Estimates of orange roughy biomass from acoustic surveys, 2022-2023

Abstract

Estimates of orange roughy biomass have been derived from 15 acoustic surveys conducted on two features (Wrongford's and Sleeping Beauty) in SIOFA area 2 in June and July of 2022 and 2023.

Three surveys on Wrongford's in 2022 produced estimates of 1500–4300 t with CV's of between 22 and 96%, eight surveys on Sleeping Beauty in 2022 produced estimates of 300–10 300 t (CV: 26–93%) and three in 2023 produced estimates of 4600–6000 t (CV: 18-22%). One survey had no observable orange roughy marks. These data add to the existing time-series of orange roughy biomass estimates that now cover years 2004–2023.

Introduction

This report documents the work carried out under Southern Indian Ocean Fisheries Agreement (SIOFA) project code ORY-2023-02, concerning the analysis of acoustic data on orange roughy (*Hoplostethus atlanticus*) to produce estimates of biomass. The work comprised five objectives (see also the project terms of reference, Appendix A):

1. Collate the existing acoustic data from Cook Island vessels with the assistance of the SIOFA Secretariat. For all the new and historical acoustic data, provide a descriptive analysis including sampling periods, locations, attributes, and other relevant information.
2. Review, and revise as appropriate, the methods for assessing data quality and selection for the orange roughy acoustic data.
3. Provide an analysis of the data quality for the most recent data (post 2020) collated in objective 1 using the same techniques applied in 2018 and 2021 assessing various levels of uncertainty (e.g., species identification, survey design, target strength, absorption, calibration, and other relevant factors) at Walters Shoal (Walters shoal, WSR and Seamounts) and on the southwest Indian Rise (Meeting, South Ridge, Middle Ridge and North Ridge). Make recommendations on which acoustic data are of sufficient quality for use in the 2024 stock assessments.
4. Using the data of appropriate quality estimate the biomass of orange roughy using the same techniques applied in 2018 and 2022 and any revised techniques to provide a time series of the orange roughy biomass estimates.
5. Tabulate all the recommended acoustic biomass estimates, along with estimates of uncertainty, from all years that are suitable for use in orange roughy stock assessments.

Methods

Data supplied

Aqualyd Ltd was provided with echosounder data collected by the Sealord vessel, *Will Watch*, from June and July of 2022 and 2023, all from SIOFA area 2 (Figure 1). In contrast to earlier work (Macaulay

2022a), only data from intentional survey activities were provided, consisting of parallel vessel transects over regions of interest. No data were provided for 2021 as the vessel did not fish for orange roughy in that year (pers. comm, Charles Heaphy, Sealord Ltd).

Tow and orange roughy length data were provided from fishing activities in March 2021 and April–August 2022. These data were from tows by three vessels in SIOFA areas 2, 3a, and 3b. The acoustic survey protocols currently in use onboard *Will Watch* were also provided (Appendix B).

Echosounder calibration

Three calibrations of the echosounder on *Will Watch* were available. The first was carried out on 13 March 2022 while the vessel was in Tasman Bay, Nelson, New Zealand (Macaulay 2022d), the second on 22 April 2023, and the third on 10 June 2024, both just off Port Louis, Mauritius. The results from these calibrations were applied to the acoustic files used in the work presented here.

The survey data from 2022 were collected with the echosounder configured to use only the centre sector of the transducer (wide beam mode), while the 2023 configuration used all sectors (narrow beam mode) of the transducer. However, only narrow beam calibrations were done in 2022 and 2023. To address this, a wide beam calibration was done as part of an otherwise unrelated calibration of the vessel in 2024. Wide beam mode does not provide the split-beam positions necessary for conventional calibration processing (Demer et al. 2015) so an alternative procedure was used – the calibration target was moved to the centre of the acoustic beam while in narrow beam mode then switched to wide beam mode and data recorded. Assuming that the calibration target remains in the same location, the resulting on-axis target echoes were then used to derive the transducer gain.

Environmental data

No water property profiles were available from the vessel during the survey and data from Argo profiling floats (Wong et al. 2020) were used instead. All profiles taken in SIOFA areas 2 and the northern part of 3b in May–August 2022 and 2023 and were obtained and for each analysed acoustic survey the sound speed and acoustic absorption were derived from the closest Argo profile. Closeness was defined as the weighted sum of distance (in kilometres) between the survey location and the profile location and the time (in hours) between the start of the survey and the profile. A weight of 0.5 was applied to the distance and a weight of 1.0 to the time.

Sound speed was estimated using the TEOS-10 equations (Roquet et al. 2015), as implemented in the Python gsw package. Absorption was calculated using the Doonan equations (Doonan et al. 2003). The harmonic mean of the sound speed between the surface and 1000 m depth was used as the single-point sound speed when viewing and echo-integrating the acoustic data. The mean of the per-metre absorption between the surface and 1000 m depth was used when integrating the acoustic data.

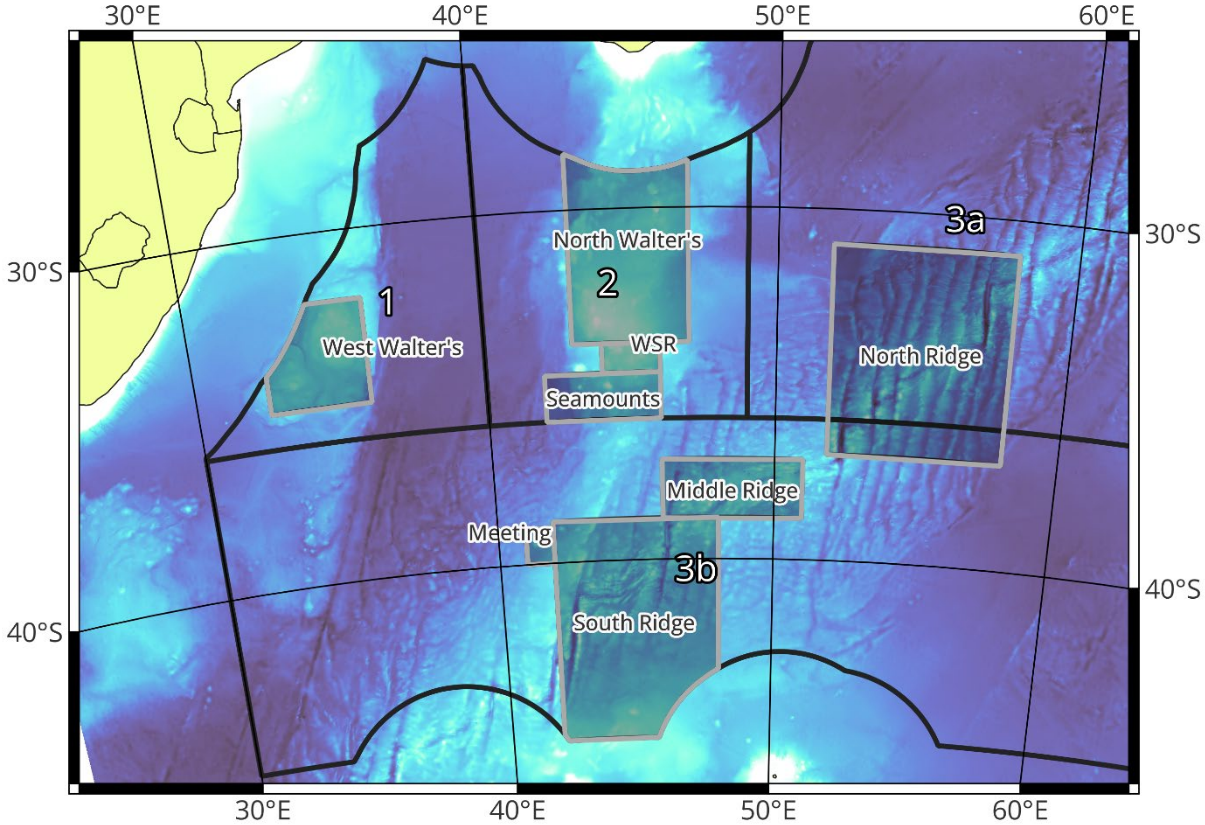

Figure 1. Location of orange roughy stock boundaries (West Walter's, North Walter's, WSR, Seamounts, North Ridge, Middle Ridge, South Ridge, and Meeting) and relevant SIOFA statistical areas (SIOFA 1, 2, 3a, and 3b) in the Southern Indian Ocean. All regions and locations are approximate. Bathymetry is derived from the GEBCO Digital Atlas, published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003.

Biological data processing

The provided tow and length data were aggregated by tow and mean length per tow calculated and attributed to known orange roughy feature names, then filtered to keep only those from features and time periods where acoustic survey data were collected. No sex data were provided.

To ensure consistency with earlier orange roughy acoustic biomass estimates in the SIOFA region, a mean orange roughy standard length of 44.6 cm was assumed, taken from the Sleeping Beauty 2009 biomass estimation (Scoulding and Kloser 2018). Length to weight relationships derived from measurements taken between 2005 and 2015 (Scoulding and Kloser 2018) were used to estimate fish weight from fish length:

$$W_m = 0.3348SL^{2.3636},$$

$$W_f = 0.2267SL^{2.4856},$$

where W_m and W_f are individual fish weight [g] for males and females respectively and SL is the standard length [cm]. A 1:1 sex ratio was assumed, from which the mean orange roughy weight used in the biomass estimation is 2.75 kg.

Acoustic pre-processing, echogram interpretation and integration

The echosounder data were provided in the Simrad 'raw' format and were pre-processed and integrated using the LSSS computer program (Korneliussen et al. 2016). The KORONA pre-processing module of LSSS was used to automatically remove noise and detect the seafloor echo. The per-survey absorption, sound speed, and echosounder calibration were applied by KORONA to the data. The KORONA processing carried out:

1. a spike filter that removed narrow vertical regions of increased signal on the echogram, replacing them with a median of the surrounding data
2. a spot noise filter that replaced individual samples with high signal level compared to the neighbouring samples with a median of the surrounding data,
3. a bubble filter than removed narrow vertical regions of decreased signal on the echogram, replacing them with a median of the surrounding data,
4. detection of the seafloor echo using the Simrad EK500 algorithm, and
5. removal of ambient background noise (Korneliussen 2000).

The parameters that controlled these operations (Table 1) were derived from the parameters used in earlier analyses (Scoulding and Kloser 2018, Macaulay 2022b) to maintain high compatibility between analyses.

Data from each survey were then manually viewed as an echogram and the seafloor line edited where it extended below the seafloor echo or where side-lobe echoes were present. Echogram noise that was not removed by the KORONA pre-processor was manually erased, as were periods where signal dropout was present (for example, due to bubble attenuation).

A map of the vessel path during the acoustic transects was viewed and used to select the start and end positions of transects. Transects were taken to be subsets of the vessel path that formed a consistent set of parallel transects in a localised area carried out in a contiguous period of time. In some cases, an area was covered more than once, typically by the vessel doing a set of parallel transects and then immediately re-covering the area with another set of transects. These were treated as separate snapshots of the same area. Backscatter within the transects that was deemed to be from orange roughy were marked and tagged as such.

Once all survey data had been inspected, orange roughy backscatter marked, noise erased and the quality of this scrutiny checked, the acoustic data were echo-integrated onto a grid with horizontal size of 100 m and vertical size of 10 m. The integrals in the form of nautical area scattering coefficients (s_A values, m^2 nmi^{-2}, MacLennan et al. 2002) were then exported for biomass estimation.

Target strength

The length to target strength relationship previously used for SIOFA orange roughy biomass estimation (Scoulding and Kloser 2018, Macaulay 2022b) was also used in the current analysis:

$$TS = 16.37\ \log_{10}\left(\overline{SL_g}\right) - 77.17, \tag{1}$$

where TS [dB re 1 m^2] is the target strength at 38 kHz of an orange roughy of length $\overline{SL_g}$[cm]. The assumed mean orange roughy length of 44.6 cm then equates to an orange roughy target strength value of –50.2 dB re 1 m^2, which is the value used in the biomass estimation.

Biomass estimation

All surveys used parallel transects – there were no star transects as in some earlier data (Macaulay 2022c). The biomass and sampling coefficient of variation (CV) for each survey were calculated (Jolly and Hampton 1990). Estimates of the survey areas were obtained by manually drawing a convex polygon around the echo-integrated transects (expanded by half the mean transect spacing for the first and last transects perpendicular to the transect direction). The area of this polygon was calculated, using a GIS program (QGIS.org 2024), via a Lambert Conic Conformal projection of the latitude/longitude survey boundary vertices.

Conversion of the 100 m resolution s_A values to per-survey biomass estimates was done via custom-written computer code that implemented the Jolly & Hampton equations. Some of the candidate survey data had no obvious orange roughy backscatter and these produced a zero biomass – such surveys were removed from the analysis at this point. Biomass estimates were rounded to the nearest 100 kg to reflect the underlying precision of the input variables.

A quantitative error assessment, following that presented in earlier analyses (Section 6 of Kloser et al. 2018, Section 4 of Scoulding and Kloser 2018, Macaulay 2022b) was also carried out.

Results

The provided echosounder data contained 15 survey-like activities on two features – Wrongford's (just outside of the Seamounts stock boundary, Figure 1) and Sleeping Beauty (in the WSR stock boundary, Figure 1). The acoustic data from both years were collected with a pulse duration of 2.048 ms and a fast pulse slope. Data from 2022 used a transmit power of 500 W and those from 2023 a power of 2000 W. The echosounder calibrations were of good quality (Table 2).

Argo CTD profiles close to the time and location of the echosounder data provided survey-specific acoustic absorption and sound speed estimates that were very consistent within each year (Table 3), so mean values of 1506.4 m s^{-1} and 8.5 dB km^{-1} were applied to the 2022 data and 1508.1 m s^{-1} and 8.4 dB $km^{-}$to the 2023 data. The Argo profiles were within 60 and 153 km of the survey locations and 0 to 63 hours of the start of each survey (Table 3). Some information on the weather conditions and vessel motion were provided with the 2023 echosounder data (Table 4).

There were data from seven tows on the Wrongford's feature and 19 on the Sleeping Beauty feature, all conducted in 2022 – 100 fish lengths were provided from each tow. The mean orange roughy length was 43.7 (s.d. ±3.8) cm at Wrongford's and 42.5 (s.d. ±3.2) cm at Sleeping Beauty (Table 5).

There were 14 surveys from which biomass estimates could be produced (Table 6) out of a total of 15 candidate surveys. One survey was removed due to there being no identified orange roughy backscatter in the acoustic transects. The biomass estimates varied from 1500 to 4300 t on Wrongford's in 2022, from 300 to 10,300 t on Sleeping Beauty in 2022, and from 4600 to 6000 t on Sleeping Beauty in 2023. The CV's ranged from 18 to 96%. All existing orange roughy acoustic biomass estimates are given in Appendix C, obtained from this and other reports (Cordue 2018a, 2018b, Macaulay 2022b) and are from the period 2004–2023.

Since the methods used to process the 2022 and 2023 data were substantially the same as used in earlier analyses, the quantitative error assessment in that work is applicable to the current analysis. Hence the error assessment for the 2022–2023 data (Table 7) is similar to earlier assessments (Macaulay 2022b).

Discussion

The quality of the acoustic data from the vessel was generally good to excellent and all of the potential surveys yielded data suitable for biomass estimation. In general, repeated surveys of the same feature in a short time period gave consistent results, lending confidence to the biomass estimates.

The number and coverage of Argo profiles was sufficient to link a profile to all surveys. The variation in acoustic absorption across these profiles was small, as was the variation in sound speed estimates (Table 3). This suggests that there is little need for survey-specific water property measurements from the surveying vessel and using the Argo profile data will be sufficient for future surveys.

The echosounder settings used in 2022 were not ideal – the transmit power was lower than normal and the acoustic beamwidth was over three times of that used in 2023, significantly reducing the acoustic signal intensity in the water. This led to more noisy echograms, although the very low levels of noise on the vessel meant that this did not materially affect the quality and usability of the data. However, these settings were not calibrated for in 2022 and 2023 and additional work was required in 2024 to obtain a suitable calibration. Fortunately, the performance of the echosounder has been very stable in 2022–2024 and the two-year period between the 2022 survey and the 2024 calibration should not give less confidence in the 2022 results.

The results presented here assume a 1:1 sex ratio of orange roughy and that the mean length for female and male orange roughy are the same as derived from earlier length data. However, mean orange roughy lengths from tows in 2022 (43.7 cm at Wrongford's, 42.5 cm at Sleeping Beauty) were shorter than used in previous analyses (44.6 cm). The TS of a 44.6 cm orange roughy (as per Eqn. (1)) is –50.2 dB (re 1 m^2), while that of a 42.5 cm fish is –50.5 dB (re 1 m^2). A difference of 0.3 dB in TS would result in a 7% change in biomass. However, given the lack of survey-specific lengths from previous surveys, it was considered more important to use a consistent length across all surveys than to introduce survey-specific lengths for just the 2022 surveys. Obtaining mean lengths for past surveys and continuing to monitor lengths in future years will be necessary to ensure that this assumption is not introducing a temporal bias to the acoustic biomass estimates.

Another assumption was that the acoustic backscatter judged to be from orange roughy was entirely from orange roughy with no intermingled species. If this assumption is incorrect, the biomass results can be significantly affected (McClatchie and Coombs 2005) and would mostly likely result in a lower biomass because many species that are found with orange roughy have higher acoustic reflectivity.

The biomass estimation presented here used, in general, the same procedures and parameters as in the 2018 and 2022 analyses (ABNJ Deep Seas Project 2017, Kloser et al. 2018, Scoulding and Kloser 2018, Macaulay 2022b) and hence no reprocessing of existing data were carried out.

Acknowledgments

The SIOFA Secretariat is thanked for facilitating access to acoustic and catch data, as are the officers and crew on *Will Watch* for collecting high quality acoustic survey data. Charles Heaphy (Sealord) is thanked for providing the acoustic data and the acoustic survey protocol used onboard *Will Watch*. Tim Ryan (Eco-Sound Solutions) and Haris Kunnath (CSIRO) are thanked for their efforts to obtain a calibration of *Will Watch's* echosounder using the 2022 configuration. The work presented in this report was funded by SIOFA.

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Table 1. KORONA pre-processing algorithm parameters.

Filter/operation	Parameter	Value	Units	Description
Spike	Total delta	14	dB	Minimum difference of current sample to search window median to be considered a spike
	Vertical delta	14	dB	Minimum difference of search column median to neighbouring pings to be considered a spike
	Vertical median search duration	0.9	ms	Half the height of the search column
	Window median search duration	4.4	ms	Half the height of the search window
Spot noise	Delta	14	dB	Candidate if centre value > 95 percentila + delta
Bubble spike	Total delta	10	dB	Minimum difference of current sample to search window median to be considered a spike
	Vertical delta	10	dB	Minimum difference of search column median to neighbouring pings to be considered a spike
	Vertical median search duration	2	ms	Half the height of the search column
	Window median search duration	4.4	ms	Half the height of the search window
Bottom	Signal threshold	–50	dB	Minimum value for a sample to be considered a bottom candidate
	Minimum bottom depth	600		Detected bottom must be greater than this value
	Maximum bottom depth	1400		Detected bottom must be less than this value

Table 2. Echosounder calibration results and configurations used in the analysis.

Parameter			
Date	13 March 2022	22 April 2023	10 June 2024
Location	Tasman Bay, NZ	Off Port Louis, Mauritius	Off Port Louis, Mauritius
Gain [dB]	25.9	26.0	16.0
Sa correction [dB]	–0.04	–0.21	–0.13
RMS error [dB]	0.13	0.11	n/a
Pulse duration [ms]	2.048	2.048	2.048
Beamwidth alongship/athwartship [°]	6.8/6.9	6.7/6.8	23.0/23.0
Transmit power [W]	2000	2000	500
Equivalent beam angle [dB re 1 sr]	–20.7	–20.7	–10.4
Transducer models/serial	ES38-7/309	ES38-7/309	ES38-7/309
Software/version	EK80/1.12.2.0	EK80/1.12.2.0	n/a
Calibration sphere	WC38.1	WC38.1	WC38.1

Table 3. Environmental properties derived for each survey from the closest available (in time and distance) Argo profile.

Area	Feature	Survey start date	Mean temperature [°C]	Mean salinity [PSU]	Mean sound speed [m s^{-1}]	Mean absorption [dB km^{-1}]	Distance [km]	Time [h]
Seamounts	Wrongford's	2022-06-21	12.4	35.3	1506.7	8.5	152	31
		2022-06-21	12.4	35.3	1506.7	8.5	152	30
		2022-06-23	12.4	35.3	1506.7	8.5	153	32
		2022-06-23	12.4	35.3	1506.7	8.5	152	33
WSR	Sleeping Beauty	2022-06-22	12.4	35.3	1506.7	8.5	60	0
		2022-06-22	12.4	35.3	1506.7	8.5	63	1
		2022-07-01	12.2	35.3	1506.0	8.5	103	28
		2022-07-01	12.2	35.3	1506.0	8.5	105	26
		2022-07-01	12.2	35.3	1506.0	8.5	106	25
		2022-07-01	12.2	35.3	1506.0	8.5	104	24
		2022-07-04	12.2	35.3	1506.0	8.5	104	56
		2022-07-04	12.2	35.3	1506.0	8.5	105	58
		2023-06-27	8.5	34.9	1508.1	8.4	91	63
		2023-06-28	8.5	34.9	1508.1	8.4	90	46

2023-06-28	8.5	34.9	1508.1	8.4	89	45

Table 4. Vessel-provided metadata for the surveys carried out in 2023.

Snapshot	1	2	3
Wind direction/speed (knots)	SE/13	SE 11	NW 12
Surface temperature (°C)	19.6	19.5	19.3
Pitch	low	low	moderate
Roll (°)	7	7	10
Sample tow #	#74	None, same marks as snapshot 1	#92

Table 5. Mean orange roughy length on surveyed features in the survey months.

Feature	Tow date	Mean length [cm]	Standard deviation [cm]
Wrongford's	2022-06-15	43.2	3.3
	2022-06-18	44.1	4.0
	2022-06-20	43.2	4.1
	2022-06-20	43.8	3.7
	2022-06-23	45.0	3.2
	2022-06-24	44.8	4.2
	2022-06-30	42.0	2.8
Sleeping Beauty	2022-06-22	42.7	3.7
	2022-06-26	42.0	2.8
	2022-06-30	42.3	3.2
	2022-07-01	43.0	3.4
	2022-07-01	43.3	3.1
	2022-07-02	42.0	3.1
	2022-07-03	43.5	3.6
	2022-07-03	41.6	3.0
	2022-07-04	42.1	3.2
	2022-07-04	42.1	3.7
	2022-07-05	43.0	3.3
	2022-07-06	41.6	2.4
	2022-07-06	41.8	2.8
	2022-07-08	41.7	2.7
	2022-07-11	42.7	3.0
	2022-07-11	43.2	3.6
	2022-07-12	43.3	3.5
	2022-07-12	43.2	3.1
	2022-07-13	42.2	2.9

Table 6. Biomass, sampling coefficient of variation (CV), fish areal density, and metadata for surveys that had identified orange roughy backscatter.

Area	Feature	Survey start date	Snapshot	Mean fish density [fish/m^2]	Biomass [t]	Sampling CV [%]	Number of transects	Survey area [km^2]
Seamounts	Wrongford's	2022-06-21	1	0.17	2400	22	5	5.2
		2022-06-21	2	0.30	4300	57	5	5.3
		2022-06-23	3	0.09	1500	96	6	6.3
WSR	Sleeping Beauty	2022-06-22	1	0.27	8700	26	7	11.9
		2022-06-22	2	0.14	4700	83	6	12.6
		2022-07-01	3	0.36	3800	50	4	3.9
		2022-07-01	4	0.59	10 300	34	6	6.3
		2022-07-01	5	0.33	6700	47	6	7.4
		2022-07-01	6	0.12	300	93	3	1.0
		2022-07-04	7	0.32	6700	38	6	7.6
		2022-07-04	8	0.24	5200	38	8	7.8
		2023-06-27	1	0.36	6000	22	6	6.1
		2023-06-28	2	0.32	5100	22	6	5.8
		2023-07-03	3	0.18	4600	18	11	9.4

Table 7. Error assessment for the 2022-2023 surveys based on typical error sources.

	Expected error bounds			
Error	**Factor**	**Measured or assumed**	**Uncertainty of error not bounded**	**Notes**
Calibration on axis gain	0.9 to 1.1	assumed	low	Calibration followed standard procedures
Calibration of beam	0.8-1.2	assumed	high	Effective beam pattern not measured
Species ID of echoes	0.8-1.1	measured	low	Fishers' feedback of low bycatch in region, expert judgement, and AOS in 2014 showed similar structures were orange roughy
Target strength	0.63-1.0	measured	low	Difference in observed to default equation
Near seabed estimate	0.95-1.05	measured	low	Very low <2 % estimate of fish in deadzone
Absorption	1.0-1.31	measured	low	Default use of Doonan equation difference to F&G
Vessel motion	1.0-1.2	assumed	low	Weather was good
Attenuation	1.0-1.1	assumed	low	Weather was good
Noise	0.95-1.0	assumed	low	Low noise observed
Fish availability	1.0-1.2	assumed	medium	Feedback from industry and compared to other estimates in same area over years, survey bounded the aggregation
Fish movement	0.8-1.2	assumed	Medium	Could be significant
Survey sampling error	0.7-1.3	measured	low	Use of standard methods
Survey analytical method	0.8-1.7	measured	low	Use of standard methods
Area estimation	0.78-1.0	measured	low	

Appendix A

The project terms of reference are available online (https://siofa.org/science/sc-works/ORY-2023-02) and are also repeated below:

2. TERMS OF REFERENCE

2.1. Objectives

1. Collate the existing acoustic data from Cook Island vessels with the assistance of the SIOFA Secretariat. For all the new and historical acoustic data, provide a descriptive analysis including sampling periods, locations, attributes, and other relevant information.
2. Review, and revise as appropriate, the methods for assessing data quality and selection for the orange roughy acoustic data.
3. Provide an analysis of the data quality for the most recent data (post 2020) collated in ToR 1 using the same techniques applied in 2018 and 2021 assessing various levels of uncertainty (e.g., species identification, survey design, target strength, absorption, calibration, and other relevant factors) at Walters Shoal (Walters shoal, WSR and Seamounts) and on the southwest Indian Rise (Meeting, South Ridge, Middle Ridge and North Ridge). Make recommendations on which acoustic data are of sufficient quality for use in the 2024 stock assessments.
4. Using the data of appropriate quality estimate the biomass of orange roughy using the same techniques applied in 2018 and 2022 and any revised techniques to provide a time series of the orange roughy biomass estimates.
5. Tabulate all the recommended acoustic biomass estimates, along with estimates of uncertainty, from all years that are suitable for use in orange roughy stock assessments.

2.2. Reporting requirements

1. Provide updates and engage with the project advisory panel that will assist the consultant access and interpret reports, data, and to provide advice on relevant analyses or data interpretation for the project.
2. Present the preliminary methods and results of the project as indicated in Section 3. Take into account any comments made during this presentation in the following part of the work.
3. Provide a draft report detailing the methods, outcomes of project objective investigation as listed in the overall objectives, conclusions, and recommendations to the SIOFA project advisory panel for review by the dates indicated in Section 3.
4. Update the draft report in by considering any comments and advice from the project advisory panel and submit this final report to SIOFA Secretariat for submission to the following SIOFA Scientific Committee annual meeting. The report should include a table of the acoustic survey protocol currently in use as an appendix.
5. Provide all the information collected to the SIOFA Secretariat (including that sourced from the Secretariat) before the final payment of the contract. Such information includes electronic data files, analysis codes, biological samples, and other relevant data if applicable.

Presentations of report to the Scientific Committee may be given virtually and travel to the meetings is not obligatory.

2.3. Confidentiality and distribution of project outcomes

The Consultant shall not release confidential data provided for conducting this study to any persons nor any organisations, other than SIOFA Secretariat. The consultant shall delete all the confidential data after the completion of the contract. Any arrangements for ownership, storage, or disposal of physical samples shall be agreed by SIOFA as a part of the contract.

All Intellectual Property generated as a part of this contract shall become the property of SIOFA unless otherwise excluded in the proposal and agreed by SIOFA in the contract.

All reports and presentations will be reviewed by the SIOFA Secretariat prior to any form of further distribution. The Consultant will revise the report according to comments received from the review process before the report or presentation is accepted as a submission against the requirements in these Terms of Reference.

2.4. Relevant SIOFA information

1. SIOFA data (provided by the SIOFA Secretariat upon request)
2. SIOFA spatial data layers. Available on https://github.com/SIOFASecretariat/SIOFA_SC_Spatial_layersAvailable on https://github.com/SIOFASecretariat/SIOFA_SC_Spatial_layers
3. SIOFA reporting templates. Available on https://github.com/SIOFASecretariat/SIOFA_Reporting_templatesAvailable on https://github.com/SIOFASecretariat/SIOFA_Reporting_templates
4. SIOFA reports:
   a. SIOFA SC, SC Working Group, and National Reports. Scientific Committee Meeting | SIOFA (https://siofa.org/)
   b. SIOFA MoP reports. Meeting of the Parties | SIOFA (https://siofa.org/)
   c. SIOFA technical and scientific reports (public reports and abstracts of restricted reports are available from https://siofa.org/, and full restricted reports will be made available by the SIOFA Secretariat to the project consultant upon request and after the approval of concerned CCPs.

Appendix B

The following is the acoustic survey protocol currently in use onboard *Will Watch*.

Where:

Walters Shoal Region (WSR)

- Wrongfords Acoustic /biological survey (or other Walters Seamount Aggregation)
  - Vessel survey 3 snapshots. Biologicals
- Sleeping Beauty Acoustic/ biological survey (or other South Walters Aggregation)
  - Vessel survey 3 snapshots. Biological
- Northern Walters Stock (DaVinci or Angelo's)
  - Vessel survey 3 snapshots. Biological

South West Indian Ocean Ridge (SWIOR)

On the main ridge we need to focus on where the biggest aggregations are. And preferably where the aggregations are just ORY with very little bycatch. Maybe: Davids, Fredericks (or nearby), Leo's, Fruitsalad and anywhere up north if you get lucky.

- At least three features
  - Vessel survey 3 snapshots. Biologicals

When:

- Surveys should be conducted at peak spawning aggregation for each feature
- When fish are aggregated for spawning and preferably when they become fully available (clear of the seabed echo) to the acoustic observation system. One of the best indicators is when the fish begin to form plumes.
- Pick the time of day when the plume is most dense for at least one of the snapshots

How: Acoustic surveys

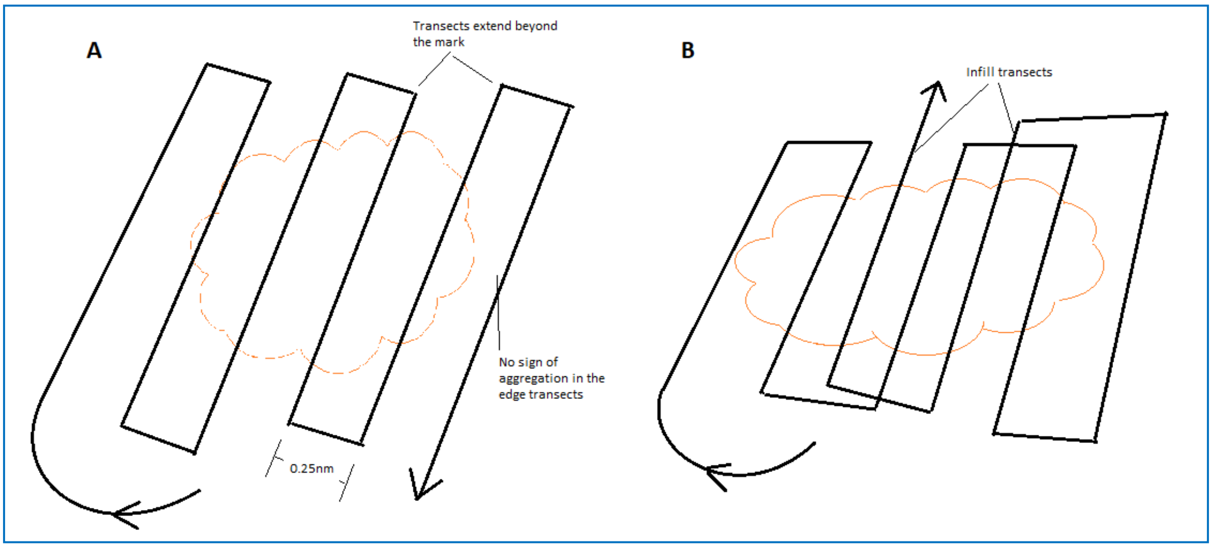
Each acoustic survey should be comprised of three snapshots and ideally each snapshot is followed by a mark identification tow. The mark ID tow tells us if there are other species mixed in with the roughy as well as collection of all the biological information we need.

For each mark ID tow, get a really accurate assessment of bycatch species – because ORH are acoustically quiet (no gas bladder) even a few small fish can change the abundance estimate.

If you have caught a big bag, it is ok to do all 3, or remaining 2, snapshots while processing. Then finish up with another mark ID tow.

Flats/banks – aggregations tend to be more mobile, irregular shaped and spread out, so a **grid survey** is to be used:

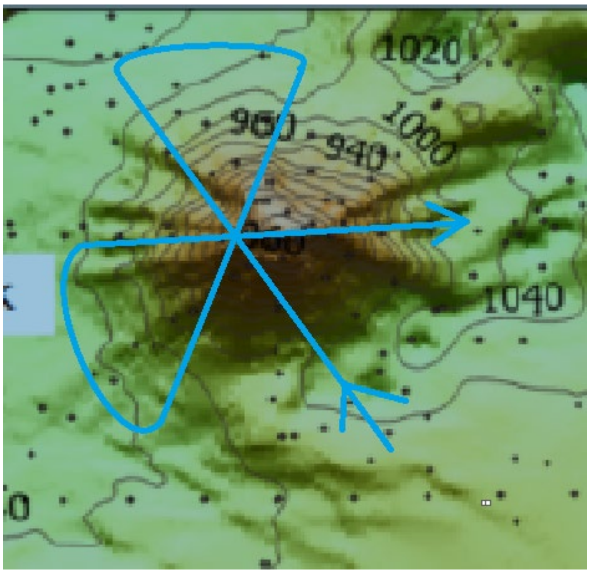
- Survey at comfortable steaming speed, ensuring that ends of transects and outside tracks are past the edges of the mark
- Do a minimum of four transects crossing the area of the aggregation. Rough spacing guide say 0.25 nmil
- The best snapshot design is an interleaved survey, this controls for fish movement over the time of the snapshot.
- If the edge of the aggregation is reached with not enough transects hitting the plume, do infill (interleaved) transects.



Grid transects: A) OK survey with the minimum number of transects across the mark and B) better survey with interleaved transects and five across the mark

For hill surveys a **star pattern snapshot** is best.

- Minimum of three transects (four is better, but if you need to catch fish just do three)
- Centre the snapshot on the middle of the aggregation (rather than the top of the pinnacle)



Star snapshot: centred on the spawning plume, minimum of three transects.

Vessel data:

- Keep a log of the timeline for each survey, just use a word doc or excel. Record the start, end, and number of transects for each snapshot; then time of mark ID/biological shot etc.
- Record in the log all the available vessel data. Wind speed, surface temperature, and include comments on vessel pitch/roll – everything helps.
- Please record water temperatures on your mark ID tows – start and end of tow. Depths can be obtained from the trawl e-log.

Biological sampling – for each mark ID tow associated with a survey snapshot

- Total catch weight and weight of each species in the bag
- Random sample 100 fish. Collected from start, middle and end of bag (for big bags)

- Length + weight by sex
- Collect otoliths as per current protocol
- Gonad staging for females

Data management:

It is important that acoustic, biological and environmental data are all labelled with time and date. All trawl sourced data should have the *Will Watch* trip and shot numbers.

For each survey make a folder and label it with the name of the feature and the date. Keep all the data for each feature survey in the same folder. When a survey is complete for the feature copy the folder onto the external hard drive.

Make sure your data is backed up!

Sounder settings for the EK80:

- Turn off all other sounders prior to starting snapshot
- Run EK80 in CW (continuous wave) mode. NOTE: It is important that data is not collected in FM (frequency modulated) mode
- 2000 W and 2.048 ms pulse duration
- Ensure transducer mode is Narrow, not Wide

Appendix C

All available biomass estimates and estimates of uncertainty are provided here for years 2018–2023 (Table 8) and prior to 2018 (Table 9).

Table 8. Acoustic biomass estimates from 2018-2023.

Area	Feature	Survey start date	Transect type	Mean fish density [fish/m^2]	Biomass [t]	Sampling CV [%]	Number of transects	Survey area [km^2]
North Ridge	Fruitsalad	2018-07-25	parallel	0.31	1800	43	6	2.1
		2018-08-30	star	0.11	400	36	11	1.2
North Walter's	Angelo's	2019-06-07	parallel	0.16	500	15	3	1.1
	Da Vinci's	2018-06-20	parallel	0.07	300	104	5	1.6
South Ridge	Crayfish	2018-08-28	parallel	1.21	6900	23	14	2.1
	Boulder	2018-07-03	parallel	0.51	4100	29	6	2.9
		2018-07-03	parallel	0.44	2000	41	6	1.7
		2018-07-03	parallel	0.66	3000	20	5	1.7
WSR	Grover	2018-07-05	parallel	0.40	1000	14	4	0.9
	Porky's	2018-07-01	parallel	0.19	700	18	8	1.4
		2018-07-09	parallel	0.01	200	68	7	5.0
	Sleeping Beauty	2018-07-01	parallel	0.35	2500	25	6	2.6
		2018-07-02	parallel	0.11	1400	33	6	4.7
		2018-07-04	parallel	0.27	1800	29	4	2.5
		2018-07-12	parallel	0.04	800	53	6	7.9
		2022-06-22	parallel	0.27	8700	26	7	11.9
		2022-06-22	parallel	0.14	4700	83	6	12.6
		2022-07-01	parallel	0.36	3800	50	4	3.9
		2022-07-01	parallel	0.59	10 300	34	6	6.3
		2022-07-01	parallel	0.33	6700	47	6	7.4
		2022-07-01	parallel	0.12	300	93	3	1.0
		2022-07-04	parallel	0.32	6700	38	6	7.6
		2022-07-04	parallel	0.24	5200	38	8	7.8
		2023-06-27	parallel	0.36	6000	22	6	6.1
		2023-06-28	parallel	0.32	5100	22	6	5.8
		2023-07-03	parallel	0.18	4600	18	11	9.4
Seamounts	Wrongford's	2018-06-22	parallel	0.08	1700	49	7	7.6
		2018-06-24	parallel	0.16	1100	28	4	2.5
		2018-06-27	parallel	0.04	1000	104	8	10.3
		2018-06-28	parallel	0.01	300	98	7	12.8
		2018-07-05	parallel	0.44	11 000	40	7	9.1
		2018-07-05	parallel	1.36	50 400	89	7	13.5
		2018-07-19	parallel	0.35	6900	23	7	7.0
		2019-06-22	parallel	0.27	2500	21	5	3.5
		2019-06-23	parallel	0.25	400	21	4	0.6
		2019-06-23	parallel	0.23	1300	17	5	2.1
		2020-07-13	star	0.57	6400	66	18	4.1
		2022-06-21	parallel	0.17	2400	22	5	5.2
		2022-06-21	parallel	0.30	4300	57	5	5.3
		2022-06-23	parallel	0.09	1500	96	6	6.3

Table 9. Acoustic biomass estimates prior to 2018 (extracted from Cordue 2018b, 2018a). The link between feature number and feature name is given in Table 10.

Area	Feature	Survey start date	Biomass [t]	Sampling CV [%]	Source
Seamounts	1	2009	381	55	Table 2a
Seamounts	1	2010	1345	35	Table 2a
Seamounts	2	2010	3331	18	Table 2a
Seamounts	3	2009	9635	16	Table 2a
North Walters	1	2009	4841	36	Table 2b
North Walters	2	2009	3136	30	Table 2b
Middle Ridge	1	2004	8463	58	Table 2c
Middle Ridge	2	2004	6892	26	Table 2c
Middle Ridge	2	2008	2451	37	Table 2c
Middle Ridge	3	2004	9311	57	Table 2c
Middle Ridge	4	2009	6924	30	Table 2c
Middle Ridge	4	2011	15635	34	Table 2c
Middle Ridge	5	2008	3179	25	Table 2c
WSR	1	2007	2902	11	Table B1
WSR	1	2015	3788	32	Table B1
WSR	2	2015	3164	12	Table B1
WSR	3	2015	3779	20	Table B1
WSR	4	2007	7923	10	Table B1
WSR	4	2009	10618	30	Table B1
WSR	5	2009	1806	21	Table B1
WSR	5	2011	1737	43	Table B1
WSR	1	2004	7549	51	Table B2
WSR	1	2004	6114	44	Table B2
WSR	1	2004	8923	37	Table B2
WSR	1	2004	9308	25	Table B2
WSR	1	2004	7951	19	Table B2
WSR	1	2007	2902	11	Table B2
WSR	1	2009	3327	34	Table B2
WSR	1	2010	4542	32	Table B2
WSR	1	2015	3788	32	Table B2
WSR	1	2015	4043	21	Table B2
WSR	3	2015	5648	27	Table B2
WSR	4	2009	5752	30	Table B2
WSR	4	2009	9137	29	Table B2
WSR	4	2009	9562	40	Table B2
WSR	4	2009	17289	36	Table B2
WSR	4	2009	9108	33	Table B2
WSR	4	2009	10170	17	Table B2
WSR	4	2010	13542	26	Table B2
WSR	4	2010	8240	23	Table B2
WSR	4	2010	10891	18	Table B2
WSR	4	2015	5269	30	Table B2
WSR	4	2009	2501	34	Table B2
WSR	5	2011	1737	43	Table B2

Table 10. Link between feature number and feature name for surveys prior to 2018, as deduced via data in the Source column.

Area	Feature number	Feature name	Source
WSR	1	Boulder	SC-03-07.1.1(01), Table 9.2
	2	OK Coral	SC-03-07.1.1(01), Table 9.2
	3	Porky's	SC-03-07.1.1(01), Table 9.2
	4	Sleeping Beauty	SC-03-07.1.1(01), Table 9.2
	5	Sleepy Hollows	SC-03-07.1.1(01), Table 9.2
Seamount	1	Grover	casal files
	2	Novel	casal files
	3	Wrongford's	casal files
North Walters	1	uncertain	
	2	uncertain	
Middle Ridge	1	Harlot	casal files
	2	M.M.	casal files
	3	Scud	casal files
	4	Zedric	casal files
	5	Sugarol	casal files