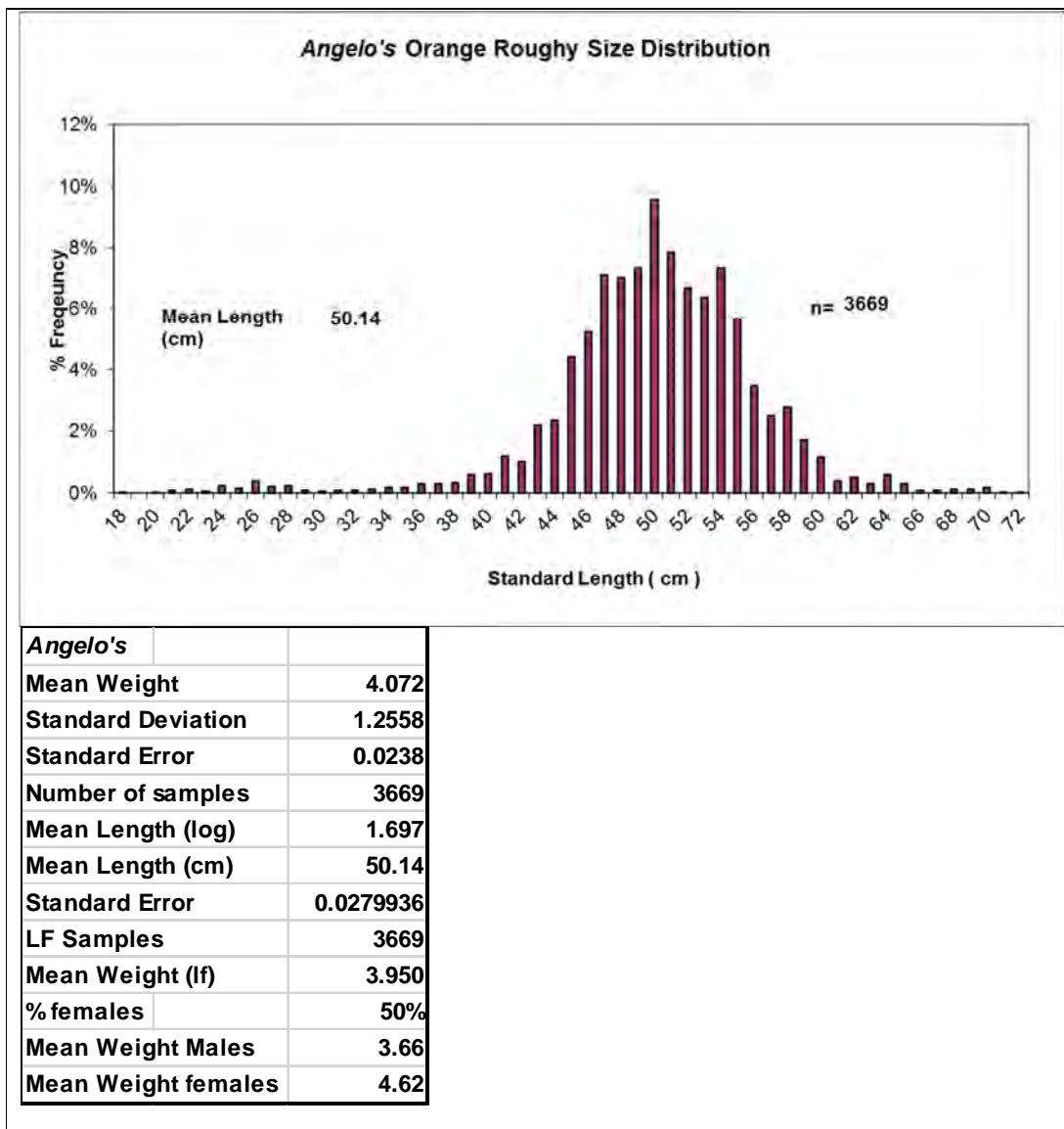
Feature Name	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Haralds	31 18	94 41	Yes	No	Lightly Fished
Rusky	31 24	94 58	Yes	Yes	BPA
Half Way	31 46	94 58	Yes	Yes	Lightly Fished
Graham's	31 51	96 03	Yes	Yes	Lightly Fished

## Species Composition and Orange Roughy Biological Data by Spawning Stock Areas

### NORTH WALTERS

North Walter's has a number of seamounts, knolls and banks, and includes the northern part of the main Walter's Shoal. Only two of the features are known to have orange roughly spawning aggregations, but orange roughly have been detected by trawl shots over most of the region.

### ANGELO'S (Bank)

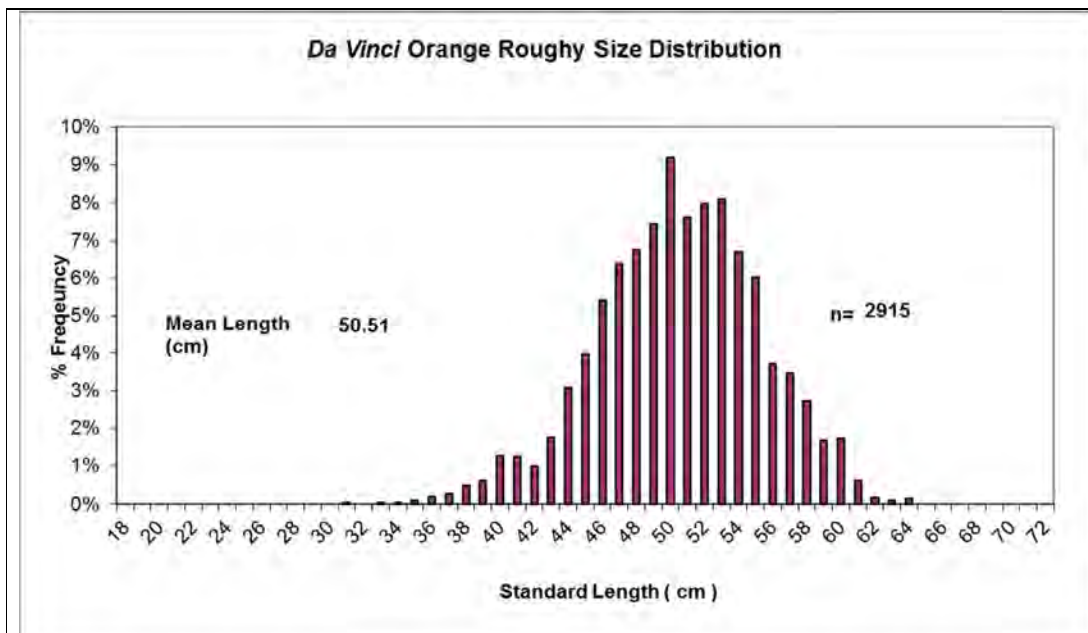


### *Species Composition*

Only orange roughy have been caught in trawls target fishing the acoustic marks observed in this area, and the fishing depth was 1100-1200 m. The 'schools' classification has identified only orange roughy marks.

Species Mix Orange Roughy = 1.0

### **DA VINCI (Seamount)**



<b>Da Vinci</b>	
Mean Weight	4.174
Standard Deviation	1.1401
Standard Error	0.0225
Number of samples	2915
Mean Length (log)	1.701
Mean Length (cm)	50.51
Standard Error	0.0315211
LF Samples	2915
Mean Weight (lf)	4.032
% females	46%
Mean Weight Males	3.63
Mean Weight females	4.82

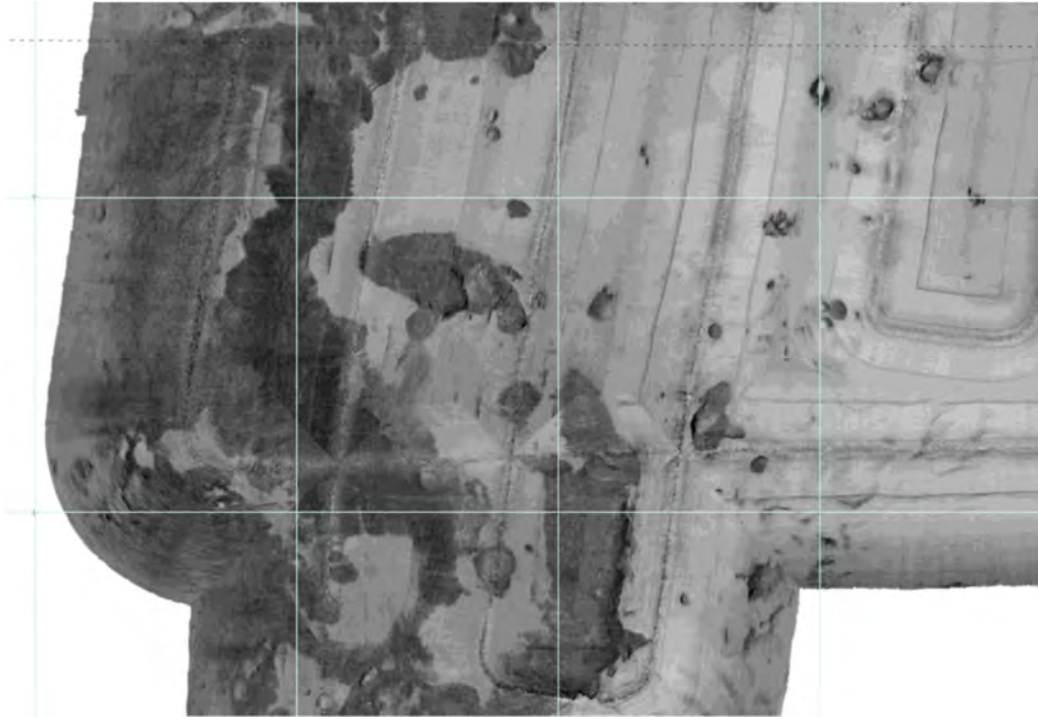
### *Species Composition*

Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area. The 'schools' classification has identified only orange roughy marks.

Species Mix Orange Roughy = 1.0

### **SOUTH WALTERS REGION (WSR)**

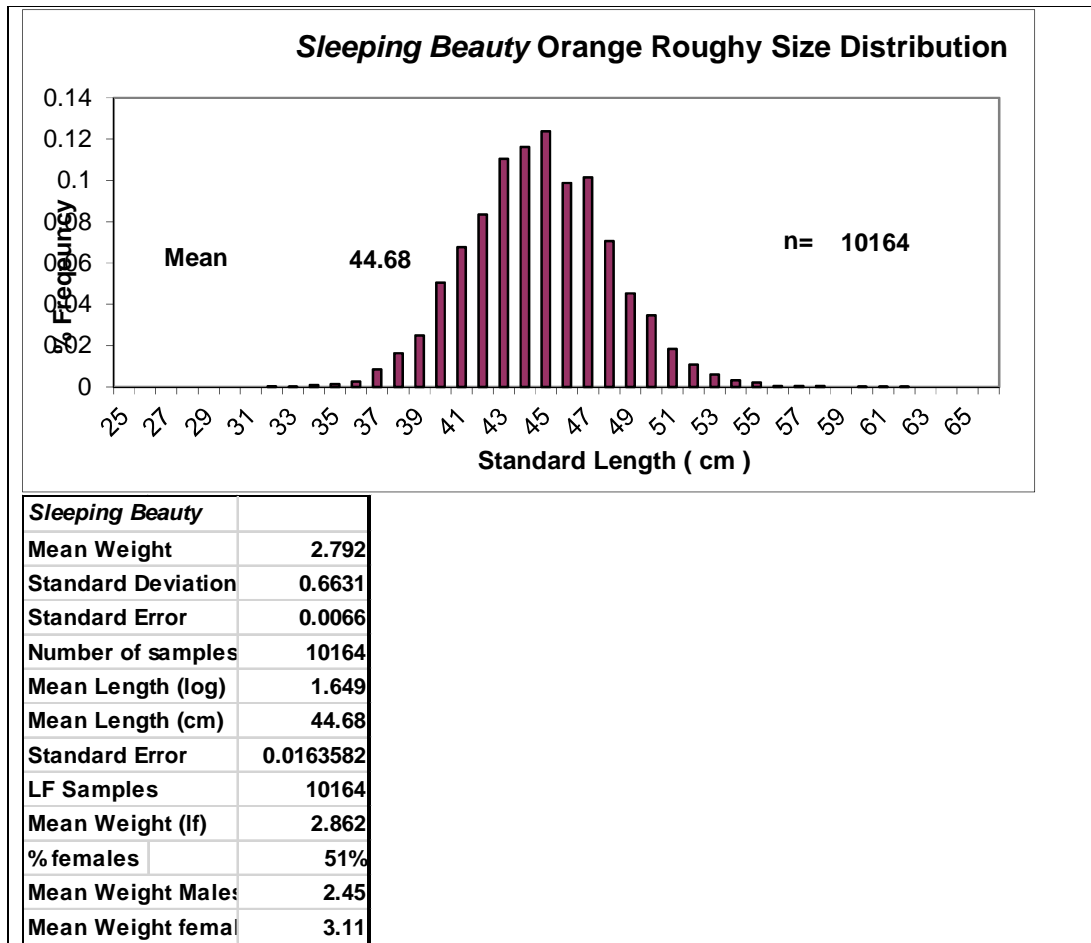
The southwestern side of Walters Shoal is a mix of a base of sand over much of the area, with some knolls, and large areas of slightly elevated rocky banks (Figure 2). A number of spawning aggregations occur in this region, and all spawn concurrently during late June into July. Some of the spawning grounds are 20-30 miles apart, but others are separated by less than 10 miles.



**Figure 2 Sidescan Sonar Imagery of Southeast Walters**

## SLEEPING BEAUTY (Bank) (3444)

Sleeping Beauty is a large area of very rocky habitat covering about 20 square miles, and is located 10 miles away from Sleepy Hollows, separated by 1200 m water depths. The area had very little fishing activity until 2004, and the spawning aggregation has been consistently present since 2004.



### *Species Composition*

Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area. The 'schools' classification has identified only orange roughy marks. In 2014 a multi-frequency AOS survey was carried out to verify species composition and the multi-frequency AOS acoustic information from within the school region routinely indicated a dB difference of 4 dB greater on 120 kHz than 38 kHz.

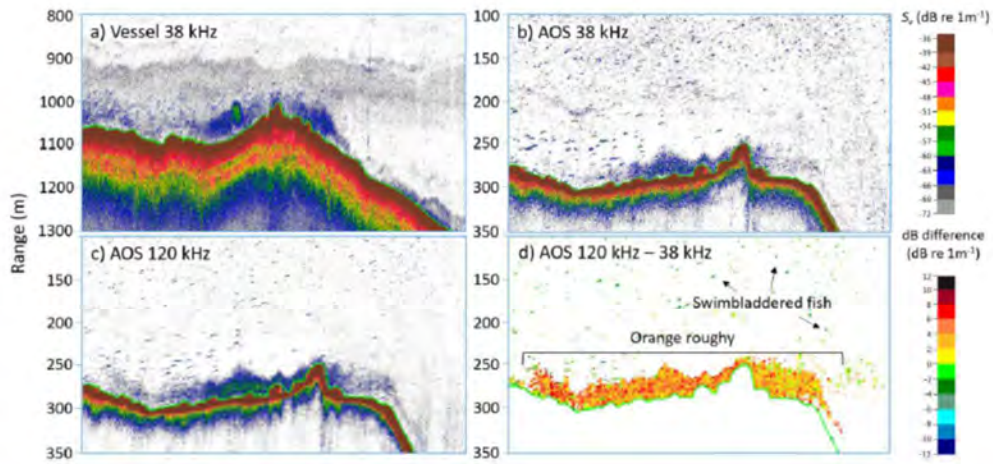
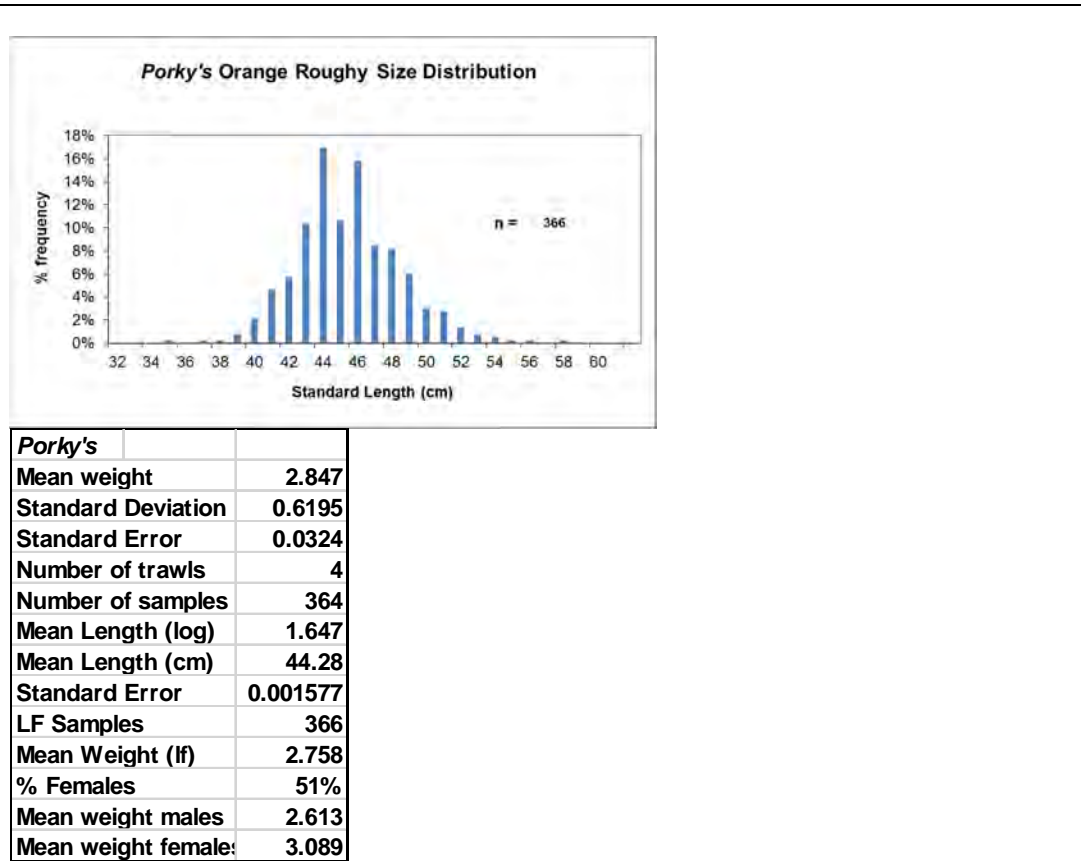


Figure 5.2 Example of two frequency species identification of orange roughy on the sleeping beauty ground at 1050 m depth comparing the a.), vessel mounted data and the net attached Acoustic Optical System (AOS) at 250 m above the seabed for the b.), AOS 38 kHz, c.), AOS 120 kHz and d.), AOS frequency dB difference. The dB difference between frequencies is  $\sim 4$  dB for this school. Note the large scattering single fish in the region that could impact a vessel mounted biomass estimate (Scouling and Kloser, 2018).

Species Mix Orange Roughy = 1.0

### **Porky's (Knoll) (3444)**

This feature situated on Walter's Shoal has an elevated bank and a small cone, and is only 6 miles from Sleeping Beauty. It was heavily fished during 2000-2001, and no aggregations were observed there from 2004-2014. However in 2015 an aggregation was observed and surveyed, with catches of spawning orange roughy taken.



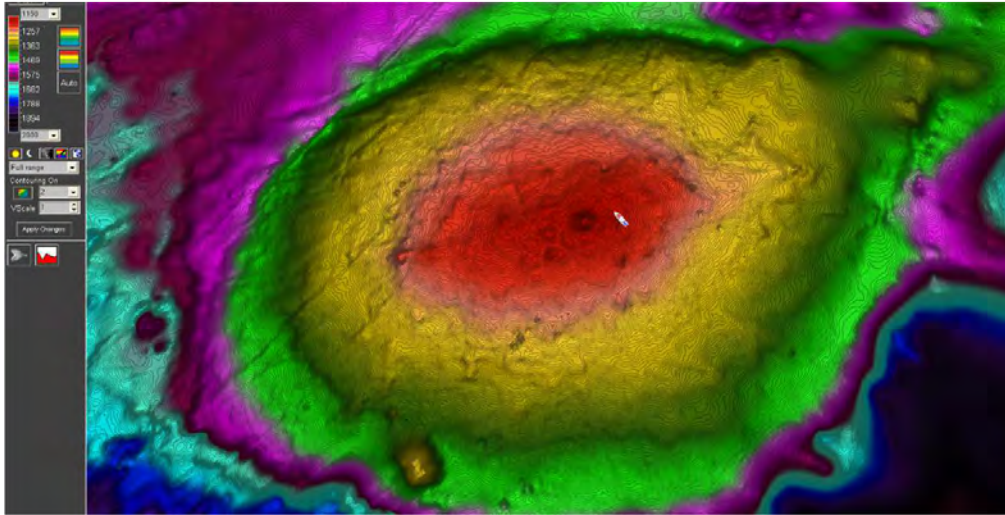
#### *Species Composition*

Only Orange Roughy have been taken in trawls on Porky's.

Species Mix Orange Roughy = 1.0

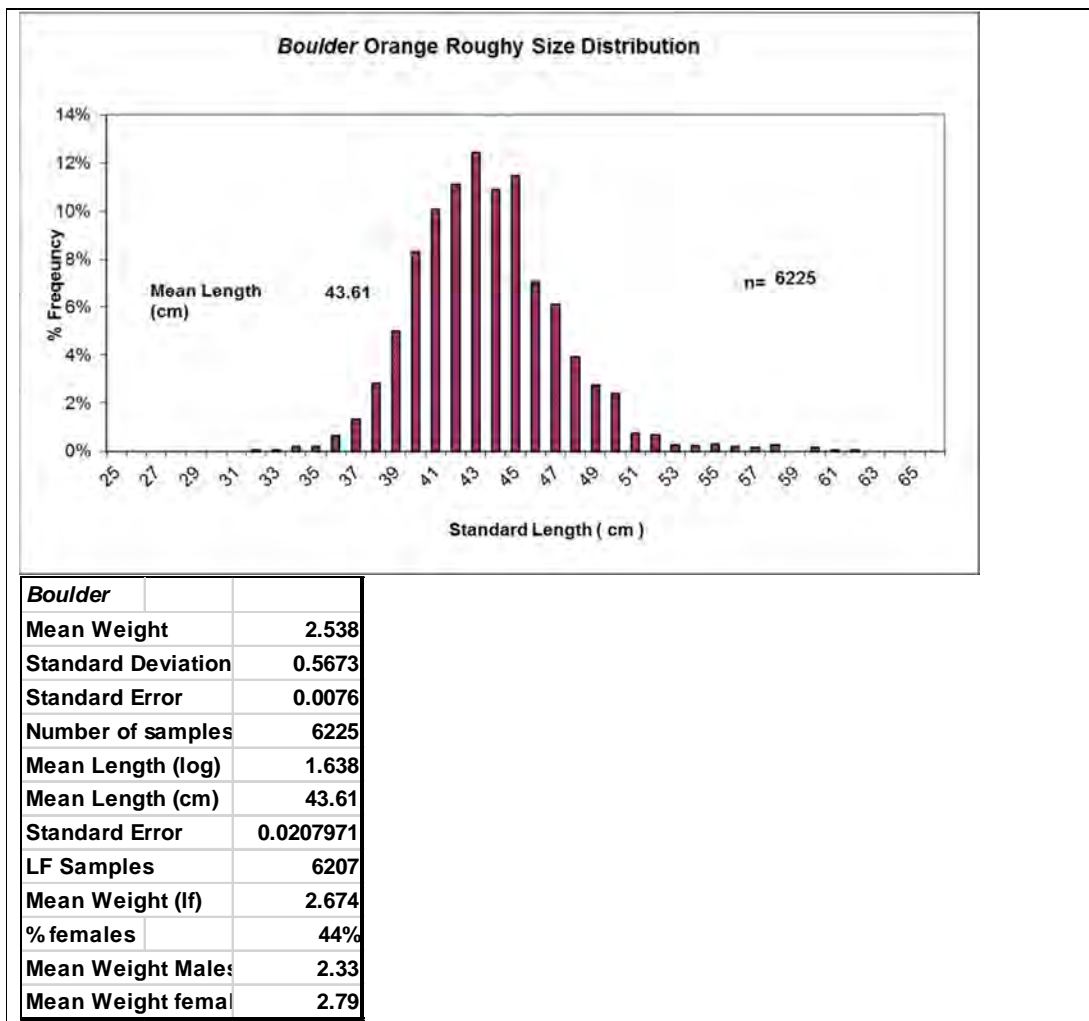
## **BOULDER (Bank) (3444)**

Boulder is a bank rising from 2000 metres, to the south of the main Walter's Shoal and covering about 40 square miles in area (Figure 3). The first recorded fishing activity was in 2004. Because of the very rugged bottom on this bank, there is unlikely to have been any significant catches during the 2000-01 season.



**Figure 3 Bathymetry of Boulder Bank**





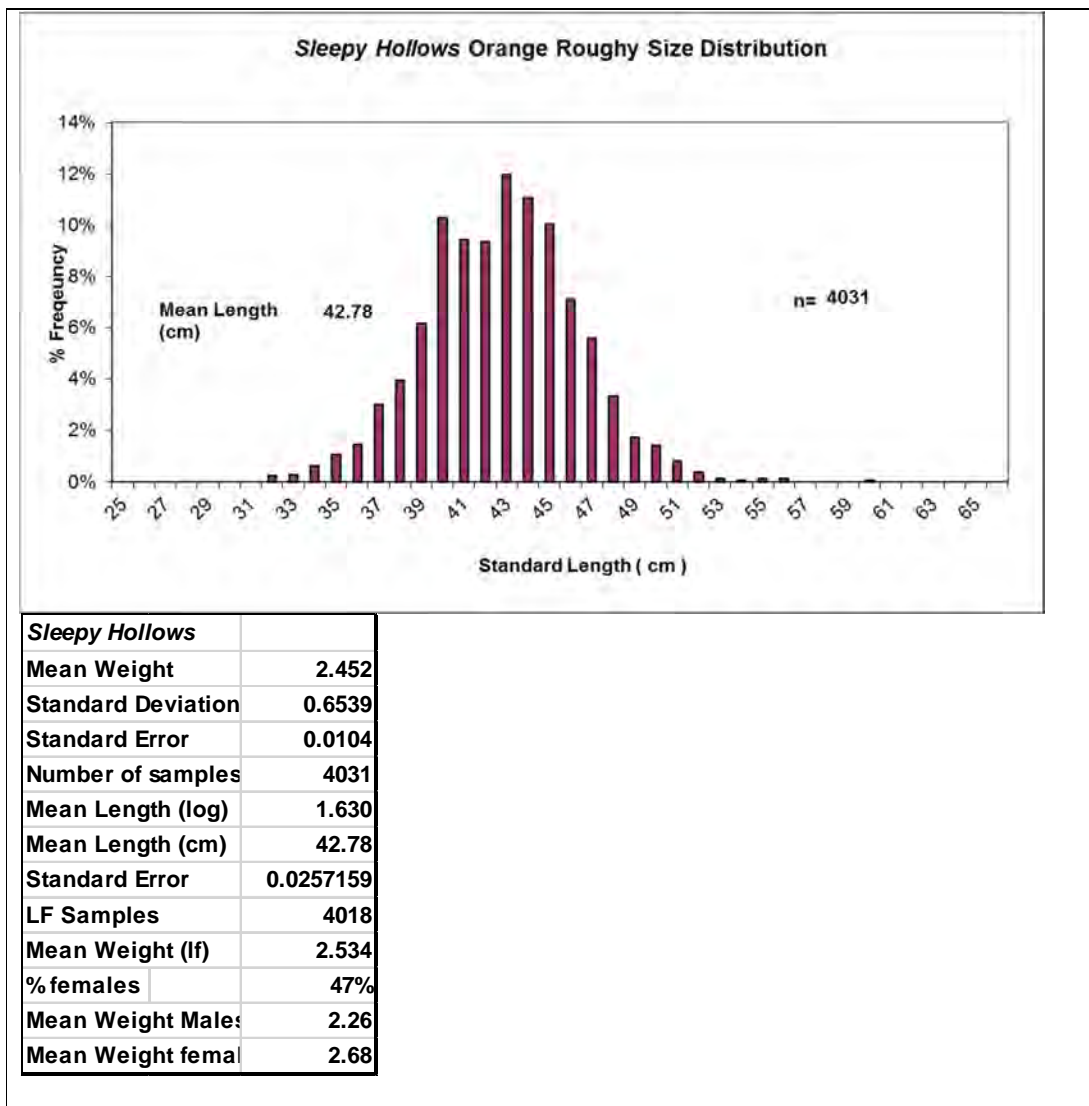
### *Species Composition*

Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area. The 'schools' classification has identified only orange roughy marks. Several multi-frequency AOS surveys confirmed that schools classification. Video footage taken on the bottom during a trawl shot showed small prawn species close to the bottom, but these are unlikely to have had a significant impact on the acoustic assessments. Only orange roughy were observed by the camera, many of these very close to the bottom.

Species Mix Orange Roughy = 1.0

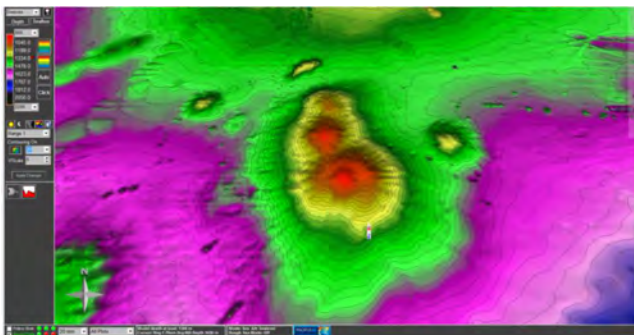
### **SLEEPY HOLLOW**

Sleepy Hollows is a series of cones covering about 6 square miles in area, rising to 990 metres on the shallowest peak (Figure 4). It is part of the southern Walter's Shoal and only separated by 1300 m water depths. Spawning aggregations occur on Sleepy Hollow at the same time as on Boulder and Sleeping Beauty, which are 20 and 15 miles away.



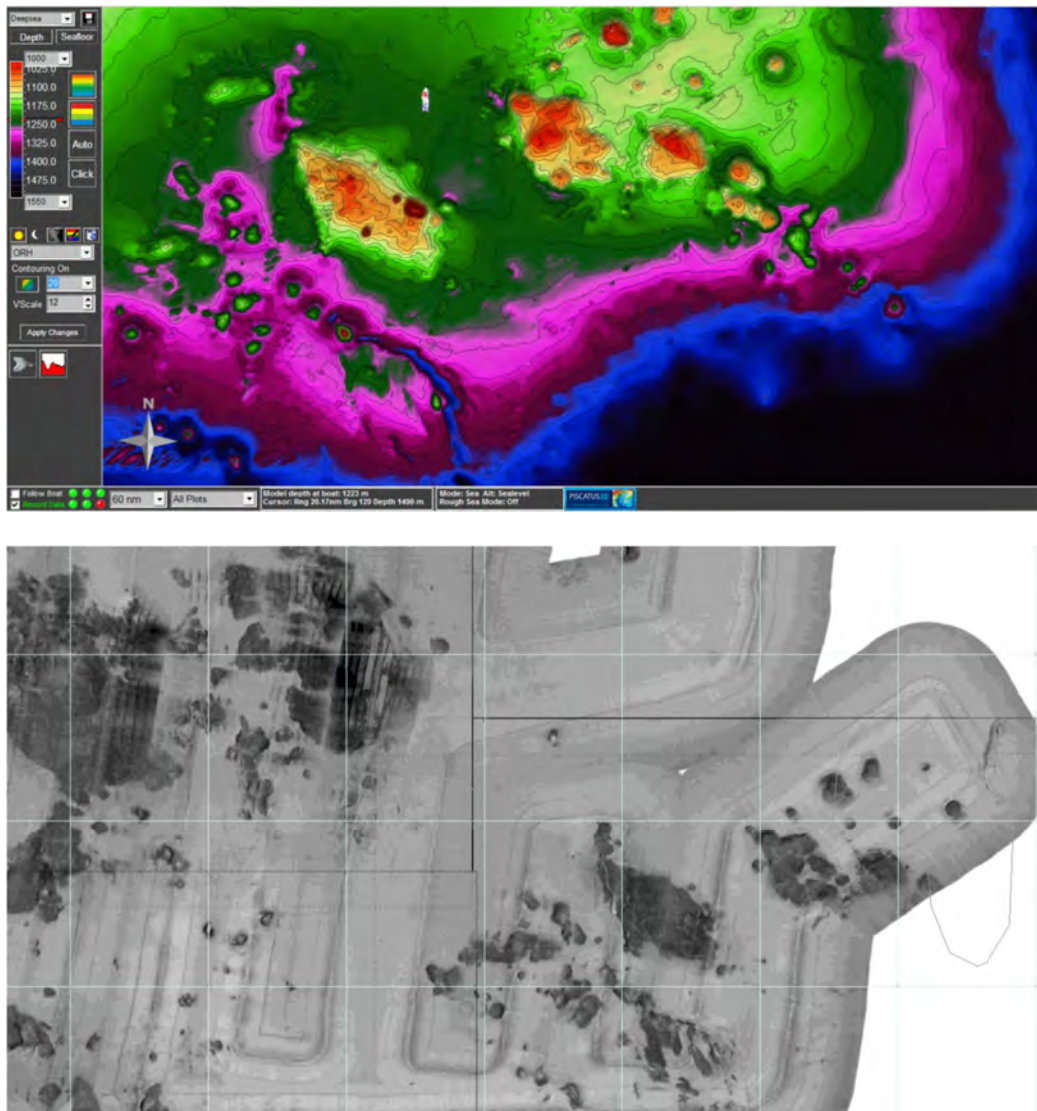
### *Species Composition*

As with all other features in this region only orange roughy were caught in trawls target fishing the acoustic marks observed in this area. The 'schools' classification has identified only orange roughy marks.



**Figure 4 Bathymetry of Sleepy Hollows**

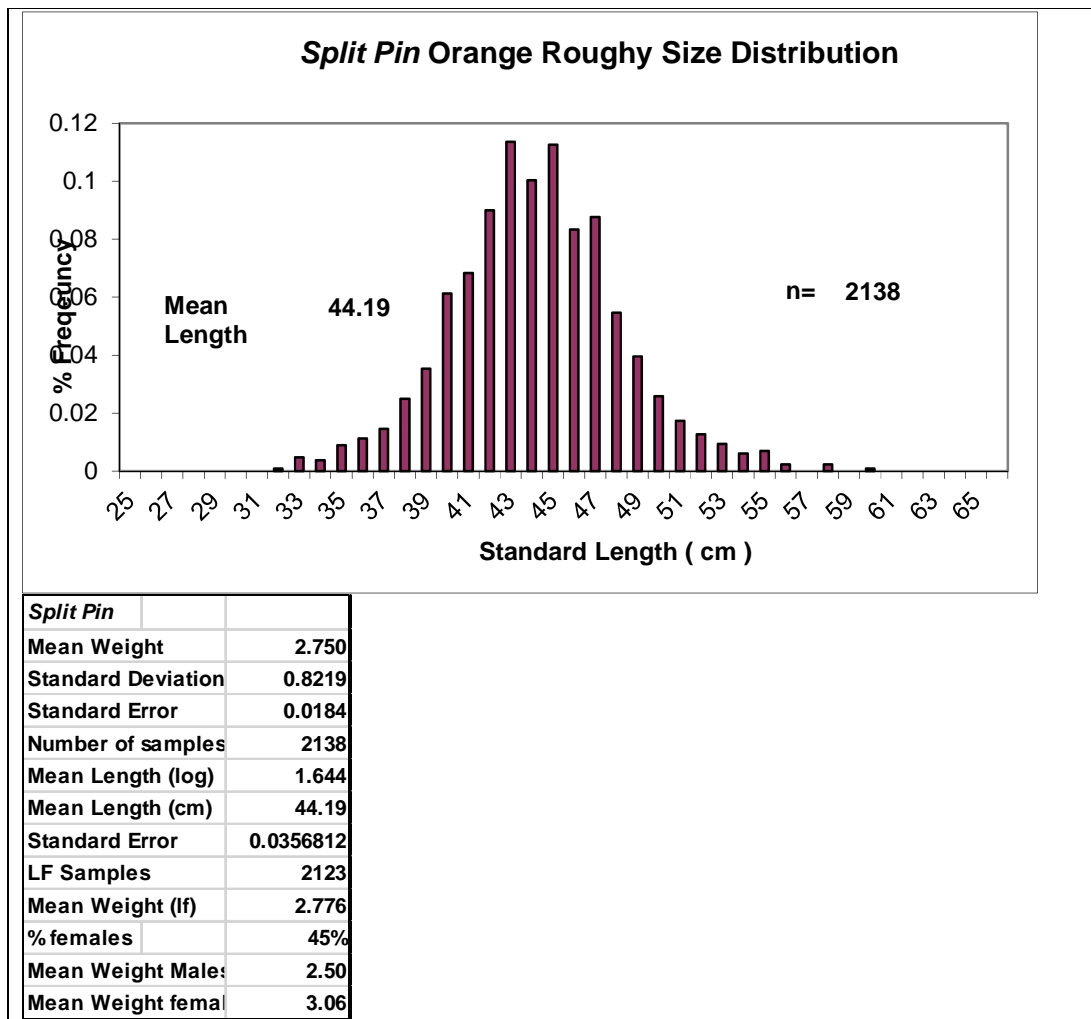
The southeast part of South Walter's contains extensive small knolls and areas of elevated hard rock banks. The area shown in Figure 5 covers 800 square miles of habitat. Sidescan imagery shows the areas of hard rock (dark), in contrast with the sand that covers much of the area.



**Figure 5 Southeast Walter's Shoal bathymetry and sidescan imagery**

### **Split Pin (Knoll) (3444)**

Split Pin is a knoll on the main Walters Bank that has been heavily fished since 2000. One side of the knoll has collapsed into a long ravine that runs past it, and this side cannot be fished. A spawning aggregation occurs here during July.



### *Species Composition*

Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area, and included in the 'schools' classification.

Species Mix Orange Roughy = 1.0

### **HARVEYS (Knoll) (3444)**

An aggregation of fish on this knoll has been surveyed. The knoll is impossible to successfully land trawl nets on to take any significant catch. Only one biological sample has been taken, with the mean gonad stage of 5.9%. The pluming and movement behaviour of the aggregation clearly identified it as an orange roughy aggregation. Outside of the spawning season there were few marks observed on this knoll.

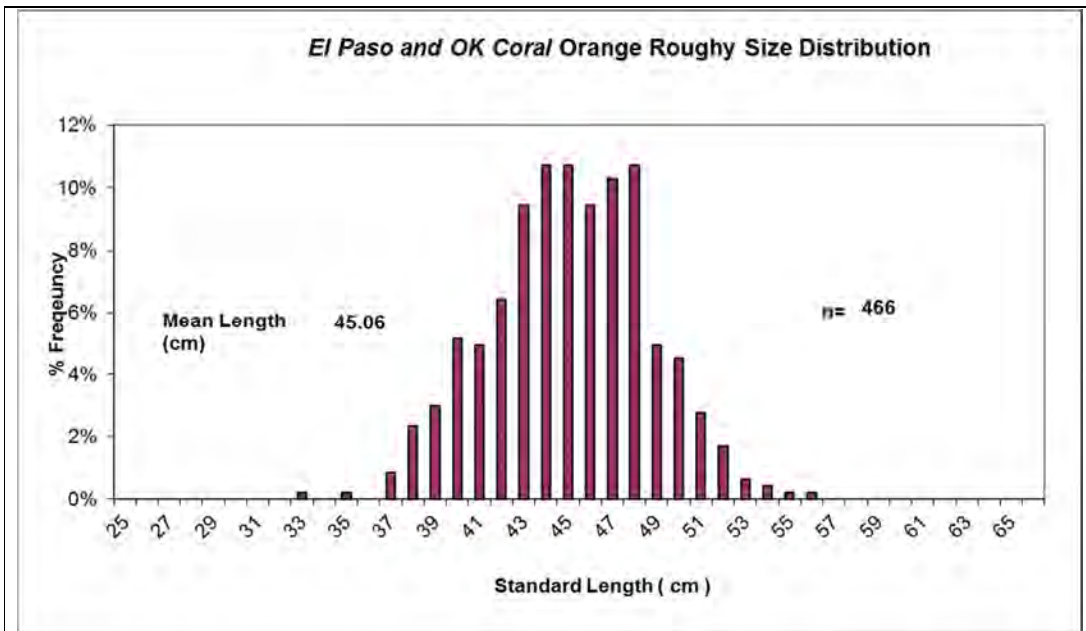
### *Species Composition*

Biological data for acoustic assessment uses *Split Pin* as the closest neighbouring knoll.

Species Mix Orange Roughy = 1.0

**El Paso (Knoll) and OK Coral (Bank)  
(3444)**

El Paso is a knoll on the main Walters Bank. Nearby is a large rocky bank named 'OK Coral' where aggregations of spawning orange roughy were located in 2015. No spawning aggregations have been observed on El Paso, although maturing fish have been caught.



<i>El Paso and OK Coral</i>	
Mean Weight	3.029
Standard Deviation	0.7546
Standard Error	0.0350
Number of samples	466
Mean Length (log)	1.652
Mean Length (cm)	45.06
Standard Error	0.0765637
LF Samples	466
Mean Weight (lf)	2.931
% females	62%
Mean Weight Males	NA
Mean Weight female	NA

*Species Composition*

Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area, and included in the 'schools' classification.

Species Mix Orange Roughy = 1.0

## ABBY ROAD (Knoll) (3444)

Abby Road is the easternmost knoll on the main Walters Bank, and it was heavily fished in 2000-01. Associated with the main knoll is a series of small pinnacles, (Figure 6) where orange roughy form schools during the spawning season. Fish move between the pinnacles and the main knoll.

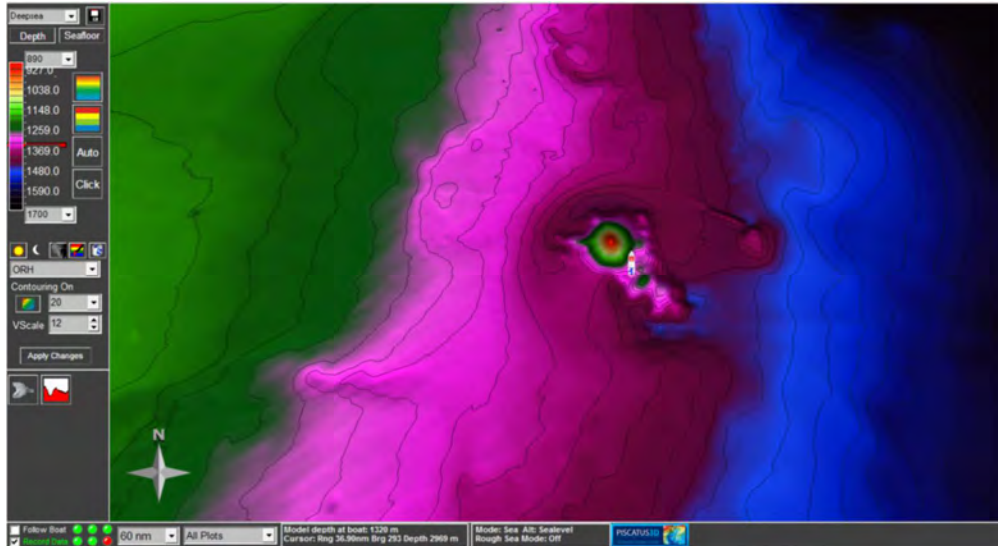
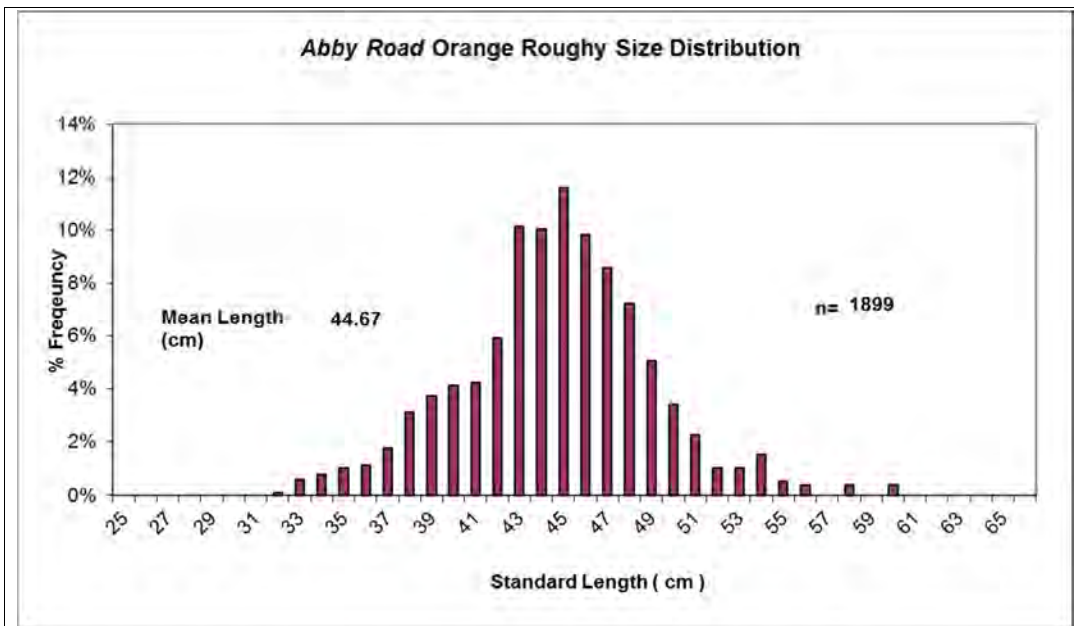


Figure 6 Bathymetry of Abby Road



<b>Abby Road</b>	
Mean Weight	2.809
Standard Deviation	0.7494
Standard Error	0.0172
Number of samples	1899
Mean Length (log)	1.648
Mean Length (cm)	44.67
Standard Error	0.0383990
LF Samples	1843
Mean Weight (lf)	2.860
% females	61%
Mean Weight Males	2.49
Mean Weight females	3.02

### *Species Composition*

Primarily only orange roughy has been caught in trawls in this whole area, and a trawl shot on the pinnacles in 2010 caught 2 tonnes of spawning orange roughy. The 'schools' classification has included only orange roughy marks.

Species Mix Orange Roughy = 1.0

## Walter's Seamounts

### SMURFS (Seamount)

Smurfs is a large seamount (400 square miles in area), south off the main Walters Shoal with 2000 metres depth of water between them. It shoals to 494 metres (Figure 7)

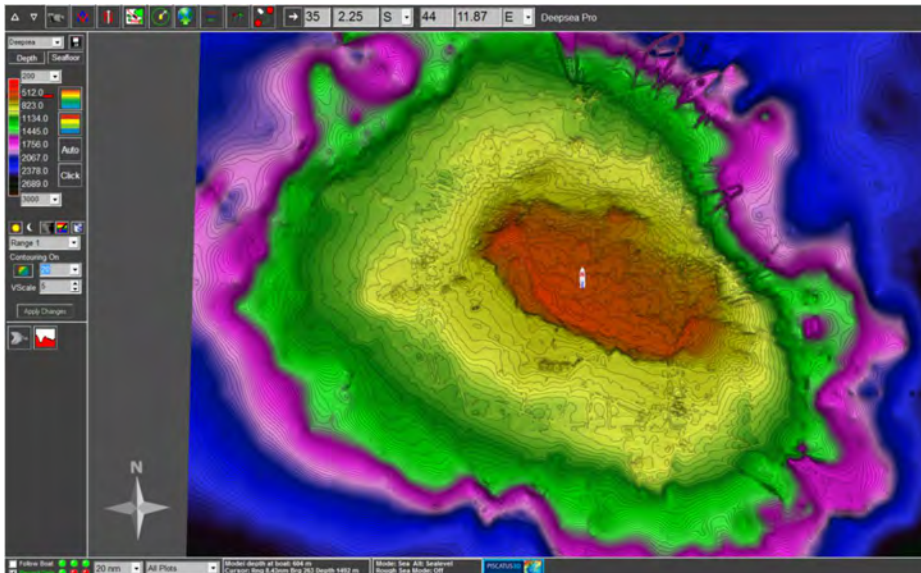
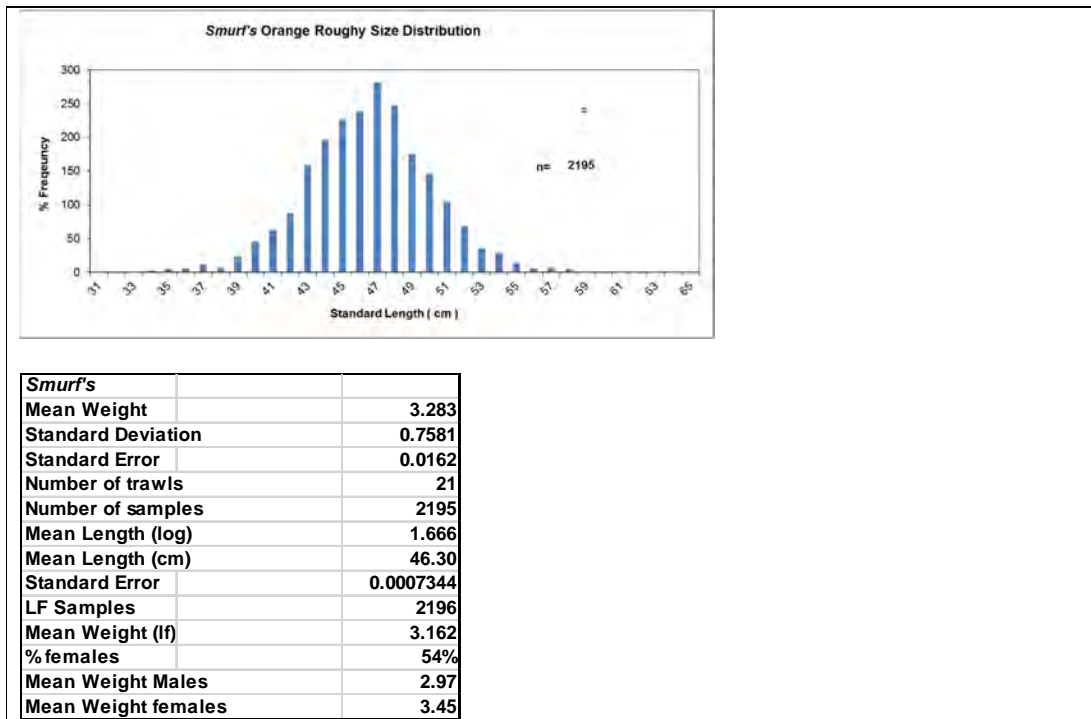


Figure 7 Bathymetry of Smurfs



### Species Composition



On this large seamount there is a mixed species distribution, including cardinal fish and orange roughly. However in schools detection all cardinal marks were removed.

Species Mix Orange Roughy = 1.0

### NOVEL (Seamount)

Novel is a large seamount (150 square miles in area) (Figure 8) extending off the main Walters Shoal with 2000 metres depth of water between them. It has a number of cones on top.

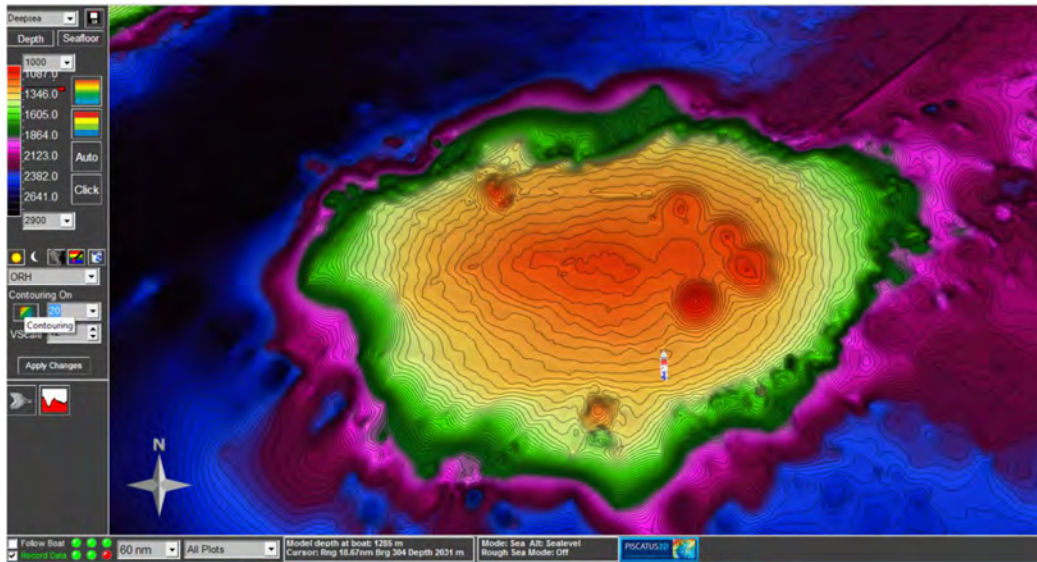
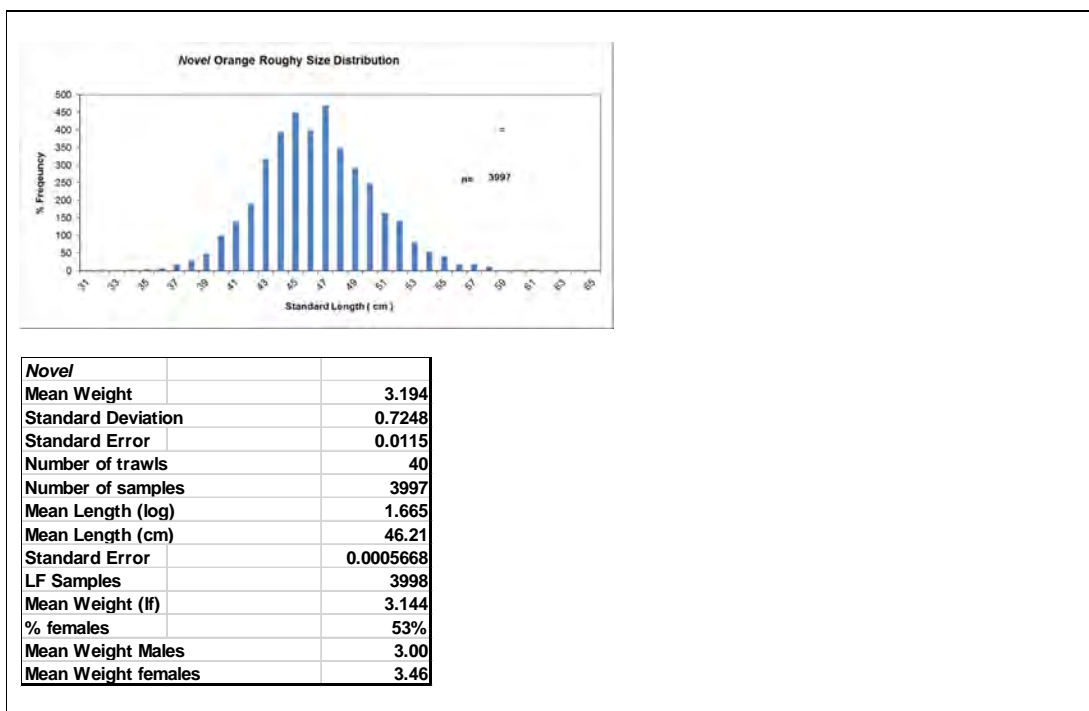


Figure 8 Bathymetry of Novel



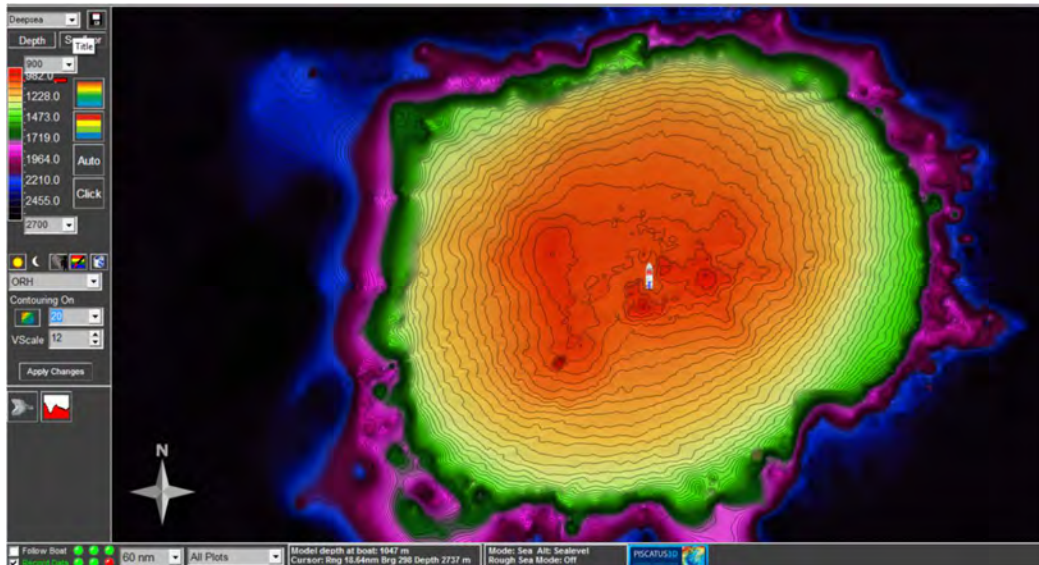
### *Species Composition*

This seamount is over 100 sq miles in area, with several hills on top. Cardinal fish are present, but highly localised. Only orange roughy were caught in trawls target fishing the acoustic marks observed in this area, and included in the 'schools' classification.

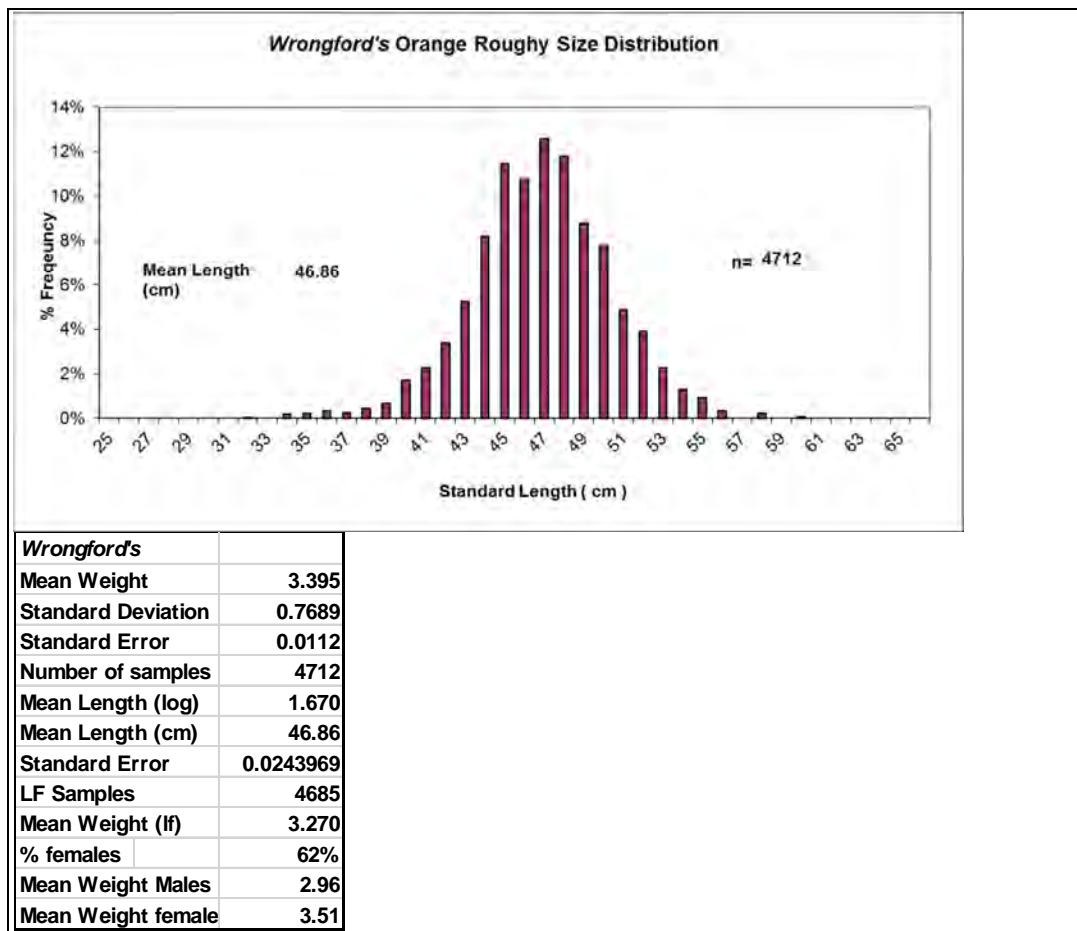
Species Mix Orange Roughy = 1.0

### **WRONGFORD'S (Seamount)**

Wrongford's is a seamount of about 400 square miles in area, rising out of 3000 m depths surrounding it (Figure 9). There are a number of cones and rocky areas on the top.



**Figure 9 Bathymetry of Wrongford's**



### *Species Composition*

On this large seamount there is a mixed species distribution, including cardinal fish and orange roughy. However in schools detection all cardinal marks were removed.

### **GROVER (Seamount)**

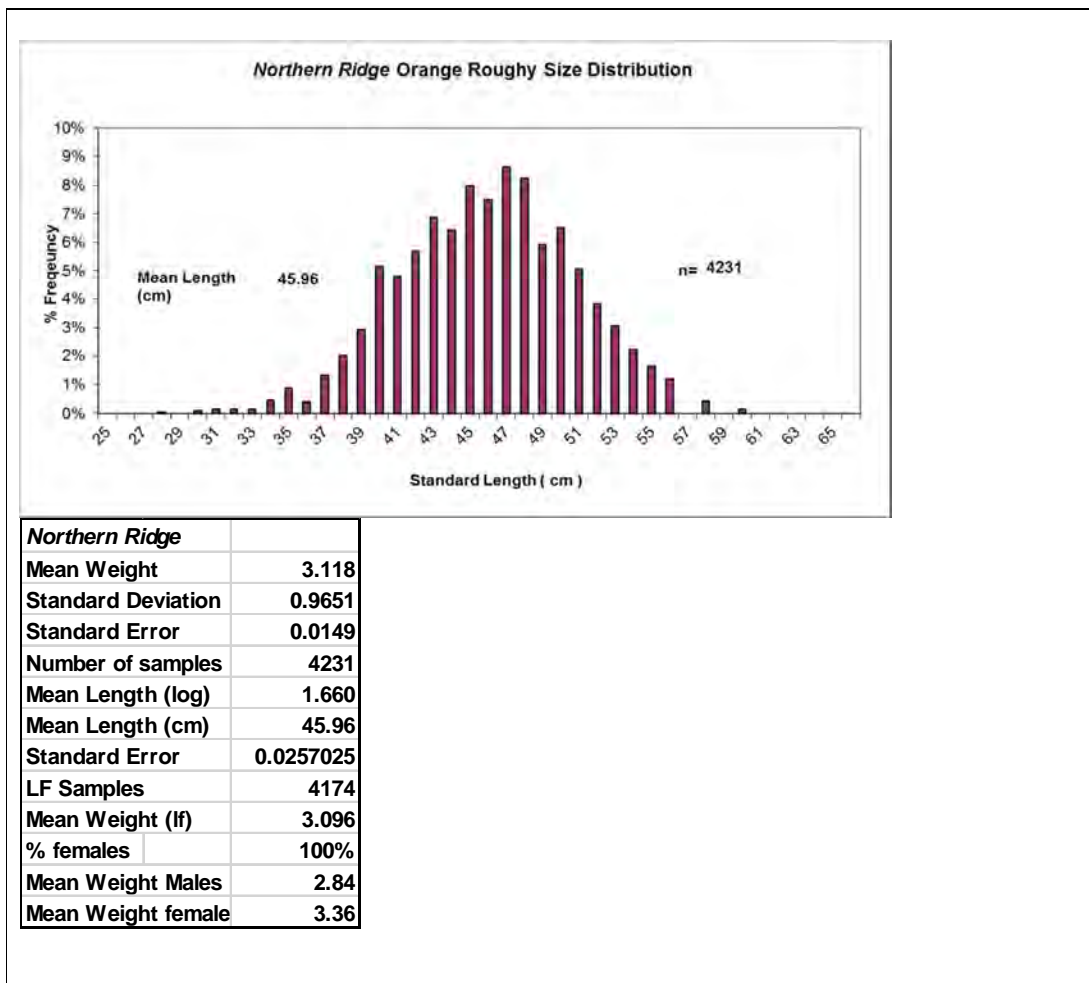
An acoustic survey was carried out on this small seamount in 2008, and 2010. Although it was not fished, a classic orange roughy spawning plume was measured. A trawl shot on this aggregation in 2009 caught only orange roughy, but the trawl became fast on the bottom at the start of the trawl. Further attempts to land the trawl on this feature have been unsuccessful.

For acoustic assessment purposes, data from Smurf's were used for size distribution and weight.

## SOUTHWEST INDIAN RIDGE

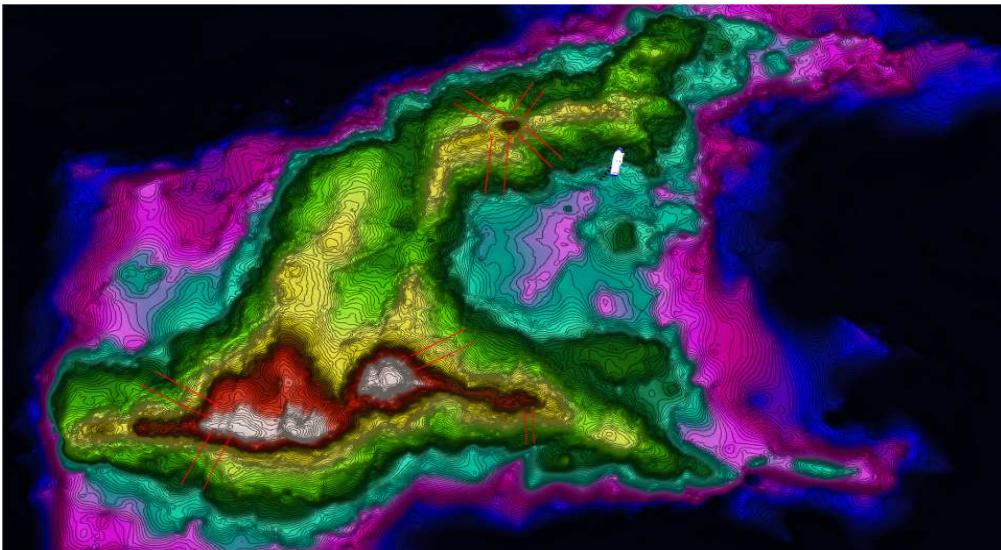
The region has a series of ridges that run southwest, extending over 1000 miles. Two main ridges run either side of the plate spreading centre, which is over 6000 meters in depth. Accessory ridges are to the east and west of these main ridges. In addition there are a number of classical seamounts, some on the ridges and in some areas they are solitary. The most well known of these is Atlantis Bank, which was closed to fishing by SIODFA members in 2006. While most aggregations which form on the ridges have had some fishing activity over the past 17 years, some areas cannot be fished because of the bottom habitat which makes it impossible to land a trawl net successfully and retrieve it. Notable for this is the area known as Bill & Ben.

## NORTHERN RIDGE



## ERICS (Seamount)

This large seamount (Figure 10) is where the deepwater fishery commenced in 1999. Significant catches were taken in 1999, but there has only been intermittent fishing activity since that time. This is because the habitat is complex, the fish highly mobile, and very little of the habitat is fishable. Only when orange roughy are present on the trawl corridors, can they be caught.



**Figure 10 Bathymetry of Eric's**

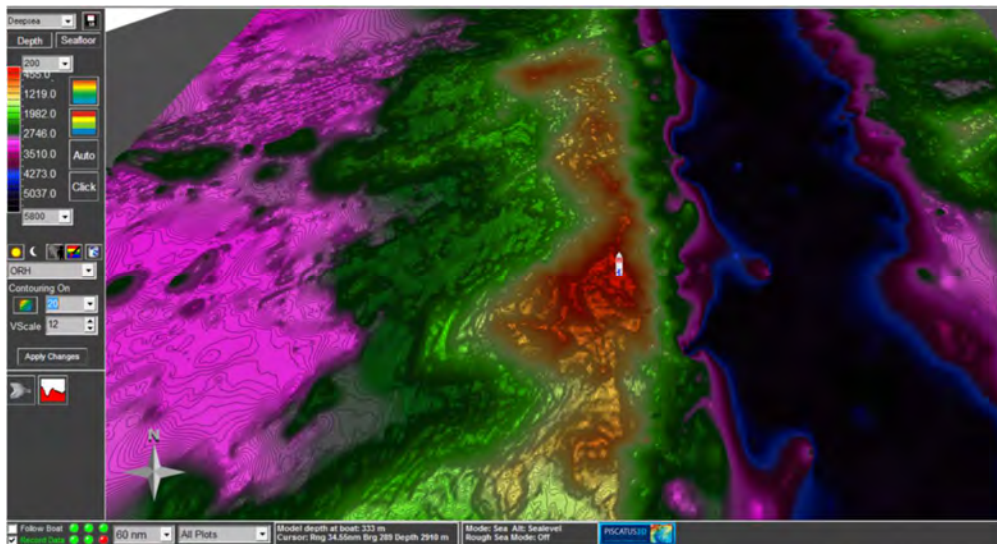
### *Species Composition*

This seamount has a complex species composition. Small black oreo occur on the top of the seamount, and can be caught if the gear is landed on the bottom too close to the top. Although these occur in all trawl shots made during the survey time, and they make up 30% of the catch by weight, in the acoustic schools identification all these marks were excluded. However to allow for a proportion of oreo marks to still be included, 5% bycatch of Black Oreo Dory of mean size 24 cm TL has been allocated in species composition. Unfortunately no size data are available for this feature.

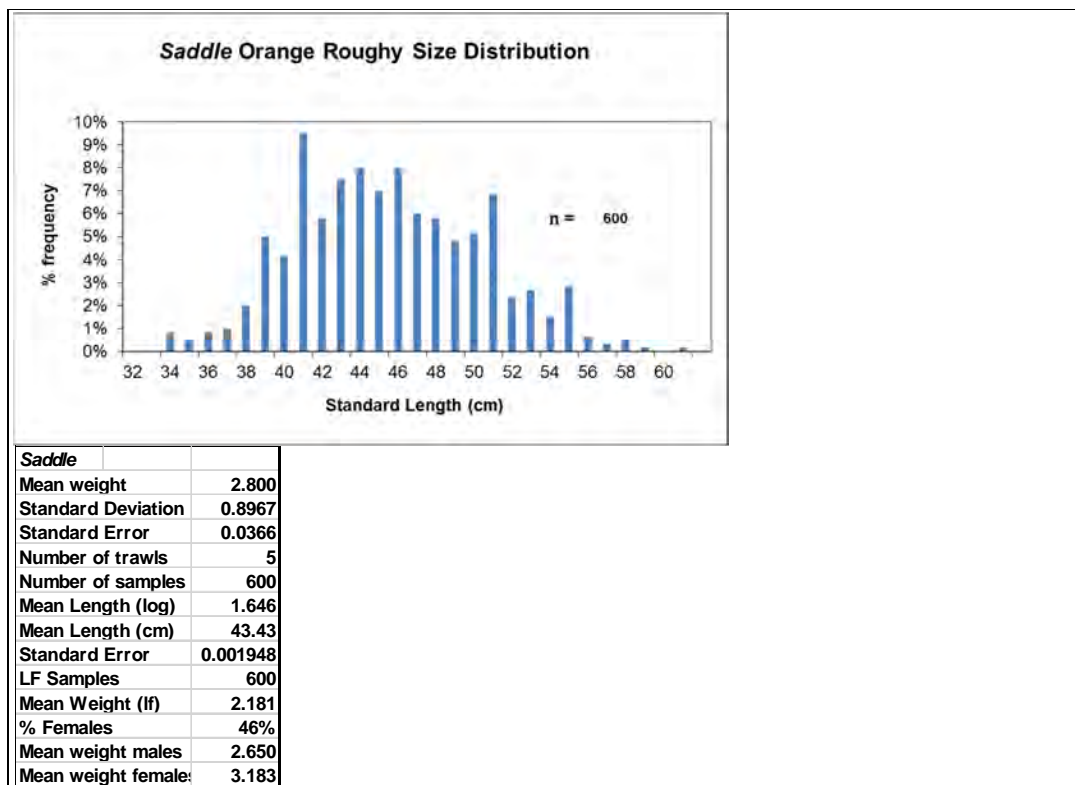
Species Mix    Orange roughy = 0.95  
                   Black Oreo     = 0.05

### **SADDLE (Ridge)**

Saddle is part of an extensive ridge system over 30 miles long (Figure 11) on the western side of the plate spreading centre, and is where much of the fleet fished in 1999 and 2000. Substantial catches of orange roughy, probably in excess of 10,000 tonnes were taken from this ridge system. Maturity data collected from 2008-2012 indicate that spawning occurs in this area during late July. The ridge includes other likely spawning aggregations known as Rodrigo's, Greedy's, and Paradise.



**Figure 11 Bathymetry of the Saddle Region**



**LEO’S (Ridge)**

Leo’s is a long ridge on the eastern side of the deep spreading centre. It is surrounded on all sides by 3000-5000 m water depths and is about 240 square miles in area (Figure 12). Spawning aggregations have been located on the largest structure on Leo’s, but also on pinnacles that are included as part of the seamount. It is also the site of an alfonsino fishery.

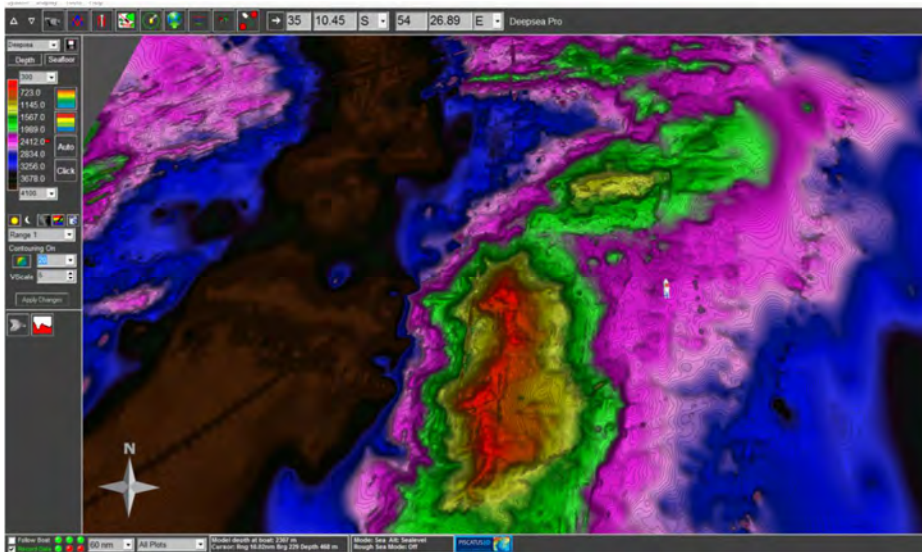
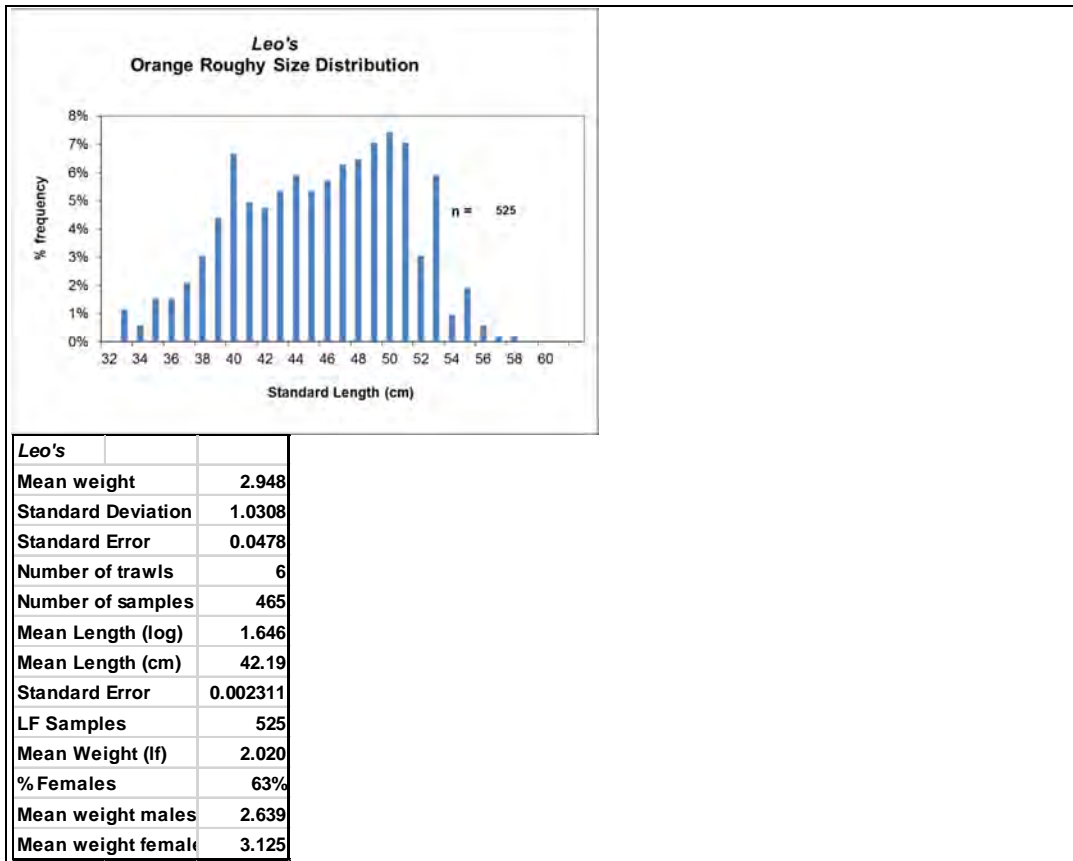


Figure 12 Bathymetry of Leo's



## MIDDLE RIDGE

### SCUD (Seamount)

Scud is one seamount on a long ridge that has a number of peaks. The region covered is about 160 square miles in area (Figure 13).

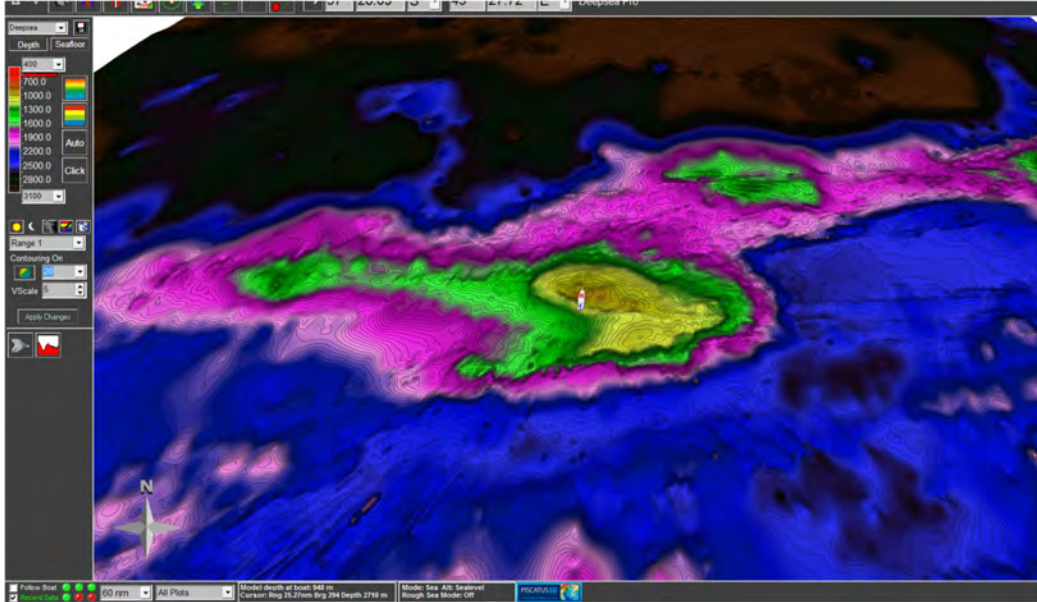
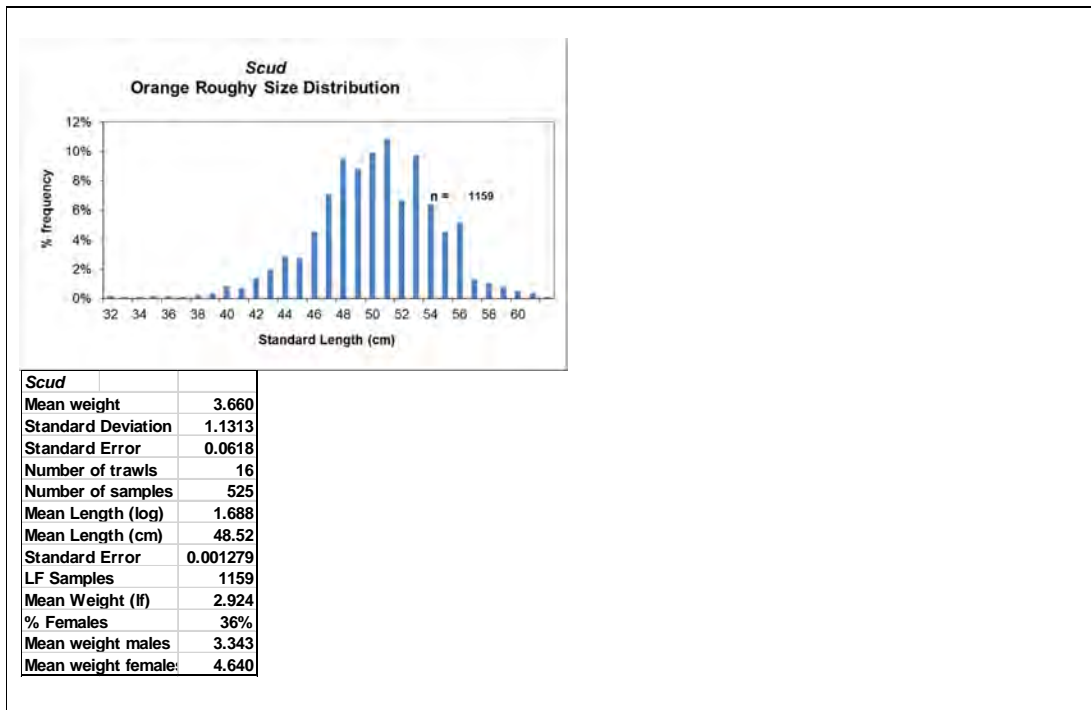


Figure 13 Bathymetry of Scud





### *Species Composition*

This seamount has a complex species composition, as it shoals to under 600 m in places, and midwater species are abundant. The total catch in tonnes by species during the period of surveying in 2005 is shown below.

However much of the SOR catch came during low catches of orange roughy, when different marks were targeted for species composition. This effectively overestimates the proportion of other species. Also on several of these tows, the trawl became fast.

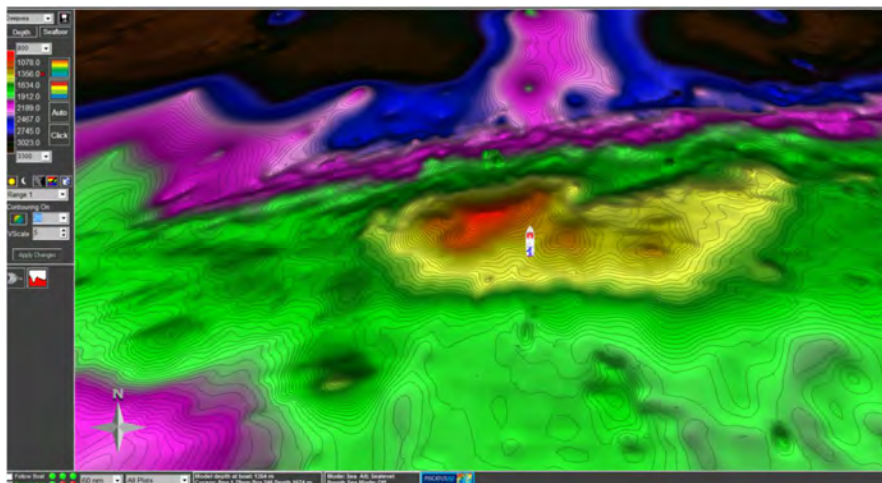
Date	27- Jul	27- Jul	27- Jul	28- Jul	28- Jul	28- Jul	28- Jul	29- Jul	29- Jul	29- Jul	29- Jul
Orange Roughy	12	4	0.5	7	25	4		50	40		2
Black Oreo				2			1			3	2
Smooth Oreo											0.5
Cardinal fish	5	15									

However to allow for a proportion of oreo marks to still be included in the acoustic classification, 5% bycatch of Black Oreo Dory of mean size 24 cm TL has been allocated in species composition. Cardinal fish were in shallower depths and thus excluded from the 'schools' classification.

Species Mix    Orange roughy = 0.95  
                   Black Oreo     = 0.05

### **HARLOT (Seamount) (3749)**

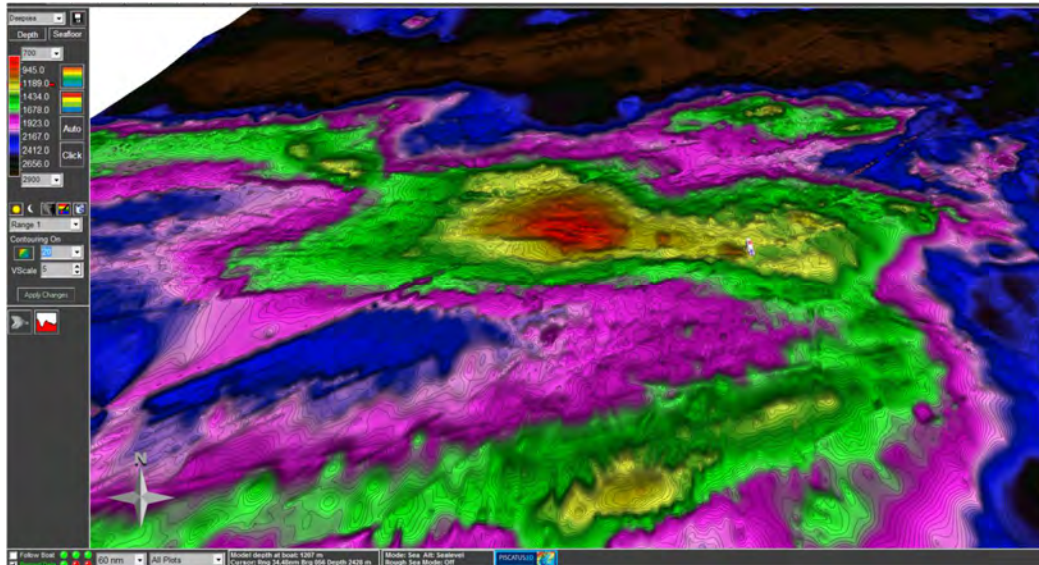
This seamount of about 30 square miles in area (Figure 14) has very steep sides, which are difficult to deploy a bottom trawl on, and limited catches have been made, although significant fish marks have been observed. For biological data, Scud is the nearest similar seamount and is further along the ridge.



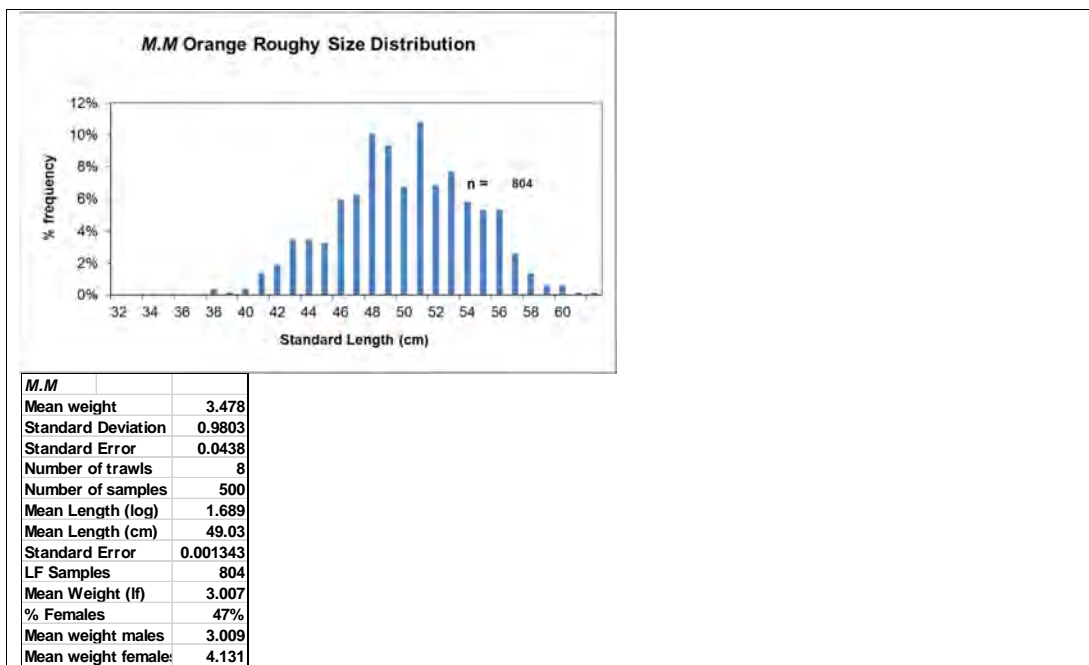
**Figure 14 Bathymetry of Harlot**

## M.M (Pinnacles) (3749)

M.M is a pinnacle with very steep sides that is part of a large structure which covers about 250 square miles in area (Figure 15). Also on this structure is Kettle which is the site for an alfonsino fishery, but also has had an orange roughy spawning stock located there. M.M is very difficult to fish on.



**Figure 15 Bathymetry of Kettle and M.M**



### *Species Composition*

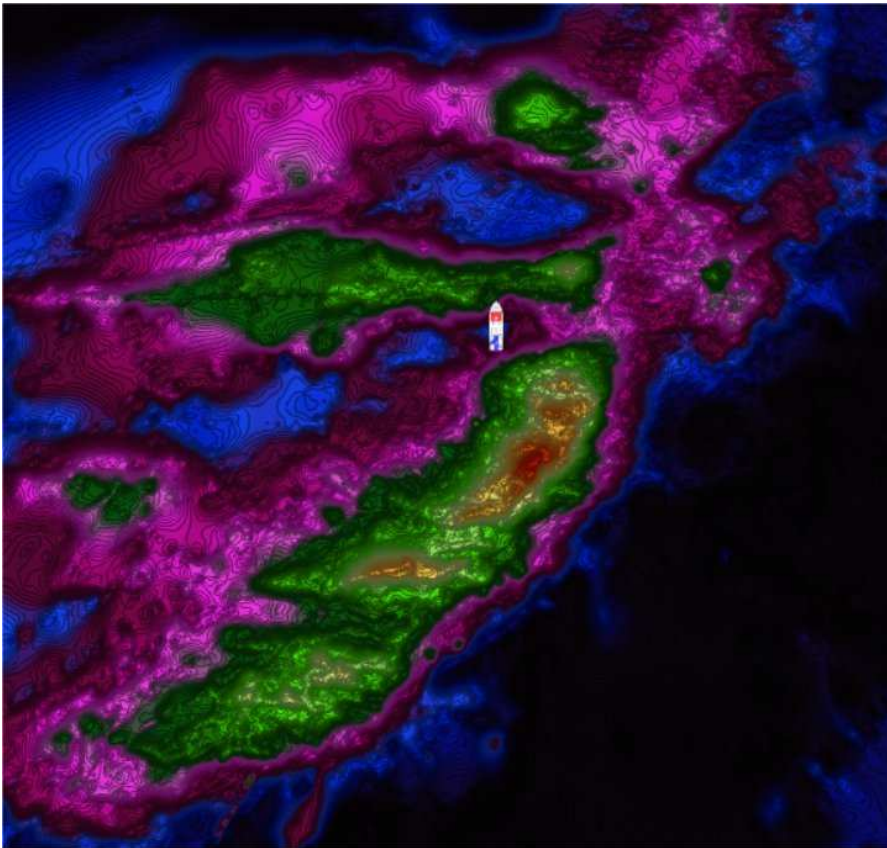
Only orange roughy was caught in trawls in this area at the time of the survey in both years. When orange roughy left the area, and no more were caught, Black oreo

aggregations moved into the area and were caught. The 'schools' classification has identified only orange roughy marks.

Species Mix Orange roughy = 1.0

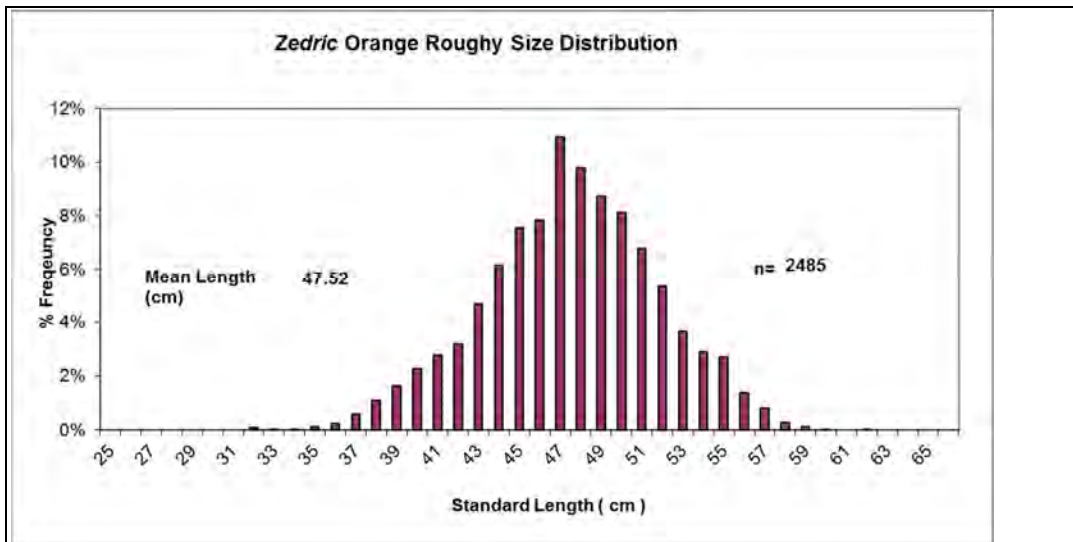
### **FREDRICK'S (Ridge)**

This is a part of a large ridge complex, covering an area 30 nautical miles by 20 nm (Figure 16), and some areas were heavily fished during 2000-2001.



**Figure 16 Zedric to Robb's Bathymetry**

Over recent years a number of spawning aggregations have been surveyed in this area, which includes Zedric and Robb's.



<b>Zedric</b>	
Mean Weight	3.316
Standard Deviation	0.8259
Standard Error	0.0166
Number of samples	2485
Mean Length (log)	1.675
Mean Length (cm)	47.52
Standard Error	0.0336331
LF Samples	2482
Mean Weight (lf)	3.401
% females	45%
Mean Weight Males	2.95
Mean Weight female	3.77

## SUGAROL (Seamount) and TONGA (Seamount)

These two features rising to about 500m are 12 nm apart on the same ridge system on the Southwest Indian Ridge (Figure 17). They provided major fisheries in 2000-2001, but have been rarely fished since then with catches of up to 100-200 tonnes some years. Orange roughy are only available for a few days each season on these grounds during the spawning season.

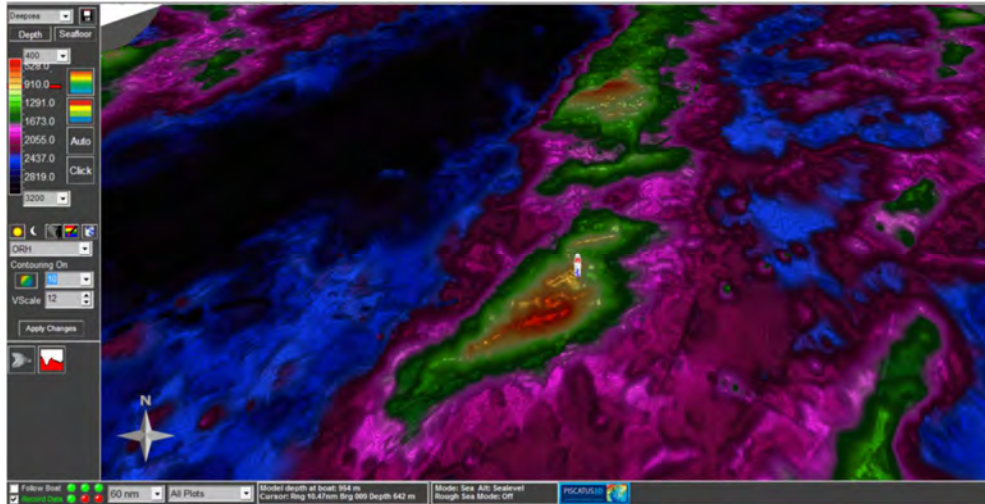
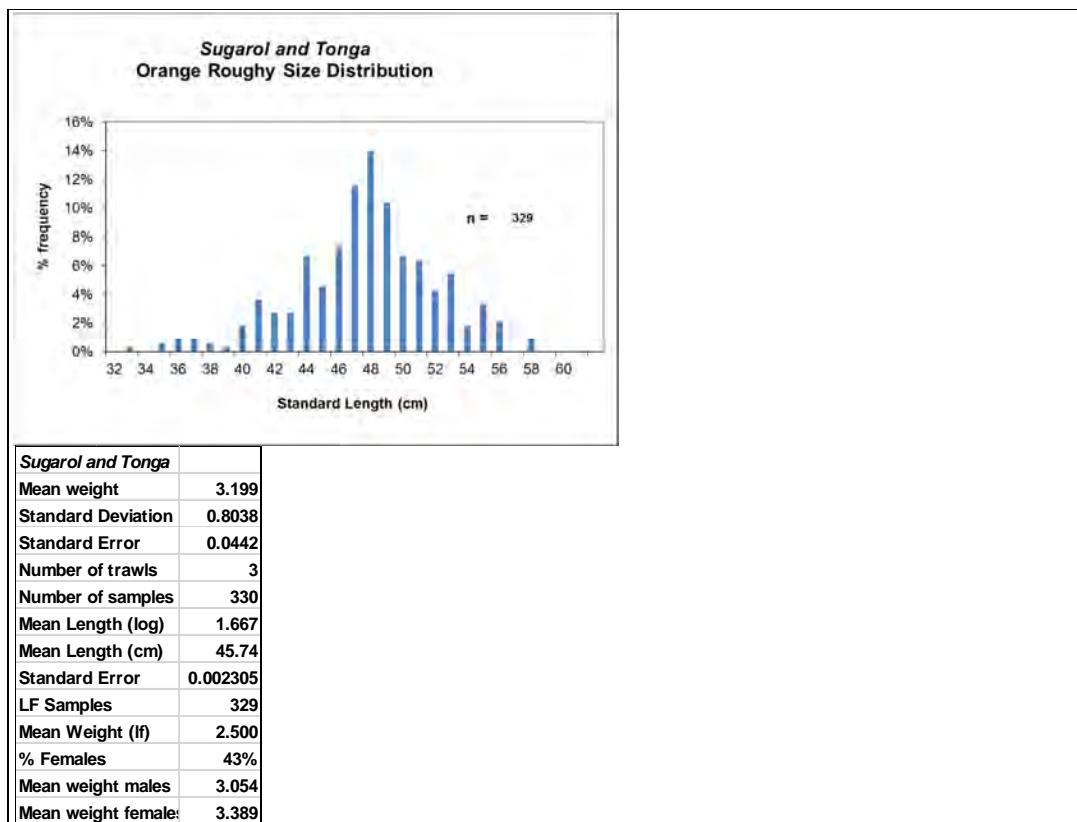


Figure 17 Bathymetry of Sugarol and Tonga



## SOUTH RIDGE

### DAVIDS (Ridge)

David's is part of a large ridge over 30 miles long which shoals to under 600 m (Figure 18). The western side drops into 4000 metres of water in one of the spreading centre trenches in the region.

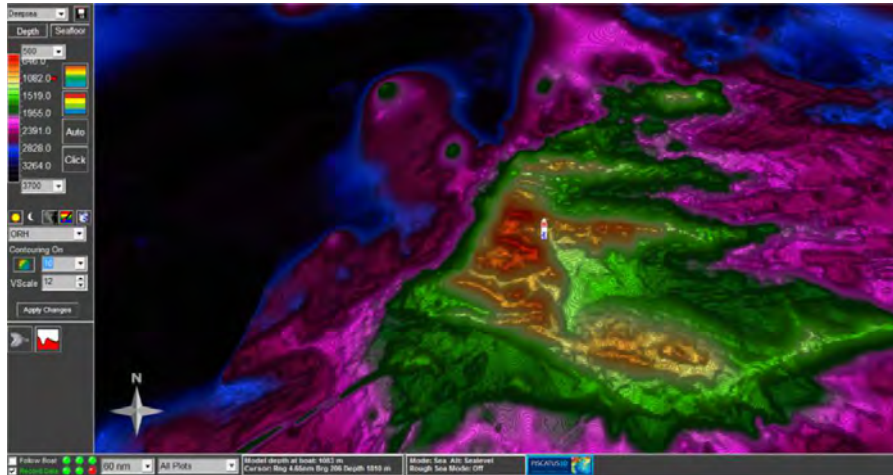
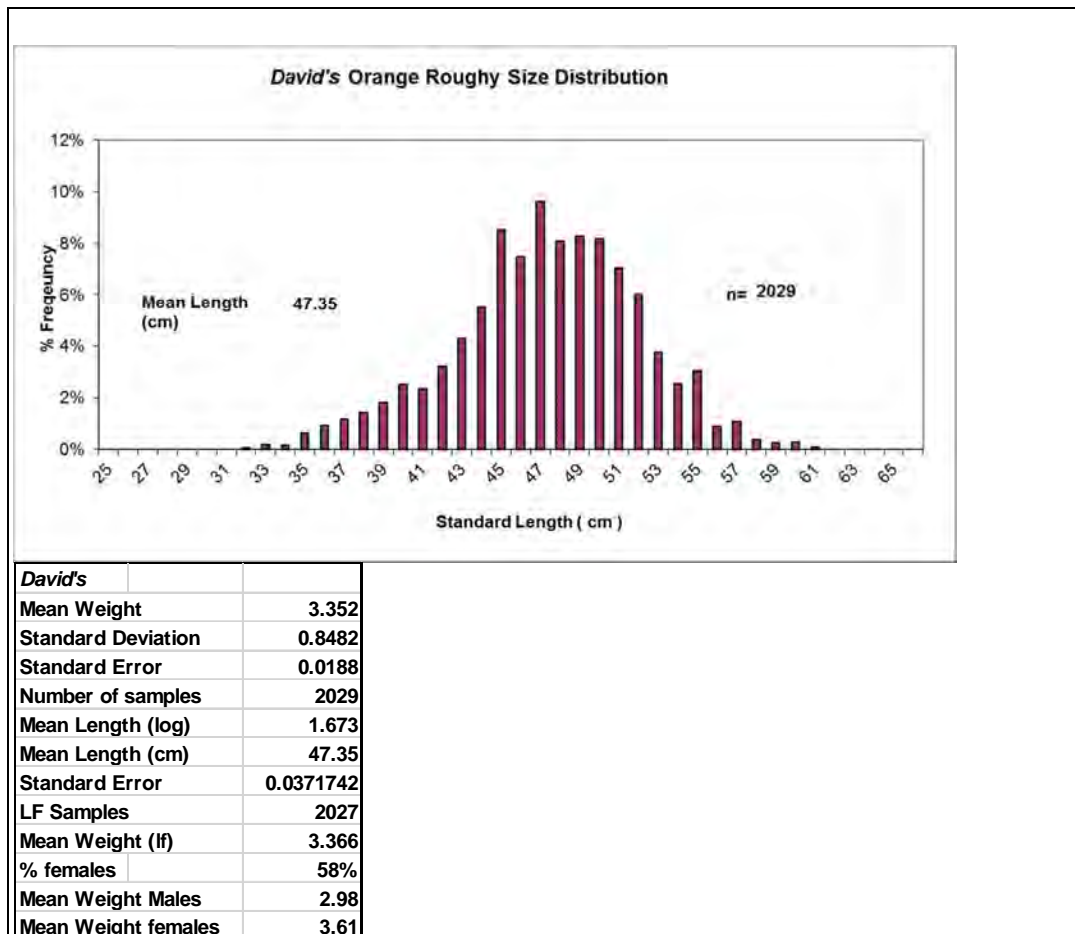
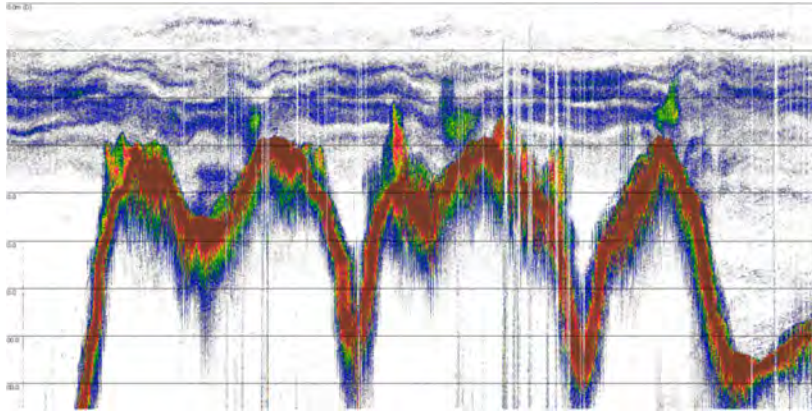


Figure 18 Bathymetry of David's



This large feature has a complex species composition which changes over time as fish move around the area. In the shallower waters alfonsino and cardinal fish (*Epigonus spp.*) can be abundant (Figure 19). Small black oreo and smooth oreo occur on the deeper ridges where orange roughy are target fished, and are also very abundant at times. Species identification has been made during survey periods with target trawls for ID purposes. Normally the southern side of the ridge cannot be fished because it is too steep. However in the 2008 survey a trawl was targeted at the aggregation by landing the net on the top of the ridge, which caught 35 tonnes of only orange roughy, before the trawl fell down into deeper water and lost contact with the bottom. This provided species verification for that survey. A S-AOS ID tow has been carried out



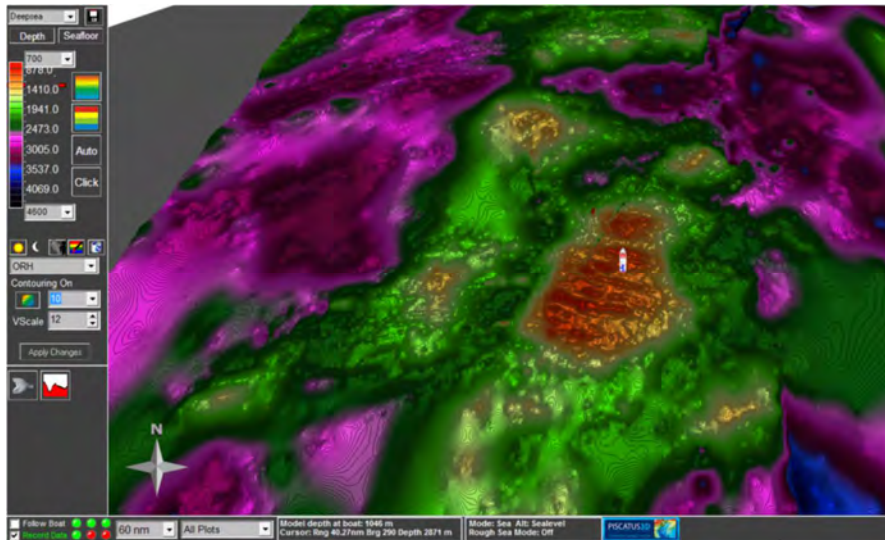
**Figure 19** Echogram of fish marks in 400-800 m depths at David's

However to allow for a proportion of oreo marks to still be included, 5% bycatch of Black Oreo Dory of mean size 24 cm TL has been allocated in species composition.

Species Mix	Orange roughy	= 0.95
	Black Oreo	= 0.05

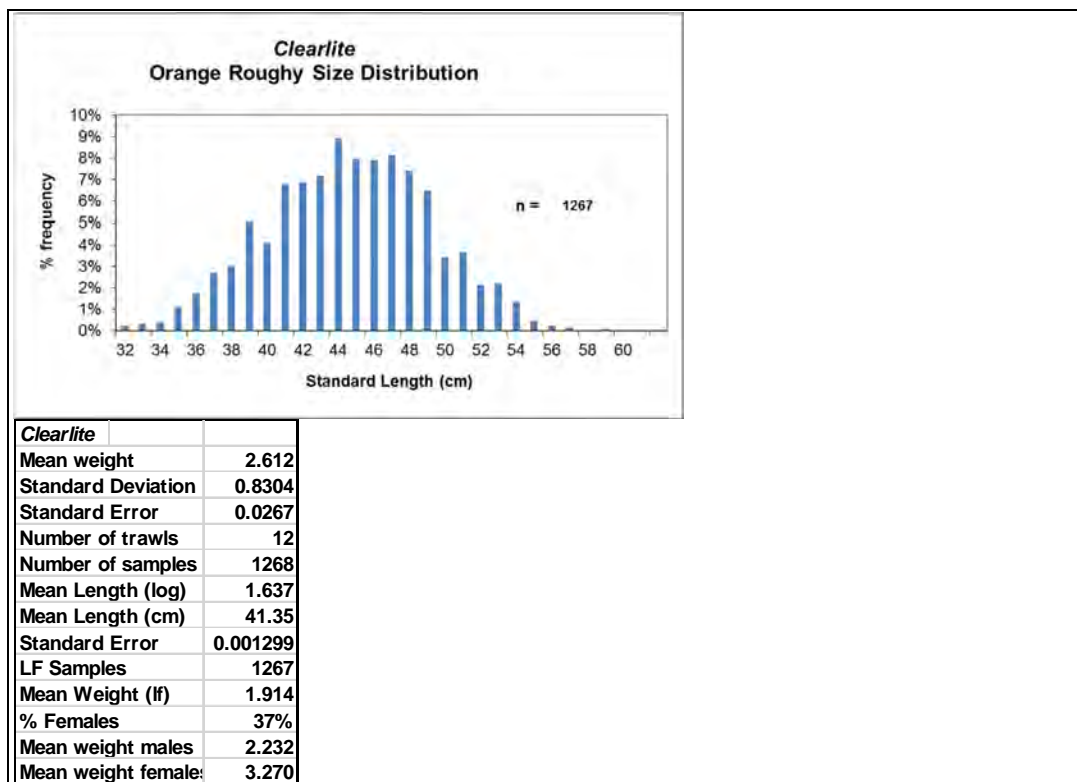
## CLEARLITE (Ridge) (4045)

Clearlite is part of a large ridge system towards the southern end of the Southwest Indian Ridge. The area of Clearlite extends over 600 square miles (Figure 20).

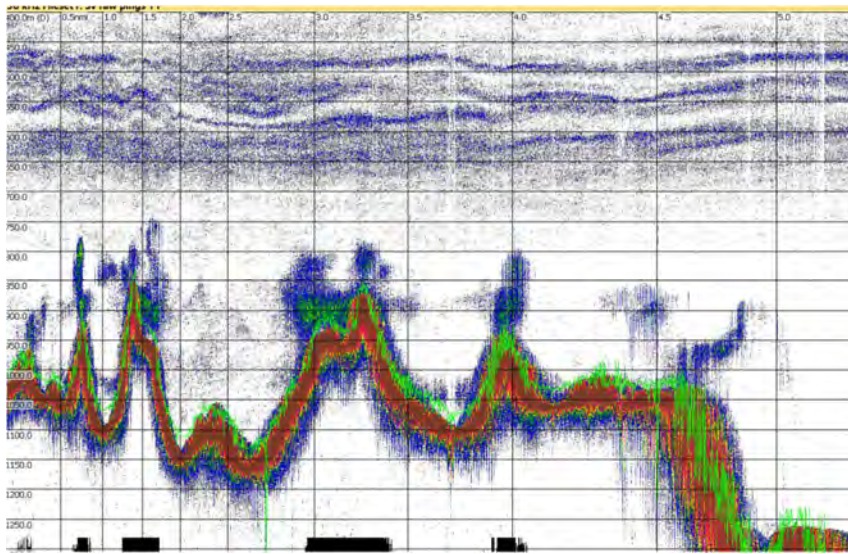


**Figure 20 Bathymetry of the Clearlite Ridge**

Some acoustic data have been collected for Clearlite, but they are inadequate for assessment purposes because of the complex mix of species in the area (Figure 21). This region will require multi-frequency surveys to assess biomass.







**Figure 21 Echogram of Species Complexity across Clearlite Region**