8. Marine Sampling Field Manual for Benthic Sleds and Bottom Trawls

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Platform Description

Benthic sleds (also called sledges) and bottom trawls both use nets to collect organisms while they are towed across the seafloor. While trawls use free nets with doors or beams spread the net, sleds use frames and runners to protect and secure the net (Eleftheriou and Mcintyre 2005). Benthic sleds target sessile or sedentary macrofauna and megafauna with some designs able to be deployed over rugged terrain, while bottom trawls are typically more successful in collecting demersal or mobile fauna and are deployed over smooth but compact terrain or soft sediments.

There is no one type of sled or trawl suitable for all habitats and depths, and selection of the most suitable gear type depends on scientific objectives, previous knowledge, targeted fauna, environment, depth, and vessel capabilities (Clark et al. 2016, Kaiser and Brenke 2016). Acquired data are often described as semi-quantitative (Table 2.1 in Schiaparelli et al. 2016a) due to inconsistencies in gear path, swept area, and movement (e.g. sled skipping along seafloor), as well as taxa targeted by the gear (e.g. avoidance by highly mobile megafauna, herding effect in some fish). Imagery of the seafloor helps enormously with sled choice and deployment techniques. Imagery and geospatial positioning can be obtained with available technology and can aid in the success of each deployment. In the absence of imagery, bathymetry can also provide a good indication of gear suitability. The use of multiple types of sleds and trawls may be most appropriate for surveys trying to quantify overall biodiversity in a given location (Williams and Bax 2001, Clark and Roberts 2008), while a single sled or trawl type may be more efficient for quantifying species in a particular location or habitat for monitoring purposes (Przeslawski et al. 2015). For these reasons, this manual does not mandate specific gear types, although sled and trawl types historically used in Australian waters are listed in Table 8.1 to help facilitate decisions regarding equipment for a given marine survey. Nevertheless, for monitoring purposes, it is preferable to maintain consistent gear in time and space, and we therefore recommend this where possible.

For further information on the advantages and disadvantages of sleds and trawls compared to other benthic sampling platforms, refer to *Comparative assessment of seafloor sampling platforms* Przeslawski et al 2018).

Table 8.1 Types of benthic sleds and trawls deployed in Australian waters and their associated characteristics. See reviews on benthic sleds and trawls for information about gear deployed elsewhere in the world (Clark et al. 2016, Kaiser and Brenke 2016). Unavailable indicates information that was unable to be obtained for this manual.

Type	Dimensions (mouth, h x w)	Weight	Target taxa	Cod end	Other features	Suitable terrain	Ref
Sherman (CSIRO-SEBS) sled	600 x 1200 mm	860 kg (excluding modifications from Lewis 2009)	Benthic invertebrates and fish	Polyethylene twine, 3.2 m long, 25 mm mesh	Reinforced frame, weak link chains, chaffing mat, net sonde, optional infaunal or 1 mm net	Seamount, rugged terrain, hard substrates	(Lewis 1999, 2009)
Rainer sled	2900 mm width	590 kg	Benthic invertebrates	25 mm stretch mesh	Sled divided into epibenthic and infaunal halves	Various shelf substrates	(Bax et al. 1999)

AIMS sled	1500 x 1000 mm		Large benthic invertebrates	45 mm stretch diamond mesh		Various shelf substrates	(Colquhoun et al. 2007)
SARDI sled	600 x 1800 mm		Sessile and sedentary epibenthos	50 mm mesh		Soft sediment shelf ecosystems	(Ward et al. 2006)
NIWA seamount sled	1130 x 380 mm	400 kg	Sessile and sedentary epibenthos	28 mm mesh	Reinforced frame, weak link chains, location beacon, anti-chafing net, smaller model available (250 kg)	Seamount, rugged terrain, hard substrates	(Clark and Stewart 2016)
Brenke Sledge (MNF)	1300 x 1240 mm	unavailable	Benthic macrofauna	0.5 mm mesh	Dual nets, nodule exclusion mesh, insulated cod end	Smooth terrain	(Brenke 2005)
MAPS sled	300 x 500 mm	unavailable	Planktobenthos	100, 500, and 1000 µm	Concurrent planktobenthic and benthic sampling, tri-layered net	Smooth terrain	(Przeslawski and McArthur 2009)
Scaled down Woods Hole	300 mm	unavailable	unavailable	unavailable	unavailable	Estuaries	(Hirst 2004)
CSIRO beam trawl	500 x 4000 mm	unavailable	unavailable	25 mm mesh	Tickler chains, triple tow bridle, chaffing mat, pivot points	Flat to low relief terrain, soft substrates	(Lewis 2010)
Orange roughy trawl (ORH)	26 000 x 6500 m	3 t in water	Large mobile fauna	Various depending on cod-end fitted (40 mm common)	Small attached cone nets to sample small animals, otter boards, heavy duty high ground gear	Rough bottom, including seamounts	(Clark et al. 2016)
Full-wing bottom trawl	28 000 x 3500 m	3 t in water	Mobile fauna, demersal and benthic species	Various depending on cod-end fitted (40 mm common)	Otter boards	Smooth terrain	(Clark and Roberts 2008)
NORFA NZ beam trawl	300 x 4000 mm	unavailable	Slower-moving demersal fish, benthic invertebrate mega-fauna	10 mm	Chaffing mat	Smooth terrain	(Clark and Roberts 2008)

Florida flyer shrimp trawl	unavailable	unavailable	Mobile fauna, demersal and benthic species	unavailable	unavailable	Smooth terrain	(Wassenberg et al. 1997)
McKenna market trawl (CSIRO)	19 000 x 5000 mm	unavailable	Mobile fauna, demersal and benthic species	15 mm	Weighted bottom line, floats hold up the upper line, doors keep the net	Smooth terrain	SEF voyages, NWS voyages, *RV Investigator* deep-sea

Scope

This Sled and Trawl Field Manual includes gear designed to sample organisms on the seafloor, excluding microbes and meiofauna (see chapters in Eleftheriou and Mcintyre 2005, Danovaro 2010 for such methods).

Pipe dredges, rock dredges and other such gear are not included because biological collections by these are incidental. Similarly, commercial dredges are not considered because they have a narrow taxonomic focus (e.g. scallop dredge) and are not suitable for general monitoring purposes. Fish traps and similar gear are not included because they often apply to shallow waters or reef-associated species and often use bait. This Field Manual does not target endobionts or burrowing species (e.g. animals living within sponges, rocks, corals) due to the excessive amount of time needed to process such animals (Coggan et al. 2005) and their limited use in a national monitoring program. Although some sleds are designed to sample small macrofauna and infauna (e.g. Brenke 2005), for the purposes of this field manual, we include only larger macrofauna and megafauna. Smaller taxa are targeted in the Grab and Boxcore Field Manual. If researchers opt to use a sled to sample smaller fauna, we recommend combining *Pre-survey Planning* and *Onboard Sample Acquisition* sections from this field manual with *Onboard Sample Processing* from the Grab and Box Corer Field Manual (Chapter 9).

Sleds and Trawls in Marine Monitoring

Sleds and trawls can be used to successfully monitor changes in benthic communities over time (Billett et al. 2001). However, they are becoming less popular for this purpose due to their destructive sampling, difficulty in revisiting locations, and sampling variability due to species and size selectivity. In addition, more quantitative underwater imagery technologies continue to develop and become more accessible.

Instead, sleds and trawls are now most likely to be used in the early stages of a monitoring program to obtain baseline data which can then inform imagery annotations by providing species inventories or biodiversity assessments (Przeslawski et al. 2015), particularly as related to new, endemic, or cryptic taxa. This is essential for environments and regions in which extractive sampling is the only means to examine and identify many species in complex ecosystems. The specimens themselves are used to inform taxonomic studies, ascertain species distributions, and as a source of genetic (DNA) data and isotope data. Thus their application is similar to grabs and boxcores, but sleds and trawls sample a large transect rather than a point. Therefore, they may be more suitable to assess macrofaunal biodiversity in the deep sea where abundances may be low and deployment times are high (e.g. O'Hara et al 2020a,b).

Equipment

Equipment must be appropriately set-up to ensure as much consistency as possible among surveys and also to facilitate gear replacement if necessary. Equipment configurations can vary among substrate types. For example, in abyssal plains, wider skids on a beam trawl reduce sinking into mud. Table 8.1 lists the specifications, where available, of benthic sleds and trawls deployed in Australian waters.

The key components for a bottom trawl include the following, all of which should be documented and photographed:

- Sampling gear
    - Net (full net plans, including mesh types and sizes)
    - Floatation system (headline floatation plan, size, number, and position of floats)
    - Groundrope (groundrope composition, length, details of all components)
- Rigging plans
    - Sweep and bridle size and lengths
    - Layback of the headline (if any)
- Deployment procedures
    - Warp-to-depth ratios for amount of trawl wire
    - Standard electronics to be used (e.g. USBL, CTD), and acceptable values of certain measurements
    - Required towing speed

The key components for a benthic sled include:

- Sampling gear
    - Net (full net plans, including mesh types and sizes)
    - Frame (full frame plan, including dimensions and weight, chafing mat)
    - Buoys (size, number, position)
    - Mouth dimensions
- Rigging plans
    - Bridle size and lengths
    - Weak links
- Deployment procedures
    - Estimated amount of trawl wire
    - Standard electronics to be used, and acceptable values of certain measurements
    - Required towing speed

Pre-Survey Preparations

Identify a chief biologist or ecologist who will be responsible for making decisions related to samples onboard, particularly regarding prioritisation of samples during onboard processing. This will be particularly helpful during busy periods with large hauls or multiple back-to-back tows. If 24-hour operations are planned, a second-in-charge will be needed as well.

Confirm sampling design meets survey objectives, is achievable with planned equipment and time, and has been communicated to all key scientists and managers. See Chapter 2 for further details on sampling design. If the study area is small with respect to the size of the combined length of all transects, then the sampling design may be better suited to transects, not points (see Foster et al. 2019 and Chapter 2).

Consideration must be given to the location of the trawl or sled during deployment. Ultra-short baseline acoustic technology (USBL) is recommended to identify the true location of the sled/trawl during bottom contact (Schlacher et al. 2007), particularly in deep waters where the sled/trawl may be kilometres away from the vessel during a tow (Clark and Stewart 2016). If a USBL is unavailable in deep waters, the angle and length of wire payed out should be recorded so that sled/trawl location can be trigonometrically estimated (Milroy 2016). Station record forms should record gear location wherever possible, with vessel location recorded as a back-up.

Consideration must be given to the stability of the trawl or sled during deployment. Ideally, a Netsonde or bottom contact sensor will be used to indicate when the gear is lifting off the seafloor so that speed can be reduced or more wire payed out or retracted. With trawls, door-spread or wing-end sensors are also useful to ensure consistency of gear set-up and performance. If these are unavailable, strict attention must be paid to the winch wire and constant adjustments performed or a self-tensioning winch used to ensure continuous bottom contact (Clark et al. 2016).

During the planning phases, taxonomists and museum curators must be engaged to ensure that samples will be appropriately identified and preserved and voucher specimens are lodged at national repositories (i.e. museums). They can also advise on the likely species selectivity of the proposed gear for certain taxa. Preferably, taxonomists will participate in marine surveys in which case they can identify much of their respective groups onboard (Zintzen et al. 2011). The appropriate taxonomic resolution at which specimens will be identified should also be determined. Species-level identification may be appropriate for voyages of discovery (Poore et al. 2015), while family level may be suited for measuring relationships with environmental covariates (Hirst 2006). For many surveys, identifications will only target selected groups (e.g. sponges in Przeslawski et al. 2015). This should be decided in the pre-survey planning stage, not after sampling has been undertaken. Importantly, non-target specimens should still be retained for museum lodgement if possible, in order to facilitate identification in the future if resources or priorities allow, particularly in locations that are infrequently visited (e.g. deep sea).

The purposes of biological samples must be determined. For monitoring purposes, samples of each target species or operational taxonomic unit (OTU) must be collected for taxonomic identifications. Further objectives specific to a given survey or project may also include samples for genetic or biochemical analyses for particular groups. Protocols for these samples (including preservation as per point below) must be developed prior to the start of the survey.

The level of onboard searching and sorting should be decided during the planning phase where there is sufficient information to inform discussion of likely catch rates. Onboard searching refers to the time spent looking through non-biogenic material to find biota, while onboard sorting refers to the taxonomic level to which biota are identified. Both will be determined by the key survey objectives, onboard taxonomic expertise, and available time and space. It is important that search effort is not adjusted between deployments as this is a source of variation in the resulting data. Onboard sorting may vary among groups (i.e. many fish may get sorted to species while invertebrates stay in coarse groups). At a minimum, samples should be sorted onboard by phylum to ensure correct preservation and assist dissemination post-voyage, but samples should also be able to readily be subdivided for many phyla (e.g. Cnidaria, Arthropoda, Echinodermata).

Taxonomists are far more likely to be willing to engage in post-survey identifications where the sample has been sorted to an appropriate level onboard.

Decide on preservation methods. This should be done in consultation with curators, taxonomists, molecular biologists, and biochemists that will be involved in using the samples. See Coggan et al. (2005) and Schiaparelli et al. (2016b) for information about appropriate preservatives for a range of taxa and purposes (e.g., species identification and description, genetic analysis, biochemical analysis), noting the variation between taxa.

Ensure adequate risk assessments are undertaken regarding safety and use of chemical onboard (i.e. ethanol, formalin), abiding by relevant state and federal legislation. This should include where appropriate onboard storage for chemicals, as well as personal protective gear, ventilation, and safety data sheets for hazardous chemicals.

Determine if specialists are needed for gear use. Many nets and sleds require experience to prepare, deploy and retrieve. The details below are not targeted for any one particular equipment or system or item, and we recommend engaging an experienced crew who have previously deployed similar devices.

Obtain appropriate permits that may apply for collection (Appendix B). Ideally, all surveys using sled, trawls or dredges will have a permit for biological collection, even if target samples are rocks and sediments. This will ensure incidental biological specimens do not get discarded overboard. Current regulations require permits for biological material being deposited in registered institutions. For Commonwealth waters, these include

1) Australian Fisheries Management Authority (AFMA) "Application for Scientific Permit"
2) Parks Australia: "Application for a permit to access biological resources in Commonwealth areas"
3) Parks Australia: "Application to Conduct Research Activities Within Commonwealth Marine Reserves"

State-based permits may also be required. For example AFMA have delegated authority in offshore areas of New South Wales and Queensland waters to the states.

Collection ethics approval may also be required from the research institution. In addition, more focussed permits including animal ethics may be needed for particular taxa (e.g. fish and cephalopods). Permits must be considered not just for collecting activities, but also for shipping and storage (e.g., biosecurity containment facilities). For example scleractinians, antipatharians, and some fishes are regulated under the Convention on International Trade in Endangered Species (CITES), and there may be restrictions on shipping these taxa to museums or other repositories (especially overseas institutions) without a permit.

Document the specifications of all sampling gear to be used, including photographs (see Equipment). Specifications that should be documented include gear size and configuration (mesh, floats, ground ropes, frame, spread between trawl doors), rigging plans (bridle, headline layback), and deployment needs (wire length estimated, required towing speed, netsonde or USBL methods). This can assist with estimating location and area of the seafloor sampled, as well as providing crucial information for comparisons with other surveys. Where possible, the gear set-up and specifications should be standardised across all surveys using the same equipment.

Decide on procedures for very large hauls. Sub-sampling or a focus on key taxonomic groups may save time needed for other survey operations (e.g. multibeam mapping) or objectives (e.g.

biodiversity characterisation in a different location) (Shimadzu and Darnell 2015). Alternatively, coarse level estimation of abundances could occur based on visual estimates or case counts. Such procedures must be decided before gear deployment and remain consistent for a given survey, and in all cases, representatives of all taxa should be collected and appropriately preserved. If time permits, pilot deployments can help determine the efficiency of the gear, deployment times, suitability of terrain, catch sizes over distances, and processing times.

Organise shipment of samples from vessel to repository (e.g. museum). If samples are frozen and are not too bulky, it may be most cost-effective to have individuals transport them on aircraft in which case airline requirements should be considered. If samples are in ethanol or formalin, transport of dangerous goods must be organised. Planning for shipment of samples well in advance of the survey will expedite demobilisation and ensures sample integrity. The destination museum can likely provide advice on shipping methods and regulations. See Schiaparelli et al. (2016b) for shipping advice.

Pre-survey checklist

	Task	Description/comments
☐	Identify onboard chief ecologist/biologist	
☐	Confirm sampling design meets necessary criteria (e.g. randomised, sufficient number of samples)	
☐	Engage taxonomists and curators	
☐	Determine onboard sorting level	
☐	Determine preservation methods	
☐	Complete necessary risk assessments	
☐	Identify specialists needed for gear configuration and deployment	
☐	Data storage needs identified and hardware purchased accordingly	
☐	Decide on methods for locating gear during deployment	
☐	Decide on methods to assess gear stability during deployment	
☐	Obtain appropriate permits	
☐	Document gear specifications	
☐	Determine procedures for large hauls	
☐	Organise shipment of samples	

Field Procedures

A visual summary of the key steps to follow when deploying benthic sleds or bottom trawls is shown in Figure 8.1.

Figure 8.1 Images from key steps involved in the use of benthic sleds and bottom trawls for marine monitoring: a) a modified WHOI sled with attached pipe dredges, b) seafloor imagery from towed video and bathymetric grids, c) lowering the AIMS benthic sled, d) sorting animals on the back deck, e) photographing specimens in ship laboratory, f) securely sealed containers to ship animals to museums

Onboard sample acquisition

1. Use acoustic data or underwater imagery to confirm areas to sample with the appropriate benthic gear (Schlacher et al. 2007, Williams et al. 2010). Do not deploy blind, as this increases the risk of equipment loss and damage, as well as unnecessary impact on potentially vulnerable ecosystems.

2. Brief crew and sorting staff on potential venomous or otherwise dangerous catch (i.e. cone shell, blue-ringed octopus, some fishes, corals, sponges, urchins).

3. Ensure the gear is set-up and deployment parameters and procedures are as documented in the gear-specific protocols.

4. Use netsonde or bottom contact sensor to ensure sled or trawl is suitably deployed along the seafloor *[Recommended]*

5. Use USBL System to ensure accurate positioning (Schlacher et al. 2007, Williams et al. 2015) *[Recommended]*

6. Mark sled runners or trawl groundline with waterproof pencil or paint to gauge success of seafloor deployment. Also check for polishing on the bobbins or runners. *[Recommended]*

7. Record all metadata related to a given tow, specified in Table 8.2.

8. For rugged slopes (e.g. seamounts), ensure appropriate gear is used and tow downslope to reduce snags.

9. Maintain speed that is appropriate for the gear and seafloor terrain. Epibenthic sleds and most beam and Agassiz trawls should be towed at 1–2 knots to maintain bottom contact, while faster speeds of 3–3.5 knots are appropriate for otter trawls and other gear dependent on speed to maintain net spreading. See Clark et al. 2016 and Kaiser and Brenke 2016 for details.

10. Tow into the swell, tide, current and/or wind so that vessel speed and steerage can be better controlled.

11. A standard fixed tow distance (i.e. bottom time) for monitoring purposes is not practical because because tow distance is highly dependent on gear type and seafloor environment. However, within a given survey, tow distance for each sled or trawl should be standardised to assess relative abundances. It should also be recorded in the metadata (Table 8.2). If the same sled is used on multiple surveys in similar environments, the tow distance should remain the same so that spatio-temporal comparisons can be made. For benthic sleds deployed along the continental shelf over mixed terrain, a tow distance of ~100 m is recommended. Longer tows (commonly 300 m) will be needed in deep waters due to lower density of macro- and megafauna. Information from multibeam data (see point 1) can help inform tow duration decisions.

12. Assess success of deployment. If there is significant damage to gear, signs of minimal bottom contact, or ripped nets, this should be recorded in the metadata (Table 8.2). The catch from such deployments can be considered for presence-only analyses, species inventories or biological analyses. Inclusion in quantitative comparisons with other tows should only be done after careful consideration of appropriate statistical methods (e.g. transformation, standardisation). In such situations, gear configuration should also be checked after recovery to ensure its correct specification for the next deployment (see point 3).

13. When the sled or trawl is lifted from the water, follow gear- and vessel-specific protocols for safe release of the catch onto the deck or sorting table.

14. Record biomass of entire catch using electronics from winch system or onboard scale *[Recommended]*

15. Photograph entire catch with station identification placard and make notes of catch composition (e.g. lots of mud or rocks) in metadata sheet (Table 8.2).

16. Remove all animals from the entire net, including the fore-parts of nets and sleds and not just the codend where most of the catch should have been collected. As soon as practical, begin onboard processing of the samples (next section).

17. Clean sled of all material and prepare for next deployment.

Onboard sample processing

18. For very large catches, implement the agreed sub-sampling protocol if applicable (see Pre-Survey Preparations).

19. Consider retaining material on ice or in an ice slurry while awaiting sorting to ensure material remains in best condition to assist accurate and consistent identification.

20. Separate large easily visible taxa into sorting trays by coarse groups: fish, sponges, soft corals, echinoderms, molluscs, ascidians, bryozoans, annelids, other. Weigh each group. Discard severely damaged organisms and non-biogenic material, unless otherwise needed. It can be useful to record the weights, descriptions, and images of rock, coral rubble and other non-biogenic material as this gives useful information on substrate type. Add a label to each sorting tray with Tow ID so as to avoid confusion when multiple tows are being processed.

21. Follow Animal Ethics procedures to euthanize animals where applicable

22. Place fragile organisms in seawater in the sorting trays. Use chilled seawater for deep-sea and polar samples to minimise sample degradation during sorting time.

23. Transfer groups to the sorting station, if not already there. See Coggan et al. (2005) for practical advice on setting up a sorting station.

24. Based on previous decisions about onboard level of sorting (Section 8.5), progressively sort organisms into finer taxonomic groups, as much as time or expertise allows, with OTU (operational taxonomic unit) or species representing the finest taxonomic level.

25. Weigh, count, and photograph each of the final groups, including a scale bar and unique identifying sample number. Ensure this is done in a way that doesn't destroy the DNA in the specimens (e.g. pericards need to be kept chilled and moist). Refer to Schiaparelli et al. 2016 for suggestions on specimen photography.

26. Record data against a unique station identifier for the data base and keep a label with the same unique identifier with the specimen(s) (Table 8.3). At this stage identify specimens (or subset of specimens) for analyses purposes (whole specimens for taxonomy/isotopes/genetics etc.) or where appropriate (and pre-determined in plan) take tissue samples for analyses (genetics, isotopes etc.) If there are large numbers of the same species or OTU, only a sub-set may need to be preserved for museum collections; this should be established during Pre-Survey Planning in consultation with taxonomists or curators. In this case, record the total number collected (i.e. number caught) as well as the number in the collection container (i.e. number preserved).

27. If applicable relax and fix specimens according to survey objectives and taxonomists' preferences (e.g. samples for genetic analysis should not be fixed in formalin).

28. Preserve specimen according to methods decided in Pre-Survey Preparations, and place into container. See Rees (2009) and Schiaparelli et al. (2016b) for comprehensive description of fixatives and preservatives used for marine invertebrates.

29. Place solvent-hardy label with unique identifier in each sample container. It is not sufficient to label only the outside of the container, as this can easily rub off. See Box 15.6 in Schiaparelli et al. 2016 for suitable label characteristics.

30. Place container in large sealable container (i.e. lidded drum) with other samples preserved using the same chemicals (e.g. ethanol) or method (e.g. freezing). It saves time in post-survey sample distribution if taxa are grouped together in containers rather than by station.

Onboard sample storage

31. Store large labelled drum onboard in the freezer or in an approved storage area for hazardous chemicals.

32. Transcribe metadata from Tables 8.2 and 8.3 into digital format as soon as possible to minimise the build-up of data entry. This must be done onboard preferably during the same shift because it provides a back-up and an immediate check of the record, as well as facilitating timely metadata release.

33. Check the data entry is correct by cross-checking field sheets with database. This is best done by a person who didn't enter the data *[Recommended]*.

34. During demobilisation, ensure samples and drums are properly labelled and closed, and implement shipping according to decisions made during pre-survey planning.

Table 8.2 Sample field datasheet to record metadata (i.e. deployment or event data) from each sled or trawl haul. Waterproof paper and pen/pencil is required.

	Gear in water			Gear on bottom				Tow speed	Wire out (length)[8]	Wire out (angle)[8]	Gear off bottom				Gear out of water			Total catch biomass[9]	Notes[10]
Tow ID	Lon	Lat	Time	Lon	Lat	Depth	Time[11]				Lon	Lat	Depth	Time[11]	Lon	Lat	Time[11]		
GENERAL GEAR NOTES (e.g. equipment configuration changes during survey, torn net, etc):																			

[8] Record the length and angle of wire payed out during seafloor contact. This is required if deep water survey with no USBL; otherwise recommended.
[9] Include units (e.g. kilograms)
[10] Record person entering data, spread of trawl doors if applicable
[11] UTC timezone

Table 8.3 Sample field datasheet to record metadata from each sorted biological sample. Waterproof paper and pen/pencil is required.

Tow ID	Sample ID	Phylum	Class	Order	Famil y	Genus, Species / Common Name	Weight	Abundance	Preservative / Quantity	Photos	Notes

Post-survey procedures

Sample curation

1. Lodge all specimens in an internationally recognised and routinely maintained specimen collection (e.g. museum) for curation and public accessibility *[Recommended]*.

35. If all specimens are unable to be lodged at a museum due to lack of resources or need for destructive analyses (e.g. biochemical analyses), voucher specimens must be lodged (i.e. at least one animal per OTU).

Data release

All data should be publicly released, unless circumstances require otherwise (e.g. confidentiality clause or embargo for commercial work). Even in situations when data cannot be shared, the metadata and deployment information should be made available (Steps 1-2 below). Poor scientific data management and lack of data sharing has been shown to hamper scientific progress (Stocks et al. 2016).

Traditional, data related to biological specimens have been delivered as presence-only taxonomic identifications. These are often managed by individual museum scientists or curators and subsequently harvested by the Atlas of Living Australia (ALA). Ala does not yet include absences or information related to sampling effort, thus reducing the applicability of such databases to monitoring purposes.

OBIS is using the data structure described in the project called OBIS-ENV-DATA that allows the linking of species data to other related information (e.g. environmental data, images, sampling effort) (De Pooter et al. 2017). It now has the capacity to store absence records and sampling effort, and is working to include this information in data downloads.

In the meantime, the steps listed below will ensure appropriate and timely release of both metadata and data:

1. Create a metadata record describing the data collection. Provide as much detail as possible on the collection/deployment (either directly in the metadata record itself, or in the form of attached field sheets as .csv, .txt or similar). This should include sampling locations and dates, equipment used, level of sorting applied, etc. All collection/deployment information must be QC-d before inclusion.

2. Publish metadata record(s) to the Australian Ocean Data Network (AODN) catalogue as soon as possible after metadata has been QC-d. This can be done in one of two ways:

    a. If metadata from your agency is regularly harvested by the AODN, follow agency-specific protocols for metadata and data release.
    b. Otherwise, metadata records can be created and submitted via the AODN Data Submission Tool. Note that this tool requires user registration, but this is free and immediate.

This step provides immediate documentation of the methods and location of the collection of biological material. This stage may also include links to field reports or data sheets.

3. Produce a technical or post-survey report documenting the purpose of the survey, survey design, sampling locations, sampling equipment specifications, and any challenges or limitations encountered (Appendix C). Provide links to this report in all associated metadata records *[Recommended]*

4. Complete the species identifications and associated abundance or biomass for targeted groups identified. This can take quite some time, depending on sample size and available resources. It is not unusual for taxonomic identifications to lag years behind survey completion, but this should not delay publication of initial metadata and deployment information. Care must be taken to ensure consistent nomenclature is used and documented for undescribed or unnamed species (e.g. defined Operational Taxonomic Units, OTUs). Ideally photographic catalogues of OTUs are established such that subsequent surveys may use consistent OTU classification, thereby ensuring comparability of data between surveys.

5. QC the data. This includes checking for spelling errors, missing data, consistent nomenclature and use of OTUs, and confirmation that outliers are not data entry errors (e.g. 100 individuals really were collected, not just 10).

6. Attach or link the full data spreadsheet (including absences and abundances/biomass) to the metadata record previously created and published to the AODN. This will ensure public discoverability and accessibility of the complete data, including absences.

   To then publish data to OBIS, inform OBIS Australia (OBISAU) using the contact details and information on http://www.obis.org.au.

   OBISAU will download the data from AODN or any other site and apply the following procedures.

   - OBISAU provides a taxa matching service using WoRMS web services and will validate the dataset as best as possible.
   - The data is tested for any temporal or spatial outliers.
   - Any observed parameters (biotic and abiotic) are matched where possible to vocabularies maintained by AODN and BODC.
   - Metadata is authored from any existing metadata or publications.
   - Finally the datasets is published via the OBIS Australia data node http://ogc-act.csiro.au/ipt/

OBISAU has the option to publish the data at the same time directly to GBIF, and it has developed a service to inform ALA that a new dataset is available to be harvested for inclusion into .ALA

Field Manual Maintenance

In accordance with the universal field manual maintenance protocol described in Chapter 1 of the Field Manual package, this manual was updated in 2020 as Version 2. Updates reflect user feedback and new developments. There is currently no long-term plan or support for future updates. See Chapter 1 (Introduction to field manual package) for further details.

The version control for Chapter 8 (field manual for sleds and trawls) is below:

Version Number	Description	Date
0	Submitted for review (NESP Marine Hub, GA, external reviewers as listed Appendix A.	22 Dec 2017
1	Publicly released on www.nespmarine.edu	28 Feb 2018
2	Minor corrections, updates and clarifications. Revised Data Release section	May 2020

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References

Bax, N., R. Kloser, A. Williams, K. Gowlett-Holmes, and T. Ryan. 1999. Seafloor habitat definition for spatial management in fisheries: a case study on the continental shelf of southeast Australia. Oceanologica Acta 22:705-720.

Billett, D. S. M., B. J. Bett, A. L. RIce, M. H. Thurston, J. Galeron, M. Sibuet, and G. A. Wolff. 2001. Long-term change in the megabenthos of the Porcupine Abyssal Plain (NE Atlantic). Progress in Oceanography 50:325-348.

Brenke, N. 2005. An epibenthic sledge for operations on marine soft bottom and bedrock. Marine Technology Society Journal 39:10-19.

Clark, M. R., N. W. Bagley, and B. Harley. 2016. Trawls. Pages 126-158 *in* M. R. Clark, M. Consalvey, and A. A. Rowden, editors. Biological Sampling in the Deep Sea. Wiley Blackwell, West Sussex.

Clark, M. R. and C. D. Roberts. 2008. Fish and Invertebrate Biodiversity on the Norfolk Ridge and Lord Howe Rise, Tasman Sea (NORFANZ voyage, 2003).

Clark, M. R. and R. Stewart. 2016. The NIWA seamount sled: An effective epibenthic sledge for sampling epifauna on seamounts and rough seafloor. Deep Sea Research Part I: Oceanographic Research Papers 108:32-38.

Coggan, R., M. Curtis, S. Vize, C. James, S. Passchier, A. Mitchell, C. J. Smit, B. Foster-Smith, J. White, S. Piel, and J. Populus. 2005. Review of standards and protocols for seabed habitat mapping. Mapping European Seabed Habitats, France, UK.

Colquhoun, J., A. Heyward, M. Rees, E. Twiggs, F. McAllister, and P. Speare. 2007. Ningaloo Reef Marine Park Deepwater Benthic Biodiversity Survey: Metadata Report - Number 2. Australian Institute of Marine Science.

Danovaro, R. 2010. Methods for the Study of Deep-Sea Sediments, their Functioning and Biodiversity. CRC Press, Boca Raton, Florida.

De Pooter, D., W. Appeltans, N. Bailly, S. Bristol, K. Deneudt, M. Eliezer, E. Fujioka, A. Giorgetti, P. Goldstein, M. Lewis, M. Lipizer, K. Mackay, M. Marin, G. Moncoiffé, S. Nikolopoulou, P. Provoost, S. Rauch, A. Roubicek, C. Torres, A. van de Putte, L. Vandepitte, B. Vanhoorne, M. Vinci, N. Wambiji, D. Watts, E. Klein Salas, and F. Hernandez. 2017. Toward a new data standard for combined marine biological and environmental datasets - expanding OBIS beyond species occurrences. Biodiversity Data Journal 5:e10989.

Eleftheriou, A. and A. Mcintyre. 2005. Methods for the Study of Marine Benthos, 3rd Edition. Blackwell Publishing, Oxford.

Foster, S.; G. Hosack, J.; Monk, E. Lawrence, N. Barrett, A. Williams, A. & R. Przeslawski. 2019. Spatially-Balanced Designs for Transect-Based Surveys. *Methods in Ecology and Evolution 11, 95-105*

Hirst, A. J. 2004. Broad-scale environmental gradients among estuarine benthic macrofaunal assemblages of south-eastern Australia: implications for monitoring estuaries. Marine and Freshwater Research 55:79-92.

Hirst, A.J., 2006. Influence of taxonomic resolution on multivariate analyses of arthropod and macroalgal reef assemblages. Marine Ecology Progress Series 324, 83-93.

Kaiser, S. and N. Brenke. 2016. Epibenthic Sledges. Pages 184-206 *in* M. R. Clark, M. Consalvey, and A. A. Rowden, editors. Biological Sampling in the Deep Sea. Wiley Blackwell, West Sussex.

Lewis, M. 1999. CSIRO-SEBS (seamount, epibenthic sampler), a new epibenthic sled for sampling seamounts and other rough terrain. Deep Sea Research 46:1101-1107.

Lewis, M. 2009. Sherman the epibenthic sled for rough terrain. CSIRO Hobart.

Lewis, M. 2010. The CSIRO 4m Beam Trawl. CSIRO Marine and Atmospheric Research, Hobart.

Milroy, S. P. 2016. Field Methods in Marine Science. Garland Science.

O'Hara, T., Williams, A., Althaus, F., Ross, A.S., Bax, N.J. 2020a. Regional‐scale patterns of deep seafloor biodiversity for conservation assessment. Diversity and Distributions 26: 479-494.

O'Hara, T., A. Williams, S.N.C. Woolley, A.W. Nau, N.J. Bax. 2020b. Deep-sea temperate-tropical faunal transition across uniform environmental gradients. Deep-Sea Research I https://doi.org/10.1016/j.dsr.2020.103283.

Poore, G.B., L. Avery, M. Błażewicz-Paszkowycz, J. Browne, N. Bruce, S. Gerken, C. Glasby, E. Greaves, A. McCallum, D. Staples, A. Syme, J. Taylor, G. Walker-Smith, M. Warne, C. Watson, A. Williams, R. Wilson, S. Woolley. 2015. Invertebrate diversity of the unexplored marine western margin of Australia: taxonomy and implications for global biodiversity. Marine Biodiversity 45, 271-286.

Przeslawski, R., B. Alvarez, J. Kool, T. Bridge, M. J. Caley, and S. Nichol. 2015. Implications of sponge biodiversity patterns for the management of a marine reserve in northern Australia. PLOS ONE.

Przeslawski, R., S. Foster, J. Monk, T. Langlois, V. Lucieer, R. Stuart-Smith. 2018. Comparative Assessment of Seafloor Sampling Platforms. Report to the National Environmental Science Programme, Marine Biodiversity Hub. Geoscience Australia. 57 pp.

Przeslawski, R. and M. McArthur. 2009. Novel method to concurrently sample the planktobenthos and benthos. Limnology and Oceanography Methods 7:823-832.

Rees, H. L., editor. 2009. Guidelines for the Study of the Epibenthos of Subtidal Environments. International Council for the Exploration of the Sea, Denmark.

Schiaparelli, S., A. A. Rowden, and M. R. Clark. 2016a. Deep-Sea Fauna. Pages 16-35 *in* M. R. Clark, M. Consalvey, and A. A. Rowden, editors. Biological Sampling in the Deep Sea. Wiley Blackwell, Oxford.

Schiaparelli, S., K. Schnabel, B. Richer de Forges, and T.-Y. Chan. 2016b. Sorting, recording, presevation and storage of biological samples. Pages 338-367 *in* M. R. Clark, M. Consalvey, and A. A. Rowden, editors. Biological Sampling in the Deep Sea. Wiley Blackwell, West Sussex.

Schlacher, T. A., M. A. Schlacher-Hoenlinger, A. Williams, F. Althaus, J. N. A. Hooper, and R. Kloser. 2007. Richness and distribution of sponge megabenthos in continental margin canyons off southeastern Australia. Marine Ecology-Progress Series 340:73-88.

Shimadzu, H. and R. Darnell. 2015. Attenuation of species abundance distributions by sampling. Royal Society Open Science 2.

Stocks, K. I., N. J. Stout, and T. M. Shank. 2016. Information management strategies for deep-sea biology. Pages 368-385 Biological Sampling in the Deep Sea. Wiley Blackwell, West Sussex.

Ward, T. M., S. J. Sorokin, D. R. Currie, P. J. Rogers, and L. J. McLeay. 2006. Epifaunal assemblages of the eastern Great Australian Bight: Effectiveness of a benthic protection zone in representing regional biodiversity. Continental Shelf Research 26:25-40.

Wassenberg, T. J., S. J. M. Blaber, C. Y. Burridge, D. T. Brewer, J. P. Salini, and N. Gribble. 1997. The effectiveness of fish and shrimp trawls for sampling fish communities in tropical Australia. Fisheries Research 30:241-251.

Williams, A., F. Althaus, P. Dunstan, G. C. B. Poore, N. J. Bax, R. J. Kloser, and F. R. McEnnulty. 2010. Scales of habitat heterogeneity and megabenthos biodiversity on an extensive Australian continental margin (100 - 1100 m depths). Marine Ecology: An Evolutionary Perspective 31:222-236.

Williams, A., F. Althaus, and T. A. Schlacher. 2015. Towed camera imagery and benthic sled catches provide different views of seamount benthic diversity. Limnology and Oceanography: Methods 13:62-73.

Williams, A. and N. J. Bax. 2001. Delineating fish-habitat associations for spatially based management: an example from the south-eastern Australian continental shelf. Marine and Freshwater Research 52:513-536.

Zintzen, V., C. D. Roberts, M. R. Clark, A. Williams, F. Althaus, and P. R. Last. 2011. Composition, distribution and regional affinities of the deepwater ichthyofauna of the Lord Howe Rise and Norfolk Ridge, south-west Pacific Ocean. Deep Sea Research Part II: Topical Studies in Oceanography 58:933-947.