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SC-01-INFO-16

Biological data from orange roughy spawning stocks in the Southwest Indian Ocean

Relates to agenda item: 8 | Working paper ☐ info paper ☒

Delegation of the Cook Islands

Abstract

This report provides summary biological data on orange roughy to assist with stock assessments using acoustic data collected by the Sealord vessel *Will Watch* from 2004 to 2015 under the flag of the Cook Islands. In total, 50,369 orange roughy were sampled for length, weight, sex and maturation, from 522 target trawls shots between 2004 and 2015. In total, there are a minimum of 37 known separate spawning stocks of orange roughy in the region. 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 in the region from June to October.

BIOLOGICAL DATA FROM ORANGE ROUGHY SPAWNING STOCKS IN THE SOUTHWEST INDIAN OCEAN

Introduction

Management of high-seas fisheries has been of increasing concern in the international community and has been one of the major motivations to promote the creation of regional fisheries management organizations worldwide. The commercial fishery for orange roughy and alfonsino in the SIOFA area commenced in 1996, and the fishery rapidly expanded in 2000 following a media covered fishing rush to the area with a large number of fishing vessels active in the region.

Governmental interest to coordinate management actions for the Indian Ocean deep-sea fisheries can be traced back to 2001, but no RFMO was put in place. Following the economic failure of many vessels in the fishery in the early 2000´s concern increased among the more stable fishing operators in the area, who formed the Southern Indian Ocean Deepsea Fisher's Association (SIODFA) in 2006 to cooperate with the aim of ensuring long-term sustainable utilization of the Indian Ocean deep-sea resources (Shotton 2006). The association noted that the great depths (600-1400m) at which marine living resources were caught in this region posed additional scientific and technical challenges in providing scientific support for management, which included:

a) the cost and logistical difficulties of conducting highly technical research and monitoring in deepsea fisheries;
b) the high temporal and spatial variability in the distribution and behaviour of some species posed difficulties for representative sampling;
c) the absence of basic biological knowledge for many species;
d) the difficulties in applying some conventional fisheries research techniques in deep waters;
e) the lack of any time series of population estimates or surveys for most high seas fisheries.

SIODFA established a set of protocols for members of the association to provide for sustainable management, and maintenance and protection of biodiversity in the region, which included establishment of Benthic Protected Areas in association with the IUCN in mid-2006 (Shotton 2006). Following this, the 2006 UNGA Resolution on sustainable fisheries (61/105) called on:

"States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystem..."

Two states operating vessels under their flags in the SIOFA area, the Cook Islands and Australia, in 2006 included adherence to the BPAs into their vessel licence requirements, the first high seas region in the world to initiate spatial management to maintain and protect biodiversity on the high seas.

Orange roughy (*Hoplostethus atlanticus*) and alfonsino (*Beryx splendens*) are the two Over recent years, acoustics methods have become the standard approach to evaluate orange roughy and alfonsino biomass in more developed orange roughy fisheries such as in: New Zealand, Australia, and Chile. In all these countries, industry vessels have played very important roles, from passive acoustic data logging to taking full responsibility for yearly evaluations (Boyer & Hampton 2001, Honkalehto & Ryan 2003, Niklitschek et al. 2007b, Hampton et al. 2008, Cordue 2014). Catch per unit effort analysis, and meta-analysis techniques are no longer acceptable for stock assessments by scientific working groups in both New Zealand and Australia.

The Southwest Indian Ocean Ridge, Walters Shoal and surrounding seamounts and banks, are an extensive area of habitat for orange roughy and other deepwater species. There are also a large number of separate aggregations of alfonsino and other semi-pelagic species spread across the whole Indian Ocean region, including Ninety-East Ridge and Broken Ridge, which come under SIOFA.

This report provides summary biological data on orange roughy to assist with stock assessments using acoustic data collected by the Sealord vessel *Will Watch* from 2004 to 2015 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). The biological sampling was 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 echosounders were carried out from 2004 to 2015, following the protocols described in Shotton (2007), and in Niklitschek and Patchell (2016).

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 alfonsino, 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, 50,369 orange roughy were sampled for length, weight, sex and maturation, from 522 target trawls shots between 2004 and 2015. In total, there are a minimum of 37 known separate spawning stocks of orange roughy in the region. 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 in 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 118 features where at least 10 kg of Orange Roughy were caught.

The data used to distinguish orange roughy stocks is from catch data from 11,337 bottom trawl shots over the region and a total greenweight catch of 24,000 tonnes of orange roughy over 18 years, and a large number of acoustic surveys on individual stocks.

Table 1 Summary Data for Southwest Indian Ocean

Orange Roughy Spawning Aggregations	54
Features with Catch data Sealord (>100 kg)	99
Number of stocks heavily fished	20
Acoustic survey biomass estimates available	24
Biological data available	54
Estimated catch available	12

Potential Spawning Stocks in the Southern Indian Ocean and estimated stock status

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.

Walters Shoal Region

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	Very Lightly 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
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
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
Grover	35 03	43 13	Yes	Yes	Very Lightly Fished
Porkys	34 23	44 17	Yes	Yes	Heavily Fished
Split Pin	34 24	45 06	Yes	Yes	Heavily Fished
ZZ Top	34 14	44 18	Yes	No	Lightly Fished
Banana	30 22	45 56	Yes	Yes	BPA
Angelo's	29 34	45 57	Yes	Yes	Moderately 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
Da Vinci's	29 52	46 04	Yes	Yes	Moderately Fished
Elm St	33 06	43 48	Yes	No	Uncertain
Sin City	34 10	33 23	Yes	Yes	Moderately Fished
Jeanies	32 46	35 21	Yes	Yes	Moderately Fished
Norman's	34 14	45 22			Very Lightly Fished
Club 21	34 18	45 28	Yes	No	Very Lightly Fished
Hank	34 18	45 28	Yes	No	Very Lightly Fished
Danilo	34 10	45 57	Yes	Yes	Uncertain

Southwest Indian Ridge

Feature Name	Latitude S	Longitude E	ORH Present	ORH Spawning Data	Status
Atlantis	32 42	57 16	Yes	No	BPA
Big Teds	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
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
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
Tonga	38 25	48 23	Yes	Yes	Heavily Fished
Sugarol	38 37	48 20	Yes	Yes	Heavily Fished
Top Knot	38 22	47 44	Yes	No	Very Lightly 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
Melville	38 28	46 45	Yes	No	Uncertain
Monitor	38 57	47 19	Yes	Yes	Lightly 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
McLay's	39 33	47 37	Yes	Yes	Heavily Fished
Clearlight	40 26	45 32	Yes	Yes	Moderately Fished
Seal Shark	40 30	44 30	Yes	No	Uncertain
Big Flat	40 04	42 59	Yes	Yes	Lightly Fished
Meeting	39 25	41 24	Yes	Yes	Heavily Fished
Coral	41 09	42 57	Yes	No	BPA
Winter	41 55	42 46	Yes	No	Uncertain

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

Length Weight Relationship

Analysis of length frequency data from the Indian Ocean indicated substantial differences in mean size of fish between the Southwest Indian Ridge (Figure 1), and the grounds around Walter's Shoal (Figure 2). Two separate length to weight relationships were calculated from a total data set of 38,171 fish.

Southwest Indian Ridge, $L=0.0001W^{2.649}$
Walter's Shoal Region, $L=9E\text{-}05W^{2.7253}$

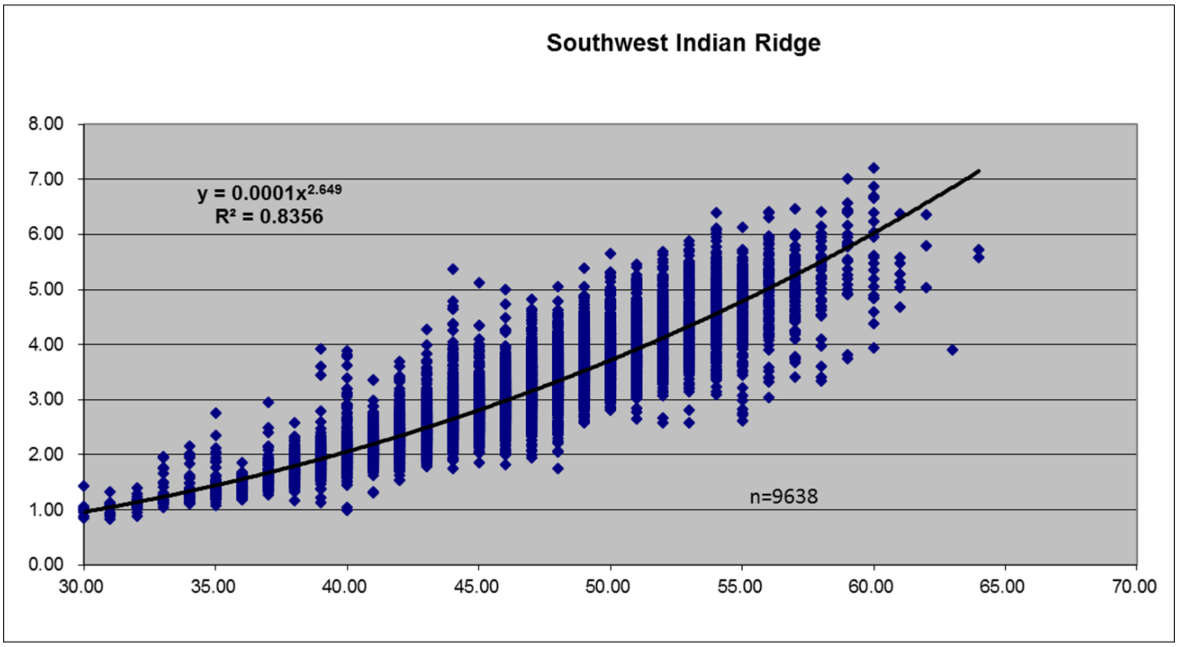


Figure 1 Length Weight Relationship for Orange Roughy along the Southwest Indian Ridge

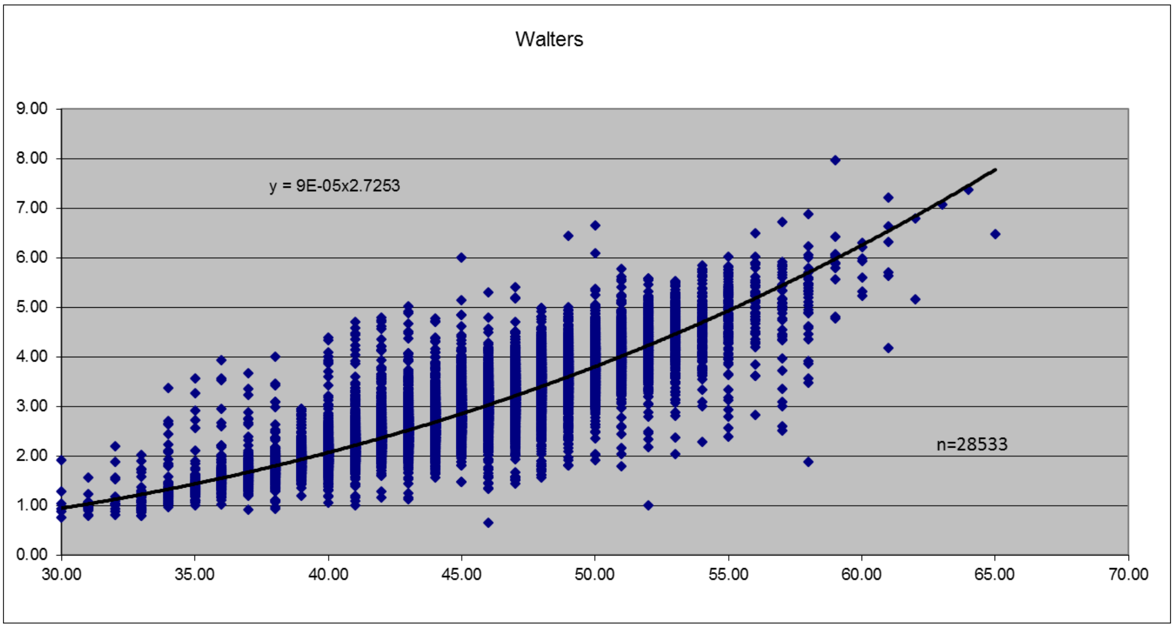
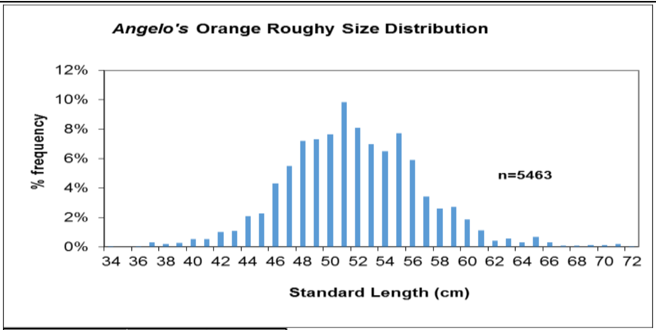


Figure 2 Length Weight Relationship for Orange Roughy around Walter's Shoal

Species Composition and Orange Roughy Biological Data by Spawning Stock Areas

NORTH WALTERS

ANGELO'S (Seamount/Bank)
(2945)



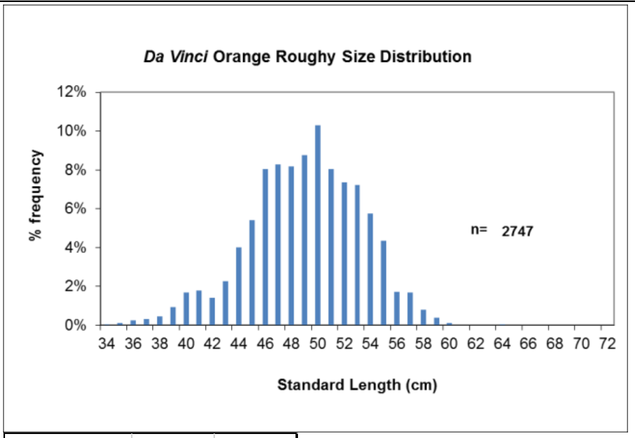
Angelo's	
Mean Weight	4.203
Standard Deviation	1.1067
Standard Error	0.0236
Number of trawls	35
Number of samples	2196
Mean Length (log)	1.712
Mean Length (cm)	51.75
Standard Error	0.000755
LF Samples	3084
Mean Weight (lf)	4.315
% females	48%
Mean weight males	2.410
Mean weight females	2.858

Species Composition

Only orange roughy were 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)
(2945)



Da Vinci	
Mean Weight	4.163
Standard Deviation	0.9763
Standard Error	0.0186
Number of trawls	28.0000
Number of samples	2747
Mean Length (log)	1.689
Mean Length (cm)	48.83
Standard Error	0.001016
LF Samples	1494
Mean Weight (lf)	3.669
% females	46%
Mean weight males	2.410
Mean weight females	2.858

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

SOUTHWEST WALTERS

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 3). A number of spawning aggregations occur in this region, and all spawn concurrently during late June into July. Some of the spawning grounds at 20-30 miles apart, but others are separated by less than 10 miles.

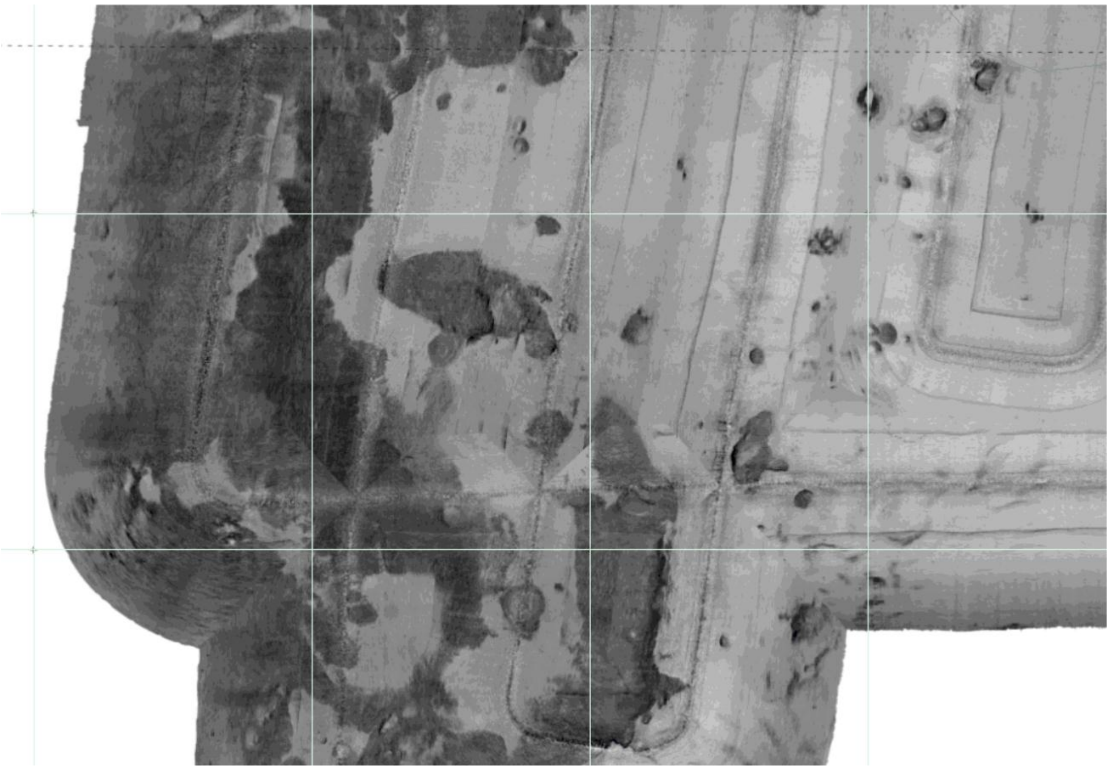
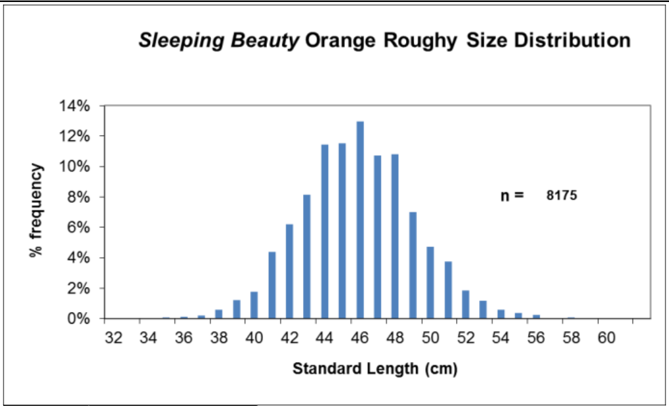


Figure 3 Sidescan Sonar Imagery of Southeast Walters

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.



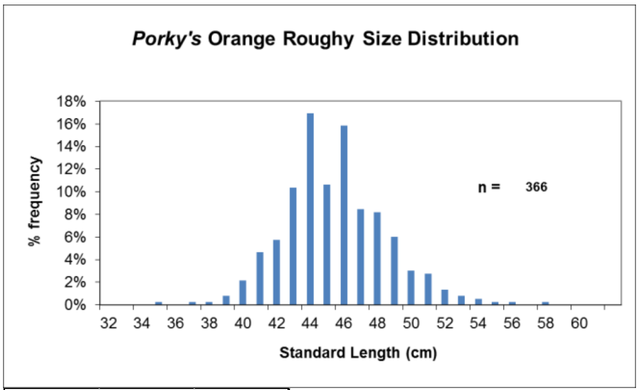
Sleeping Beauty	
Mean weight	2.858
Standard Deviation	0.6487
Standard Error	0.0223
Number of trawls	81
Number of samples	8024
Mean Length (log)	1.651
Mean Length (cm)	44.74
Standard Error	0.000351
LF Samples	8175
Mean Weight (lf)	2.838
% Females	53%
Mean weight males	2.528
Mean weight female:	3.147

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 2-10 dB greater on 120 kHz than 38 kHz. This is higher than the dB range for New Zealand orange roughy, and further research into this issue is underway

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.



Porky's	
Mean weight	2.847
Standard Deviation	0.6195
Standard Error	0.0324
Number of trawls	4
Number of samples	364
Mean Length (log)	1.647
Mean Length (cm)	44.28
Standard Error	0.001577
LF Samples	366
Mean Weight (lf)	2.758
% Females	51%
Mean weight males	2.613
Mean weight female:	3.089

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 4). 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.

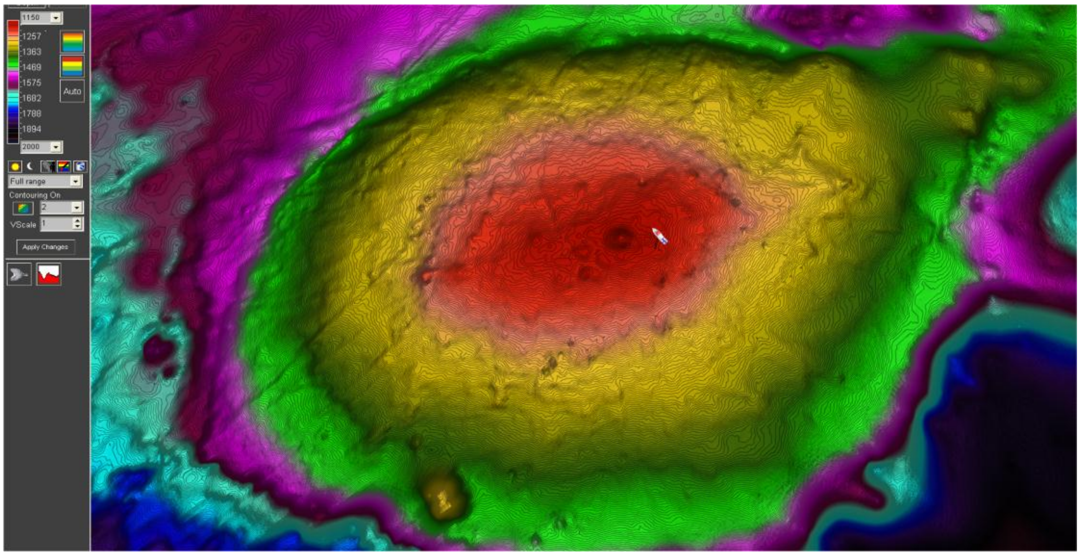
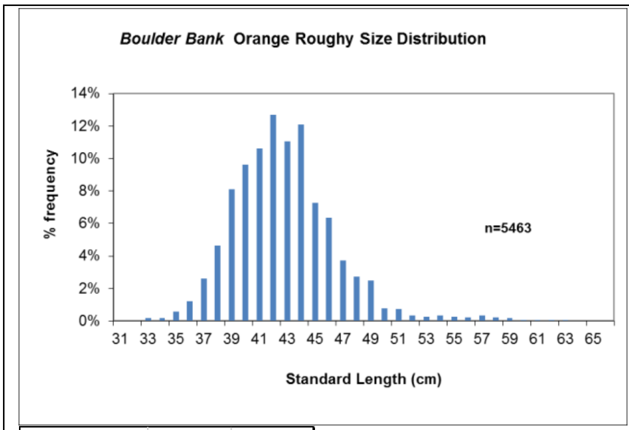


Figure 4 Bathymetry of Boulder Bank



Boulder Bank	
Mean Weight	2.568
Standard Deviation	0.5722
Standard Error	0.0083
Number of trawls	60
Number of samples	301
Mean Length (log)	1.619
Mean Length (cm)	40.12
Standard Error	0.000511
LF Samples	5463
Mean Weight (lf)	2.118
% females	0%
Mean weight males	2.399
Mean weight females	2.860

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 HOLLOWS
(3444)

Sleepy Hollows is a series of cones covering about 6 square miles in area, rising to 990 metres on the shallowest peak (Figure 5). 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.

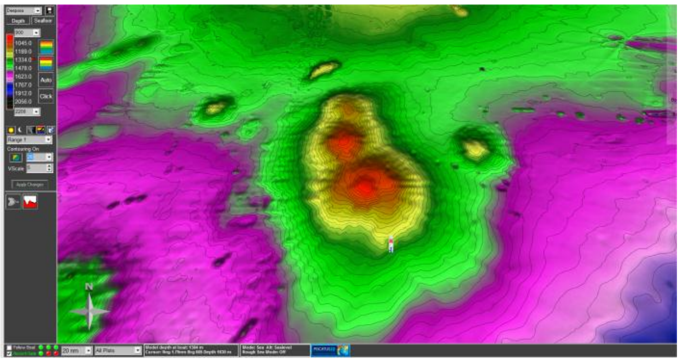
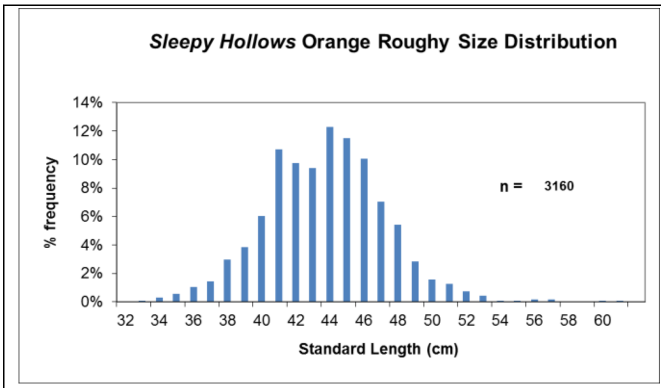


Figure 5 Bathymetry of Sleepy Hollows



Sleepy Hollows	
Mean weight	2.443
Standard Deviation	0.6364
Standard Error	0.0114
Number of trawls	30
Number of samples	3102
Mean Length (log)	1.630
Mean Length (cm)	41.55
Standard Error	0.00064
LF Samples	3160
Mean Weight (lf)	2.320
% Females	46%
Mean weight males	2.650
Mean weight femal	3.183

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.

SMURFS (Seamount)
(3544)

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 6)

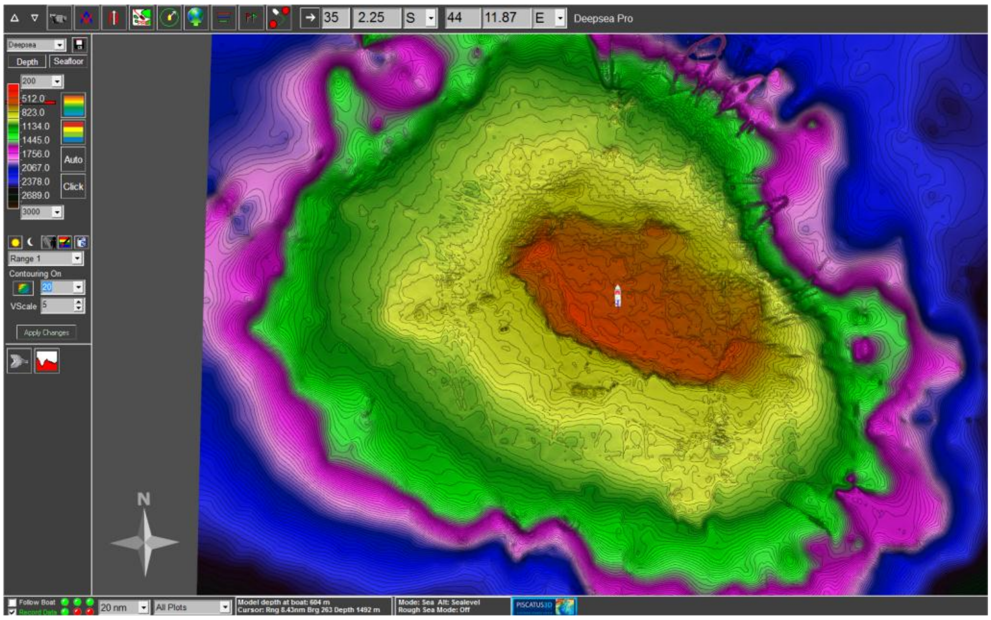
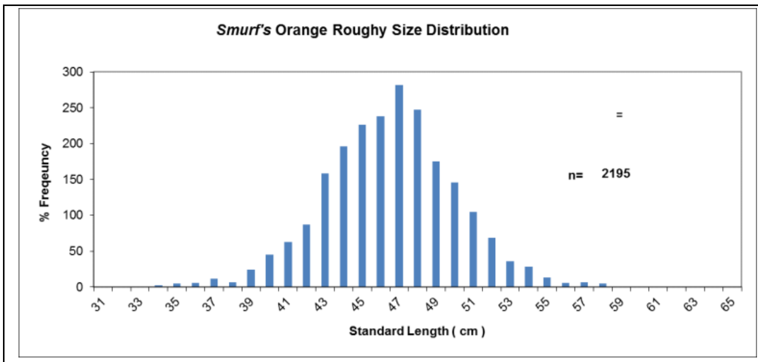


Figure 6 Bathymetry of Smurfs



Smurf's		
Mean Weight		3.283
Standard Deviation		0.7581
Standard Error		0.0162
Number of trawls		21
Number of samples		2195
Mean Length (log)		1.666
Mean Length (cm)		46.30
Standard Error		0.0007344
LF Samples		2196
Mean Weight (lf)		3.162
% females		54%
Mean Weight Males		2.97
Mean Weight females		3.45

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.

Species Mix   Orange Roughy = 1.0

NOVEL (Seamount)
(3444)

Novel is a large seamount (150 square miles in area) (Figure 7) extending off the main Walters Shoal with 2000 metres depth of water between them. It has a number of cones on top.

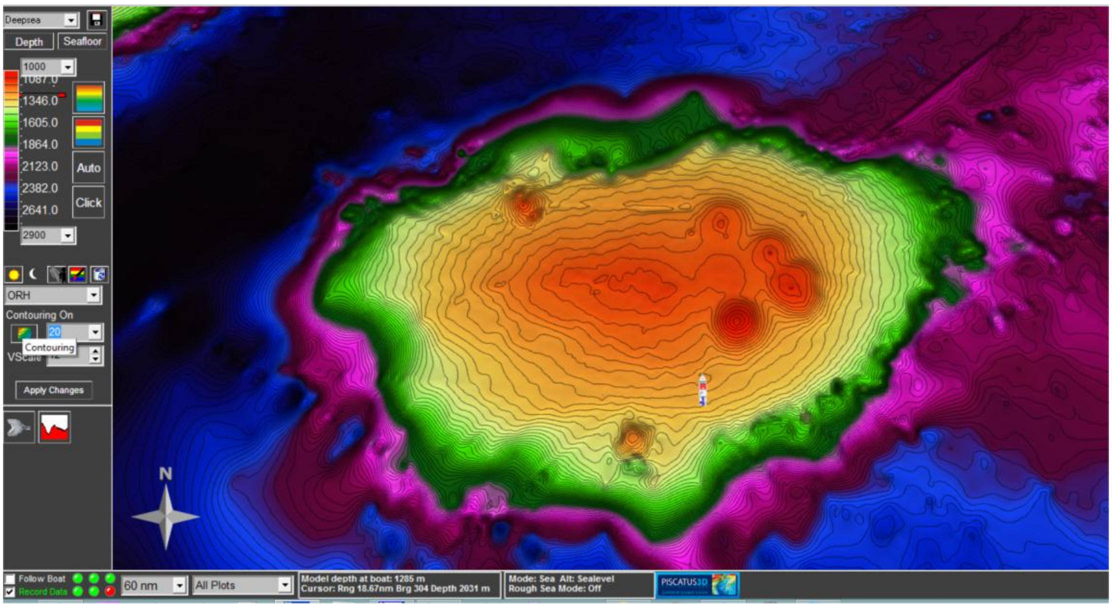
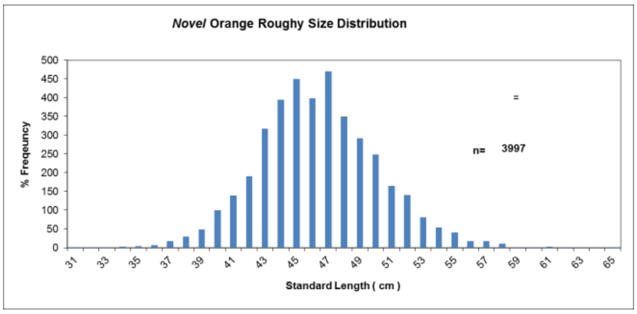


Figure 7 Bathymetry of Novel



Novel		
Mean Weight		3.194
Standard Deviation		0.7248
Standard Error		0.0115
Number of trawls		40
Number of samples		3997
Mean Length (log)		1.665
Mean Length (cm)		46.21
Standard Error		0.0005668
LF Samples		3998
Mean Weight (lf)		3.144
% females		53%
Mean Weight Males		3.00
Mean Weight females		3.46

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)
(3543)

Wrongford's is a seamount of about 400 square miles in area, rising out of 3000 m depths surrounding it (Figure 8). There are a number of cones and rocky areas on the top.

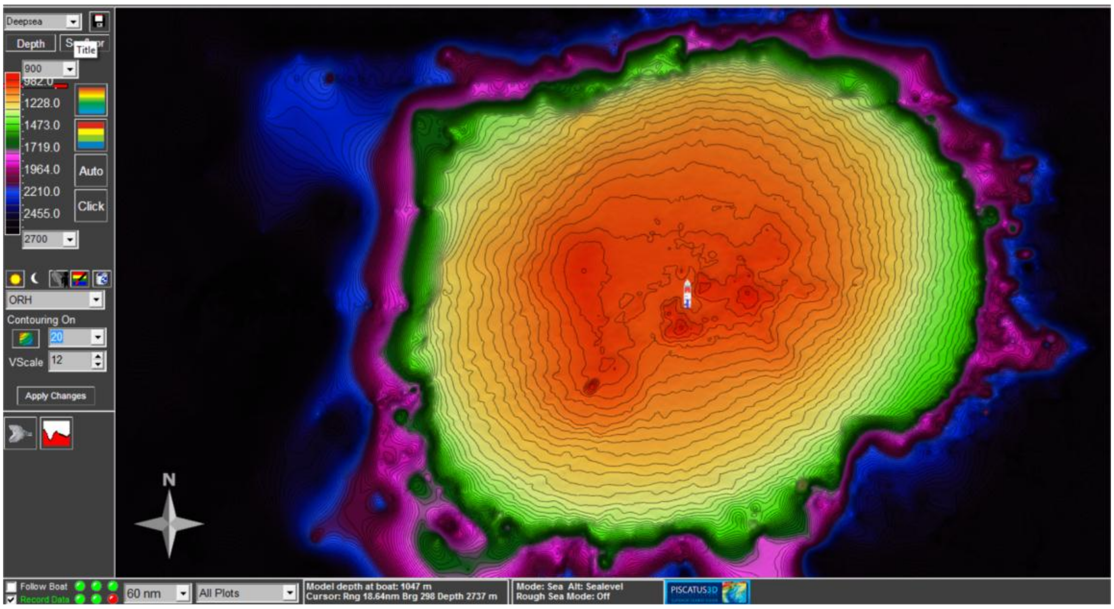
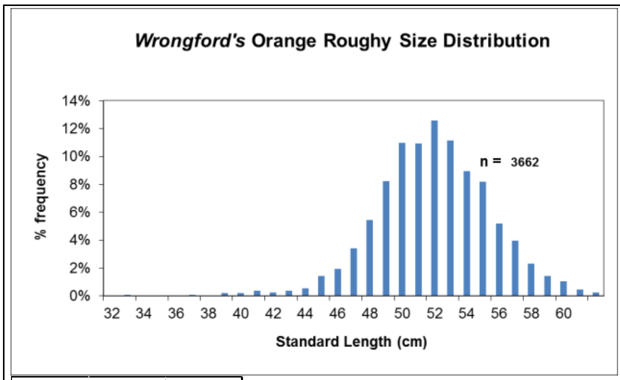


Figure 8 Bathymetry of Wrongford's



Wrongford's	
Mean weight	3.419
Standard Deviation	0.7776
Standard Error	0.0246
Number of trawls	35
Number of samples	3686
Mean Length (log)	1.706
Mean Length (cm)	50.87
Standard Error	0.000512
LF Samples	3662
Mean Weight (lf)	4.026
% Females	64%
Mean weight males	2.978
Mean weight female:	3.669

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)
(3543)

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

SOUTHEAST WALTERS

The southeast region of Walters contains extensive small knolls and areas of elevated hard rock banks. The area shown in Figure 9 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.

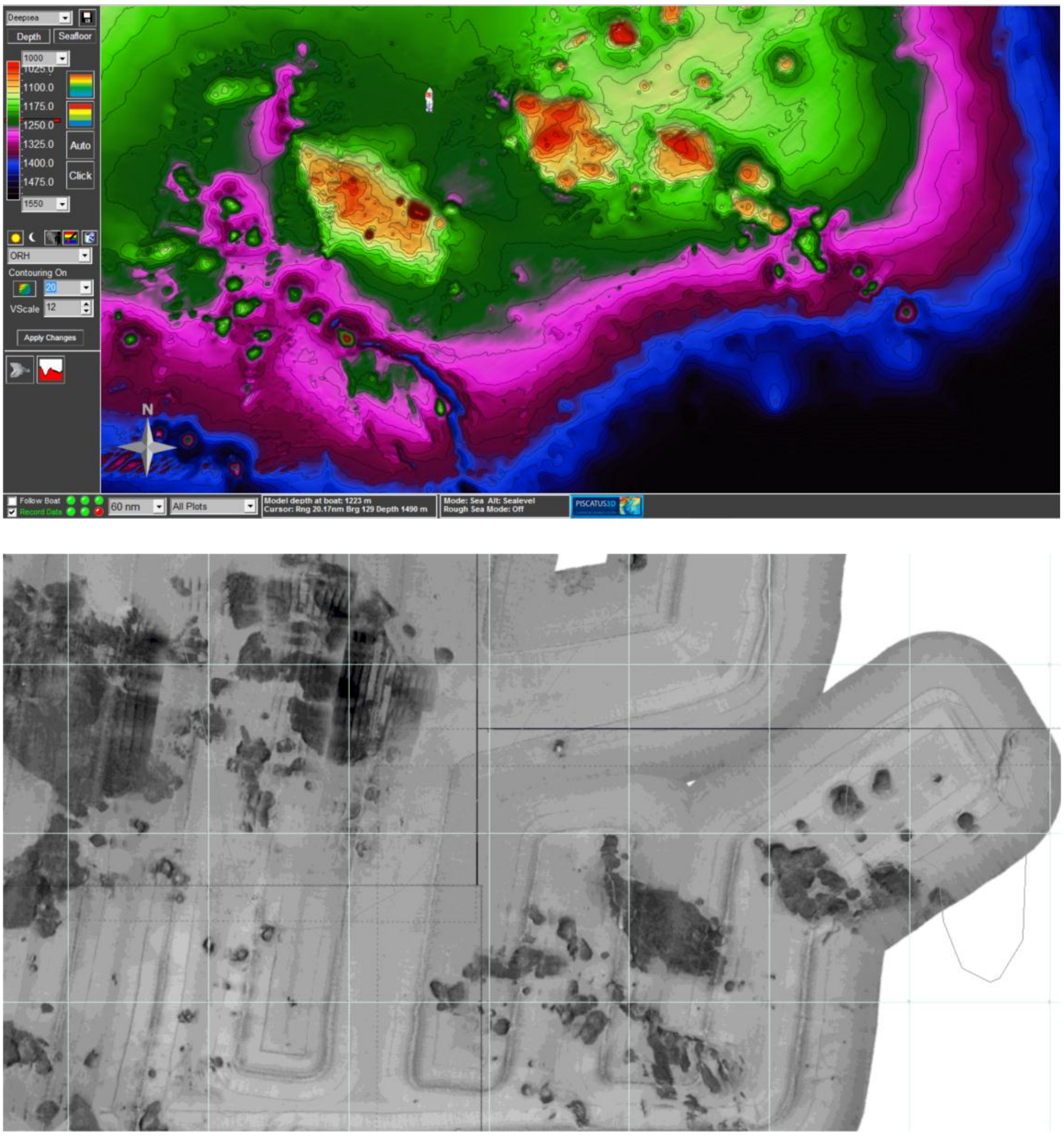
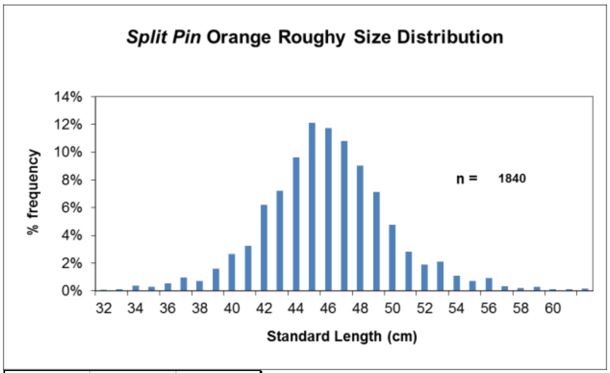


Figure 9 Southeast Walter's Shoal bathymetry and sidescan imagery

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.



Split Pin	
Mean weight	2.797
Standard Deviation	0.8320
Standard Error	0.0289
Number of trawls	17
Number of samples	1699
Mean Length (log)	1.651
Mean Length (cm)	44.15
Standard Error	0.000913
LF Samples	1840
Mean Weight (lf)	2.737
% Females	46%
Mean weight males	2.545
Mean weight female:	3.101

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.

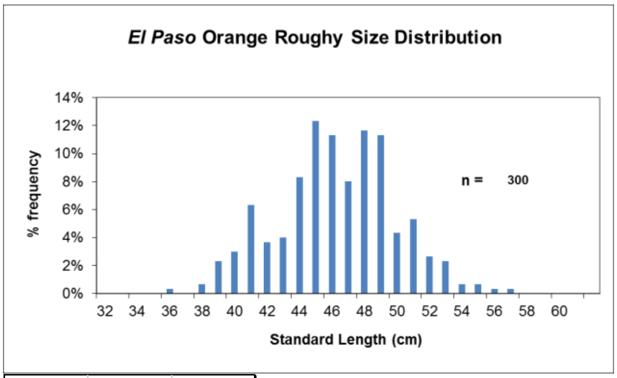
Species Composition

Biological data for this 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 aggregations have been observed on El Paso, although maturing fish have been caught.



El Paso	
Mean weight	3.069
Standard Deviation	0.7781
Standard Error	0.0449
Number of trawls	3
Number of samples	298
Mean Length (log)	1.655
Mean Length (cm)	45.18
Standard Error	0.002036
LF Samples	300
Mean Weight (lf)	2.914
% Females	72%
Mean weight males	2.758
Mean weight females	3.191

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 10) where orange roughy form schools during the spawning season. Fish move between the pinnacles and the main knoll.

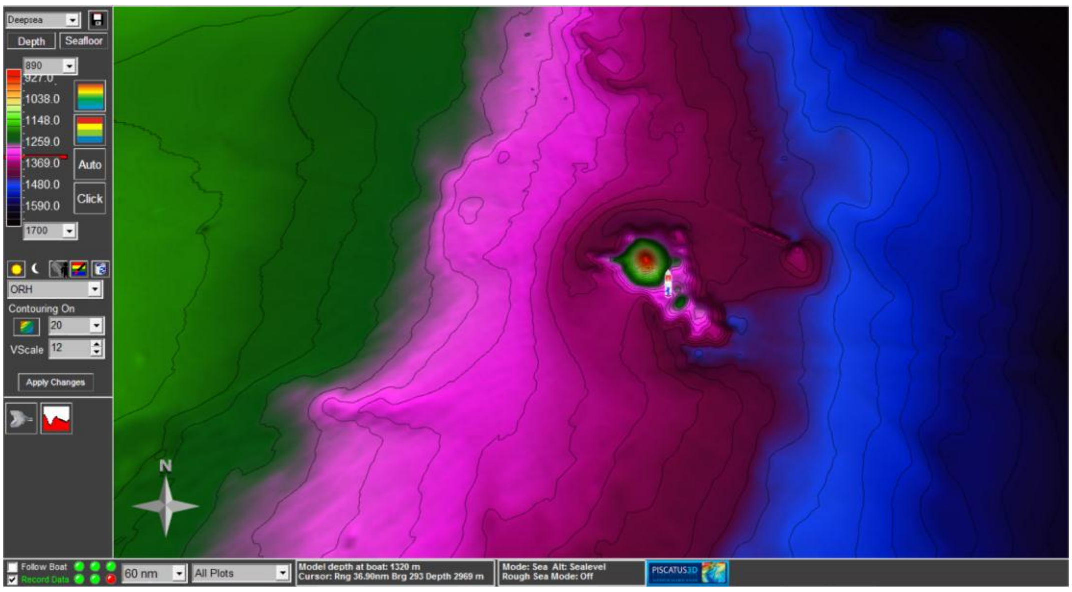
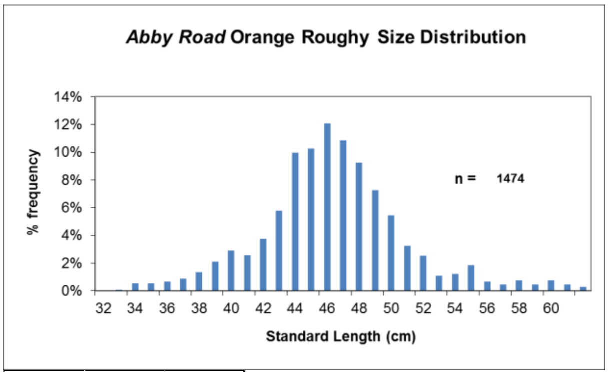


Figure 10 Bathymetry of Abby Road



Abby Road	
Mean weight	2.886
Standard Deviation	0.7122
Standard Error	0.0225
Number of trawls	16
Number of samples	1497
Mean Length (log)	1.655
Mean Length (cm)	44.47
Standard Error	0.001135
LF Samples	1474
Mean Weight (lf)	2.790
% Females	63%
Mean weight males	2.590
Mean weight females	3.062

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

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.

SCUD (Seamount)
(3749)

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 11).

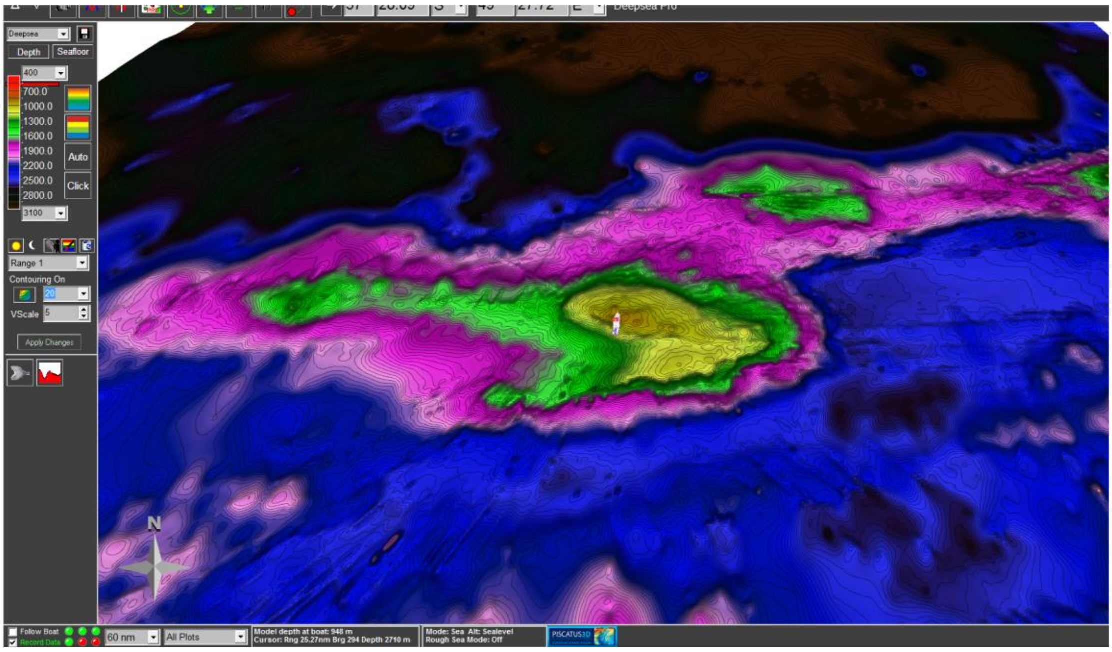
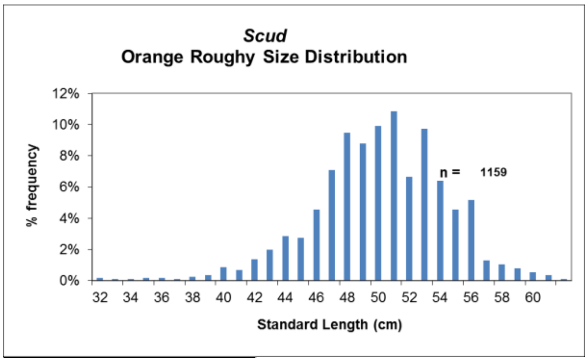


Figure 11 Bathymetry of Scud



Scud	
Mean weight	3.660
Standard Deviation	1.1313
Standard Error	0.0618
Number of trawls	16
Number of samples	525
Mean Length (log)	1.688
Mean Length (cm)	48.52
Standard Error	0.001279
LF Samples	1159
Mean Weight (lf)	2.924
% Females	36%
Mean weight males	3.343
Mean weight female:	4.640

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 12) 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.

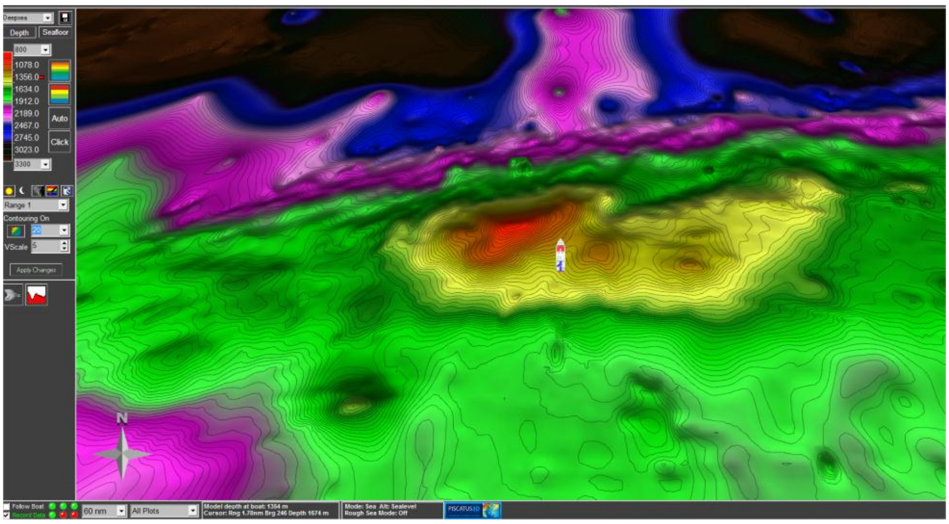


Figure 12 Bathymetry of Harlot

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 13). 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.

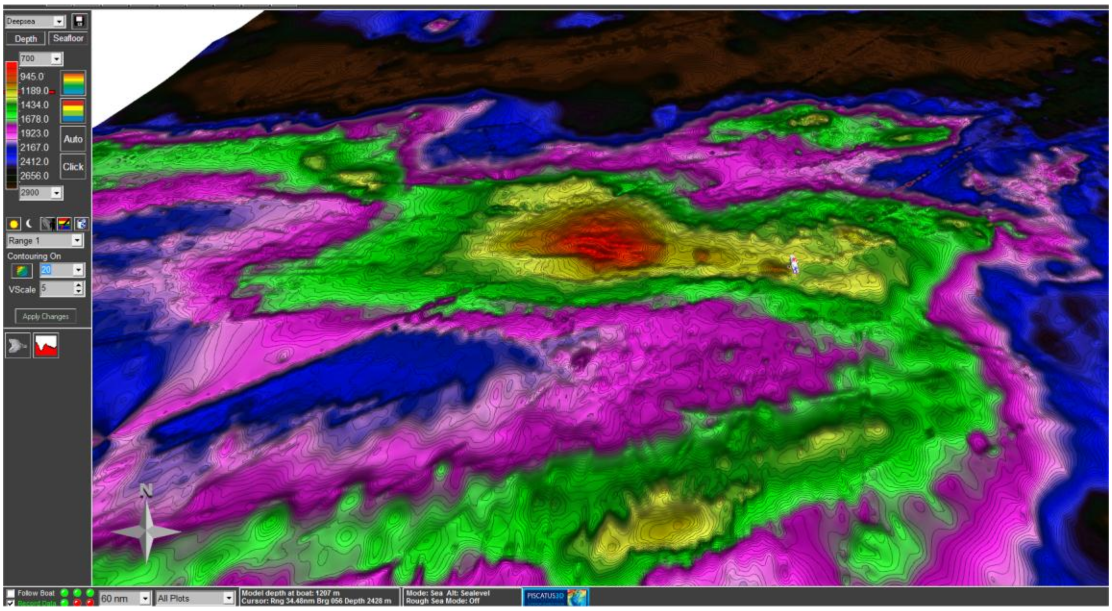
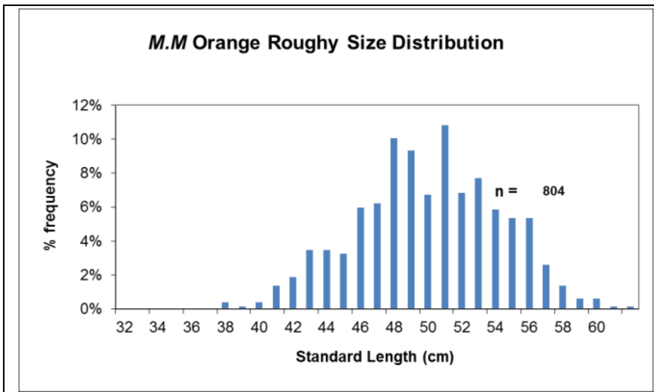


Figure 13 Bathymetry of Kettle and M.M



M.M	
Mean weight	3.478
Standard Deviation	0.9803
Standard Error	0.0438
Number of trawls	8
Number of samples	500
Mean Length (log)	1.689
Mean Length (cm)	49.03
Standard Error	0.001343
LF Samples	804
Mean Weight (lf)	3.007
% Females	47%
Mean weight males	3.009
Mean weight females	4.131

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

ERICS (Seamount)
(3553)

This large seamount (Figure 14) is where the deepwater fishery commenced in 1999. Significant catches were taken in 1999 and 2000, 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.

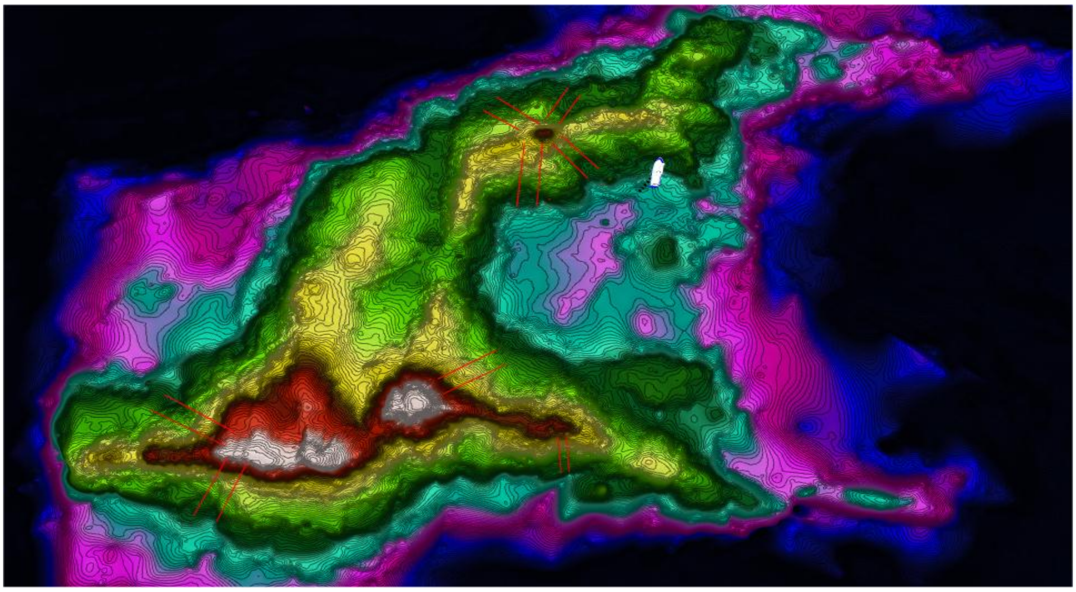


Figure 14 Bathymetry of Eric's

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

DAVIDS (Ridge)
(3946)

David's is part of a large ridge over 30 miles long which shoals to under 600 m (Figure 15). The western side drops into 4000 metres of water in one of the spreading centre trenches in the region.

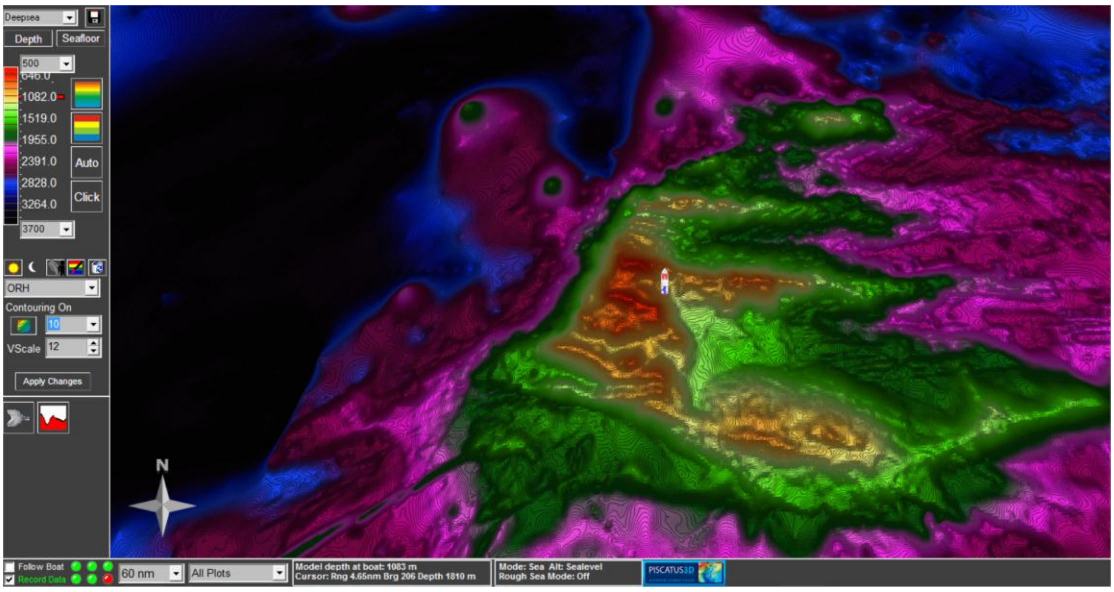
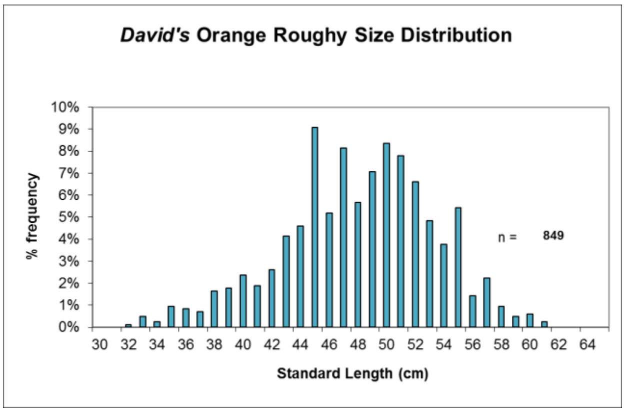


Figure 15 Bathymetry of David's



David's	
Mean weight	3.321
Standard Deviation	0.8539
Standard Error	0.0293
Number of trawls	7
Number of samples	848
Mean Length (log)	1.679
Mean Length (cm)	47.18
Standard Error	0.001685
LF Samples	849
Mean Weight (lf)	2.714
% Females	
Mean weight males	2.872
Mean weight female:	3.567

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*.) are abundant (Figure 16). 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.

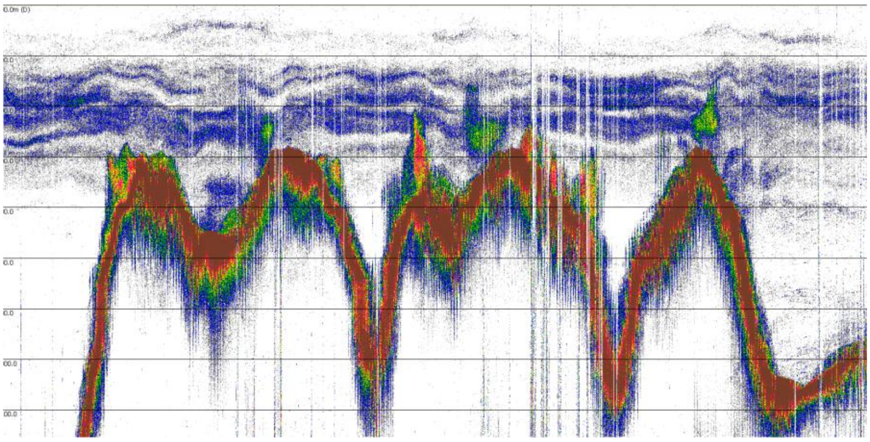


Figure 16 Echogram of fish marks in 400-800 m depths at David's

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

FREDRICK'S (Ridge)
(3847)

This is a part of a large ridge complex, covering an area 30 nautical miles by 20 nm (Figure 17), and some areas were heavily fished during 2000-2001.

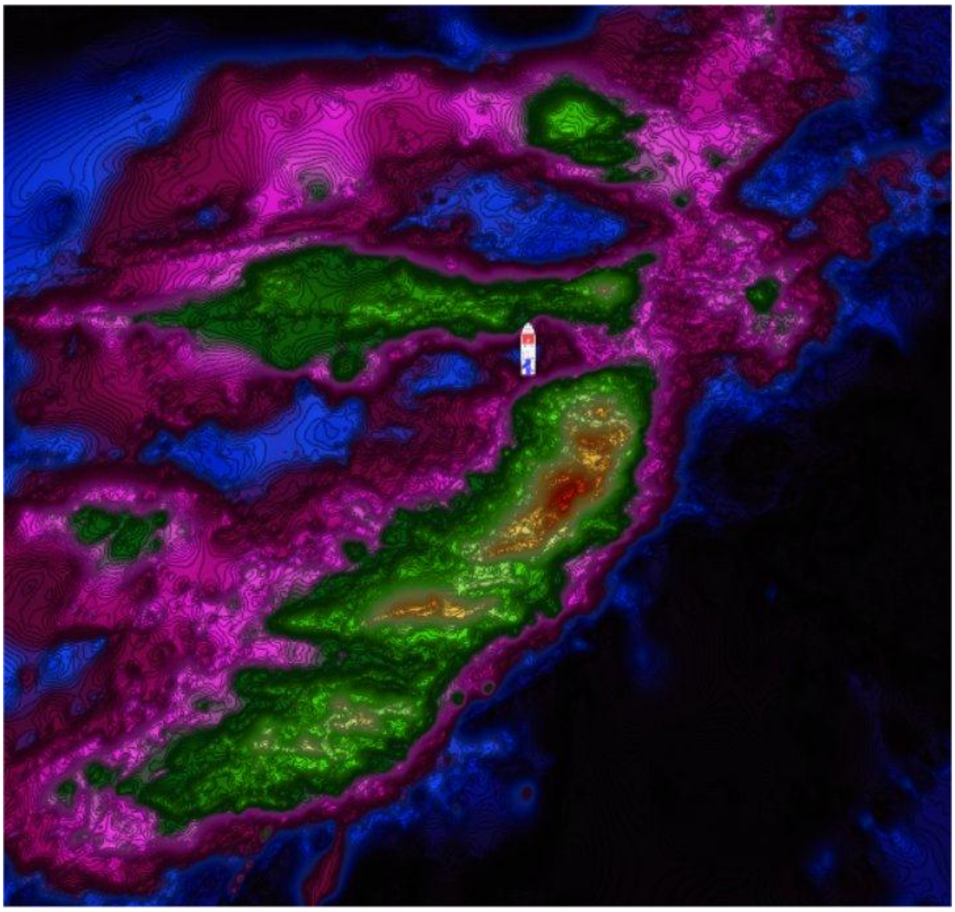
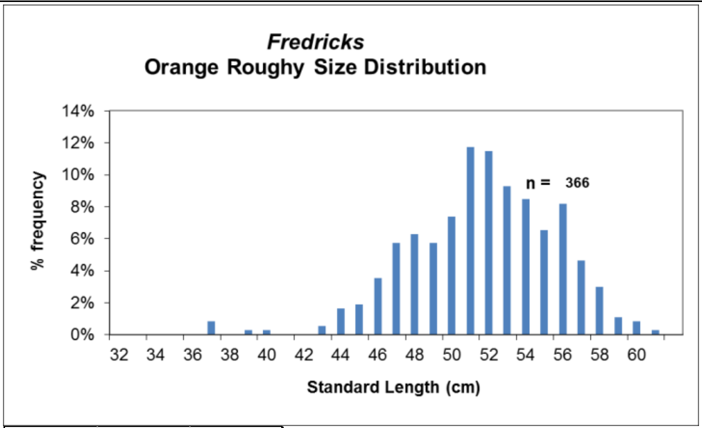
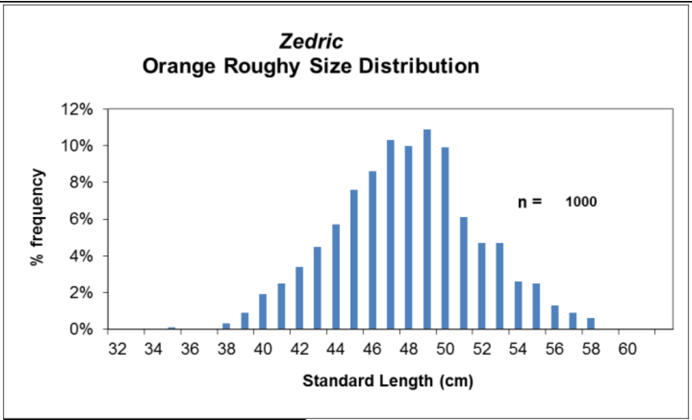


Figure 17 Zedric to Robb's Bathymetry

Over recent yeas a number of spawning aggregations have been surveyed in this area, which includes Zedric and Robb's. More biological sampling is required in this region.



Fredricks	
Mean weight	3.602
Standard Deviation	0.8163
Standard Error	0.0337
Number of trawls	4
Number of samples	586
Mean Length (log)	1.704
Mean Length (cm)	50.41
Standard Error	0.001838
LF Samples	366
Mean Weight (lf)	3.235
% Females	62%
Mean weight males	3.145
Mean weight female:	3.877



Zedric	
Mean weight	3.176
Standard Deviation	0.7702
Standard Error	0.0247
Number of trawls	10
Number of samples	1000
Mean Length (log)	1.669
Mean Length (cm)	46.84
Standard Error	0.001155
LF Samples	1000
Mean Weight (lf)	2.664
% Females	37%
Mean weight males	2.884
Mean weight female:	3.683

SUGAROL (Seamount) andTONGA (Seamount) (3848)

These two features rising to about 500m are 12 nm apart on the same ridge system on the Southwest Indian Ridge (Figure 18). 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.

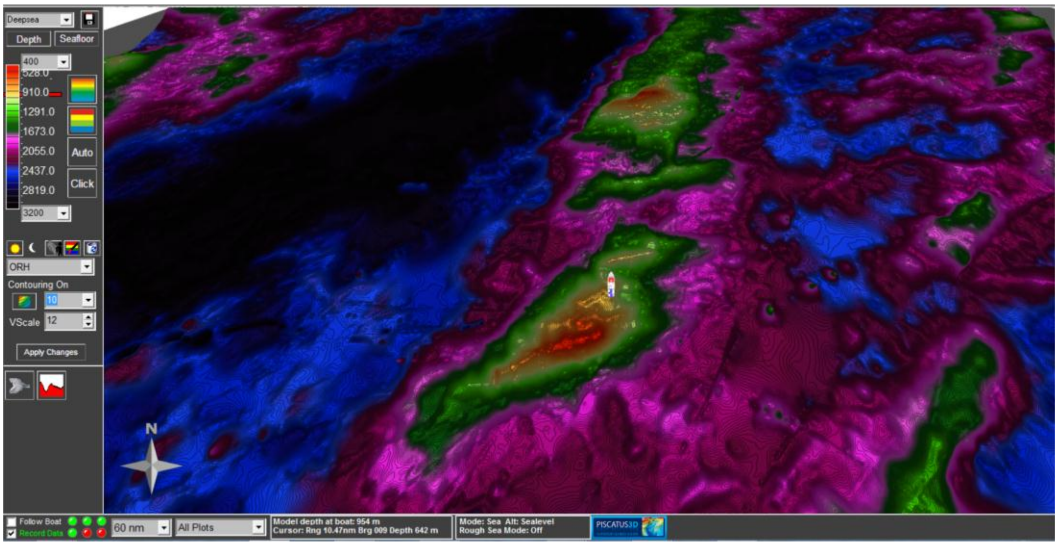
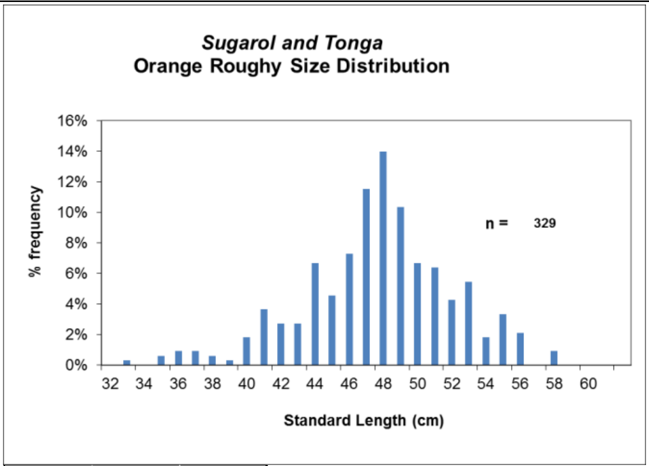


Figure 18 Bathymetry of Sugarol and Tonga



Sugarol and Tonga	
Mean weight	3.199
Standard Deviation	0.8038
Standard Error	0.0442
Number of trawls	3
Number of samples	330
Mean Length (log)	1.667
Mean Length (cm)	45.74
Standard Error	0.002305
LF Samples	329
Mean Weight (lf)	2.500
% Females	43%
Mean weight males	3.054
Mean weight female:	3.389

SADDLE (Ridge)
(3652)

Saddle is part of an extensive ridge system over 30 miles long (Figure 19) on the Southwest Indian Ridge, where much of the fleet fished in 2000. Substantial catches of orange roughy, probably in excess of 10,000 tonnes were been taken from this ridge. Maturity data collected from 2008-2012 indicate that spawning occurs in this area during late July. The ridge includes other likely spawning grounds known as Rodrigo's, Greedy's, and Paradise.

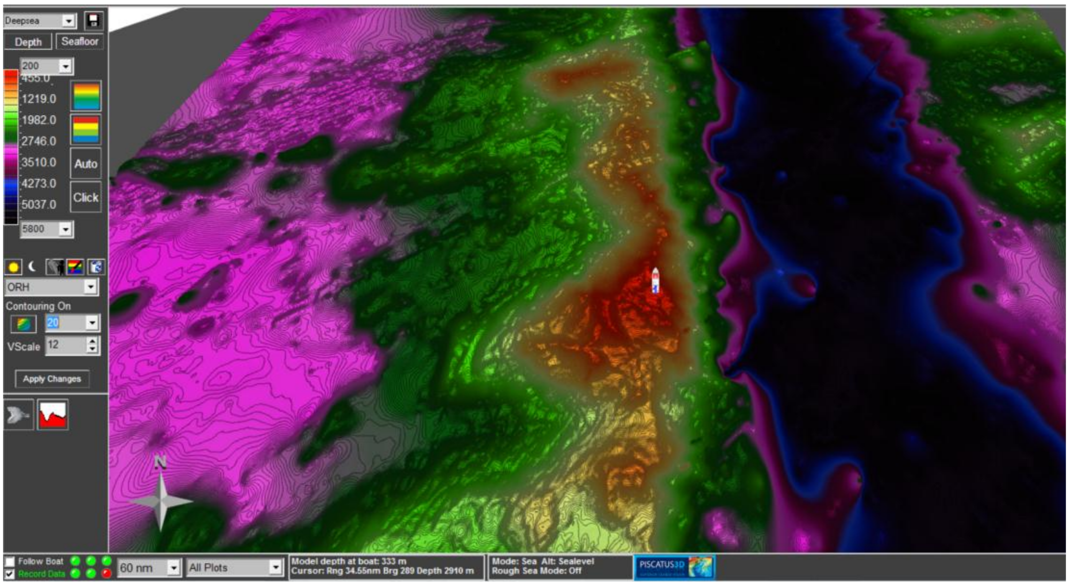
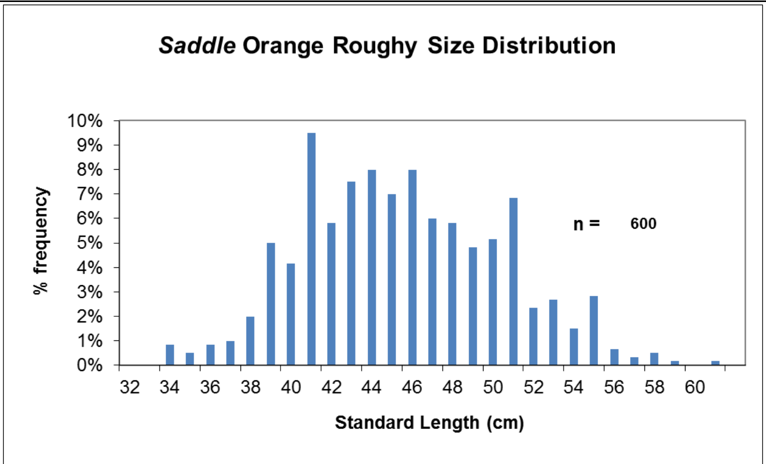


Figure 19 Bathymetry of the Saddle Region



Saddle	
Mean weight	2.800
Standard Deviation	0.8967
Standard Error	0.0366
Number of trawls	5
Number of samples	600
Mean Length (log)	1.646
Mean Length (cm)	43.43
Standard Error	0.001948
LF Samples	600
Mean Weight (lf)	2.181
% Females	46%
Mean weight males	2.650
Mean weight females	3.183

LEO'S (Seamount)
(3554)

Leo's is a large seamount that has the deep spreading centre to the west, and 4500 m water depths. It is surrounded on all sides by 3000-5000 m water depths and is about 240 square miles in area (Figure 20). Spawning aggregations have been located on the largest structure on Leo's, but also on pinnacles that are included as part of the seamount.

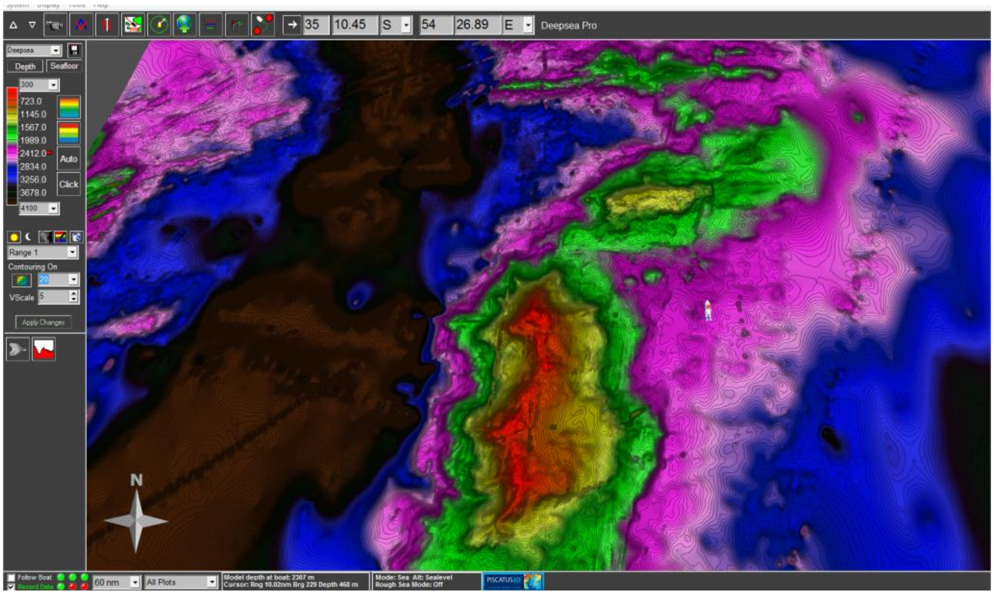
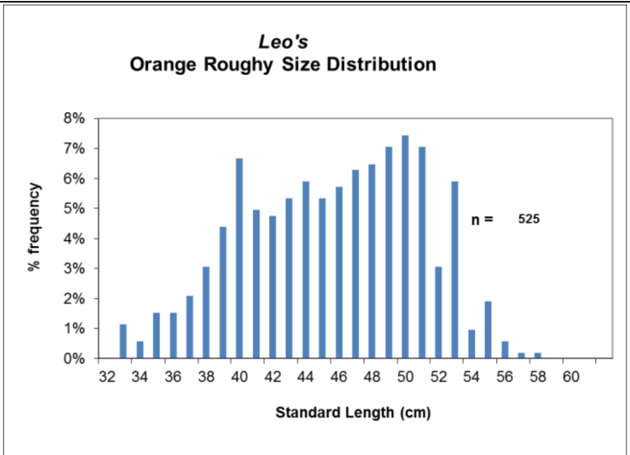


Figure 20 Bathymetry of Leo's



Leo's	
Mean weight	2.948
Standard Deviation	1.0308
Standard Error	0.0478
Number of trawls	6
Number of samples	465
Mean Length (log)	1.646
Mean Length (cm)	42.19
Standard Error	0.002311
LF Samples	525
Mean Weight (lf)	2.020
% Females	63%
Mean weight males	2.639
Mean weight femal	3.125

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 21).

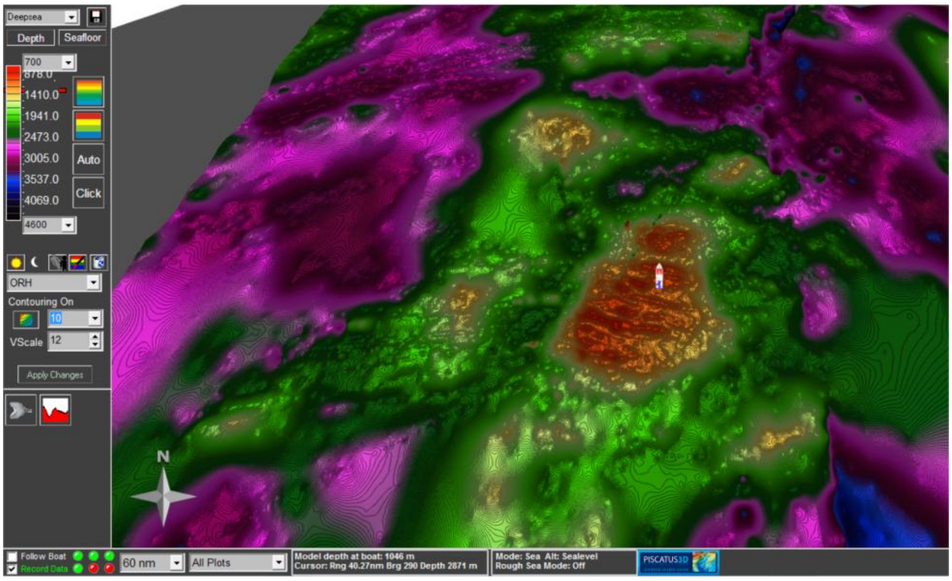
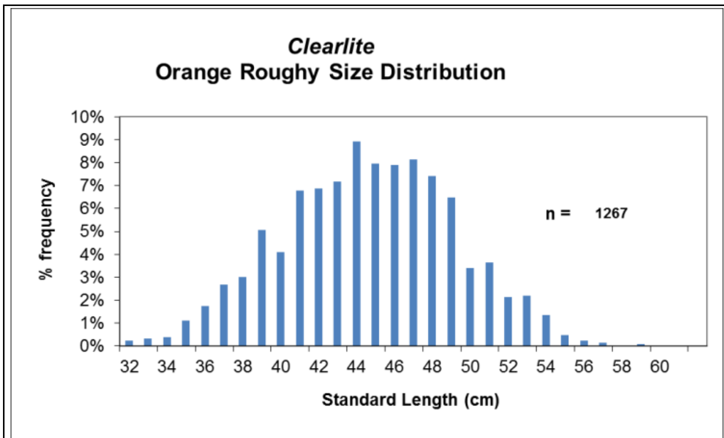


Figure 21 Bathymetry of the Clearlite Region

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 22). This region will require multi-frequency surveys to assess biomass.



Clearlite	
Mean weight	2.612
Standard Deviation	0.8304
Standard Error	0.0267
Number of trawls	12
Number of samples	1268
Mean Length (log)	1.637
Mean Length (cm)	41.35
Standard Error	0.001299
LF Samples	1267
Mean Weight (lf)	1.914
% Females	37%
Mean weight males	2.232
Mean weight female:	3.270

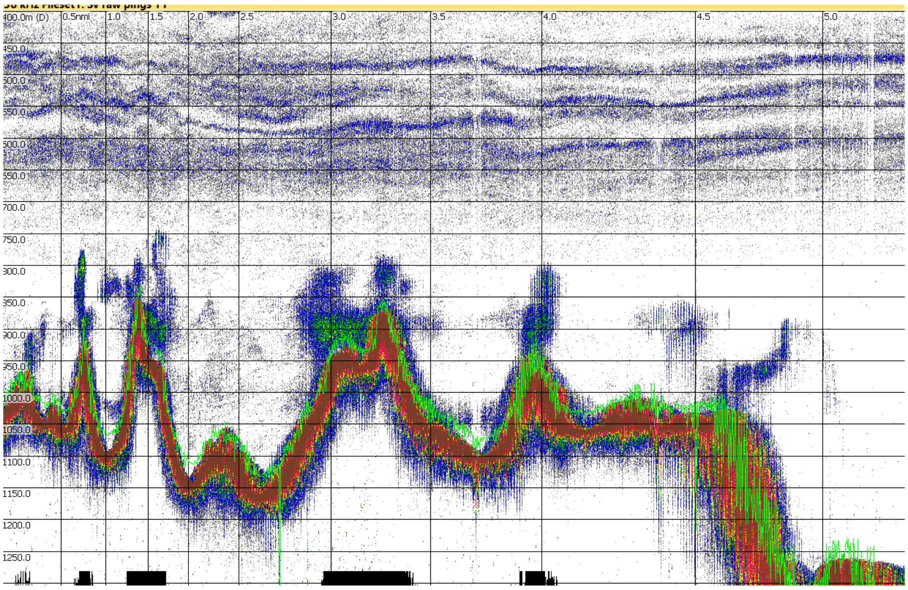


Figure 22 Echogram of Species Complexity across Clearlite Region

REFERENCES

Ryan, T. E., O Driscoll, R. L., Downie, R. A., and Kloser.R.J. 2015. Biomass estimates of West Coast New Zealand orange roughy in June and July 2014 using a net attached acoustic optical system at The Volcano, Kaipara Flats and Tauroa Knoll Client report to Sealord Group, New Zealand.