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Athens, Greece, 30 March - 1 April 2015

Agenda item 4: Discussion of the Main elements of the Draft Monitoring and Assessment Programme in break-out groups of (1) Biodiversity and Fisheries; (2) Pollution and Litter; (3) Coast and Hydrography

ACCOBAMS contribution for supporting the implementation of the Ecosystem Approach in the Mediterranean regarding cetacean population estimates and distribution

UNEP/MAP
Athens, 2015

Methodological requirements for carrying out visual and acoustic line transect surveys

Introduction

The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) has been working for several years on defining an exhaustive program for estimating abundance of cetaceans and assessing their distribution and habitat preferences in the Mediterranean Sea (the "ACCOBAMS Survey Initiative"). This initiative consists in a synoptic survey to be carried out in a short period of time in the whole Mediterranean Sea and it will combine visual survey methods (boat- and ship-based surveys) and acoustic detection techniques.

Today ACCOBAMS is collaborating with the Regional Activity Center for Specially Protected Areas (UNEP/MAP/RAC-SPA), the IUCN Center for Mediterranean Cooperation and the French Agency for Marine Protected Areas, through an Agreement established in 2011 between these four organizations, in order to facilitate the implementation of this project planned for 2016-2018.

Within the framework of the Ecosystem Approach process implemented by the Mediterranean Action Plan (UNEP/MAP), cetaceans are considered as indicators of the Good Environmental Status (GES).

Given the significant contribution that the “ACCOBAMS Survey Initiative” could provide for the implementation of the UNEP/MAP EcAp process, in particular through the establishment of reliable baseline data for the monitoring of cetacean populations in the Mediterranean, the ACCOBAMS Secretariat approached the MAP Coordinating Unit for proposing to present information on this topic. An information note on the “ACCOBAMS Survey Initiative” was then distributed at the last Meeting of the Ecosystem Approach Coordination group (Athens, Greece, 9-10 October 2014).

In December 2014, in order to improve coherence and synergies between the different regional policies that are considering collection of data on cetaceans, the ACCOBAMS Secretariat was mandated by the Bureau of the Parties to ACCOBAMS to disseminate information on the “ACCOBAMS Survey Initiative”, in particular on its protocols and methodologies to be used for estimating abundance of cetaceans and assessing their distribution and habitat preferences in the Mediterranean Sea. This is the purpose of this document.

This document was elaborated based on the documents prepared by the ACCOBAMS Scientific Committee that has worked for several years on the definition of the most appropriate methodologies for collecting data on cetaceans in the whole Mediterranean Sea, taking into account the protocols used in other regional contexts[1].

At the beginning of 2015, after consulting with the UNEP/MAP Coordinating Unit, it was jointly decided to present this document as a working document to the Meeting of the Integrated Monitoring Correspondence Group (Athens, Greece, 30 March- 1 April 2015) and to invite the Contracting Parties to the Barcelona Convention to decide on the next steps to be taken regarding elements related to cetaceans to be considered in the draft Integrated Monitoring and Assessment Programme.

This document was elaborated based on the documents prepared by the ACCOBAMS Scientific Committee that has worked for several years on the definition of the most appropriate methodologies for collecting data on cetaceans in the whole Mediterranean Sea, taking into account the protocols used in other regional contexts[2]. It presents specific information on monitoring by visual line transect

[1] *e.g.* in the Atlantic waters within the framework of (i) the SCANS surveys undertaken to assess the populations of Small Cetaceans in the European Atlantic and North Sea, and (ii) the CODA surveys (Cetacean Offshore Distribution and Abundance in the European Atlantic) aiming to estimate cetacean abundance in European Atlantic waters.

[2] *e.g.* in the Atlantic waters within the framework of (i) the SCANS surveys undertaken to assess the populations of Small Cetaceans in the European Atlantic and North Sea, and (ii) the CODA surveys (Cetacean Offshore Distribution and Abundance in the European Atlantic) aiming to estimate cetacean abundance in European Atlantic waters.

surveys (conducted from boat and airplane) and by acoustic survey. It should be noted that it does not address all the tools and methods that could be used for cetacean survey, neither new technologies that are experimented (i.e. drones and satellite imagery). Significant information also comes from stranding networks. Lastly, this document is considering surveys using large ships, but the shipboard cetacean surveys conducted from small vessels would also make use of this document.

By presenting this document at the Meeting of the Integrated COR-MON, the ACCOBAMS Secretariat reassures its willingness to collaborate with the UNEP/MAP system to contribute to and to support the implementation of the Ecosystem Approach in the Mediterranean.

1. Target species

1.1 Cetaceans

Eleven species of cetaceans are considered as regularly present in the Mediterranean and contiguous Atlantic area: short-beaked common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), common bottlenose dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), long-finned pilot whale (*Globicephala melas*), rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), fin whales (*Balaenoptera physalus*), sperm whales (*Physeter macrocephalus*), Cuvier's beaked whale (*Ziphius cavirostris*) and killer whale (*Orcinus orca*).

Little is known about the ecology, abundance and habitat preferences of any of these species, including the most abundant ones, at the scale of the Mediterranean. The knowledge is patchy and concentrated in a few areas only, where survey effort has been intense during the last 20 years. Almost nothing is known from the whole southeastern portion of the basin, the coasts of North Africa and the central offshore waters.

Table 1 gives a brief summary of what is known about the main cetacean species found in the ACCOBAMS area. Information presented hereafter is taken from the 2010 status report "Conserving whales, dolphins and porpoises in the Mediterranean and Black Seas: an ACCOBAMS Status report" (Notarbartolo di Sciara G., Birkun A., 2010, ACCOBAMS, Monaco 212p.). This document can be downloaded from the ACCOBAMS website:
http://www.accobams.org/index.php?option=com_docman&task=doc_download&gid=119&Itemid=50

Table 1 - Brief summary of what is known about the main cetacean species found in the ACCOBAMS area

Species	Conservation issues	Distribution/occurrence	Stock ID	Abundance/ density
Short-beaked common dolphin	Prey depletion, incidental by-catch, contamination.	Now relatively abundant only in the Alboran Sea. Sparse records off the coast of Algeria, around Sardinia and Corsica, in the south-eastern Tyrrhenian Sea off the island of Ischia, in the Strait of Sicily and around Malta, in portions of the eastern Ionian Sea and in the Gulf of Corinth, in the Aegean Sea, and off southern Israel.	Genetic exchange between common dolphins from the Mediterranean Sea and Atlantic Ocean appears to involve only animals from the Alboran Sea.	No overall population estimate. Some information from the Alboran Sea, the Maltese Islands, the eastern Ionian Sea.
Striped dolphin	Morbillivirus epizootics, contamination, by-catch in pelagic driftnets.	The commonest oceanic cetacean in the Mediterranean, found in offshore waters from Gibraltar to the Aegean Sea and the Levant basin.	Mediterranean animals differentiated from eastern North Atlantic. Some differentiation between offshore and inshore samples collected in the Ligurian Sea.	Considered to be the most abundant cetaceans in the Mediterranean, although no overall population estimate for the region exists. Line-transect surveys have been conducted over portions of the region, especially
Common bottlenose dolphin	Prey depletion and environmental degradation, incidental mortality in fishing gear, contamination	The commonest cetacean through the Mediterranean Sea continental shelf, where its distribution appears today to be scattered and fragmented into small units.	Several localised ‘populations’ known in some coastal areas of the Mediterranean Sea. Also in oceanic areas, at least in the Alboran Sea.	There is no basin-wide abundance estimate, with quantitative knowledge deriving from local studies.
Harbour	No special conservation problems in Aegean,	Small part of the Aegean	Harbour porpoises	No current estimates of total

Species	Conservation issues	Distribution/occurrence	Stock ID	Abundance/ density
porpoise	but limited range and probable small population size may make it vulnerable.	Sea, Atlantic contiguous waters.	found in the Contiguous Atlantic belong to a North Atlantic population unit. Harbour porpoises found in the Aegean Sea belong to the Black Sea subspecies (possibly a subpopulation).	population size.
Long-finned pilot whale	By catch in pelagic driftnets, ship strikes, toxic pollution, morbillivirus infection and anthropogenic noise.	Common in the western portion of the Mediterranean basin (Alboran and Balearic Seas). Its presence east of Italy is extremely rare.	Population structure in the Mediterranean is unknown. Assumption that there is a single subpopulation in the region.	Estimates of abundance based on photo-identification studies exist for the Strait of Gibraltar, where 249-270 individuals are thought to be resident. In the Alboran Sea, numbers are thought to be comprised between several hundred and a few thousands.
Rough-toothed dolphin	No information.	Rare in the Mediterranean, and only in the eastern portion	No information.	No information but reported sightings rare.
Risso's dolphin	Entanglements in pelagic driftnets and longlines, ingestion of plastic debris and contamination	Widespread throughout the Mediterranean in oceanic areas. Common along the northern shores of the western Mediterranean. No data available for the Southern Mediterranean Sea.	Mediterranean populations distinct from eastern North Atlantic populations.	Abundance estimates exist for very limited portions of the region (aerial surveys off eastern Spain).

Species	Conservation issues	Distribution/occurrence	Stock ID	Abundance/ density
Fin whale	Ship strikes known to occur	Found mostly in deep, offshore waters of the western portion of the region, from the waters north and east of the Balearic Islands to and including the Ionian and southern Adriatic Seas. Extremely rare in the Adriatic, Aegean and Levantine Seas.	Mediterranean animals differentiated from eastern North Atlantic. No information on structure within Mediterranean.	No population estimates exist for the entire region. Line-transect surveys in 1991 yielded fin whale estimates in excess of 3,500 individuals over a large portion of the western Mediterranean (Forcada et al. 1996). Reasonable to assume that a realistic estimate for the total basin would not exceed 5,000 individuals.
Sperm whale	Entanglement in driftnets, disturbance from intense marine traffic and collisions with large vessels, underwater noise.	Widely distributed in the Mediterranean from the Gibraltar Strait area to the eastern basin.	Mediterranean animals differentiated from eastern North Atlantic. No evidence exists of population fragmentation across the region.	Some information based on survey data collected in various portions of the Mediterranean in recent years (in the Strait of Gibraltar, near the Gulf of Lions, in portions of the Ionian Sea, in the Hellenic Trench).
Cuvier's beaked whale	Susceptible to anthropogenic noise (e.g. military –see Frantzis, 1998; and industrial)	Widely distributed along slope areas in the Mediterranean. Some predictable specific locations over deep canyons.	The Mediterranean population is genetically distinct from neighbouring populations in the eastern North Atlantic.	Information on abundance estimates exists for very limited areas, such as the Gulf of Genoa, the northern Alboran Sea.
Killer whale	Prey depletion, direct killing by fishermen and habitat degradation.	Regularly found only in the Strait of Gibraltar and Contiguous Atlantic. Rare in the Mediterranean	Gibraltar killer whales are considered as a resident population.	Estimate available from photo-identification in the Strait of Gibraltar

1.2 Other marine endangered species

Even if cetacean species are the first targets of this effort, the observations of other marine endangered species, such as marine turtles, giant devil rays, monk seals and sea birds, and other elements such as marine debris, could be reported during the survey. Specific protocols have to be designed for these opportunistic observations, bearing in mind that the primary objective is to collect data on cetaceans.

2. Visual line transect methods

Line transect visual surveys are amongst the best understood and most commonly used when estimating cetacean abundance. The objective is to estimate the density of the target species in strips sampled by surveying along a series of transects, and to extrapolate this density to the entire survey area. The calculated number is therefore an estimate of abundance in a defined area at a particular time.

However, this method has some important assumptions, such as that all animals on the trackline are detected (g(0) problem), and that animals do not move in response to the presence of the observation platform before they are detected (responsive movement), which, if violated, could lead to significative biases in the results.

2.1 Bias in the detection of the animals

a) The g(0) problem

The validity of the assumption that all animals on the trackline are detected is colloquially known as the g(0) problem. There are two potential categories of bias that may invalidate the assumption that g(0)=1: availability bias (because the animal is underwater and not available to be seen during the period it is within visual range) and perception bias (because for whatever reason an observer misses a whale that is at the surface). To address the availability bias, data on diving behavior of the target species must be taken into consideration. If perception perception can be considered a reasonable assumption (i.e. that g(0) is equal to or approximately equal to 1), for example with trained observers and large cetaceans, then field methods and subsequent analysis are relatively simple; searching can be carried out from a single observation platform, with consequently a minimum number of observers needed.

However, if g(0) is significantly lower than one (as is often the case for small cetaceans and sea turtles) then this will result in a considerably negatively biased estimate and the true value of g(0) must be estimated. In such cases, both the field methods and subsequent data analysis become more complex. For shipboard surveys, the double-platform approach has been successfully used to address this problem. Availability bias is a particular problem for animals with very long dives. In the case of the sperm whale, acoustic techniques can overcome this problem.

b) Responsive movement

Responsive movement by animals to the surveying vessel can also cause significant bias in abundance estimates (positive bias if animals are attracted to the vessel and negative if they avoid the vessel). As for the g(0) case, field and analytical method can be employed that enable responsive movement to be taken into account. This method also involves the use of two observation platforms with one observation platform searching far enough in front of the vessel to detect and track the animals before the animals react to the vessel.

c) The two-platform approach

For shipboard surveys, the double-platform approach has to be followed to address the problems of g(0) and responsive movement.

According to this method, observations are carried out from two platforms. Observers from the secondary or 'tracking' platform search an area ahead of the 'primary' survey area and sufficiently wide to ensure that animals are detected prior to any responsive movement to the ship, and to allow the tracking of animals until they are detected by the primary platform. The primary survey area is wider and possibly has a lower probability of detection. The observers from the primary platform search independently of the tracking platform.

2.3 Survey design

The areas to be surveyed are usually divided into survey blocks and the transects are designed to ensure equal coverage probability, using the dedicated software Distance.

a) Blocks

The development of appropriate survey blocks is a combination of biological factors (species, distribution/stock structure and abundance, habitat types etc.) and pragmatism associated with the logistics (numbers of vessels/planes; port/airport facilities; transit times; national boarders etc.).

b) Effort required per block

The effort required per block is determined as a function of ship/airplane time available in each block, available information on density of species and logistical constraints. The higher the level of coverage the better, as it allows for a larger sample size and therefore for an easier and better analysis and results.

c) Survey design

The basic requirement for a line transect survey is that it provides representative coverage of the area for which an abundance estimate is desired *(i.e.* each point in the area has an equal or quantifiable probability of being sampled). A common design for vessel-based surveys at sea is a set of zig-zag lines following a regular pattern, starting from a random point along one edge of the survey area. In aerial surveys, 'parallel transects' are to be preferred and the coverage should be allocated according to target species' density: more coverage where their density is higher.

There are some practical points needing attention when designing a survey. Transects should, as far as possible, run perpendicular to any density gradient; for example, coastal surveys typically have transects that run more or less perpendicular to the shore line.

To generate this kind of survey, specialized software (for example DISTANCE, developed by the Centre for Research into Ecological & Environmental Modelling of the University of St Andrews) is highly recommended.

d) Closing mode versus passing mode

In order to confirm certain information (species identification, group size and, historically, distance to sighting), cetacean surveys could be operated in 'closing mode'. In this mode, once a sighting has been made and the initial distance and angle been recorded, the vessel then approaches the animal(s) to 'confirm'. It is also used if, for example, it is desired to obtain biopsy samples or photographs.

Nevertheless, operating in ‘closing’ mode can result in biased abundance and estimates. The preferred approach is thus to operate in ‘passing mode’ wherever possible (*i.e.* once a sighting is made the vessel remains on the designated course). However, this too has its problems, if, for example, many sightings are unidentified to species.

2.4 How to proceed for visual line transect surveys?

a) Deciding between vessel and aerial surveys

Visual line transects surveys can be operated from a ship and from an aircraft. When deciding which platform to use, the relative merits of each approach for the species and areas to be covered must be considered. These include:

• aerial surveys are usually more cost-efficient per area than large vessel surveys, provided that the area to be covered is within the range of the aircraft from an airport and taking safety considerations into account (this often means not travelling more than 200 nautical miles or so offshore);

• aerial surveys can take better advantage of good weather conditions, in that they can cover much larger areas in the same period;

• aerial surveys are more efficient (and trackline design is easier) if the area to be covered has complex coastlines, many islands or large areas of shallow waters;

• aerial surveys can be more tolerant of swell but less tolerant of sea state and low cloud – they can also be affected by poor weather at the airport even if survey conditions are acceptable at sea;

• animals are less disturbed (if at all) by aircraft at normal flying altitudes and thus the problem of responsive movement is minimal;

• for multispecies aerial surveys, compromises must be made in terms of the optimum altitude for flying e.g. flying at the optimum altitude for a harbour porpoise survey means that the searching area for larger species such as fin whales is considerably reduced;

• vessels are generally better platforms for photo-identification and aircraft are unsuitable for biopsy sampling and acoustic recording;

• availability bias is much greater for aerial surveys;

• it is generally easier to obtain a suitable vessel than a suitable aircraft.

Here below are presented the equipment and human resources required for both vessel and aerial surveys, as well as the minimum set of data to be gathered when sighting cetaceans.

b) Vessel survey

The standard equipment needed is:

- Suitable vessel (see the specifications in Annex 2) and its crew
- Binoculars
- Computer
- Watch
- GPS

In terms of human resources, there need to be 10/12 observers per vessel. Eight are dedicated to the double platform method for cetaceans: 2 in Primary Platform (PP), 2 in Tracker Platform (TP), one as Data Recorder (DR), one as Duplicate Identifier (DI) and 2 resting. The roles of the various observers are described in Annex 1.

In addition, at least the 2 PP observers are searching and recording sea turtles and seals. For seabirds there are at least 2 observers (ideally 4 to take turns and cover the whole day-time period on effort).

One of the visual observers in each vessel can act also as acoustic observer.

Data to be collected during a two-platform line transect survey are:

Sightings	Date and sighting number Exact time (important for identifying duplicates) Geographic coordinates of the sighting Radial distance to sighting Angle to sighting Species Group size (note whether estimated or verified) Anything else that could affect detection probability (behavior, heading, etc.)
Effort	When on or off primary searching effort Nature of effort (e.g. closing/passing etc) Who is primary/tracker/duplicate recorder and time Environmental data that might affect detection probability (e.g. sea state; cloud cover, glare etc.) Other factors affecting quality of effort (e.g. hung-over observers)
Duplicate status	Measure of certainty that a pair of sightings are duplicates.

c) *Arial survey*

The standard equipment needed is:

- Suitable aircraft (see the specifications in Annex 2) and its crew
- Computer with dedicated software
- Watch
- Clinometers
- GPS

In terms of human resources, there are a minimum of aerial observers: one data recorder and 4 observers at any time (two on each side of the aircraft).

Data to be collected during an aerial survey are:

Sightings	Date and sighting number Exact time (important for identifying duplicates) Geographic coordinates of the sighting Angle to sighting Species Group size (note whether estimated or verified) Anything else that could affect detection probability (behavior, heading, etc.)
Effort	When on or off primary searching effort Nature of effort (e.g. on effort / off effort / circle back)

	Who is primary/duplicate recorder and time Environmental data that might affect detection probability (e.g. sea state; cloud cover, glare etc.) Other factors affecting quality of effort (e.g. hung-over observers)
Duplicate status	Measure of certainty that a pair of sightings are duplicates (if possible)

3. Acoustic survey method

Ship-board line transect acoustic survey is the most effective way of surveying sperm whales in the open sea and to collect the data required for accurate and robust estimation of absolute abundance in these waters. Using only visual survey techniques is problematic given their long dive duration, which makes them unavailable for visual detection most of the time.

a) Description

Acoustic data from sperm whales can be used to assess both relative and absolute abundance provided the appropriate equipment and survey design is followed. Sperm whales produce loud regular clicks, which can be detected at ranges of tens of km. From their frequency, amplitude and the intervals between successive clicks, they are generally easily recognized. Automatic software has been developed and used on a number of surveys which can measure bearings to sperm whale clicks. By tracking a whale for a period of time, crossed bearings to successive clicks give a position for each whale, which can be used in a Distance-based analysis.

A major task in this type of analysis is the assignment of clicks to individual whales when many are vocalizing simultaneously. Often, clicks from different whales are easily resolved using bearing information (Figure 2). The regularity of the click train on each bearing indicates that they represent a single whale. On occasions where more than one whale is on the same bearing, clicks can be assigned to individuals using spectral and amplitude information. By identifying the most obvious whale in a group and removing those clicks from the analysis, identification of successive whales becomes progressively easier until all clicks are assigned.

For whales close to the trackline, during surveys of the Ionian Sea in 2003 (IFAW, 2004), no situations arose when the researchers could not confidently identify the number of whales in a group and track individual animals to obtain distances. For more distant animals, click trains start to break up and identification of complete trains and the assessment of the number of animals present becomes more difficult. Development of analytical techniques to deal with broken click trains is an ongoing area of research.

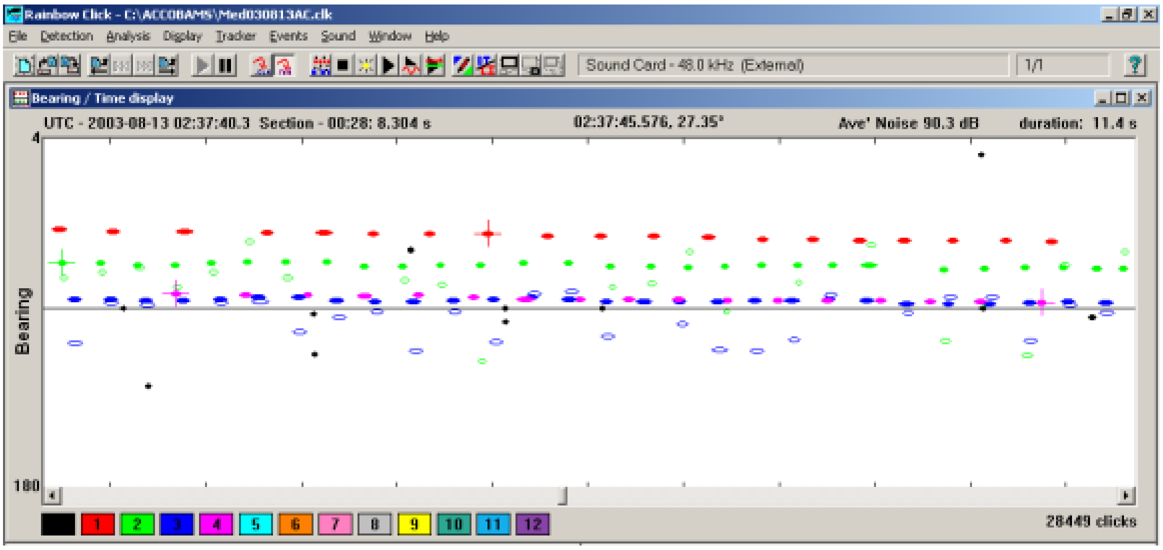

Fig. 2. Tracks of four sperm whales passing a survey vessel on a plot of bearing against time. Each closed circle represents a single sperm whale click, open circles are echoes. Two of the whales are easily separated on bearing information alone. Separating two further whales on a similar bearing required the use of additional information such as click regularity and the frequency structure of clicks from each animal.

Since acoustic detection ranges are generally ~10 km, a survey vessel travelling at 18 km per hour (10 knots) will be in acoustic range of a sperm whale close to the track line for over an hour. Typically, sperm whales dive for approximately 30-50 minutes followed by 10-15 minutes at the surface. Clicking is generally continuous when the whales are submerged and they are silent while resting at the surface.

On occasion, whales cease clicking regularly for periods of 2-3 hours, but evidence from tagging and observational studies suggests this is infrequent (e.g. Watkins et al., 1999). The probability of a whale remaining silent for the entire time that the vessel is in range is therefore considered to be small, indicating that g(0) for acoustic surveys is close to 1. During dual visual acoustic surveys conducted by IFAW in the Mediterranean and other regions (IFAW 2003; Leaper et al., 2000), there were no instances when sperm whales were seen without being heard first. However, calves (which may represent up to 20% of the population) do not make long foraging dives and are not clicking regularly. Consequently, their detection may have low efficiency and a correction factor calculated from existing data should be applied.

b) How to proceed for acoustic ship-based line transect survey (sperm whales)?

Acoustic survey data for sperm whales can generally be collected simultaneously with visual data for other species particularly if the survey is operating primarily in passing mode. Survey vessels can also continue acoustic sampling in conditions unsuitable for visual survey (bad weather and night time).

Abundance estimates, based on acoustic methods, are only possible for sperm whales. Potentially, information on distribution can be obtained from acoustic data for all species, although with much more uncertainties for common and striped dolphins, given the difficulties in distinguishing their vocalizations.

A hydrophone array is towed behind each vessel. The equipment consists of a desktop computer running automatic detection software, the towed hydrophone, and various interface cards for getting sounds into the computer. The computer is running all the time, and one scientist is in charge of the acoustic system on each vessel. This can be one of the visual observers as the acoustic system only needs checking from time to time and backup at the end of each day.

4. Season

In the framework of the ACCOBAMS Survey Initiative, it is important that the survey takes place over a short time period as possible, to minimize the potential problem of movement of animals between areas. In this sense, it is also important that the whole basin is covered simultaneously, if at all possible. July is the most appropriate survey month because of the higher probability of good sighting conditions.

Annex I
Role of the various observers during a vessel-based survey with double-platform

Annex I – Role of the various observers during a vessel-based survey with double-platform

1. *Primary platform (usually two observers)*

(a) Observers must search ‘normally’ – with naked eye or low-powered binoculars and in an area closer to the vessel than the tracker.
(b) Must not be aware of what the tracker is doing.
(c) Must record the exact time of sighting with bearing and angle – best achieved an audio recording system with time stamp.
(d) Must pass time, bearing and angle data, together with at least species and group size estimate to duplicate recorder instantly.
(e) Has own sighting form.
(f) Must record times and positions of resightings, but must not divert effort from normal search procedure to track sightings.

2. *Tracker (usually one observer is sufficient)*

(a) Tracker's role is to allow the primary detection function to be estimated.
(b) Should search far enough ahead of vessel that animals are unlikely to have responded by the time they are detected (use powerful binoculars if necessary).
(c) Searches a region wide enough that no animals outside of it could be detected by primary.
(d) Tracks every sighting until it passes abeam or is detected by primary.
(e) Need not be independent of primary – in fact duplicate identification is made easier if tracker (and duplicate identifier) know where and when primary makes detections.
(f) Need not search all the time – does need to search enough to generate sample size adequate for estimation of primary detection function. Required sample size depends on context but a sample of at least 60 with at least 20 duplicates is probably a reasonable target.
(g) Assisted by duplicate recorder, collects data on exact times and locations of initial sighting and all resightings.
(h) Tracker estimate of group size might be best because has higher-powered binoculars and follows group.

3. *Duplicate Recorder (two scientists is best)*

(a) Responsible for identifying duplicates in real time: Fed information on all detections by tracker and primary to identify duplicates.
(b) Responsible for recording all effort and environment/weather data – this should be done on a regular basis (every 10/15/x minutes) and whenever conditions change.
(c) Assists tracker in recording tracker sightings data (tracker should not look away from sighting; audio recording is valuable).
(d) Needs to pass back sighting numbers to primary and tracker in real time (or else when more than one sighting is in view, there may be confusion about which is which).

Annex II
Ship and aircraft specifications

Annex II– Ship and aircraft specifications

Ship specifications presented hereafter are for surveys using large ships but it should be considered that smaller vessels could also be used for carrying out cetaceans surveys. In this case, methodologies applied present some differences (it is not possible to apply the double-platform approach).

Ship specifications

- Ships need to be able to accommodate at least 10 observers (8 for the cetacean and turtle work; 2 for the seabird work).
- There must be two observation platforms (permanent or temporary), one at least 5m above sea level (often at the level of the bridge) and one at least 9-10m above sea level (often on the flying bridge or a temporary construction) – see Figs 1 and 2.
- The two platforms must:
    - be audibly and visually isolated from each other
    - be able to accommodate at least 3 observers – see Fig. 3
    - have an unobstructed view (from 270° to 90° with direction of sailing 0°)
- Power supplies for computers and other equipment must be available
- The ship must carry appropriate navigational equipment.
    - Accurate information on location (GPS) and other information (e.g. wind speed) should be available through NMEA outputs from the ship's instruments.
- The ship must hold valid certification and comply with current safety regulations
- Standard cruise speed: no less than 10 knots
- Endurance: ideally at least 25-30 days
- Good stability
- Capability for acoustic surveying (hydrophone array with a 200m cable):
- Safe area for deployment and storage of hydrophone.
- Power supply for hydrophone and computer.
- Cable route between computer and hydrophone
- Preference for vessels that introduce least amount of noise into the sea at survey cruise speed (objective information on such noise levels can only be obtained by measurement at sea, however, the noise produced is likely to be more for larger vessels, vessels with variable pitch propellers and older vessels).
- Capability for continuous oceanographic data collection (desirable but not necessary)

Fig. 1. A 43m long vessel equipped with a temporary observation platform at about 9m above sea level

Fig. 2. A 60 m long vessel equipped with a temporary observation platform at over 10 m on the sea level

Fig.3 Inside a platform

Fig. 4 Hydrophone

Aerial survey

Survey aircraft must:

- hold valid certification, comply with current safety regulations and be equipped with the following safety equipment: an emergency rescue boat, life vests (manual release) and two emergency satellite locator transmitters (one fixed in the plane, one portable);
- provide a list of countries in which they are not able to operate;
- be twin engined;
- be able to fly at a speed of between 80 and 100 knots (ground speed) at an altitude of about 180-200m when undertaking the survey;
- have bubble windows on each side of the aircraft for two observers and good viewing conditions for the navigator in the front seat (double bubble windows would be preferable to apply double-platform data collection and analysis);
- be high winged to allow for full downward view from the bubble windows;
- have an unobstructed view of the sea directly under the plane (i.e. the view is not obscured by the undercarriage);
- be equipped with GPS and a radar altimeter (geographical position, survey altitude, speed should be available through NMEA outputs from the aircraft instruments);
- have enough fuel capacity to allow a minimum endurance of 5 hours;
- have an intercom system that allows clear communication between all observers and the pilot;
- have a power supply (12V or 24V) to connect a laptop;
- The seats should be located parallel to or facing the windows to allow the seating to be as comfortable as possible. There needs to be the option to darken the upper part of the bubble windows to reduce reflection on the window.
- Pilots should have relevant experience of survey flying, especially at low altitudes over water.

Fig. 5. Partenavia P-68 Observer aircraft with bubble window