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Trial acoustic surveys of alfonsino in the southern Indian Ocean, December 2025

The Common Oceans Deep-sea Fisheries Project, FAO

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Abstract

Three acoustic surveys targeting alfonsino were conducted during RV Dr. Fridtjof Nansen voyage 2025004012 (20 Nov–11 Dec 2025) in the SIOFA Area, south of Walter's Shoal on the Madagascar Ridge. Surveys covered 70.3 km^2 using calibrated 18 and 38 kHz echosounders and standard echo-integration methods. Biomass estimates relied on an existing length–target strength relationship and biological data from two nearby trawl hauls.

Alfonsino-like aggregations were observed only during night-time surveys—at depths of 850–950 m, 100–150 m above the seabed—consistent with known diel vertical migration. Aggregations were typically 150–500 m wide and up to 150 m high. Indicative biomass estimates were ~2,200 t and ~300 t for the two night surveys, but coefficients of variation exceeded 300%, reflecting extreme spatial patchiness. Estimates remain highly tentative due to uncertain mark identification, lack of targeted trawl validation, use of non-local biological samples, and a target strength relationship derived from distant populations.

Nonetheless, results confirm that southern Indian Ocean alfonsino form discrete, near-bottom aggregations detectable by acoustics—especially at night. Future surveys require improved trawl validation, region-specific target strength parameters, and more intensive sampling to reduce uncertainty. Given logistical constraints, collaboration with deepwater fishing vessels—equipped with calibrated echosounders or towed systems—could offer a practical monitoring pathway. With refinement, acoustic methods could support regional stock assessment.

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Trial acoustic surveys of alfonsino in the southern Indian Ocean, December 2025

DEEP-SEA FISHERIES RESOURCES SURVEY IN THE SIOFA CONVENTION AREA

Gavin Macaulay

Executive Summary

Three acoustic surveys targeting alfonsino were conducted as part of voyage 2025004012 of the RV Dr. Fridtjof Nansen (20 November to 11 December 2025) in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area. The surveys were carried out at Station X, south of Walter's Shoal on the Madagascar Ridge, and comprised three sets of parallel-transects over an area of 70.3 km². Calibrated 18 and 38 kHz echosounders were used and data were processed using established echo-integration methods. Biomass estimates were derived using an existing length to target strength relationship and biological data from two nearby trawl hauls.

Alfonsino-like aggregations were observed only during night-time surveys, consistent with known alfonsino vertical behaviour, at seafloor depths of 850-950 m. These were typically 150–500 m wide and up to 150 m high, 100–150 m above the seafloor. Mean backscattering coefficients differed substantially between surveys, resulting in indicative biomass estimates of approximately 2,200 t and 300 t, respectively, for the two night-time surveys. However, sampling coefficients of variation exceeded 300%, reflecting high spatial patchiness. Biomass estimates remain very tentative due to uncertainty in mark identification, absence of targeted validation trawls on acoustic marks, reliance on substitute biological samples, and use of a target strength relationship derived from alfonsino populations outside the region.

The surveys demonstrated that alfonsino in the southern Indian Ocean form aggregations amenable to acoustic assessment, particularly at night when fish are clear of the seabed. Future surveys will require improved trawl validation, refined target strength information specific to the region, and potentially more spatially focused or intensive sampling designs to reduce sampling uncertainty. Given logistical constraints in this remote area, collaboration with deepwater fishing vessels—either equipped with quantitative echosounders or using towed acoustic systems—may provide a practical and cost-effective approach. With further methodological refinement and repeated surveys, acoustic approaches could become a reliable component of alfonsino stock assessment in the region.

Introduction

The work presented in this report was conducted during a fixed-term consultant employment with FAO as part of FAO's "Deep-sea Fisheries under the Ecosystem Approach" (DSF) project under the GEF-7 ABNJ Program "Global Sustainable Fisheries Management and Biodiversity Conversation in the Areas Beyond National Jurisdiction". A component of the DSF project were trial acoustic surveys of alfonsino (*Beryx splendens)* in cooperation with the EAF-Nansen programme and partnering with the Southern Indian Ocean Fisheries Agreement (SIOFA).

The consultant's tasks were to:

1. Lead in the preparation of the acoustics sections of the sailing orders to ensure that they include the necessary equipment calibrations and standards, the appropriate survey design, and suitable data storage systems, including attending online meetings as required,
2. Be available for contact during the cruise period to provide expert advice and guidance should this be required during the cruise (and potentially to undertake initial data analysis during the cruise to confirm validity of the results),
3. Undertake data analysis post-cruise on the acoustic data collected and the supporting fisheries information from the trawls,
4. Prepare the technical report on the findings of the acoustic work and submit it to SIOFA's scientific committee through the Secretariat. The consultant should be available to present this to SIOFA's SC and, as an international acoustics expert, provide recommendation on the feasibility of undertaking alfonsino biomass determination in the Indian Ocean,
5. Submit to FAO a short report summarizing the work and documenting the conclusions.

This report addresses item 4 above and contains the work of item 3. The executive summary of this report corresponds to item 5 above. Details on the overall objectives of the cruise and other data collected are available in the voyage report (Axelsen et al., 2026)

Methods

Acoustic data and surveys

Echosounder data were collected during voyage 2025004012 of *RV Dr. Fridtjof Nansen* from 20 November to 11 December 2025 (Axelsen et al., 2026) in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area (Figure 1). Acoustic data from parallel transect surveys of alfonsino were provided for one area (station X, south of Walter's Shoal, which is near the southern end of the Madagascar Ridge) and form the basis of the work in this report.

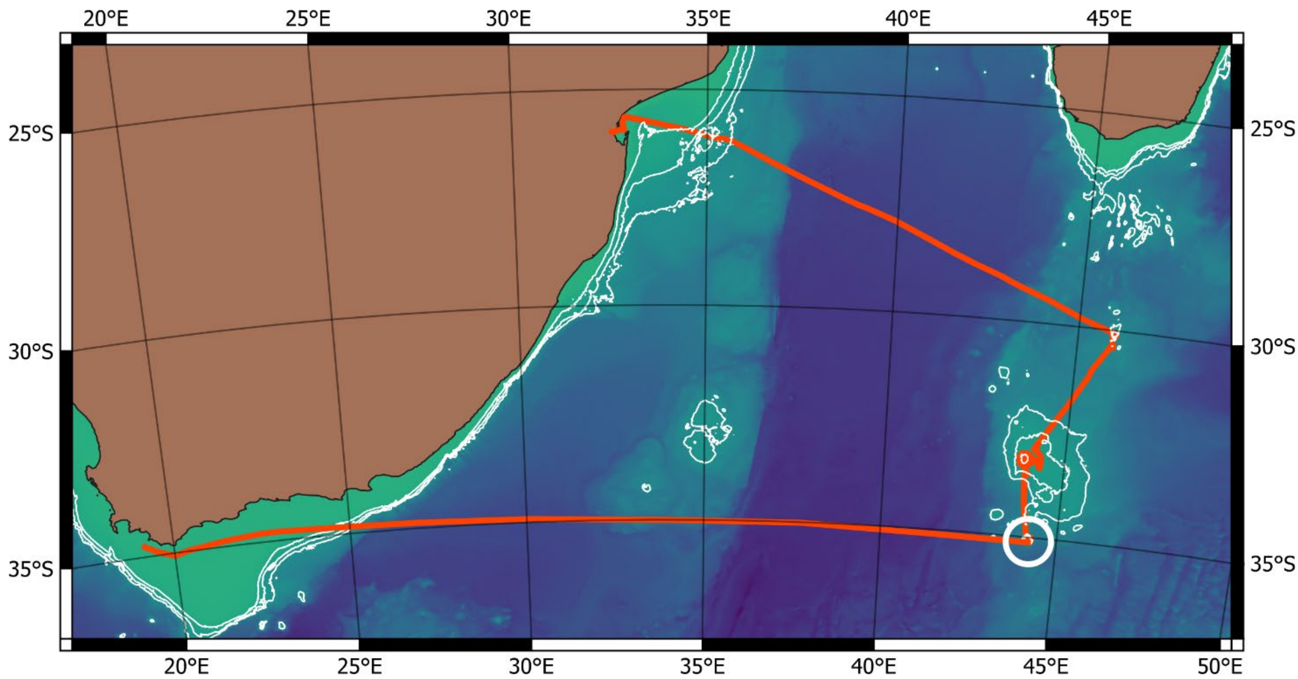

Figure 1. Overview of vessel track (orange path) during the voyage and location of alfonsino surveys (within white circle). The vessel departed from Maputo, Mozambique and arrived at Cape Town, South Africa at the end of the voyage. Contours are at 500, 1000, and 1500 m depths. Background bathymetry from GEBCO Compilation Group, 2025 (doi:10.5285/ 37c52e96-24ea-67ce-e063-7086abc05f29)

The echosounder data were scrutinized onboard and echogram marks partitioned and annotated with expected species compositions based on the "historically used convention for the area" and that were "agreed upon a priori" (Axelsen et al., 2026). Using the LSSS acoustic analysis program (Korneliussen et al., 2006), the seafloor line was applied, noise and off-transect periods masked out, and echo integrals calculated along each transect into 185.2 m (0.1 nmi) horizontal bins. These integrals were exported to a file and further analysis was carried out by custom-written Python scripts. The echosounder configuration was as per standard survey settings (Table 1) and was calibrated on 27 October 2025, offshore from Mozambique (36 days before the start of the alfonsino surveys). Due to the depth at which alfonsino marks were observed (>700 m), only the 18 and 38 kHz echosounder channels were used in the analysis.

Estimates of mean area backscattering coefficient, s_a (MacLennan et al., 2002), in each transect and over each survey were calculated using the method of Jolly & Hampton (1990). The survey area was 70.3 km^2, calculated as the area of the convex hull of the ten transects scaled by a factor of $1 + {}^{1}/_{n}$, where *n* is the number of transects in the survey.

Under the assumption that the alfonsino proportions in the identified marks were correct, an indicative biomass estimate was calculated. The mean s_a values were converted to numbers of alfonsino by dividing by the backscattering cross-section, σ_{bs} (MacLennan et al., 2002), of an alfonsino of mean length and thence to a biomass by multiplying by a mean alfonsino weight.

No alfonsino individuals were sampled from the survey area and as a substitute, two trawls (id no. 6108, deployed 3 hours prior to the start of the survey and id no. 6109, deployed in the period between the second and third surveys), about 3 km to the north west of the acoustic survey area (Figure 2) were used. The total length (TL, as measured onboard) and weight of the 120 alfonsino individuals caught in these two trawls were used to calculate the mean standard length (SL) and weight, after converting from total to standard length via SL = 0.77 TL (Shotton, 2016, sec. 2). A length to target strength relationship, $TS = 20\log_{10} L - 67.7$, where L is standard length, cm, and TS the target strength, dB re 1 m^2, at 38 kHz was used to estimate σ_{bs} (where $TS = 10\log_{10}\sigma_{bs}$). This relationship was derived from in-situ alfonsino measurement above seamounts off the coast of Chile (Niklitschek et al., 2007). This length to TS relationship has been used previously for alfonsino biomass estimation in the southern Indian Ocean (e.g., Niklitschek and Patchell, 2015).

Table 1. Echosounder configuration and relevant echo-integration parameters used during the surveys.

Parameter		Value
Operating frequency (kHz)	18	38
Transducer model	ES18	ES38-7
Transducer serial	2145	578
Transceiver serial	580703	580713
Pulse duration (ms)	1.024	1.024
Transmit power (W)	1000	2000
Ping interval (s)	2.2	2.2
System gain (dB)	23.04	26.29
S_a correction (dB)	0.06	0.08
Equivalent beam angle (sr)	0.0200	0.0085

Results

Three surveys were conducted (Table 2) using ten parallel transects spaced approximately 920 m (0.5 n. mile) apart (Figure 2), beginning on 2 December 2025 (UTC). Each survey took 8.5–10 hours to complete and 44 hours elapsed between the start of the first survey and the end of the third survey. The first survey was nominally conducted during the day and other two nominally during the night. In the survey location, sunrise occurred at 01:42 UTC and sunset at 16:03 UTC on 4 December 2025. As a result, the end of survey 1 and start of survey 2 occurred at dusk and survey 3 ended about 2 hours after sunrise.

Table 2. Alfonsino survey timings at Station X, South of Walter's Shoal.

Survey number	1	2	3
Start time (UTC)	2025-12-02 07:48	2025-12-02 16:18	2025-12-03 17:56
End time (UTC)	2025-12-02 16:16	2025-12-03 02:09	2025-12-04 03:40
Duration (hours)	8.5	9.8	9.7

Marks considered to be alfonsino were observed in a subset of the surveyed area (Figure 2) during surveys 2 and 3, and were typically aggregations 150 to 500 m wide, up to 150 m high, and 100-150 m clear of the seafloor (Figure 3). No alfonsino-like marks were seen during the first (daytime) survey. On two occasions during survey 2, the vessel returned to a mark detected during the standard transect. The first was 55 minutes later and no mark was present. The second was revisited 15 minutes later and the mark was still present. A pass another 15 minutes later about 400 m to the southwest found a similar aggregation, suggesting that the aggregation was moving in a south-westerly direction.

No targeted tows on the surveyed aggregations were made due to unsuitable trawling conditions[3], and the species composition of these marks cannot be confidently attributed to alfonsino. However, the characteristics of the marks, such as their size and location in the water column, and diurnal behaviour are consistent with other examples of alfonsino marks (e.g., Shotton, 2016, fig. 13).

The mean alfonsino standard length from the two substitute trawls was 24.4 cm and the mean weight was 0.44 kg (Figure 4). Via the length-to-TS relationship of Niklitschek et al. (2007), this gave a mean TS of –40.0 dB (re 1 m^2). None of the alfonsino caught in the substitute trawls were in spawning condition.

The mean area backscattering coefficients were 7.2×10^{-6} and 0.9×10^{-6} m^2 m^{-2} for surveys 2 and 3, respectively (or as mean nautical area scattering coefficients, 311 and 40 m^2 nmi^{-2}), with a survey sampling coefficient of variation (CV) greater than 300% for both surveys. Using the estimated alfonsino TS and mean weight, this converts to a biomass of 2200 and 300 t for surveys 2 and 3, respectively.

[3] The *Dr. Fridtjof Nansen* was unable to shoot at these locations but a commercial fishing vessel such as the F/V *Will Watch* would have been able to shoot on all the observed aggregations (Phil Gaugler (ex-*Will Watch* skipper), on-board and pers. com.)

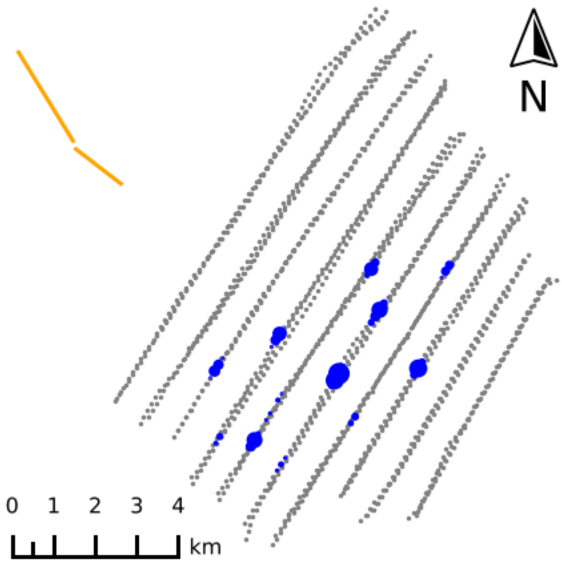

Figure 2. Overview of all survey transects (grey dots, one at each echo-integral grid spacing of 185.2 m) at Station X, south of Walter's Shoal, Southern Indian Ocean. Each survey repeated the same transects so tend to overlay each other in the map. Also shown are marks allocated to alfonsino (blue circles with larger diameters indicating stronger backscatter) and the two trawls (orange lines) used for mean length and weight of alfonsino. Map coordinates are intentionally not provided.

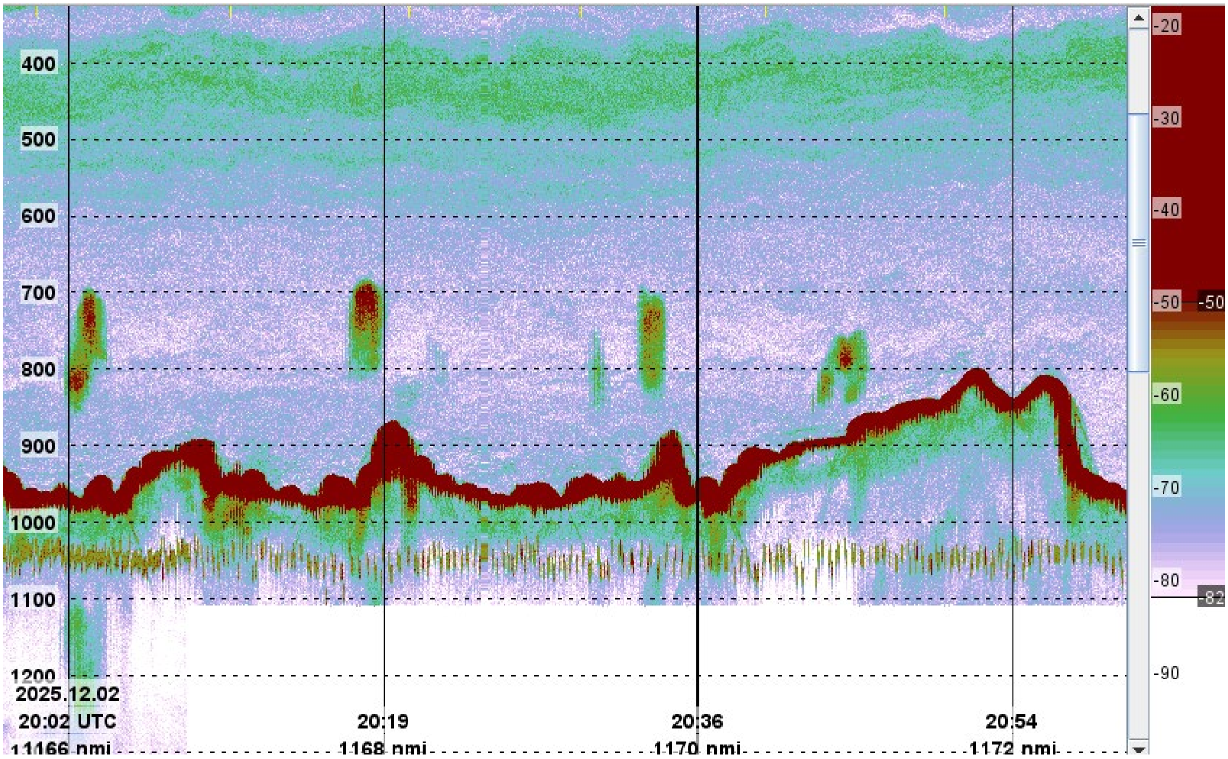

Figure 3. A 38 kHz echogram showing alfonsino marks 100-150 m clear of the seafloor during survey 2. The first mark was seen on a survey transect, while the next two were passes of the vessel over the same location. The fourth was a separate mark seen after resuming the survey transect. Echogram colours correspond to the volume backscattering coefficient, S_v [dB re 1 m^{-1}], as per the colour bar; the depth (m) below the surface is given by the scale on the left of the echogram; time (UTC) and distance (nmi) travelled are along the bottom of the echogram.

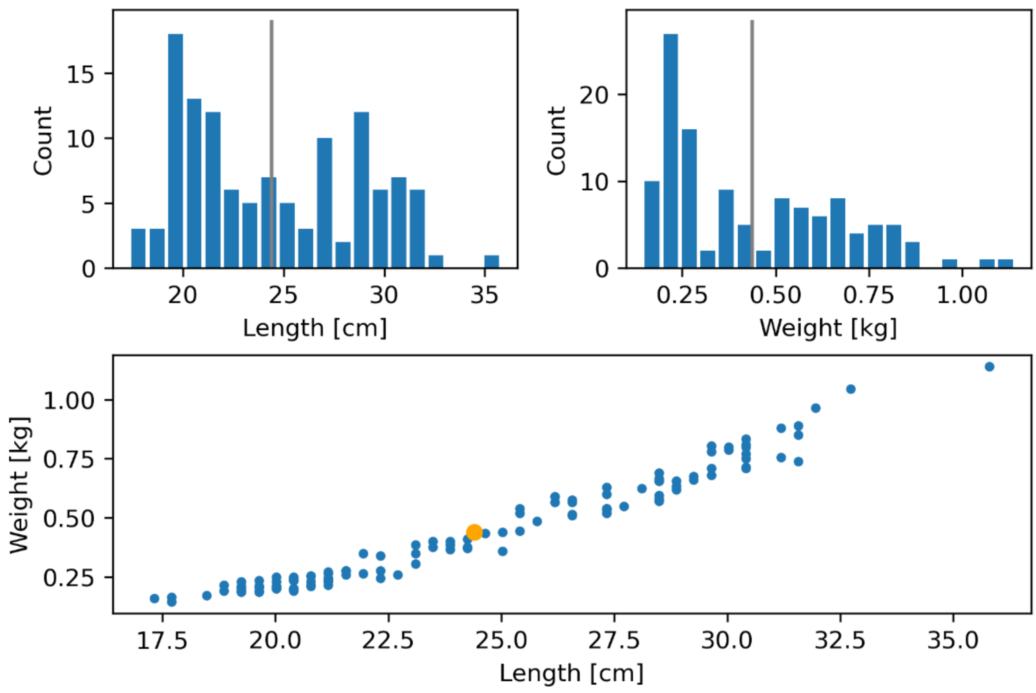

Figure 4. Standard length (upper left) and weight (upper right) distributions for the alfonsino caught in two hauls close to the survey area, and the standard length/weight curve for the same fish (lower plot). Mean standard length and weight are shown with the orange dot and grey vertical lines. There were 120 alfonsino individuals in this dataset.

Discussion

Mark identification

The lack of successful trawls on the marks considered to be alfonsino is unfortunate and will need to be addressed in any future acoustic surveys. However, the marks allocated to alfonsino during the 2025 Nansen surveys were consistent with confirmed alfonsino marks seen in other work (e.g., Shotton, 2016, fig. 13). During the day, alfonsino disperse onto the seafloor, and at times form dense aggregations on or close to the seafloor. They move off the seafloor during the night, forming schools 100-150 m off the seafloor or dispersing as individuals (Shotton, 2016, sec. 2.4.3, 2.44), also consistent with the 2025 Nansen surveys.

This gives some confidence that the marks were from alfonsino, but it is possible that the marks tagged as alfonsino could instead be black cardinal fish (*Epigonus telescopus*) or pelagic armourhead (*Pentaceros richardsoni*), both of which aggregate in a similar manner and were found in the region during the Nansen surveys. Both of these species have a swimbladder (as does alfonsino) and so are strong acoustic reflectors. Orange roughy (*Hoplostethus atlanticus*) also form aggregations in the area (Niklitschek and Patchell, 2015) but are more typically directly associated with the seafloor or a pronounced feature and generally only form aggregations while spawning in winter (June-July in the southern hemisphere).

The marks attributed to alfonsino in the 2025 Nansen surveys had 5-15% less backscatter at 18 kHz than at 38 kHz. Some other marks seen during the Nansen surveys had 50-100% more backscatter at 18 kHz than at 38 kHz. These latter marks were also more diffuse and weaker at 38 kHz than the alfonsino marks. Large fish with a swimbladder have similar backscatter at 18 and 38 kHz (Lavery et al., 2007), consistent with alfonsino (or black cardinal fish or pelagic armourhead), while stronger backscatter at 18 kHz is indicative of smaller fishes with a swimbladder, such as some mesopelagic species (the strong backscatter at lower frequencies is an indicator of acoustic resonance from a small swimbladder).

Biomass estimate

The biomass calculated from the acoustic surveys must be treated as tentative and used with caution, as it relies on unverified information about the composition of the marks, the size distribution of alfonsino in the marks, and the accuracy of the length to TS relationship. The large sampling coefficient of variation (CV) also adds considerable uncertainty to the biomass values. The estimate is provided here solely to demonstrate the methodology that could be used for this purpose, should better data become available.

Some of these uncertainties can be addressed with improved information about the characteristics of alfonsino marks, species composition and fish size distributions in such marks, and a length to TS relationship specific to the Southern Indian Ocean alfonsino. Note that the mean area backscattering coefficients from the 2025 Nansen surveys can be reprocessed to yield revised biomass estimates if improved information becomes available. The current CV values are large partially due to the several transects with no observed marks (Figure 2) – removing those transects reduces the CV from >300% to 140% and 260% for surveys 2 and 3 respectively. These are still large and a more intensive or spatially focussed survey may be necessary to obtain lower CV values.

Survey vessel and equipment

The two basic requirements for a quantitative acoustic survey are a calibrated echosounder and some means to estimate the species and length composition of the surveyed organisms. The seafloor depths at which alfonsino were observed (c. 1000 m) requires an echosounder that operates at frequencies below about 50 kHz and the ability to operate trawls to those depths. Fisheries research vessels typically have the required echosounder systems but can lack the required trawling ability (notable exceptions are RV *Tangaroa* from New Zealand and some fisheries research vessels operating in the north Atlantic). Conversely, deepwater fishing vessels can operate trawls to those depths, but can lack quantitative echosounders.

Future acoustic surveys of alfonsino in the southern Indian Ocean will require increased trawling ability than was present during the 2025 Nansen survey. This can be achieved with a research vessel that can routinely trawl to 1000 m, a second vessel with deepwater trawling abilities (e.g., a commercial fishing vessel), or by adding suitable acoustic systems to a commercial fishing vessel. The remoteness of where alfonsino concentrations are found in the Southern Indian Ocean creates logistical and resource challenges when using research vessels and instead utilising fishing vessels that are already in the area can be more effective. In particular, some types of fishing operations have down time between trawls that can be used for other activities, such as acoustic surveys (e.g., O'Driscoll and Macaulay, 2005). This methodology has been used to conduct acoustic surveys of orange roughy and alfonsino in the Southern Indian Ocean (Niklitschek and Patchell, 2015).

If it is not feasible to have quantitative hull-mounted echosounders on a fishing vessel, they can instead be towed. This was commonly done from research vessels, but the need for this reduced with the addition of drop keel mounted echosounder systems. However, self-contained echosounders are available and have been attached to the headlines of commercial trawls and used for acoustic surveys (Kloser et al., 2018). The main disadvantage is that the surveying speed is restricted to the trawl towing speed, but it can be an effective solution when surveying small areas.

Acoustic survey design

Strategies for surveying pelagic fish populations are determined by the temporal and spatial characteristics of the fish, including diurnal vertical migrations, aggregating behaviours, association with seafloor features, and interactions with prey, predators, and oceanographic conditions.

A survey should aim to measure the fish when a stable and preferably high proportion of the population is available to the echosounders, the acoustic reflectivity (TS) is stable, and double counting of fish is minimised. No marks were attributed to alfonsino during the day in the 2025 Nansen surveys, but during the night relatively large aggregations were observed well clear of the seafloor and were seen over an area of several square kilometres. These characteristics are suitable for an acoustic survey with parallel transects. For statistical reasons, it is recommended to have a random variation in the transect spacing (Jolly and Hampton, 1990), although many surveys do not do this.

Some deepwater acoustic surveys use star transects (Doonan et al., 2003) where multiple transects all cross at a single point. This is intended for surveying an aggregation that has much of the biomass in a fixed and temporally consistent location, such as spawning orange roughy on seamounts. The marks attributed to alfonsino in the 2025 Nansen surveys did not have this characteristic and star transects would not be a suitable survey strategy.

Choosing a transect spacing for parallel transect surveys depends on factors such as the spatial distribution of the surveyed species, the time taken to do a survey, and the time available for a survey. Closer transect spacings cover more of the survey area and tend to produce a lower sampling coefficient of variation but take more time to carry out – it can be more effective to conduct multiple surveys than one survey with a smaller transect spacing. Questions around optimal transect spacing can be informed by simulated surveys, although for alfonsino in the surveyed area, more data on typical aggregation distributions would be necessary than is available from the three 2025 Nansen surveys. Transect orientation is also important – it is common to run transects perpendicular to the seafloor contours when surveying species that have some association with the seafloor, but any directed movement of the fish (e.g., migrations, movement with currents) must also be considered to reduce double counting.

Survey and stock assessment methodology

The 2025 Nansen surveys and earlier work from fishing vessels indicate that alfonsino are available to acoustic systems and aggregate and behave in ways that are amenable to typical acoustic survey methodologies. Further work and data are needed on the target strength of alfonsino in the Southern Indian Ocean, and on ways to refine survey strategies to yield useful sampling CVs.

A statistical underpinning of parallel transect acoustic surveys of aggregated fish is that the aggregations are randomly distributed throughout the survey area (Jolly and Hampton, 1990) and that enough transects are done to encounter sufficient aggregations to obtain a reliable biomass estimate. A survey area can be stratified to deal with spatially variable aggregation densities and rules developed to adapt strata and survey effort to observed distributions. This type of adaptive survey strategy has been applied to orange roughy spawning aggregations in areas without anchoring bathymetric features (e.g., Escobar-Flores and Maurice, 2024).

Biomass estimates of orange roughy have been obtained from fishing vessel surveys in the Southern Indian Ocean – the vessels carry out surveys between trawling activities. This is feasible because the survey areas are relatively small and can be completed in a few hours. The area in which alfonsino aggregations were observed in the 2025 Nansen surveys was also small and could similarly be surveyed between fishing activities.

The accuracy and reliability of stock assessments based on acoustic alfonsino surveys will ultimately depend on stock characteristics, such as the proportion of the stock that is found in aggregations, how that varies, and changes in spatial distribution with time. Information on these factors typically only becomes available after multiple surveys and informed stock assessment simulations.

Conclusions

The 2025 Nansen acoustic surveys at Station X south of Walter's Shoal observed alfonsino-like aggregations using ship-mounted 18 and 38 kHz echosounders. Night-time surveys identified distinct midwater aggregations 100–150 m above the seafloor, at seafloor depths of 850-950 m, consistent with known vertical behaviour of alfonsino. These observations indicate that the species is acoustically available. Parallel transect acoustic surveys designs are likely to be suitable for surveying such aggregations.

Reliable acoustic biomass estimates of alfonsino require additional information not collected during the 2025 Nansen voyage or not currently available. This includes targeted validation trawls on observed marks, potential species misidentification, reliance on biological samples collected outside the surveyed area, and the application of a target strength relationship derived from other regions. In addition, very high sampling coefficients of variation reflect the patchy distribution of aggregations and highlight limitations in survey effort in 2025.

Future work should validate acoustic mark composition, develop a region-specific target strength relationship, and refine survey strategies to reduce biomass uncertainty. Given the remoteness of the fishing grounds and the relatively small spatial extent of observed aggregations, suitably equipped commercial fishing vessels may provide practical and cost-effective survey platforms. With refined methodologies and additional survey data that can better characterize spatial and temporal variability, acoustic methods are likely to provide reliable alfonsino biomass estimates.

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