
Reef life Survey

**Standardized Survey Procedures for Monitoring
Reef Ecosystems**



Introduction

Methods for estimating densities of fishes, large macroinvertebrates, sessile invertebrates, and seaweeds on reefs are described here. This protocol, and compatible methods with more replication, have now been applied during surveys undertaken in Australia and the Pacific region at many hundreds of sites (e.g., Barrett and Buxton, 2002; Edmunds and Hart, 2003; Edgar et al., 2004b; Edgar et al., 2004a).

Visual census techniques provide the most effective way to monitor species at shallow-water sites because large amounts of data on a broad range of species can be collected within a short dive period, with little post-processing time required. In addition, monitoring programs associated with marine protected areas (MPAs) should be non-destructive. MPA surveys need to cover a range of taxa because, in addition to heavily-exploited species that are predicted to recover in no-fishing MPAs, significant flow on effects associated with increased predator numbers may occur that would otherwise go undetected.

The reef survey technique described here was designed to maximise the amount of ecological information related to all conspicuous taxa that can be obtained during a dive with a single tank of air. The basic unit monitored is a 50 m long transect line. The width of transect blocks varies with different major taxonomic groupings surveyed (large fish, cryptic fish and macroinvertebrates, and sessile invertebrates and seaweeds), with information relating to all taxa obtained along each line.

Because data, particularly for fishes, can vary with relatively slight changes to protocols (e.g. with different transect band width or diver swimming speed), it is important that these methods are consistently applied. Data generated are most usefully applied in a relative sense (i.e. for comparing one site with another or one time with another when data are collected using the same methods).

Data collected by different divers on a field trip should be compared for consistency as soon as possible, particularly during the early surveys. Thus, for example, if two divers are collecting fish information then their data should be compared after dives.

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How it works

- Figure 1 shows a diagrammatic layout of the survey and the blocks.
- The following scientific information is collected at each site:
 - Fishes are surveyed in two 5 m wide bands, parallel with the 50 m transect line.
 - Invertebrates and cryptic fish are surveyed in two 1 m wide bands on either side of the transect line (2 x 1 m x 50 m per transect).
 - Digital photo-quadrats are taken at 5 m (or 2.5 m for cameras without a wide-angle lens) intervals along the transect line (i.e. 10 or 20 per 50 m transect) to allow percentage cover of sessile invertebrates and macroalgae to be later estimated using the appropriate computer software.
- Two divers can efficiently survey one transect by dividing tasks between them. For example, one diver lays transect line swimming along a defined depth contour while the other follows taking photo-quadrats. Then both divers record fishes in 5 m wide bands whilst swimming back along the transect line, one either side. Both divers then return along the line recording invertebrates, one either side again. The survey is now complete and the transect line can be reeled in. Two transects set at different depths can often be surveyed on the one dive if two divers are available.
- See “details of methods” below for specific details on each component of the survey

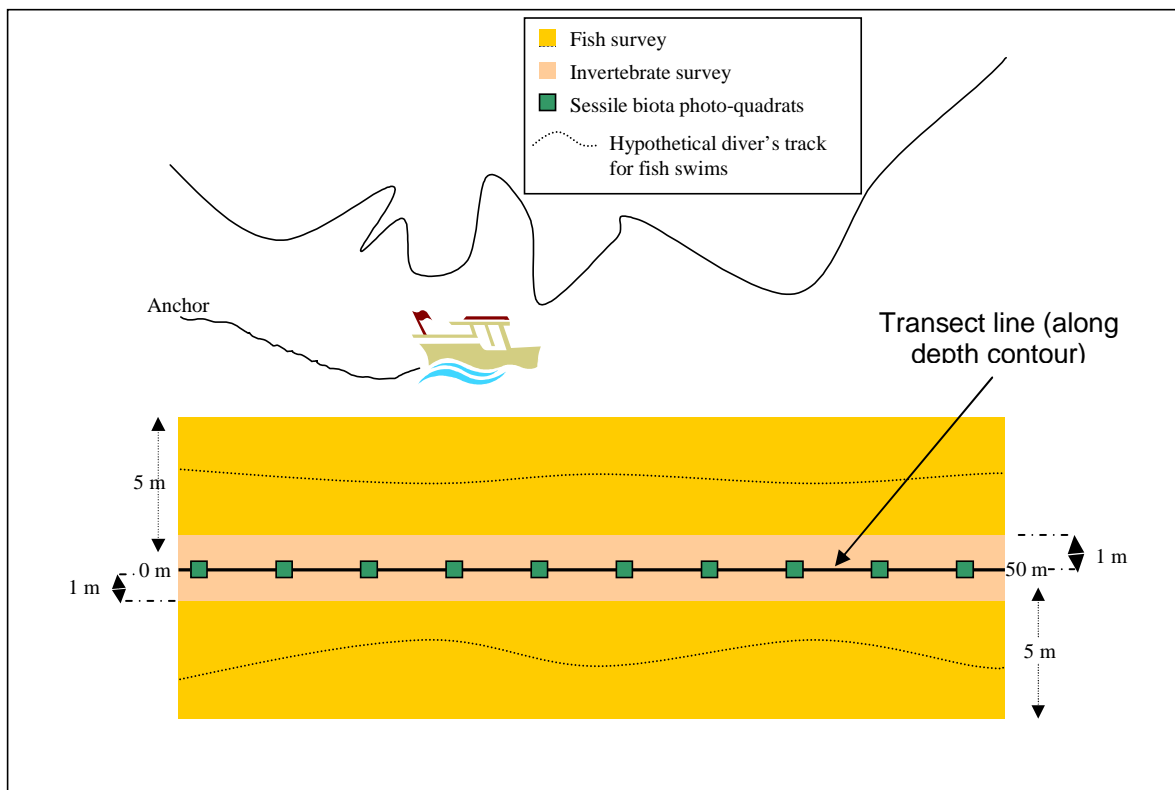


Figure 1: Stylised representation of survey technique.

Details of methods

Prior to all surveys, dive teams need to be clear on diver safety procedures, both to minimize the risk of problems developing, and so that participants all know what actions are required if an accident does occur. Safety margins should be factored into all dive plans, and usual buddy checks are recommended before entering the water.

Choice of depth is up to the divers, and will depend on wave turbulence (the deeper the better), shelter (in sheltered habitats reefs will normally not extend to much depth), air consumption rates (the shallower the more time available), decompression tables (the shallower the better), and other activities that the divers want to undertake on the dive (e.g. photography).

Fish surveys

The number and estimated size-category of all fishes sighted within 5 m blocks either side of the transect line is recorded as the divers swim slowly along. The depth contour that the transect line has been laid along is always recorded on the datasheet, and in cases where the depth differs between fish blocks either side of the line (i.e. where a reasonable slope exists), these are also recorded. The general rule of thumb for labeling these depths is to allocate the deeper side of the line as “B1”, and the shallower side, “B2”. Data for the two blocks are recorded separately if done by the same diver.

Size-classes of total fish length (from snout to tip of tail, or longest distance. This includes for stingrays) used are 25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 400, 500, 625 mm, and above. Lengths of fish larger than 500 mm should be estimated to the nearest 12.5 cm and individually recorded. Fish species sighted away from transect lines during a dive can be recorded separately if believed to be a sighting of interest (as “method 0”, or “fish off line”), These fishes do not need to be counted, only the species name recorded.

Macroinvertebrate and cryptic fish surveys

Large macro-invertebrates (large molluscs, echinoderms and crustaceans) and cryptic fishes (i.e. inconspicuous fish species closely associated with the seabed that were likely to be overlooked during general fish surveys) are censused along the same transect lines set for fish surveys. Divers swim along the bottom, either side of the transect, counting all mobile macroinvertebrates within 1 m of the line. Data for the two blocks are recorded separately if done by the same diver. A mental tally can be kept to minimise the number of times that abundances are recorded on the slate, but at locations where large numbers of macroinvertebrates (particularly sea urchins) are present, divers should write down data on the underwater slate at least each 5 m along the transect line.

Photo-quadrats for seaweeds, corals and other sessile animals

Information on the percentage cover of sessile animals and seaweeds along the transect lines set for fish and invertebrate censuses are monitored using photo-quadrats taken sequentially each 2.5 m (or 5 m, see below for more information) along the 50 m transect. Digital photo-quadrats are taken vertically-downward from a height sufficient to encompass an area of at least 0.3 m x 0.3 m. The wider the angle on zoom lenses the better (wide-angle lenses should easily capture 0.5 m x 0.5 m). The scale of each photo-quadrat is evident from centimeter markings along the transect line, so it is not necessary to place a physical quadrat when photos are taken. The percentage cover of different macroalgal, coral, sponge and other attached invertebrate species in photo-quadrats are digitally quantified in the laboratory using computer software.

Choosing a site

- Transects should be positioned on hard substratum (patches of sand or silt are acceptable, but aim for at least 90% hard substratum).
- Select reefs that extend for at least 50 m along a given depth contour.
- Reference points in relation to the shore should be recorded where possible.
- Anchor in a position so that the transect line can be extended for 50 m in a right-hand direction when facing the shore. It is important that the direction from the anchor is consistent or written down so that if the transect is resurveyed at a later date then the line will be placed in the correct direction from anchoring position. Different depth strata at a site should commence from an imaginary line that extends from the shore through the position of the anchor (i.e. commence deep transects directly below the anchor).
- Record the anchor position in decimal degrees to at least 5 decimal places using WGS 84. [Note a boat at anchor will sit away from the anchor].

Naming a site

- Each site is identified by a number and diver's initials, in addition to a local name (such as a geographical feature) for that site.
- Site numbering is allocated to one diver for each site, so the number and initials should be of only one of the divers if done by trained buddies (i.e. RSS1, RSS2, etc).
- Numbering should start at "1" for the first site following training (i.e. don't count training dives for the purposes of numbering) for each diver.
- In cases where more than one transect is surveyed at a site (i.e. from the same GPS point, but at a different depth), these transects will still use the same site number, but will have different depth values, i.e. it is the site number x depth x date combination that identifies a particular transect. It is important to ensure both buddies have the same transect depth and site number for all surveys done together.

Laying of the transect

- Transects are laid along a specified depth contour.
- Depth of the transect line is recorded.
- To hold the line in position, wrap the transect line around a rock or clump of seaweed or barnacles where necessary. This is particularly important where there is a steep profile or drop off. If deeper gutters are encountered, sometimes it is possible to swim up into these at the same contour and wrap the line around a rock or seaweed at the apex to keep it from pulling across the gutter. This is not essential, however, and largely depends on whether it is practical.
- If extensive sand or soft sediment is encountered then change direction, following inside the reef edge (keeping far enough inside the reef edge if possible so that the full width searched for fish remains over reef substratum). In these circumstances avoid sharp angles and if the line ends up parallel to itself make sure there is a least a 10 m gap. In some cases the reef edge will become progressively shallower, in which case it is best to stay inside the reef rather than extend the transect line over sand. If a change in depth occurs, then the actual depth range of the transect should be recorded on data sheets (e.g. 3.8-5.0 m rather than 5 m).

Despite laying only a single transect line at each site, data for fishes and invertebrates are collected along two separate, replicate transects. This helps provide an idea of variation in animal abundance within the area of the site (particularly between the two depths censused for fishes). It is therefore important to make it clear which “block” the observation was when recording data on the data sheet. The convention is to call the deeper block “B1” (for “block 1”), and the shallower, “B2”.

Data sheet protocols

- Write words on underwater data sheets as clearly as possible with printed letters.
- Record the following header information: site number (which consists of the number and initials), site name, latitude, longitude, date, time, direction from GPS point (anchor), diver name, depth of transect line, depth of fish “B1” and “B2” *when different*, and underwater visibility (measure this out along the transect line while underwater)
- Record what block you are working on and make a clear distinction (draw a line) between data belonging to different blocks
- Record frequency information as either a written number or by using tally lines in groups of 5. Always distinguish between groups of numbers with commas or underline (eg avoid 32 being interpreted as a 3+2) and take particular care with written 11 (eleven) as this looks identical to two 1 strokes. To avoid problems, eleven and other multiple digit numbers should be underlined on data sheets if there is any possibility of confusion.
- Try and use recognised names for animals (preferably scientific but common names are fine). It is o.k. to make up your own naming conventions for species but make sure you are consistent and that you add the correct name clearly in PEN at the end of the line after checking it up in books at the end of the day.
- Data should be recorded digitally as soon as possible after the dive to improve accuracy and loss of important information (i.e. before memory becomes fuzzy).

Survey equipment

- 50 m fibreglass transect line.
- Catch bags – to fit underwater slate and transect line.
- Camera for photo-quadrats
- Slates, pencils and waterproof paper
- For a more comprehensive checklist of field equipment see final table. This includes GPS to record site position.

Important things for people to know when learning fish surveys

Target group

All fish and other large swimming animals (eg squid, octopus, seals, turtles, whales etc)

Technique

- Establish the size of a 5 m band (usually bordered on one side by the transect line). Divers swim along the middle of this band, but can move to the right or left to search caves, etc. [As a reference, the distance of 2.5 m is approximately the length of a tall diver with arm outstretched in front from fin tip to finger tip.]
- Swim slowly approximately 1 m off of the bottom looking side to side and up and down. If underwater visibility is low, then the maximum visibility can be used as a subsampling unit. Thus, if the visibility is, for example, 5 m then the diver should write down information on data sheets every 5 m, before progressing along the next 5 m, etc.
- Record the size and frequency of fish species seen.
- If identification is not possible, then draw a picture, take a photograph and/or write a descriptive note (the more information the better). Be sure to ask others/check books at the end of the dive.
- Where fish are schooling, estimate abundance by counting a block and then multiplying by the number of similar blocks you would estimate to fit into the school.
- Record estimated size of fish using the following size classes:

| | | | | | | | | | | | | |
|--------|-----|---|-----|----|------|----|----|----|----|----|----|----|
| cm | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 20 | 25 | 30 | 35 | 40 | 50 |
| Inches | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 20 |
- The length of fish larger than 50 cm should be estimated to the nearest 12.5 cm and individually recorded.
- When it is impossible to record counts for all fishes seen, the highest priority is to record names of all fish species seen on each transect, then abundance of large species, then abundance of small species, then size classes of each species.

Other

- Look under overhangs and in caves within the 5 m wide band. Record fish such as damselfishes that live in cave habitat by peering in from the cave entrance, but don't enter.
- Avoid counting fish when there are other divers in close proximity as this can affect fish counts. [Plan dives so fish counts can be done with minimal disturbance.] If sea lions or other large marine mammals are around, then make sure that their presence is noted on data sheets since this can greatly affect the fish survey.
- Don't count fish that overtake you.
- If you recognise the same fish that has been recorded in the other block (i.e. see a fish that has obviously moved across the transect line), still record this animal [This balances out other fish that moved across the line in the opposite direction, and were not counted].

How to deal with situations, such as coral rich areas, where diverse communities of fishes are seen swimming in all directions and you feel overwhelmed

At some sites, trying to assess the abundance of fish life at first glance seems extremely daunting. These situations are, however, manageable if you recognise that it will be impossible to count all the fishes and that for the most abundant species estimates will be necessary.

As the diver swims along, data should be written down in order of priority:

Highest priority is the total species list for the transect. Thus, if a diver sights a species of fish previously unrecorded on the transect, this should be written down immediately. Before the diver starts the fish swim, the names of all species sighted in the likely path should be written down.

Second priority is the abundance of large and rare fishes. The numbers of any large, rare and/or commercially important fish should be written down as these are sighted. If a school of say jack mackerel swims past, then the total numbers in a small section of that school should be counted and multiplied by an estimate of what proportion of the total school that section comprises.

Third priority is the number of common small fishes. This number is usually estimated rather than counted directly. It is important to recognise that numbers recorded in transects will be log transformed in most statistical analyses, hence whether you record 300 or 400 of a species will make less difference to interpretation of data, than recording a 1 or 3 of a less common species for example. Thus, don't be overly concerned about accurately counting numbers of say *Chromis* or Mado in a flock. For extremely abundant species, it is often sufficient to ignore these while swimming along the transect other than writing down the species name, then at the end count the number in say a 1 m wide block that extends 5 m along the transect line, then multiply that number by 50 to get numbers for the 50 m x 5 m wide transect block, adjusting up and down a bit for whether the number in the area counted seems more or less than the average for the whole transect length.

Fourth and lowest priority is the size-distribution. This should be done as accurately as possible for the large commercial species, but for others size structure is often assessed by partitioning total abundance counts. For example, you may estimate 400 blue-spotted

damsel fish for the transect length, then think that about half were in the 75 mm size class, with about 10 animals in the 100 mm size class and the rest evenly divided between the 50 mm and 25 mm classes – making 10 at 100 mm, 200 at 75 mm, 95 at 50 mm and 95 at 25 mm when written down.

Important things for people to know when learning invertebrate surveys

Target group

- All ‘large’ mobile invertebrates and cryptic fish are counted. ‘Large’ invertebrates are defined as animals that are more than 2.5 cm (approximately 1 thumb tip) when mature. Species counted include large gastropods (including nudibranchs), crinoids, sea cucumbers, sea stars, sea urchins, lobsters and large crabs. Cryptic fish are those closely associated with seaweeds or the seabed such as gobies, blennies, threespines, cardinal fishes, scorpion fishes, frogfishes, cat sharks, rays, and moray eels.
- Fishes not regarded as cryptic, hence not generally counted on invertebrate/cryptic fish surveys, include wrasses and damselfishes.
- Invertebrates not counted include any species permanently attached to the seabed other than scallops. Thus, oysters, mussels, sponges, anemones (other than the large ‘swimming’ anemones), barnacles and corals are not counted. Small (<2.5 cm) molluscs also are not counted, as these can occur in very high abundance and take up too much dive time. Shrimps and Chitons are also not counted, even if they grow larger than 2.5 cm.

Technique

- Stay close to the bottom and push aside any large seaweeds to reveal the substratum. It usually helps to clip your slate off to your BC and use both arms in a “breaststroke” fashion to part the seaweed for this (this also helps ensure that the full 1 m width can be effectively searched).
- Some urchins live curled up in seaweeds and can be felt as the seaweeds are moved aside. These should be counted.
- Record abundance of all invertebrates and cryptic fish in 1 m bands on each side of the transect line.
- It is easy to accidentally “narrow” your focus and search a band less than a metre wide when in dense kelp. To avoid this, using the tape as a ruler, measure where on your body 1 m reaches from fingertips across your outstretched arm and chest. Then, as you search, regularly reach out to the tape to remind yourself of the outer boundary of the band. This is particularly important when deciding whether to count an animal that is close to 1 m away from the tape.
- It is also easy to accidentally “broaden” your focus to wider than 1 m when in areas dominated by bare rock or coral and when not swimming close enough to the substrate. This is easily fixed by always swimming close enough to be able to reach out and touch the tape to the side of you to regularly check the distance as described above.
- Estimate size of cryptic fish using the same size categories as for large fish.
- Search all crevices and cracks but do not turn over rocks or boulders.

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- If identification is not possible, make a note on your data sheet, and either take a photograph (of both the upper and lower views for molluscs) or put the specimen in your catch bag and ask others or check books at the end of the dive when on the boat, then return the animal to the sea.
 - Record rock lobster and abalone that you estimate as legal-sized separately from those that are estimated to be sub-legal.

Important things for people to know when using digital photo-quadrats

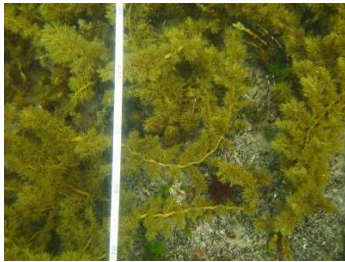
Target group

All algae, sessile invertebrates and substratum categories

Technique

- Using a digital camera, 20 quadrats (10 for a camera with a wide-angle lens, i.e. < 28 mm), each covering an area of at least 0.3 m x 0.3 m (or 0.5 m x 0.5 m for a wide-angle lens), are photographed along each 50 m transect, at 2.5, 5, 7.5, 10, 12.5, 15, 17.5m, and so on up to 45m, then at 47.5 and 49 m positions as marked on the transect line.
- Photo-quadrats are centred on the transect line, with the line running across the shortest axis of the picture (see examples below). A physical quadrat is not required because size information is evident from markings on the transect line.
- On transects > 5 m depth or when there is little ambient light, a flash should be used. If a separate strobe is not available and the camera's in-built flash is used, a closer shot that encompasses a smaller area of the seabed, but more clearly shows the algal canopy/substratum, is preferred over a quadrat of 50 cm x 50 cm in which the substratum is unclear due to the reflected light off particles in the water.
- The exact area photographed is not critical because information is calculated from each image as a percentage, not total density. It is more important to take a sharp image without dark areas than to worry too much about the size of image.
- Photo-quadrats should be digitally labelled as soon as possible, with transect depth, date and site.
- A photo should be taken at the start and end of the photo-quadrat run along each transect showing the divers depth gauge or dive computer (for permanent record of depth and to bookmark the start and end of a photo-quadrat run).
- Use wide angle lens or zoom at widest angle when available.
- Use highest digital resolution and largest recorded image size possible. Save images in highest resolution .jpg rather than .raw.
- Use camera that records at least 6 mega pixels.
- When a number of sites have been completed, photo-quadrats should be copied on to CD and forwarded to Reef Life Survey, the Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, GPO Box 252-49, Hobart, Tas 7001.

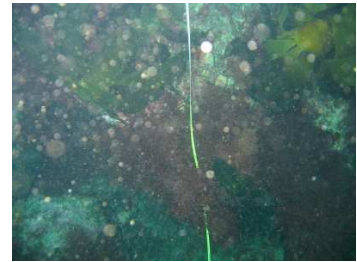
Examples of good and bad photo-quadrats:



Good – in focus and sufficiently lit. Transect line vertical across shortest axis (note: taken without wide-angle lens)



Bad – seaweed in focus, but large dark areas.



Bad – too much backscatter, seaweeds not easily identifiable

Archiving photo-quadrats

Photo-quadrats should be labelled as a batch for each transect using the Rename function in Windows (or Mac equivalent). This involves highlighting all photos for one transect, leaving the cursor on the first of these highlighted quadrats, right-clicking and going down the bottom of the scroll list to the Rename function, then highlighting the title of the first photo-quadrat and writing in details using the following code:

Site number/divers initials/depth (followed by m for metres)/date (six digits where 021108 means 2 November 2008)/site name.

Thus 125GJE5m080407Pt Labatt means site number 125 by Graham Edgar at 5m depth on 8 April 2007 at Point Labatt.

The rename function will apply this code to all transect photo-quadrats followed by (1), (2) etc. At sites in which more than one transect is surveyed (i.e. from the same GPS point, and hence using the same site number and name/initials), the different depth value will distinguish photo-quadrats taken on each of these transects. If two transects are surveyed at the same depth at one site, then make the depth of one of them 0.1 m different to distinguish them.

Data entry

Data should be entered onto Excel worksheets, which can be downloaded as templates for each state from the RLS website. Once filled in, these should be forwarded electronically to reeflife.survey@utas.edu.au

References

- Barrett, N.S., Buxton, C.D., 2002. Examining underwater visual census techniques for the assessment of population structure and biodiversity in temperate coastal marine protected areas. *Tasmanian Aquaculture and Fisheries Technical Report Series 11*, 1-114.
- Edgar, G.J., Barrett, N.S., Morton, A.J., 2004a. Biases associated with the use of underwater visual census techniques to quantify the density and size-structure of fish populations. *Journal of Experimental Marine Biology and Ecology* 308, 269-290.
- Edgar, G.J., Banks, S., Fariña, J.M., Calvopiña, M., Martínez, C., 2004b. Regional biogeography of shallow reef fish and macro-invertebrate communities in the Galapagos Archipelago. *Journal of Biogeography* 31, 1107–1124.
- Edmunds, M., Hart, S., 2003. Parks Victoria Standard Operating Procedure. *Biological Monitoring of Subtidal Reefs. Parks Victoria Technical Series 9*, 1-48.

Suggested equipment checklist for fieldwork

| Survey Equipment | Personal dive Equipment | Miscellaneous/spares | Safety items |
|--|---|---|--|
| slate & pencil transect line waterproof paper camera housing strobe | B.C. SCUBA tanks regs computer wetsuit booties/gloves mask and snorkel fins weights knife torch | GPS spare pencils this field manual ID books GPS & camera batteries rubber bands O-rings scissors cable ties fin and mask straps | O2 cylinder O2 kit Mobile phone dive tables |