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Guidelines on a Protocol for Acoustic Data Collection

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NATIONAL FISHERIES SOCIETY – SNP
HUMBOLDT INSTITUTE OF MARINE AND AQUATIC RESEARCH - IHMA

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Guidelines for Acoustic Data Collection aboard Fishing Vessels operating in waters under national jurisdiction and the SPRFMO area

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Guidelines for Acoustic Data Collection aboard Fishing Vessels operating in waters under national jurisdiction and the SPRFMO area

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Guidelines for Acoustic Data Collection aboard Fishing Vessels operating in waters under national jurisdiction and the SPRFMO area

1. Background

The Habitat Monitoring Working Group (HMWG) faces the need of data and analysis of scientific quality in order to provide advice for the management of species being exploited. Resources for scientific surveys are scarce therefore it is of the highest interest to access to ‘vessels of opportunity’ to acquire data for habitat monitoring purposes.

Acoustic data from fishing vessels provide a valuable source of information. To maximize the utility of the fishing vessels’ acoustic data, objectives on the use of that data must be clearly defined in the context of the needs for habitat monitoring. This can be achieved through a qualitative or quantitative evaluation of all monitoring needs within the fisheries. Therefore, it is necessary to explore the available technologies aboard fishing vessels authorized to operate in the SPRFMO convention area.

Most of the present proposal is based on the ICES COOPERATIVE RESEARCH REPORT N°287: COLLECTION OF ACOUSTIC DATA FROM FISHING VESSELS[1]. It was published by the Study Group on the Collection of Acoustic Data from Fishing Vessels (SGAFV) during 2007. Annex 1 introduces a list of manufacturers and acoustic software providers (including free access software). Annex 2 provide a first version of the inventory of technologies available aboard Peruvian vessels authorized to operate in the Jack Mackerel fishery.

2. Main SGAFV findings and recommendations

2.1. General

- Acoustic data in support of a range of research and monitoring objectives can be collected successfully from commercial fishing vessels. However, some objectives are better addressed through data collection from dedicated research vessels and some objectives can only be fully addressed by utilizing modern vessels with low radiated noise characteristics. Some fishing vessels are only suitable for supporting a limited range of objectives.
- Investigators should define research objectives and data-collection requirements carefully. This will provide a basis for determining vessel and instrumentation needs, and biological sampling requirements.
- Certain objectives can be addressed through unsupervised collection of acoustic data aboard fishing vessels, but most will require a supervised approach.

[1] ICES. 2007. Collection of acoustic data from fishing vessels. ICES Cooperative Research Report No. 287. 83 pp.

2.2. Radiated noise, fish behaviour, and selection of fishing vessels

- Some species of fish are more sensitive to radiated noise than others, and sensitivity may vary by physiological condition.
- Sound intensity attenuates with distance; therefore concerns regarding the impact of radiated noise from fishing vessels (or older research vessels) will be greatest for fish close to the vessel.

2.3. Other vessel selection considerations

- Acoustic performance is an important criterion in any fishing-vessel-based monitoring programme. The seagoing qualities of vessels should be considered when selecting commercial vessels for scientific purposes, and transducer placement should be given particular consideration. Vessels known to force aerated bow waves under and along the hull during bad weather and at normal cruising speeds should be avoided.
- Propeller blades should be in good condition to minimize cavitation and generation of associated noise.
- Investigators should ensure that there is no electrical interference that will affect the survey echosounders, and that the electrical supply is stable in voltage and frequency.
- Vessel self-noise tests are recommended and easy to conduct through use of the noise measurement facility built into many echosounders.
- Noise ranging is recommended.

2.4. Selection of instrumentation

- The performance of echosounders selected to support scientific objectives should be stable; digital systems that provide control over the temporal and spatial resolution of output data are preferred.
- Split-beam transducers and echosounders are generally preferred because these systems facilitate calibration and in situ target-strength measurement.
- Selection of appropriate echosounder settings is particularly important (e.g. transmit power, pulse length, frequency).
- Instrument settings should be checked and recorded periodically.
- GPS data should always be collected and properly interfaced with the acoustic instruments.
- The need to collect ancillary data depends on the objectives of the study.
- When appropriate, ping synchronization of acoustic systems and time synchronization of all instruments should be implemented.

2.5. Collection of acoustic and ancillary data

- Investigators are advised to draft a survey plan that defines the survey goals and objectives and details protocols associated with all aspects of the study. This plan should also consider logistical tasks (e.g. retrieval of data, communication, and port visits).
- Collection of raw data files is generally recommended, although the storage of digital data collected during prolonged surveys can be problematic. Researchers should consider carefully the trade-offs between quantity and resolution of data collected and the ability to meet research objectives.
- Metadata requirements and recording protocols should be established and documented.
- It is useful to begin with the end in mind. Consider how data synthesis and post-voyage analysis will be done when planning fieldwork.
- Calibration of acoustic systems is required for the quantitative use of acoustic data and is recommended for all studies.

- Time synchronization of acoustic and ancillary instruments is critical. All instruments should be time-synchronized using a GPS receiver against a common standard (e.g. GMT time).
- Ping synchronization is also critical to acoustic instruments. In general, the master synchronization pulse should be provided by the scientific echosounder, and all other acoustic instruments should be set up as slaves. Custom electronics may be required to address specific timing or pulse form needs. It may be necessary to turn off some vessel acoustic instruments during scientific data collection.
- Potential sources of interference by other on-board acoustic systems should be identified. In many cases, interfering sounders will need to be either synchronized with the survey sounder or turned off when collecting survey data.
- Vessel characteristics may preclude the collection of scientifically useful data under some weather and/or operating conditions. Guidelines for sea state, survey speed, etc. should be provided in the operations manual and amended as appropriate.
- Biological sampling must be consistent with survey objectives. Gear selectivity and temporal and spatial resolution will be of particular concern in this regard. It is important to ensure that sampling gear and protocols for fishing are consistent with the research/survey information needs.

2.6. Data processing and analysis

- While the requirements for processing, analysis, and interpretation of acoustic (and ancillary) data collected aboard fishing vessels may not differ markedly from the requirements for similar types of data collected aboard research vessels, some considerations are particularly important:

    - Large quantities of data may be collected, and this may require the establishment of special procedures for storage and archiving of data.
    - Metadata will be especially useful in the identification of subsets of data for detailed analysis.
    - It may be advisable to collect raw data and low-resolution data simultaneously. Low-resolution data can be reviewed rapidly to assist in identifying sequences of high-resolution data for detailed analysis.

2.7. **Cooperative (industry/agency) research considerations** (Table 1)

- Scientists should communicate clearly the objectives of the proposed research and the potential benefits to industry participants and other stakeholders.
- Scientific and industry stakeholders should strive to achieve a shared vision for the project and to identify the roles and responsibilities of the various participants. Care should be taken to ensure that terminology is understood by all participants.
- Vessel requirements should be defined and communicated as early and as clearly as possible in the process.
- Written protocols for all sampling and related operations should be drafted and agreed upon well in advance of the first sampling trip.
- A comprehensive and clear legal contract or working agreement must be developed that defines the duties and responsibilities of all partners before, during, and after a survey or specific scientific study.
- Responsibilities for drafting and publishing research results should be understood in advance. Opportunities to review draft reports and recommendations should be provided to all stakeholders. When appropriate, weekly/monthly progress reports should be provided to participants and stakeholder organizations.
- Industry participants must be assured that proprietary information they provide will not be released without consent.

- Cooperative research agreements should encourage evaluation of performance by industry and scientific participants with a focus on the development and implementation of future projects.

Table 1. Checklist of research phases by entities

Activities	Industry	Scientific Institutions	SPRFMO	Especific Protocols
Planning				
Setting of instruments				
Fishing trips (data storage)				
Data retrieval				
Data analysis				
Reports				

3. Fishing vessels as data collectors by levels

The first approach for implementing a protocol is to determine the amount and quality of available platforms of observation (fishing vessels).

3.1. The need of an inventory of fishing vessels and acoustic systems operating in the SPRFMO area. All vessels should contribute information regardless of its technical sophistication.

3.2. To classify the vessels according to 'levels of equipment' (Table 2):

3.2.1. Level 1, vessels equipped with digital systems (digital echosounders of at least 2 frequencies split beam, scientific sounders or similar; and a sonar). "Level 1+" will be assigned if the sonar is of a digital grade.
3.2.2. Level 2, vessels equipped with digital systems (digital echosounders of 1 frequencies split beam or similar; and a sonar). "Level 2+" will be assigned if the sonar is of a digital grade.
3.2.3. Level 3, vessels equipped with digital systems (digital echosounders of 1 frequencies single beam; and a sonar). "Level 3+" will be assigned if the sonar is of a digital grade.
3.2.4. Level 4, vessels with digital systems (analogue echosounders of 1 frequencies single beam; and a sonar).
3.2.5. Level 5, all other possible combination.

3.3. To establish minimum conditions for every level (e.g. level 1: need of an annual calibration and noise measurement, need of using a datalogger etc) and possibilities of use (e.g. fish stock biomass, habitat characterization etc).

3.4. To propose a recognized procedure for gathering data from national vessels. This should be performed by the marine research institutes of the area. To propose annual workshops for data exchange and joint analysis.

3.5. To propose a data analysis methods based on previous cooperative research (e.g. CCAMLR).

Table 2. Proposal of classification of fishing vessels by levels

Item	Systems / Levels	Fishing Vessels classification according to their acoustic systems				
		Level 1	Level 2	Level 3	Level 4	Level 5
Equipment	Digital echosounders of at least 2 frequencies split beam, scientific sounders or similar	■				
	Digital echosounders of 1 frequencies split beam or similar		■			
	Digital echosounders of 1 frequencies single beam			■		
	Analogue echosounders of 1 frequencies single beam				■	
	All other possible combination					■
Calibration	Calibration using spheres	■	■			
	Calibration using hydrophones			■	■	
	Noise measurement			■	■	
	Target Strength measurements	■	■			
Fish	Accurate fish biomass estimation and calssification	■	■			
	Fish biomass estimation			■	■	
	Relative abundance estimations					■
	Fish typology	■	■	■	■	■
Zooplankton	Accurate zooplankton abundance estimation and classification	■	■			
	Zooplankton abundance estimation		■	■		
	Relative zooplankton abundance estimations from visual contact				■	■
Habitat	Depth of oxycline	■	■	■		
	Depth of thermocline	■	■	■		
	Depth of thermocline from visual contact				■	■
	Carbon and CO_2 relative measurements	■	■			
	Prey-predator interactions observations	■	■	■	■	■
Other	Seabird observations	■	■	■	■	■
	Marine mammals observations	■	■	■	■	■
	Big pelagics and highly migratory fish observations	■	■	■	■	■
	Fishing devices for providing biological sampling	■	■	■	■	■

4. Calibration and noise

- Radiated vessel noise is a serious concern, and failure to recognize the consequences of fish behavior in relation to vessel noise may compromise research results.
- Sensitivity of fish to sound is influenced by morphological and physiological factors. Less-sensitive species may be less susceptible to radiated noise than sensitive species. The prospective researcher is cautioned to review the literature relating to the species of interest.
- Sound intensity attenuates by distance (square of the distance, as a rule of thumb) and even the most sensitive species may not demonstrate behavioral responses to high levels of radiated noise at distances greater than 200 m.

4.1. Criteria for selecting vessels

- Noise-reduced vessels are preferred but generally unavailable in the fishing fleet. In these types of vessels, the diesel engines are double isolated from the hull, and a DC propulsion motor drives a large-diameter fixed-pitch (usually five-bladed) propeller. With such a specification, the distance for avoidance behaviour by sensitive fish species should be approximately 15–30 m.
- Vessels with propulsion systems consisting of diesel generators that are isolated from the hull and supply AC current to an AC electric motor driving a fixed-pitch propeller are generally quieter than direct-drive, variable-pitch propelled vessels, but radiated tonal noise may still be problematic. Avoidance behaviour by sensitive fish species may occur at ranges between 100 m and 200 m.
- Vessels with propulsion systems consisting of diesel engines that are bolted to the hull and gearboxes that drive controllable-pitch propellers are generally the noisiest and may disturb ensitive fish species at distances >200 m, although careful selection of propeller pitch may mitigate radiated noise to a limited extent.
- Fixed-pitch propellers (with four or more blades) are highly recommended, especially for assessment of sensitive species at close range. Controllable-pitch propellers should be avoided if at all possible owing to the high levels and variability of the radiated noise they produce, particularly transients.
- When only controllable-pitch propellers are available, selection of optimal propeller pitch and engine rpm combinations is essential. This is difficult to accomplish without noise ranging tests, although self-noise testing (see next recommendation) will be extremely useful.
- The seagoing qualities of vessels should be considered when selecting commercial vessels for scientific purposes. Vessels known to force aerated bow waves under and along the hull during bad weather and at normal cruising speeds should be avoided.

4.2. Other recommendations

- Vessel self-noise tests are highly recommended and easy to conduct, if the noise measurement facility built into the echosounders is used.
- Propeller blades should be in good condition to minimize cavitation and generation of associated noise.
- Noise ranging is highly recommended.
- Documentation of noise signatures would assist in the selection process of vessels suitable for acoustic surveys. A vessel whose signature is closest to the ICES Cooperative Research Report No. 209 recommended levels and does not exceed them by more than 20 dB at frequencies up to 1 kHz would be preferred. A minimal and low level tonal content is desirable.
- It is essential to ensure there is no electrical interference that will affect the survey echosounders and that the electrical supply is stable in voltage and frequency.
- Potential sources of interference by other on-board acoustic systems should be identified. In many cases, interfering sounders will need to be either synchronized with the survey sounder or turned off when collecting survey data.

4.3. **Summary** (Table 3)

Table 3. Summary on requisites for acoustic fish stock assessment from Vessels's data

Item	Systems / Levels	Fishing Vessels classification according to their acoustic systems					Purpose	Frequency
		Level 1	Level 2	Level 3	Level 4	Level 5		
Noise	Low frequency noise	fbr = (shaft rpm × no. of blades)/60 [Hz]					At which speed the noise is critical	Once a year
	High frequency noise				by visual inspección		At which speed the noise is critical	Once a year
	Noise signature	ICES CRR 209					Noise ranging	Once a year
	Propeller blades inspection and maintenance	ICES CRR 209					Reduce radiated noise	Once a year
	Data recording in passive mode						Noise substracting	Once a month
Calibration	Remotion of fowling						Transducer clearance	Once a year
	Calibration using spheres	ICES CRR 326 - Calibration of FV					Reduce bias of performed measurements	Once a year
	Table for TVG corrections						To compensante inaccuracy of TVG function	After every calibration

5. **Instrumentation** (Table 4)

- Calibration of acoustic systems is required for quantitative use of acoustic data and is recommended for all applications.
- Known and appropriate echosounder settings are of particular importance (e.g. transmit power, pulse length, frequency).
- A procedure should be put in place to record and check periodically that the equipment settings are as required.
- GPS (global positioning system) data should always be collected and properly interfaced with the acoustic instruments.
- The need to collect ancillary data depends to a great degree on the intended use of the acoustic data, and it is difficult to provide general recommendations in this regard.
- When appropriate, ping synchronization of acoustic systems and time synchronization of all instruments should be implemented.

Table 4. Desirable ancillary data for acoustic data collection

Systems / Levels	Fishing Vessels classification according to their acoustic systems					Condition	Frequency
	Level 1	Level 2	Level 3	Level 4	Level 5		
GPS						Required	
Vessel Motion						Adventageous	
Metereological Station						Adventageous	
CTD						Required	
Thermosalinograph						Adventageous	
Temperature sensor						Adventageous	
Syncronization, Log Counter						Required	
ADCP						Adventageous	
Fishing gear						Required	
External tranducers						May be necessary	
Towed body						Adventageous	
External data logger through out a LAN net						May be necessary	Permanent
Logbook (writeen) for seabirds, marine mammals and top pelagic observations						Required	Permanent
Instruments settings logbook (written)						Required	At every relevant modification

6. Data collection and management

A range of data products can be acquired (or developed) from acoustic systems operated on board commercial vessels. These include:

- Bathymetry
- Acoustic indices of seabed roughness and hardness
- Presence/absence of schools
- Spatial and temporal distribution of schools
- School metrics (e.g. interpreted species composition, school height, intensity, length, and shape)
- Information on fish response to survey and/or fishing vessels
- Information on fish distribution and/or distribution of fishing effort
- Quantitative echo integration biomass estimates.
- Depth of thermocline and oxycline
- Relative abundance of zooplankton
- Relative concentration or carbon and CO_2

Echosounder systems that can record data will be able to output some, and possibly all, of the following data types:

- Data at full-sample resolution, recorded at a power level;
- Phase information at full-sample resolution (split-beam systems only);
- Data at full-sample resolution converted to Sv (volume backscattering strength; dB re 1m-1) or target-strength values;
- Single target detections;
- Full-sample data converted to a summary format with a limited (possibly user-defined) number of samples per ping;
- Bottom detection values.

The researcher should consider which of the possible data types should be recorded. Ideally, data should be recorded in a format that is as “raw” as possible (i.e. at full-sample resolution over the entire dynamic range of the system, with key system-setting parameters included with the record for each ping). Recording at full-sample resolution will generate a large quantity of data but, with the low cost of storage media, this is becoming less of a problem. Data volumes may be reduced by recording at a lower resolution and/or with minimum detection thresholds. It may also be advisable to record multiple data output formats in parallel. For example, full sample data may be recorded as a minimum requirement, but lower-resolution data could also be recorded both for redundancy and to take advantage of the lower data volume, and allow quick review of the echograms.

6.1. When to log data

Storage of digital data can be problematic because raw data files may be quite large, especially if multifrequency information is collected. The researcher should consider carefully the tradeoffs between quantity of data stored (and associated data-management, archiving, and processing issues), and the ability to meet research objectives. Logging data only during defined sampling periods will save storage space at the risk of missing off-survey observations that may be of scientific interest. Furthermore, instructions to the skipper for turning data logging on and off may not always be followed. During the initial phase of a project, it is advised that the systems be turned on for the duration of the trip. Once the programme has been operational for some time, it may be possible to develop some simple rules specifying when data logging should occur and to work with the skipper to ensure these rules are followed. A log (paper or electronic) should be established to record these activities, to identify important observations, and to assist in the filtering of unwanted data files.

6.2. Logistical considerations

Ensuring that acoustic data collected on fishing vessels is retrieved and distributed to the scientists involved in the project may be problematic. Data files should be downloaded from the recording system on a regular basis to prevent losses caused by a hard disk failure or storage capacity being exceeded. It is also important that no data be erased from the recording echosounder until it is verified that data files have reached their final destination and can be read. Viable options for data storage and retrieval include CD/DVDs, USB portable hard disk drives, and direct networking with the logging system. Retrieval of data from fishing vessels will depend on the equipment set-up and downloading hardware, and will probably vary from vessel to vessel. However, the following practical steps in the process are generally applicable:

- Retrieve acoustic data files from the echosounder;
- Transfer data to the processing site;
- Verify readability and archive;
- Delete earlier downloaded files from the vessel's computer after verification and archiving.

A generalized flowchart illustrates the downloading steps (Figure 1):

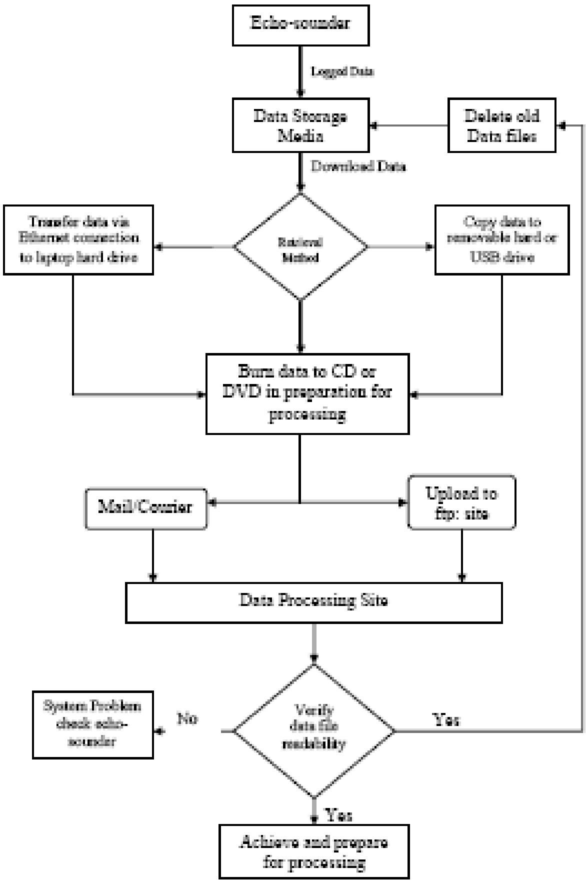

Figure 1. Flowchart on the collection of acoustic data

6.3. Metadata

Comprehensive recording of metadata is an essential part of a well-executed survey programme and is particularly important when working with multiple vessels over a number of years. Recording metadata may present some difficulties in an industry setting, especially when there is limited or no at-sea presence of survey scientists. Consideration of metadata issues during the planning stage of a survey will greatly assist in ensuring that the right information is collected.

Metadata will range from macroscale information, such as trip details through to detailed information specific to particular instruments and possibly specific to each data point. Metadata information may include:

- Voyage details (location, dates, personnel, fish species being studied);
- Time convention used (UTC or local time);
- Echosounder equipment (manufacturer, model, serial number, key specifications, such as frequency or software version);
- Echosounder calibration details;
- Fishing gear specifications;
- Trawl (or other net sampling) information (start, stop, location, depth);
- Biological sampling details (measurements made and details of protocols used, such as conventions for measuring length, etc.);
- Details of other measurement systems and their deployment and sampling settings (e.g. CTD, motion sensors, temperature loggers);
- Key echosounder transceiver settings, ideally embedded in each ping record;
- Other important trip events (start, stop, interruptions, calibration events, etc.).

Metadata information will often be recorded on paper or in a computer text file in the first instance, but may be transferred to a database subsequently. A post-voyage report that summarizes the macroscale metadata (e.g. voyage details, table of voyage activities) is an essential document that will be referred to often during data analysis.

7. Biological sampling

Although biological sampling is not needed to address some types of survey objectives, in most situations, the identification and characterization of backscatter is required. This is achieved generally through direct sampling.

Although an important goal of direct sampling during scientific surveys is to minimize selectivity, this is not normally the case in commercial fishing. Furthermore, fishers may be reluctant to set gear in locations where catch rates will probably be low, even if this is necessary to provide scientists with information on biological characteristics at appropriate temporal and spatial scales. Under certain circumstances, it may be possible to provide fishing vessel operators with incentives (such as additional harvesting opportunities) to set gear in commercially unproductive areas, to modify gear to reduce selectivity, or to deploy ancillary scientific sampling gear.

Sampling effectiveness does not depend only on gear selectivity. Avoidance may also be important. It is important for investigators to be mindful of potential vertical or horizontal gear avoidance that may be related to radiated vessel noise, disturbances caused by fishing operations, or other factors. Modern fishing vessels and research vessels are equipped with a range of sonars that can provide evidence of sampling gear avoidance. The vertical echosounders used for fishing and scientific operations may also be useful in this context. It is also important to bear in mind that hull-mounted vertical echosounders do not sample the epipelagic (upper 5–15 m) layers of the water column and that this zone is particularly difficult to sample with most conventional sampling gears.

Even under the best conditions, biological sampling may be insufficient. Useful size and species composition may be available from other sources, such as commercial catches and landings, but care must be taken to ensure temporal and spatial correspondence.

7.1. Types of sampling

The extent to which biological sampling can or cannot be conducted and the sampling method employed will limit the types of objectives that can be addressed by the research project or survey. Several general cases are defined for the purposes of this discussion.

7.1.1. Biological sampling data cannot be collected

It may not be possible to collect biological data when the vessel is transiting to or from the fishing grounds or if the vessel's gear is unsuitable for sampling the echo traces encountered during all or part of the survey. Under these circumstances, it will generally not be possible to develop quantitative information regarding distribution, abundance, or biological characteristics of the echo traces. Inference regarding some characteristics may be possible through classification of echo-trace patterns and/or evaluation of the spatial extent of echo traces.

7.1.2. Limited sampling with commercial gear

Sometimes, limited biological data are provided because commercial gear is directed to sample only aggregations of commercial interest. This would occur under normal fishing conditions. Under this circumstance, it will generally be possible to identify the size and species composition of backscatter within fished aggregations, although it should be noted that substantial contributions to backscatter in fished aggregations may not be well sampled by commercial gear. If it is possible to make assumptions regarding overall size and species composition (from prior surveys or historical commercial fishing information), this may provide a basis for quantitative estimation.

7.1.3. Directed sampling with unmodified gear

In some cases, unmodified commercial gear is available, but vessel operators are willing to collect additional samples in accordance with agreed-upon protocols. Here, information on echo trace biological characteristics will be available from throughout the region covered by commercial vessels. This will enable more comprehensive matching of echo traces to catch composition during post-survey review. However, the aforementioned concerns about the selective characteristics of commercial fishing gear are also relevant under these circumstances.

7.1.4. Sampling according to research protocols (gear may be modified)

In some situations, some modification of commercial gear is possible to reduce selectivity (e.g. a trawl modified with a codend liner) and/or the vessel is willing to deploy sampling gear in accordance with agreed-upon protocols. Caveats that apply to any research sampling activity apply under this circumstance. These include adequacy of spatial coverage, the extent to which the selective characteristics of the sampling gear are understood, and the extent to which these patterns of selectivity constrain sampling of important scatterers. As in the previous cases, historical knowledge of patterns of scatterers' distribution in the region of interest will be particularly important when interpreting catch information.

7.1.5. Concurrent scientific sampling

If concurrently collected scientific sampling data are available (e.g. from research surveys conducted in the same location during the same period) or echo trace composition can be inferred from other research activities. However, unless research vessel operations are directed in response to observations made aboard commercial vessels, or truly concurrent operations occur, assumptions regarding temporal and spatial consistency may be difficult to substantiate. In situations where echo-trace and biological characteristics are consistent within a given temporal/spatial stratum, the use of catch composition data from other sources will be more defensible.

7.1.6. Catch processing

Catch processing is a routine operation aboard research vessels. Techniques have been developed to address subsampling concerns, trained technicians are available to sort, process, and record sampling data, and vessel layout and the pace of operations are designed to optimize sampling and resultant data quality. This is generally not the case aboard commercial vessels during normal fishing operations.

7.1.7. Observers

When at-sea observers are deployed aboard commercial vessels collecting acoustic data, standardized, high-quality biological data collection is generally straightforward. Observer programmes generally have well-developed methods for sampling to provide species and size composition information, procedures for evaluating the quality of data collected by observers, and database systems which provide easy access to sample information during data analysis. Even when observers are deployed, however, access to catch may be restricted by vessel configuration and operations. For example, selection of random or systematic subsamples from a catch may not be possible if the entire catch is dumped into a refrigerated seawater tank or hold, and observers may not be able to sample all catches if round-the-clock fishing operations are taking place.

It may be possible to train observers to monitor a vessel's echosounders and to document important information regarding the proximity of fishing operations to echo-trace features. Also, in situations where commercial vessel operators are willing to make additional sets or deploy ancillary sampling gear, observers could be trained to identify echo traces of interest and direct sampling operations. In situations where observers are not routinely deployed, the benefits of observer coverage could also be obtained by deploying specially trained scientific technicians aboard selected commercial vessels. Whether observers or technicians are employed to collect these types of data, it may be beneficial to hold periodic workshops for these individuals to compare notes and share knowledge.

7.1.8. Port sampling

The preferred method for obtaining catch data in many countries is to sample deliveries in port, but use of these types of data to characterize acoustic scatterers may be unwise for several reasons. First, deliveries contain only retained catch, and use of landings data to characterize catch is appropriate only in situations where discarding of undersized or unmarketable fish at sea does not occur. Second, haul-specific information is not available during delivery, so it is impossible to characterize echo traces at the necessary temporal and spatial scales. Under circumstances where sampling at sea is not possible, it may be possible to characterize echo traces based on sampled catches from other vessels in the fleet or, perhaps, vessel crew may be willing to separate samples of unsorted catches and retain them for processing when the vessel returns to port.

7.1.9. Implications for data processing

During analysis of data collected during research involving the collection of acoustic and direct sampling data from research vessels, considerable effort is directed at interpreting echo traces to ensure that size- and species-related impacts on mean target strength are accounted for during echo integration and to support appropriate partitioning of acoustic biomass estimates (whether relative or absolute). Advances in methods for automatic school recognition, bottom-tracking correction, and identification of areas where records are contaminated with noise by weather, acoustic interference, or electrical interference, hold promise and may well be useful for preliminary review of acoustic data collected aboard commercial vessels. This is particularly important because of the potential for collecting vast quantities of acoustic data from vessels of opportunity. Although these approaches will probably be useful for initial filtering of data, an interactive process for combining acoustic and direct sampling data will continue to be necessary for many applications. Investigators should be mindful of the time and staff resources necessary to conduct this work, and of the need to develop clear protocols to ensure that matching of echo traces with direct sampling data is consistent and defensible.

7.1.9. Other considerations

Ancillary environmental data are often collected during research surveys, either to address specific research information needs or as part of a broader ecosystem monitoring plan. Because many of the commonly monitored environmental factors influence fish behaviour and distribution directly, they are often useful during the review process. Investigators should be encouraged to include systems for automated collection of basic environmental data aboard fishing vessels that are equipped to provide acoustic data for scientific purposes.

7.2. Recommendations

- Biological sampling must be consistent with survey objectives; investigators must ensure that sampling gear and protocols for fishing are consistent with the research and survey information needs.
- Gear selectivity and temporal and spatial resolution require careful consideration.
- Scientists and vessel personnel should develop and agree on scientific (biological) sampling protocols (see Section 7).

8. Data processing and analysis

Data processing and analysis is the means by which collected data are converted into information. The type of information that may be extracted from the data is intrinsically linked to the method by which it was collected. Examples range from data collected during normal fishing operations to data collected under a formal survey design. In many cases, the latter may be treated in a manner similar to research vessel data, while the former may require novel methods and/or assumptions to be made before meaningful information can be extracted.

This section provides a general overview of processing considerations, analysis procedures, and the subsequent uses of the data products and results.

Analytical software currently available falls into three categories:

- Processing software supplied as part of the echosounder system (e.g. Simrad ER80 software supplied with EK80 echosounders), which typically can only work with the proprietary storage formats used by the manufacturer's hardware.
- Software developed by research institutes, which may have been designed for a particular purpose and may not be available to the public.
- Commercial software developed by third-party companies. These packages strive to support the data formats of most commercial and scientific echosounders (see Annex 1).

The various software packages typically have the ability to:

- Load and manage filesets of recorded acoustic data;
- View and move forwards and backwards through the recorded echograms;
- Apply calibration corrections;
- Define regions and layers on the echogram and enable data quality edits (e.g. define regions of bad data);
- Apply interpretations to the echogram, including identification, classification and isolation of targets of interest within the echogram;
- Process the echogram to produce various outputs (e.g. echo integration of data qualitychecked echogram);
- Support specialized analysis (e.g. analysis if multifrequency data);
- Save analytical sessions to files.

8.1. Data processing and analysis

Data processing begins when the analyst receives the complete set of survey data files (both data and metadata information). Survey metadata are an essential aid to efficient data processing and should inform the analyst which portions of data are of more interest (e.g. grid survey start/stop times, times and locations of observed school marks) and what survey settings were used. Metadata will aid in decision-making during the analytical process.

8.2. Archiving

Archiving of data is the starting point in the processing sequence. Large amounts of data may be collected from fishing vessels, and it is important that appropriate archival procedures are established. Data files should first be validated to confirm that they are useable (e.g. ensuring that survey settings were used correctly and that GPS information is properly recorded). Data files typically fall into three broad categories: (i) files specific to the objectives of the current study; (ii) files containing information that may be useful for another purpose in the future; (iii) files that are incomplete or contain no relevant data. Files in the first two categories should be archived, beginning with those relevant to the existing project. Files in the last category (i.e. found to be incomplete, lacking sensor input, or containing useless data) should probably be deleted. For example, the continuous recording of the water column under a vessel while it is moored at the wharf, because the system was inadvertently left on, can represent a large portion of the archive storage media.

8.3. Filtering and data reprocessing

Once the original data are archived, attention can turn to preparing acoustic data files for analysis. The archiving process will have removed data files that are of no value, but it is usually necessary to identify the portions of data that are of interest from the remaining dataset. Often, survey metadata will be sufficient for this purpose (e.g. start/stop times of formal grid surveys). Sometimes, it will be necessary to scroll through echograms for the entire dataset, noting time periods of interest. This will allow the selection of a set of files for detailed analysis.

The large quantities of data collected during many of these types of surveys may be difficult to process efficiently. It may be appropriate to reprocess the data to reduce the data volume by (i) resampling at a lower resolution; (ii) removing or averaging data below or above a set threshold; (iii) including only data from a defined depth range; and/or (iv) excluding data types that are not required for the study (e.g. phase information, extra frequencies that are not of interest). These data reduction methods may be a compromise, and the implications for any quantitative results should be understood. In some situations, it is best to use reprocessed lower-resolution data for a rapid qualitative review, but to revert to the original data for detailed quantitative analysis. The manufacturer's echosounder software may allow output of lower-resolution data at the time of acquisition or during post-processing.

Reprocessing may be necessary to remove intrinsic errors in the data. See ICES (2004) for an example of a problem identified in the output of some versions of the Simrad ES60 echosounder and a solution that can be implemented through reprocessing.

8.4. Data analysis

These steps outline the analytical procedures for echo integration:

Apply corrections for sound speed and absorption.

1) Sound speed and absorption are ideally derived from direct measurements of conductivity and temperature profiles, but possibly from temperature profiles alone (with assumed conductivity values) or from oceanographic models of conductivity and temperature. Estimates of seawater sound speed and acoustic absorption can be made using the commonly accepted equations of Mackenzie (1981) and Francois and Garrison (1982), but see also Doonan et al. (2003) for an alternative absorption equation.
2) Apply calibration corrections for volume backscatter and/or target strength gain.
3) Apply correction values from echosounder calibration obtained prior to and/or subsequent to the survey, using the suspended sphere method as described by Foote et al. (1987).
4) Data quality control typically involves visual inspection of the echogram, followed by marking regions of bad data with polygon tools. Seabed bottom may be inspected and edited manually when the automatic seabed detection algorithm has failed. Pings that suffer from excessive noise spikes or aeration dropouts might be marked as bad, either manually or using automatic algorithms. Figure 2.
5) Corrections for transducer off-axis motion (Stanton, 1982) and for acoustic deadzone (Ona and Mitson, 1996) may be necessary, especially for deep-water situations or sloping bottoms.

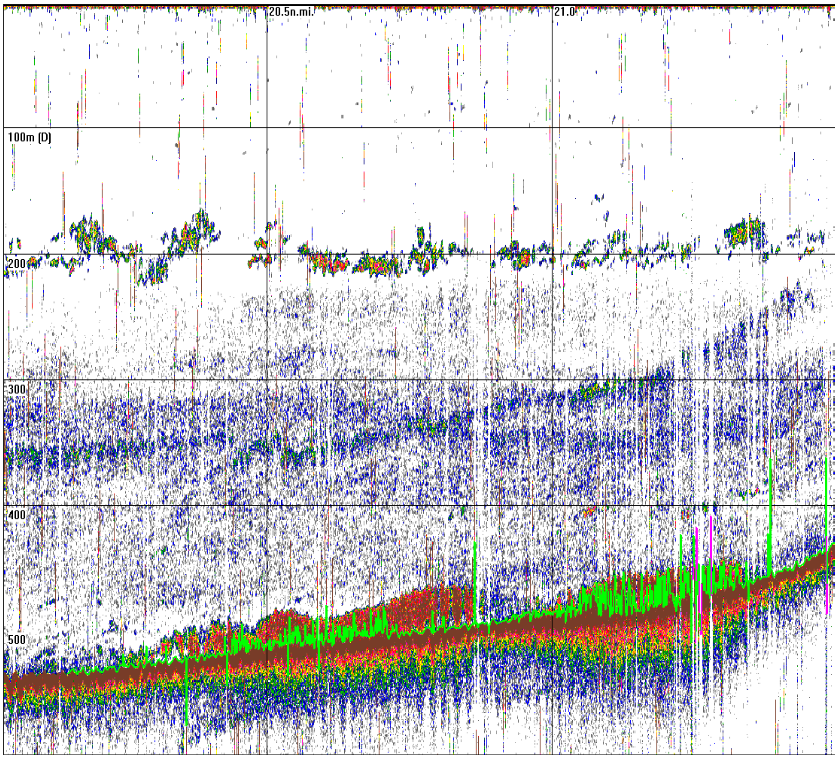

Figure 2. Echogram image with examples of poor data quality. Noise spikes from another sounder and signal loss caused by aeration can be marked manually as bad data or, in some cases, identified automatically.

Automatic detection has failed to discriminate between the seabed and the signal from a school immediately above the seabed. The input parameters to the algorithm could be tuned to improve the detection, but in some cases manual definition of the seabed is required.

Determining species composition and relative proportions may be problematic when multiple species co-occur, and even more so if there are significant differences in target strength between species. For pelagic species that tend to aggregate into single-species groups, the main concern is school (or aggregation) identification, which is usually facilitated by directsampling and/or use of multifrequency acoustic data. However, for species that are generally found in close association and, possibly, in varying proportions, determination of the contribution of each species may be difficult. Investigators should collect acoustic data and carry out direct sampling under a range of diel, seasonal, and environmental conditions to determine optimal times for conducting surveys and/or optimal segments of survey data for analysis.

Interpretation can be particularly difficult when acoustic data have been collected autonomously from a fishing vessel. In these situations, there has been no at-sea interpretation of the data, leaving it to the shore-based data analyst to piece together various datasets (e.g. trawl catch, vessel location) to assist in interpretation. Furthermore, sampling of echo traces may not have occurred or may have been inadequate. If ancillary data are inadequate, it may not be possible to complete a full quantitative analysis. In such situations, it is important to identify deficiencies in the data and the underlying survey design, and use this information as a guide when designing future surveys.

The isolation or discrimination of targets or groups of targets into categories is generally accomplished by drawing (using the mouse) a box, ellipse, or polygon around the area of interest in the echogram and defining the category or species composition. The various definitions (bad data, school region, seabed detection, etc.) form a mask (or overlay), which is applied to the data by the echogram processing and export routines. Upon completion of target classification, summary statistics for the categories, school characteristics, and backscatter are exported for analysis.

1) Echo integration. Once the editing or classification of targets is complete, the integration is a simple software function. Integration data may be output from the acoustic analysis package for conversion to a biomass estimate and for detailed statistical analysis.
2) Error considerations. There are many sources of error in any acoustic analysis (e.g. Rose et al., 2000; Demer, 2004; Simmonds and MacLennan, 2005). The subject of error analysis is discussed in Section 1, and the reader is advised to pay careful attention to all sources of error during collection and analysis of data (see Table 1.1). Quantitative acoustic survey results should be accompanied by estimates of error, which take these sources into account.

8.5. Automation

Processing and analysis of the vast amounts of data collected by fishing vessels could benefit from automation. Unfortunately, although the automation of acoustic-data and signal processing for fishery and environmental application is developing rapidly, it is still in its infancy. Most automated processing is related to either filtering or isolation of physical characteristics and provision of summary statistics for features within the echograms. Most algorithms are unreliable in multipurpose applications and still require a significant amount of user intervention and interpretation. Areas of application research include artificial intelligence, neural networking, image analysis, shape recognition (Barange, 1994; ICES, 2000), and frequency differences (e.g. Kloser et al., 2002; Korneliussen and Ona, 2003b). However, even automated bottom-detection and removal algorithms, which are commonly used by all acoustic packages, often require some user scrutinizing and manual input to ensure that unwanted signals are excluded from the integration process. Processing procedures for individual target detection, echo counting, and target tracking are prime candidates for automation. Integration of the data from multifrequency acoustic systems is now being used to identify species and estimate fish size. Seabed classification with echosounder data is also being automated. A key component in seabed classification, as with all acoustical analysis, is ground-truthing. Data collected on the characteristics and physical properties of the seabed via direct methods are required to classify the acoustic categories with the corresponding seabed type.

8.6. Use of results

Throughout this document, attention has been paid to the importance of defining research goals and employing appropriate strategies for data collection and analysis. Standard survey designs employing random or systematic transects within an area of interest, and associated methods of providing biomass estimates and associated measures of error, are provided in the literature (Simmonds and MacLennan, 2005). However, many studies involving the collection of acoustic data will deviate from this “standard” model and may require specialized analytical approaches. Examples are provided in Section 8 on the use of acoustic data collection from fishing vessels in support of stock assessment, in-season management, and more general objectives related to understanding the dynamics of fish behaviour in an ecosystem context, taking into account biotic and abiotic factors.

In this section, we have provided a generalized approach that focuses on the goal of abundance estimation using echo integration methodology. Techniques for visualization of large datasets with temporal and spatial characteristics have been adopted for interpretation of acoustic data by many investigators in recent years.

Figure 1 provides a generalized flowchart to aid in the development of either a scientific or industry acoustic data-collection/survey programme.

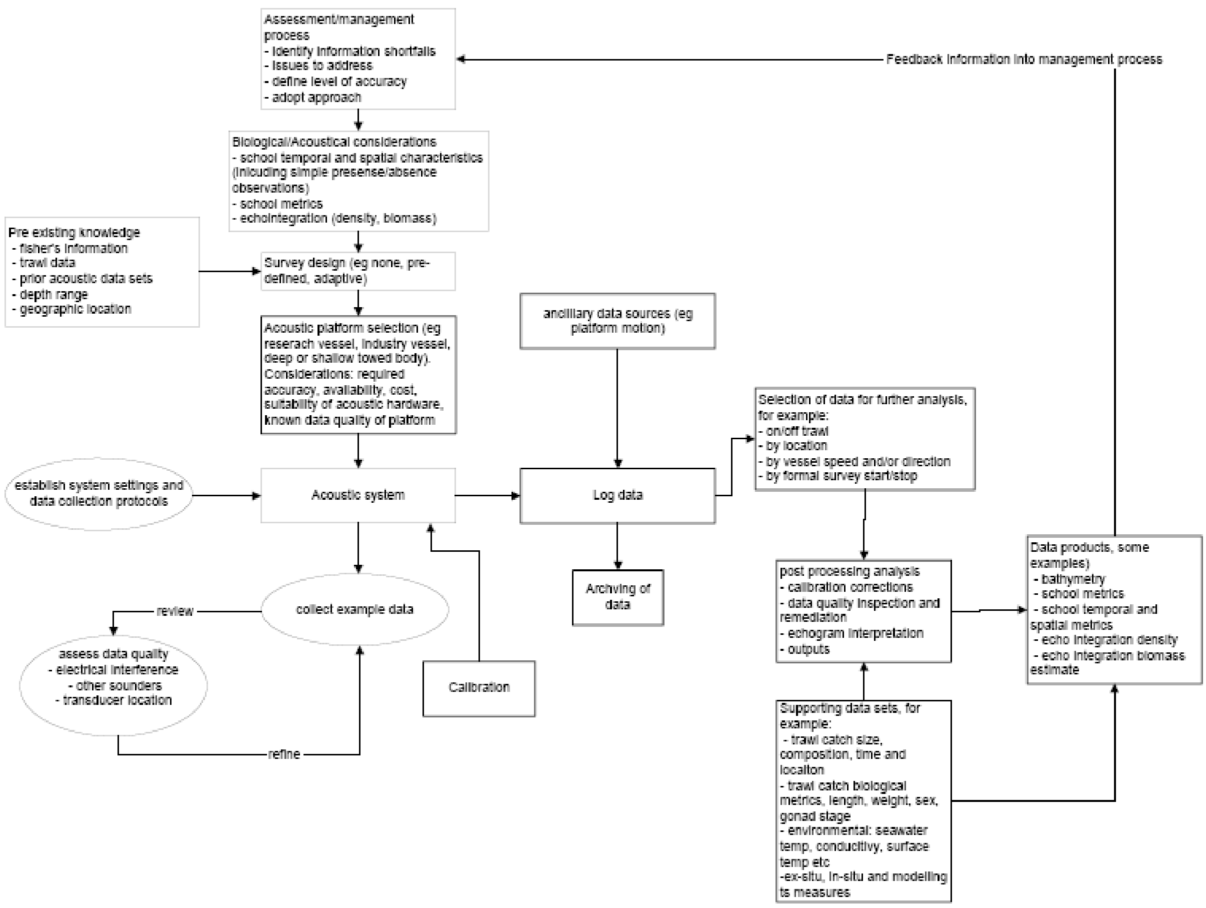

Figure 3. Key elements of an acoustic survey programme starting with assessment of the management perspective and considering sampling and data-processing details and the provision of feedback to the survey design.

8.7. Summary

The processing and analysis of acoustic data collected by vessels of opportunity can be complex and extremely variable. In this section, we have discussed in general terms a number of generic applications, concerns, and practical solutions to the use of these data. Acceptance and inclusion of information, such as echosounder data collected by commercial fishing vessels, into the analytical assessment forum and subsequent management of a fish stock may be even more difficult. However, both technological advancements, such as near-scientific quality echosounders with logging capabilities, and the fishing industry's understanding of scientific survey requirements are paving the way for unsupervised and autonomous data collections from many types of vessels.

8.8. Recommendations

Although requirements for processing, analysis, and interpretation of acoustic (and ancillary) data collected on board fishing vessels may not differ markedly from requirements for similar types of data collected on board research vessels, some considerations are particularly important:

1) Large quantities of data may be collected, requiring special procedures for the storage and archiving of data.
2) Metadata will be especially useful in the identification of subsets of data for detailed analysis.

3) It may be advisable to collect raw data and low-resolution data simultaneously. Low-resolution data can be reviewed rapidly to assist in identifying sequences of high-resolution data for detailed analysis.

Annex 1 : Hardware and software contact information

BioSonics, Inc.	Scientific echosounders	http://www.biosonicsinc.com
Femto Electronics Ltd	Acoustic hardware and software	http://www.femto-electronics.com
Furuno Marine Electronics	Commercial echosounders	http://www.furuno.com
Hydroacoustic Technology, Inc.	Scientific echosounders	http://www.htisonar.com
Simrad A/S	Comm. and scientific echosounders	http://www.simrad.com
Echoview Pty. Ltd	Fishery acoustics software	http://www.echoview.com

List of open-source efforts to read, process, analyze, and interpret fisheries acoustic data (Source: ICES FAST WG, 2020)

- **Echopype**

URL: https://github.com/OSOceanAcoustics/echopype
Language: Python
Description: Enhance interoperability and scalability of fisheries acoustics data based on the pydata suite of tools.
Contact name: Wu-Jung Lee
Contact e-mail: leewujung@gmail.com

- **ExCal**

URL: https://github.com/gavinmacaulay/calibration-code
Language: Matlab
Description: Calculate calibration coefficients for EK/ES60 echosounders.
Contact name: Gavin Macaulay
Contact e-mail: gavin.macaulay@hi.no

- Echopy

URL: https://github.com/bas-acoustics/echopy
Language: Python, v3
Description: Fisheries acoustic data processing and analysis, such as noise removal, binning, seabed detection and target detection. The library provides building blocks that can be assembled to design custom processing routines.
Contact name: Alejandro Ariza
Contact e-mail: alejandro.ariza@ird.fr

- **EchoR**

URL: https://gitlab.ifremer.fr/md0276b/echor
Language: R
Description: R package to handle pre-processed fisheries acoustics data collected during sea surveys and to produce and analyse ec(h)osystem indices and maps based on fisheries acoustics data.
Contact name: Mathieu Doray
Contact e-mail: mathieu.doray@ifremer.fr

- **pyEcholab**

URL: https://github.com/CI-CMG/pyEcholab
Language: Python, v3
Description: pyEcholab is an open-source, Python-based toolkit for reading, processing, plotting and exporting fisheries acoustic echosounder data.
Contact name: Carrie Wall, Chuck Anderson
Contact e-mail: carrie.wall@noaa.gov, charles.anderson@noaa.gov

- **ESP3**

URL: https://sourceforge.net/projects/esp3
Language: Matlab (standalone available)
Description: ESP3 is an open-source software package for visualising and processing active acoustics data, developed at NIWA (Wellington, New Zealand) by the Fisheries Monitoring and Acoustics group. ESP3 is designed for single-beam and split-beam echosounder data. The software has been written mainly for processing fisheries acoustic surveys, with attention to reproducibility, consistency and efficiency. Although ESP3 was initialy developed to visualise and process single, multi-frequency and broadband SIMRAD EK60 and EK80 raw data, it also supports other formats (e.g., NIWA CREST, Furuno FCV-30 and ASL AZFP). The software allows standard post-processing and analysis of fisheries acoustic survey data such as calibration, scrutinisation using in-house algorithms (e.g, bad transmits identification, automated bottom detection, single targets detection and tracking, schools detection, etc.) and others developed by the scientific community (e.g., background noise removal), multi-frequency analysis and echo-integration.
Contact name: Yoann Ladroit
Contact e-mail: yoann.ladroit@niwa.co.nz

- **Matecho**

URL: ftp://ftp.ifremer.fr/ifremer/ird/acoustics/survey_kit
Language: Matlab
Description: Matecho is an automated processing method to extract information and perform echo-integration and fish shoal extraction from various scientific echo-sounder sources. The procedure allows the semiautomatic cleaning of echogram data and the application of automatic data filters. Echo-integration processing is executed for each depth layer and integrates their characteristics per elementary sampling unit. Sound scattered layers are automatically detected by segmentation from the echo-integrated echogram, and shoals are extracted according to an iterative process of aggregation of filtered echogram echoes that allows, in both cases, the calculation of the ad hoc parameters describing morphological, spatial location and acoustic characteristics of sound scattered layers and shoals.
Contact name: Yannick Perrot
Contact e-mail: yannick.perrot@ird.fr

Annex 2 : First version of the inventory of technologies available aboard Peruvian vessels authorized to operate in the Jack Mackerel fishery

The next is the list of fishing vessels authorized to operate in the Jack Mackerel ("jurel") fishery in the marine Peruvian jurisdiction. It is described by columns the main acoustic equipment currently deployed by every vessel.

N°	Vessel Name	Sonar	Type	Echosounder	Manufacturer	Frequency	Power Kw	Pulse length ranges	Transducer model
1	JUANCHO	SIMRAD SU-93 / FURUNO CSH-5LMK2	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
2	KIANA	OMNI SIMRAD SX93 / FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
3	MALENA	OMNI SIMRAD SX93 / FURUNO CSH-5LMK2	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
4	MARIA PIA	OMNI SIMRAD SX93 / FURUNO CSH-5LMK2	DIGITAL	KSE-200	KAIJO	120khz Split Beam	1kw		
5	NVA OFELITA	OMNI FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
6	NVA. RESBALOSA	OMNI SIMRAD SX93 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
7	PITI	OMNI KAIJO KCS-5221Z / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
8	SIMON	OMNI SIMRAD SX93 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
9	LIGRUNN	OMNI KAIJO KCS-3221Z / kaijo ks-60	DIGITAL	ES-70	SIMRAD	120khz Split Beam	1kw	64ms - 1024ms	ES 120 - 7C
10	DON OLE	SIMRAD SU90 / KAIJO KCS60	DIGITAL	ES-70	SIMRAD	38, 70 Y 120* khz Split Beam	1kw *	64ms - 1024ms *	ES 120 - 7C *
11	CHIMBOTE 1	OMNI CSH-5L	ANALOGICA	FCV-582L	FURUNO	50/200KHZ	0.5Kw	0.13 a 3.6ms	50/200-1T
12	CRISTINA	OMNI FSV-30	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.6Kw	0.13 a 3.6ms	50/200-1T
13	INCAMAR 1	OMNI FSV-30/OMNI CSH-5L	DIGITAL/ANALOG	ES-80/FCV-1150	SIMRAD / FURUNO	120khz/28 - 200KHZ	1Kw/2Kw	(64ms - 1024ms)/(0.1 a 5ms)	ES120-7C/50B-12
14	INCAMAR 2	OMNI FSV-30/OMNI CSH-5L	DIGITAL/ANALOG	FCV-30/FCV-1150	FURUNO	38khz/28 - 200KHZ	4Kw/2Kw	(0.5 a 26ms)/(0.1 a 5ms)	CV-303/50B-12
15	INCAMAR 3	OMNI FSV-30/OMNI CSH-5L	DIGITAL/ANALOG	FCV-30/FCV-1150	FURUNO	38khz/28 - 200KHZ	4Kw/2Kw	(0.5 a 26ms)/(0.1 a 5ms)	CV-303/50B-12
16	MARU	OMNI SX-93/OMNI CSH-5L	DIGITAL/ANALOG	ES-80/FCV-588	SIMRAD / FURUNO	120Khz/50-200Khz	1Kw/0.6kw	(0.64 a 5ms)/(0.13 a 3.6ms)	(120-7C)/(50/200-1T)
17	MATTY	OMNI CSH-5L	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.6Kw	0.13 a 3.6ms	50/200-1T
18	RIBAR I	OMNI CSH-5L/SECT CH-37	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.5Kw	0.13 a 3.6ms	50/200-1T
19	RIBAR III	OMNI FSV-24/SECT CH-36	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.6Kw	0.13 a 3.6ms	50/200-1T
20	RIBAR IX	OMNI FSV-30/SECT CH-36	DIGITAL/ANALOG	FCV-30/FCV-587	FURUNO	38khz/50 - 200KHZ	4Kw/0.6Kw	(0.5 a 26ms)/(0.1 a 3ms)	CV-303/(5O/200-1T)
21	RIBAR VI	OMNI FSV-30/SECT CH-36	DIGITAL/ANALOG	FCV-30/FCV-1000	FURUNO	38khz/50 - 200KHZ	4Kw/1Kw	(0.5 a 26ms)/(0.1 a 4ms)	CV-303/(5O/200-1T)
22	RIBAR XIII	OMNI FSV-24/SECT CH-36	ANALOGICA	FCV-585	FURUNO	50/200KHZ	0.6Kw	0.1 a 3ms	50/200-1T
23	RIBAR XIV	OMNI CSH-5L/SECT CH-36	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.6Kw	0.1 a 3ms	50/200-1T
24	RIBAR XV	OMNI CSH-5L/SECT CH-36	ANALOGICA	FCV-582L	FURUNO	50/200KHZ	0.5Kw	0.13 a 3.6ms	50/200-1T
25	RIBAR XVI	OMNI FSV-30/SECT CH-36	DIGITAL/ANALOG	FCV-30/FCV-585	FURUNO	38khz/50 - 200KHZ	4Kw/0.6Kw	(0.5 a 26ms)/(0.1 a 3ms)	CV-303/(5O/200-1T)
26	RIBAR XVIII	SIMRAD SU 93/SECT CH-36	DIGITAL/ANALOG	FCV-30/FCV-588	FURUNO	38khz/50KHZ	4Kw/0.6Kw	(0.5 a 26ms)/(0.13 a 3.6ms)	CV-303/(5O/200-1T)
27	RICARDO	OMNI CSH-5L	ANALOGICA	FCV-585	FURUNO	50/200KHZ	0.6Kw	0.1 a 3ms	50/200-1T
28	RODGA 1	OMNI CSH-5L/SECT CH-37	ANALOGICA	FCV-585	FURUNO	50/200KHZ	0.6Kw	0.1 a 3ms	50/200-1T
29	SAN FERNANDO	OMNI KCS-2500	ANALOGICA	FCV-588	FURUNO	50/200KHZ	0.6Kw	0.1 a 3ms	50/200-1T
30	ALESSANDRO	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
32	CONSTANZA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C

34	CHIARA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
35	DANIELLA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-80	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
36	DON JUAN	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	EK-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
41	GRACIELA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	FCV-585	FURUNO	50/200KHz	1 KW	0.04 a 3 ms	50/2001T
43	MARIA JOSE	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
45	OLGA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
46	PATRICIA	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
49	POLAR IV	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
51	POLAR VII	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
54	SEBASTIAN	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
55	STEFANO	OMNIDIRECCIONAL FURUNO CSH-5L	DIGITAL	ES-60	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
56	MARIA I	SONAR OMNIDIRECCIONAL ,FURUNO CSH-5L	DIGITAL	FCV - 1000	FURUNO	50/200 kHz)	0.6 kw	0,04 a 3,0 ms; Máx. 5.000 pulsos/min	CA 50/200-1T 1KW
57	MARY	SONAR OMNIDIRECCIONAL ,FURUNO CSH-5L	DIGITAL	FCV-588.	FURUNO	50/200 kHz)	0.6 kw	0.04 to 3.0 ms, Max 3,000 pulse/min	CA 50/200-1T 1KW
58	POLAR I	SONAR OMNIDIRECCIONAL ,FURUNO CSH-5LMK2	DIGITAL	FCV-588.	FURUNO	50/200 kHz)	0.6 kw	0.04 to 3.0 ms, Max 3,000 pulse/min	CA 50/200-1T 1KW
59	SANTA ADELA II	SONAR OMNIDIRECCIONAL ,FURUNO CSH-5LMK2	DIGITAL	FCV-588.	FURUNO	50/200 kHz	0.6 kw	0.04 to 3.0 ms, Max 3,000 pulse/min	CA 50/200-1T 1KW
60	ANCASH 2	OMNI FURUNO FSV-30 / OMNI FURUNO CSH-5L	DIGITAL	(FCV-30) / (FCV-585)	FURUNO	(38kHz) / (50/200KHz)	(4kw) / (1kw)	(0.5 - 26 ms) / (0.1 - 3 ms)	(CV-303) /
61	CARMENCITA	OMNI FURUNO FSV-30 / DIECCIONAL FURUNO CH-37	DIGITAL	FCV-30 / FCV-582L	FURUNO	(38khz) / (50/200KHz)	(4kw) / (1kw)	(0.5 a 26 ms) / (0.13 - 3.6 ms)	(CV-303) /
62	CRETA	OMNI FURUNO FSV-30 / OMNI FURUNO CSH-5L	DIGITAL	FCV-30 / FCV-582L	FURUNO	(38khz) / (50/200KHz)	(4kw) / (1kw)	(0.5 a 26 ms) / (0.13 - 3.6 ms)	(CV-303) /
63	CUZCO 4	OMNI FURUNO FSV-30 / OMNI FURUNO CSH-5L	DIGITAL	(FCV-30) / (FCV-587)	FURUNO	(38kHz) / (50/200KHz)	(4kw) / (0.6kw)	(0.5 - 26 ms) / (0.1 - 3 ms)	(CV-303) /
64	DON ALFREDO	OMNI FURUNO FSV-30 / OMNI FURUNO CSH-5L	DIGITAL	FCV-30 / FCV-585	FURUNO	(38khz) / (50/200KHz)	(4kw) / (1kw)	(0.5 a 26 ms) / (0.1 - 3 ms)	(CV-303) /
65	RODAS	OMNI FURUNO FSV-35 / OMNI FURUNO CSH-5L	DIGITAL	ES-80 / FCV-585	SIMRAD / FURUNO	120kHz / (50/200KHz)	(1kw) / (1kw)	(64ms - 1024ms) / (0.1 - 3 ms)	split beam
66	BAMAR I	OMNI FURUNO FSV-30 / OMNI FURUNO CSH-8L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
67	BAMAR II	OMNI KAIJO KCS-3221Z / KAIJO KCS-2881	DIGITAL	ES-80	SIMRAD	10 a 500 KHz	4 KW	0.5 a 26 ms	ES120-8C
68	BAMAR IV	OMNI KAIJO KCS-3221Z / OMNI FURUNO CSH-8L	DIGITAL	FCV-30	FURUNO	38 KHz	4 KW	0.5 a 26 ms	CV-303
69	BAMAR VIII		DIGITAL	KSE-100	KAIJO	38 KHz	3 KW	0.5 a 26 ms	T-178
70	CHAVELI II	SIMRAD SU-90 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
71	ISABELITA	SIMRAD SU-90/ FURUNO CSH-8L	DIGITAL	FCV-30	FURUNO	38 KHz	4 KW	0.5 a 26 ms	CV-303
72	IVANA B	KAIJO KCS-3220Z / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
73	JADRANKA B	SIMRAD SU-90 / FURUNO CSH-8L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
74	KIARA B	KAIJO KCS-3220Z / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
75	MARIANA B	FURUNO FSV-30 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
76	MARYLIN II	FURUNO FSV-30 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
77	YAGODA B	SIMRAD SX-90 / FURUNO CSH-5L	DIGITAL	ES-70	SIMRAD	12 a 200 KHz	4 KW	0.05 a 16 ms	ES120-7C
78	TASA 41	OMNIDIRECCIONAL FURUNO FSV-30	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
79	TASA 42	OMNIDIRECCIONAL FURUNO FSV-30	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
80	TASA 427	OMNIDIRECCIONAL FURUNO FSV-35	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
81	TASA 51	OMNIDIRECCIONAL SIMRAD SX-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
82	TASA 52	OMNIDIRECCIONAL SIMRAD SX-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
83	TASA 53	OMNIDIRECCIONAL SIMRAD SX-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
84	TASA 54	OMNIDIRECCIONAL FURUNO FSV-25	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C

85	TASA 55	OMNIDIRECCIONAL SIMRAD SU-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
86	TASA 56	OMNIDIRECCIONAL FURUNO FSV-30	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
87	TASA 57	OMNIDIRECCIONAL FURUNO FSV-35	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
88	TASA 58	OMNIDIRECCIONAL FURUNO FSV-30	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
89	TASA 59	OMNIDIRECCIONAL SIMRAD SX-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C
90	TASA 71	OMNIDIRECCIONAL SIMRAD SX-90	DIGITAL	ES-70	SIMRAD	120KHZ Split Beam	1000W	64ms - 1024ms	ES120-7C