Progress on Atlantic humpback dolphin conservation and research efforts in Congo and Gabon

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INTRODUCTION

The Atlantic humpback dolphin (*Sousa teuszii*) is endemic to tropical and sub-tropical near-shore waters of western Africa. The species occupies an obligate shallow-water niche and a preference for sheltered coastal areas. It is probable that the species has never been very common (Reeves *et al.* 2003). Although there are no published estimates of its abundance, available evidence suggests a precipitous decline in numbers, a patchy distribution of subpopulations and many documented threats (Van Waerebeek *et al.* 2004; Van Waerebeek & Perrin 2007). Directed catches by fishermen, fisheries competition, habitat loss and disturbance are factors believed to be responsible for the species' decline. Evidence presented at the 2010 meeting of the IWC provided strong support for this hypothesis; the species had either not been encountered in recent surveys or encounter rates were much reduced. Given a general absence of effective monitoring and law enforcement in most areas, long-term, range-wide prospects for the species are poor.

In 2011 the IWC Voluntary Fund for Small Cetacean Research awarded funding to the Wildlife Conservation Society (WCS) Atlantic Humpback Dolphin project. The project, formalized in 2009 after several years of sporadic effort, focuses on the waters of Gabon and the Republic of Congo (hereafter Congo) and has a series of interlinked objectives. These are listed below, the first two being central to the IWC proposal:

- Estimating the abundance of humpback dolphins in Gabon and Congo and refining scientific methods for robust and cost-effective assessment.
- Characterising the distribution and habitat preferences of humpback dolphins in Gabon and Congo, including identification of critical habitat and candidate sites for increased protection
- Assessing and mitigating key threats to the long term health of coastal dolphins in Gabon and Congo
- Raising awareness of the species amongst coastal fishermen and limiting takes in coastal gillnets

- Raising awareness amongst and training key personnel (including national park and fisheries managers) in research and conservation methodologies

A progress report was provided to the IWC Scientific Committee (SC) in 2012 (SC/64/SM22). The report highlighted a bycatch issue in Congo that necessitated development of an outreach program with contingent funding. An additional issue was the loss of all vessels from the WCS 'fleet' due to either accidents or mechanical failure and all boat based work was delayed whilst funds were secured for either their repair or replacement. For Congo this problem has only very recently been resolved; a new vessel purchased in late 2011 spent all of 2012 in customs and the vessel only became operational in May 2013. Thus meeting the majority of boat based objectives for this project has been impossible. Continued efforts to tackle bycatch in Congo have led to the project focusing most of its energy there, and so this report focuses on Congo, with brief mention of work conducted in Gabon.

Focal study area – Conkouati Douli National Park

The work described here focuses on the coastal waters of Congo, with most effort occurring within Conkouati Douli National Park (CDNP). CDNP includes both terrestrial and marine PA's, the latter being established to protect turtle nesting beaches, as well as the inshore approaches to these beaches. The park is one of two that comprise the transboundary protected area of Mayumba-Conkouati (the other being Mayumba National Park in Gabon), established under a formal bilateral agreement. Combined the two PA's protect over 120 km of some of the most important turtle nesting beaches in the Atlantic, and the occurrence of a healthy population of humpback dolphins is a fortunate coincidence. As with the rest of the Congolese coast (~170 km long) CDNP is also home to an active artisanal fishery, comprising ~13 landing sites (some seasonal variation) and fishers use hand-paddled dug-out pirogues to set gillnets in near-shore waters. Gabon in contrast is blessed with an extremely low coastal population density, and there is no tradition of coastal artisanal fishing. Associated threats to coastal dolphins from fisheries are thus much reduced in the latter, and explain the projects primary emphasis on Congolese waters, at least in the short term. A map of the focal study area is provided in Figure 1.

A progress report for several aspects of the project is provided here. This includes:

1. Initial assessment and analyses of beach based survey data for assessment of distribution, occupancy and abundance
2. Initial assessment of acoustic detections recorded by CPODs, with associated information on recent attempts to record humpback and bottlenose dolphins vocalisations
3. A review of bycatches and bycatch risk within CDNP and some consideration of next steps towards mitigation of this risk
4. A review of project status, funding support and future directions

(Note that these bullet numbers correspond with relevant sections below).

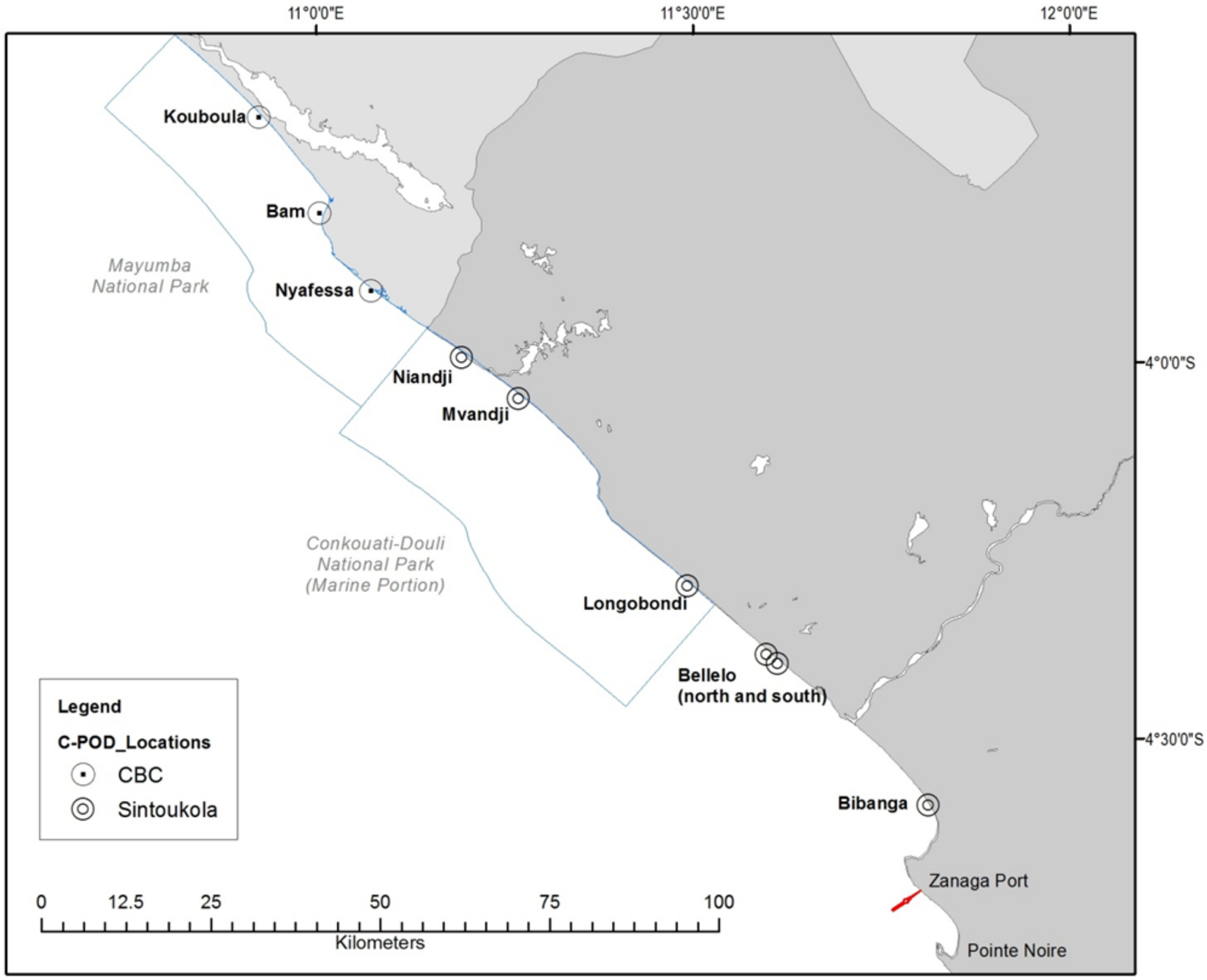


Figure 1: The Mayumba-Conkouati Transboundary protected area, spanning the border of Gabon and Congo. The project has focused the vast majority of its effort in Conkouati Douli National Park, largely because of fisheries bycatches.

1. ASSESSMENT OF OCCUPANCY, DISTRIBUTION AND ABUNDANCE

Developing robust and cost effective methods to survey and monitor the status of humpback and other coastal dolphins is a primary objective of this work. Ideally we would like to be able to estimate their abundance and distribution, and also investigate the key drivers influencing that distribution. Given that humpback dolphins along the coasts of Congo and Gabon are patchily distributed and extremely cryptic, existing methods have to be adapted and field protocols refined in order to estimate these state variables. Under the original proposal we had anticipated developing a status assessment for humpback dolphins in both Gabon and Congo. This remains an unfulfilled objective of the work but we still intend to evaluate several other methods for estimating abundance directly, such as distance sampling, strip transect sampling, capture-recapture methods based on photo-identification, and acoustic methods (including appropriate use of C-POD detections, see below). Here we provide initial information using a focal dataset for CDNP.

Available sightings data
A total of 419 beach-based cetacean sightings have been made in CDNP since work started in 2008. These have been recorded by researchers (n=139), CDNP fishers hired and trained as project 'pickets' (n=266) and other incidental sightings (n=14) that could be confirmed. Of these 230 sightings were of *Sousa*, 147 of *Tursiops.* Sixteen of these sightings were of mixed *Sousa/Tursiops* although none were made by the PI and we await photos to confirm these. The remainder of sightings were of large whales, likely in every case to have been migratory humpback whales (*Megaptera novaeangliae*).

To estimate distribution and the proportion of habitat occupied we used occupancy methods (Mackenzie *et al.* 2002, Mackenzie *et al.* 2003, Mackenzie *et al.* 2006). The analysis recognizes three states: occupied and detected, occupied and not detected, and not occupied. It provides estimates of the probability that a sampling unit is occupied and the probability that an individual animal (or group) is detected. It requires replicated observations on each sampling unit and it allows for covariates that might affect occupancy or detection to be incorporated into the analysis. The basic method assumes demographic and spatial closure during a sampling period (referred to as a season) such that the occupancy status does not change and that sampling units states are independent. Additional assumptions include no errors in species identification and that observations are independent. There are analysis options that relax most of these assumptions should this be needed. Occupancy methods permit estimation of detectability and thus provide robust metrics for comparisons over time and space.

A variation on regular occupancy models uses the variation in detection probability of a species in space to estimate its abundance at each sampling point (Royle and Nichols 2003). This model presents some difficulties in terms of interpretation of results, as under most circumstances localized estimates of abundance cannot be translated into a meaningful estimate for the entire study area. The assumption that detectability is a function of abundance is also likely to be difficult to meet for humpback dolphins. Multi-season integrated habitat occupancy offers a more promising approach that could be used to examine how habitat suitability and factors that affect habitat suitability can influence the distribution and relative abundance of humpback dolphins over time (Mackenzie *et al.* 2009, Martin *et al.* 2010).

To pilot the basic occupancy approach we focused on the 60 km stretch of coastline in CDNP. Each one kilometre segment of the beach is treated as a sampling unit, providing us with 60 sampling units. For the analysis presented here we limited the dataset even further, using just data for 2012. It is important to note that when sampling units are scaled to the home range size of target species, the resulting interpretation of the analyses is that it provides an estimate of the proportion of the survey area occupied. When sampling units are smaller than home ranges, as is likely to be the case for humpback dolphins in this focal area, the interpretation is intensity of use. Each of the sampling units in CDNP was visited between one and 23 times during a total of 76 survey days completed in 2012. For the initial analysis we assumed population closure given that we believe we are dealing with a resident population of territorial dolphins, although it is likely that this population of humpback dolphins also uses the adjacent coastlines south of the park as well as those of neighbouring Gabon, namely Mayumba National Park.

To avoid biased estimates heterogeneity in detectability must be accounted for explicitly, thus during each visit to a sampling unit information was collected on the factors most likely to influence detectability for humpback dolphins:

- Sea state – ranging from 1 (calm) to 5 with conditions above 3 generally not appropriate for humpback dolphin surveys.
- Swell height – recorded in meters.
- Visibility – ranging from 1 (poor) to 5 (excellent).

Missing information on the factors likely to cause heterogeneity in occupancy does not bias the estimates, but instead simply provides an average estimate across all the factors likely to influence occupancy. Due to time limitations factors potentially influencing occupancy were omitted from the initial analysis. For the final analysis we aim to include occupancy covariates such as: fishing intensity (likely to impact prey availability and potentially also have an associated bycatch risk), fine scale bathymetry, substrate type, sea surface temperature, sea surface height, wind, net primary productivity, chlorophyll-a.

The initial analysis of the pilot data was completed using Presence software (Hines 2013). Model selection was completed using the Akaike's Information Criterion (AIC) values produced by the software (Burnham and Anderson 2002). Final analyses will be completed using the STOCC library for R, which implements a set of Bayesian spatial-temporal presence models (Johnson *et al.* 2013). The latter is more stable and manages to avoid numerical issues that tend to occur when dealing with low rates of detection and occupancy, as is the case for humpback dolphins.

The data for both humpback dolphins and bottlenose dolphins were analyzed using point transect distance sampling methods. During the occupancy study observers measured the radial distance from 60 point locations to observations of cetaceans. Distance sampling techniques (Buckland *et al.*, 2001) have been successfully used to obtain density and abundance estimates for many cetacean species based on data collected along line transects. Although, estimates of abundance have been obtained from shore-based counts of cetaceans, these have generally been based on methods other than distance sampling (Buckland & Breiwick, 2004; Laake *et al.* 2012).The hesitation in applying the method to data collected from shore-based points is due to a possible violation of the assumption of uniform distribution of the animals relative to the sampling points.

The results described below seem to indicate that the method has some potential for humpback dolphins and (to a lesser extent) bottlenose dolphins in our study area, which may be due to their particular behavioural characteristics and life histories. The 60 point transects were located at the centre point of the segments covered during the collection of the occupancy data in 2012 were used Although, the data were pooled for analysis across the sampling occasions to produce an average estimate of density and abundance for 2012, due to small sample sizes all the observation collected from 2009 to 2013 were used to fit the detection function. Radial distance data were analyzed using Distance 6 (Thomas *et al.*, 2010) with the sampling fraction set to 0.5 given the observers only covered half the circular area surrounding then, i.e. the 180^{o} facing the ocean. Although, both encounter rate and group size estimates were stratified by species for 2012, the results from fitting the detection function to both stratified and pooled data by species to were considered for the 2009 - 2013 data. The data were grouped into intervals for analysis due to rounding in the data and likely inaccuracies in the distance measurements that were estimated by eye. To test for potential bias in the estimate of group size we applied a statistical hypothesis test at the 15% a-level to the regression of natural logarithm of group size against the probability of detection. A variety of key functions and adjustment term combinations were considered to model the detection function and Akaike's Information Criterion for small sample sizes (AICc) was used in model selection (Buckland *et al.*, 2001).

Occupancy analysis from shore-based observations

The naive estimate of occupancy for humpback dolphins was 0.2131. The model without covariates that assumed constant occupancy across the study area and constant detectability provided an estimate for occupancy $\hat{\psi}$ of 0.8551(95% CI = 0.0106 - 0.9997) and detection probability $\hat{\phi}$ of 0.0431(95% CI = 0.0167 - 0.1067).

Inclusion of the sea state, swell height and visibility as sampling covariates seemed to improve models in terms of their AIC ranking. In particular, swell height or swell height in conjunction with the other sampling covariates seemed to improve the model (Table 1). The top-ranked model included swell height and sea state as covariates for detectability, which provided an estimate for occupancy $\hat{\psi}$ of 0.8301(95% CI = 0.0309 - 0.9987) with increases in estimated detectability for calmer sea states and less swell height. For example, with sea state one and a swell height of 1 m the estimated detection probability $\hat{\phi}$ was 0.0821 (95% CI = 0.0362 - 0.1754) and in sea state two with a swell height of 2 m this drops to an estimated 0.0079 (0.0014 – 0.0433).

Distance sampling from shore-based point transects

For the final analysis a detection function pooled across the two species was fit (Figure 2) with encounter rates and group size stratified by species (Table 2). For the final model with five equal intervals and right truncation set at 445m leaving a total of 107 observations, the detection probability was estimated as 0.28 and the effective detection radius (EDR) as 235.98m. There was no significant size bias detected with average group sizes of 10.91 (95%CI = 7.92 - 15.02) and 4.30 (95% CI = 2.43 - 7.62) for humpback dolphins and bottlenose dolphins, respectively (Note that these results are based on 11 and 10 groups for the 2012 period under consideration. For the entire 2009-2013 sample based on 71 and 36 observations of humpback dolphins and bottlenose dolphins groups, the average group size was 17.90 and 8.22, respectively). Average encounter rates were significantly lower for bottlenose dolphins. Encounter rates (n/L) in number/km was 0.023 and 0.021 for humpback dolphins and bottlenose dolphins groups, respectively. The overall results for 2012 are shown in Table 2.

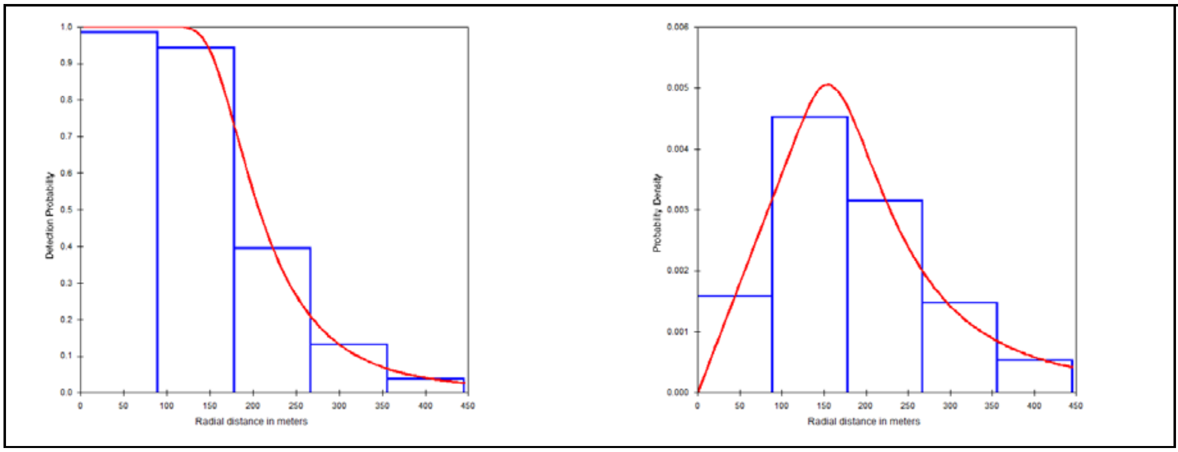
Table 1: The model results for humpback dolphins *Sousa teuszii* occupancy analysis. The parameterization of each model is shown (Model), along with the AIC value, the difference in AIC value between the top-ranked model and each model listed (ΔAIC), the relative support for the model given the data using AIC weight, the strength of evidence of each model relative to the other models in the set (Model Likelihood) and number of parameters estimated (Num. Par).

Model	**AIC**	**ΔAIC**	**AIC Weight**	**Model Likelihood**	**Num. Par**
psi(.),p(Sea State, Swell)	144.28	0.00	0.4518	1.0000	3
psi(.),p(Sea State, Swell, Vis)	146.18	1.90	0.1747	0.3867	4
psi(.),p(Swell)	146.22	1.94	0.1713	0.3791	2
psi(.),p(Swell, Vis)	147.51	3.23	0.0899	0.1989	3
psi(.),p(Sea State, Vis)	148.76	4.48	0.0481	0.1065	3
psi(.),p(.)	148.93	4.65	0.0442	0.0978	2
psi(.),p(SeaState)	150.97	6.69	0.0159	0.0353	2
psi(.),p(Vis)	153.71	9.43	0.0040	0.0090	2

Table 2. Average estimates for 2012 for humpback dolphins *Sousa teuszii* and bottlenose dolphins *Tursiops sp.*. Estimates of group density ($\hat{D}_s$) and individual density ($\hat{D}$) both in number/km^2 and abundance ($\hat{N}$) for each species, all with their 95% confidence intervals (95% CI), as well as the overall percent coefficient of variation (%CV).

Species	$\hat{D}_s$	**95% CI**	$\hat{D}$	**95% CI**	**(% CV)**	$\hat{N}$	**95% CI**
Humpback dolphins	0.266	(0.204 – 0.347)	2.902	(1.949 – 4.320)	19.74	348	(234 – 518)
Bottlenose dolphins	0.242	(0.186 – 0.315)	1.040	(0.566 – 1.909)	29.01	125	(68 – 229)

Figure 2: Detection probability functions (left) and probability density functions (right) using a hazard rate function with no adjustment terms for pooled data for humpback dolphins *Sousa teuszii* and bottlenose dolphins *Tursiops sp.*



2. ACOUSTIC ASSESSMENT

In SC/64/SM22 we described our intent to deploy C-PODs. Static acoustic monitoring has been used to assess patterns of habitat use in a wide variety of small cetaceans (e.g. Castellote *et al.* 2012; Gallus *et al.* 2012; Leeney *et al.* 2011). Furthermore, recent work has linked acoustic detection rates with abundance, or number of animals (Kyhn *et al.* 2012). C-PODs can provide data around-the-clock and over long time periods (a single deployment can run for over three months), and operate regardless of weather and sea conditions. The use of C-PODs is especially appropriate in inaccessible areas or where funding or personnel (or boats) are not frequently available for boat-based sightings surveys. We aimed to use C-PODs to characterise patterns of habitat use by dolphin at six sites along the coast of Congo and Gabon. These we felt would give us a means to gather important baseline data (with caveats) on species presence and thus key habitats. Given constraints with boat availability in Congo we were forced to use an alternative method to deploy our units, namely pirogues belonging to local artisanal fishers. This has provided additional opportunities to interact with fishers (see below for more).

Characterisation of dolphin vocalisations within CDNP

C-PODs are capable of recording over a wide frequency spectrum but in the absence of corollary information on the particular frequency spectrum of recorded clicks inferences made must be cautious. Atlantic humpback dolphins are known to produce whistles, likely used for communication (Weir 2010b). They also use echolocation to hunt and explore their environment, as do all other odontocetes. The clicks of Atlantic humpback dolphins have not been studied in detail, but clicks from a closely-related species, the Indo-Pacific humpback dolphin (*Sousa chinensis*) have been reported as having a frequency spectrum between 30 kHz and 200 kHz (or beyond) and appeared to be bimodal, with a peak around 100 kHz and a secondary peak at 180 kHz (Goold & Jefferson 2004).

In order to improve on the available information on click spectra we recently attempted to directly record humpback and bottlenose dolphins within CDNP. Using a borrowed vessel surveys were conducted over 7 days (May 17^{th} – 25^{th}). Surveys were conducted at a speed of ~10 kts and at a distance of 200-400 meters from shore. Whenever dolphins were encountered the vessel was either stopped or speed was reduced to 1-2 kts in order to facilitate species identification and group sizes. Dolphins were then carefully approached, the engine stopped and recordings initiated when at a distance of <100. Acoustic recordings were conducted with the engine off while drifting or anchored. Additionally, baseline recordings were conducted at random locations when no dolphins had been sighted for at least one hour. These recordings were used to assess noise levels due to the environment (e.g. breaking waves and sediment movement), the research vessel and/or the recording system. The wideband multi-channel recording system consisted of four Reson TC 4034 spherical hydrophones with flat frequency response (+2,-4 dB) up to 250 kHz and an omnidirectional response.

Results of attempts to directly record dolphin clicks

Acoustic recordings were carried out during 11 dolphin encounters (six with humpback dolphin encounters and 5 with bottlenose dolphins). Bottlenose dolphin mildly avoided the research boat during encounters but careful boat handling allowed us to approach and prolong encounters for >30 minutes. Acoustic recordings were made at estimated visual ranges (to where dolphin surfaced) of 20-50 metres (see figure. Atlantic humpback dolphins on the other hand were extremely evasive and except on one occasion, encounters count not be prolonged beyond 5-10 minutes. Every attempt to record these animals was a failure it seems as no pulsed sounds (clicks) that could confidently be attributed to humpback dolphins were detected in recordings made in their vicinity. It appeared that the animals ceased to vocalise in the vicinity of the research boat. We were however able to assess ambient noise, particularly in areas proximate to the beach, and in a roundabout way assess, at least qualitatively, frequencies that humpback dolphins would have to contend with in finding food.

Although the recordings of bottlenose dolphins provide a reference for discriminating between sympatric dolphin species that occur at CDNP, we believe that it is imperative to obtain recordings of humpback dolphins. Wideband recordings are not only necessary to develop methods to discriminate between the recorded on CPODs at CDNP, but they would also constitute a scientific advance about echolocation signals of this species, a near-shore, turbid water specialist. Local fisherman report occasional close range encounters with humpback dolphins indicating that, under certain conditions, this species is approachable at CDNP. Future recording attempts may benefit from using other types of vessel such as local pirogues.

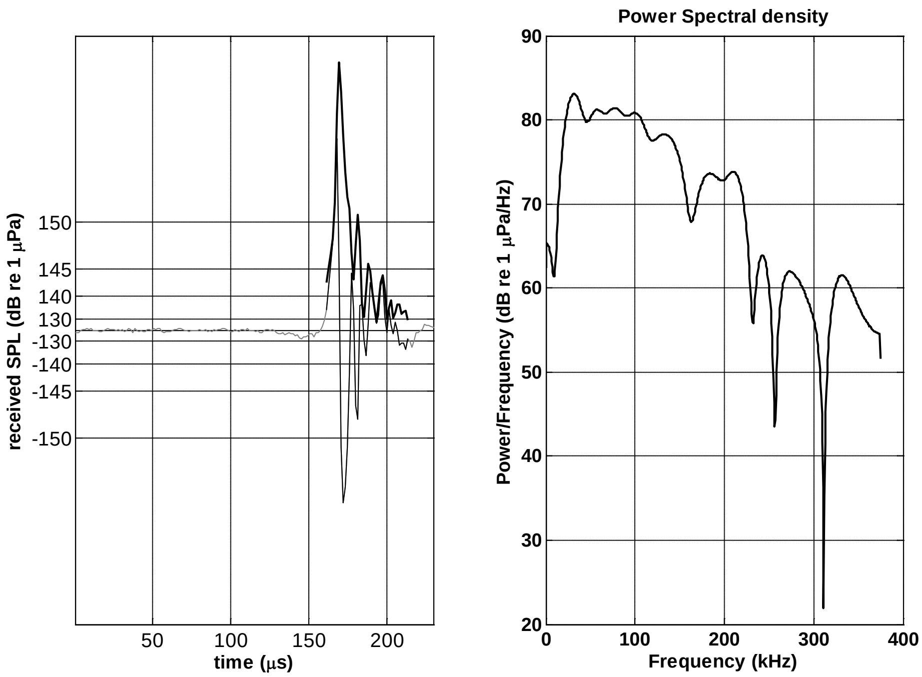


Figure 3: Waveform and power spectral density of one CDNP bottlenose dolphin click recorded on one hydrophone of the vertical array.

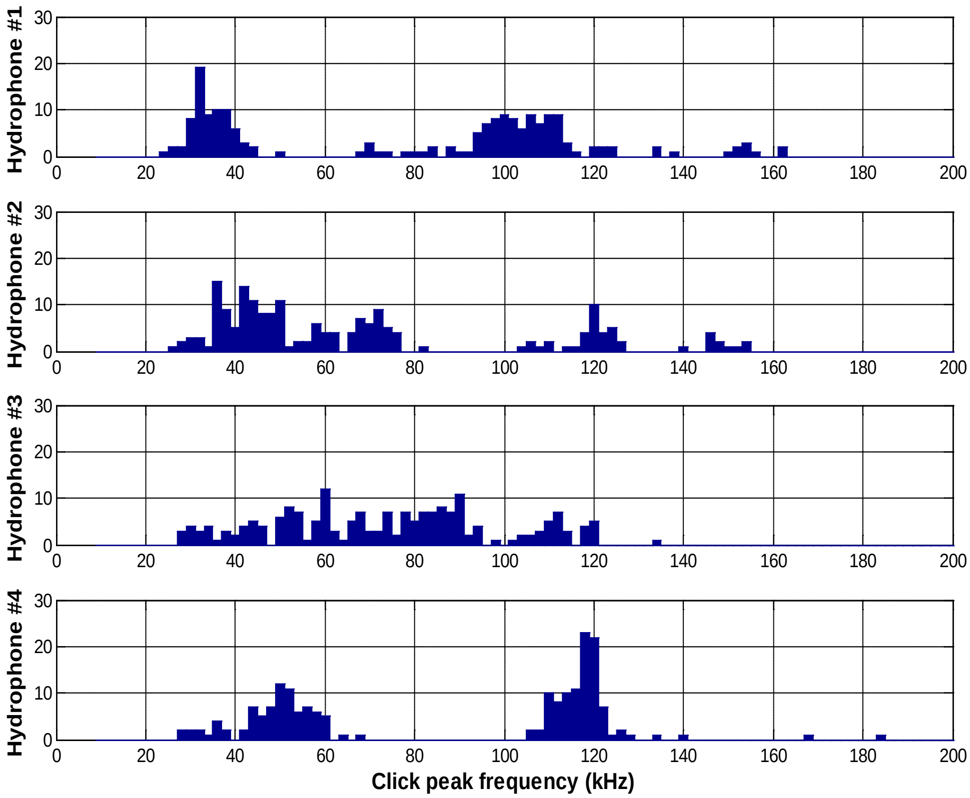


Figure 4: Distribution of click peak frequency for clicks recorded on each of the four hydrophones in our vertical array at CDNP

C-POD methods

C-PODs (http://www.chelonia.co.uk/cpod_specification.htm) are self-contained, submersible units containing a hydrophone and a computer chip. The C-POD uses digital waveform characterisation to select clicks with cetacean-like characteristics from background noise; the time, centre frequency, sound pressure level, duration and bandwidth of each click is then logged. C-PODs were deployed on L-shaped moorings using a dual anchor system, which provides a secure mooring but allows deployment teams to easily retrieve C-PODs by only having to lift one of the anchors.

Nine C-PODs were deployed between July and October in the Mayumba region (southern Gabon), and between late October/ early November and March for the Conkouati region (Congo). Analyses for five of these sites are provided here and details on dates and lengths of deployments are provided in Table 3. As well as the 5 sites listed, C-PODs deployed at Bam, between Kouboula and Nyafessa (Fig. 1) and Bibanga are missing and presumed stolen.

C-POD analysis

C-POD files were filtered using CPOD.exe software. Dolphin click trains and background noise levels were extracted to examine patterns of noise and detections at each site. The following variables were examined as means of describing dolphin echolocation activity at each site:

- *Detection-Positive Minutes per hour (DPM.h^{-1})*
- *Detection-Positive Hours per day (DPH.d^{-1})*

Detection rates on the two Bellelo C-PODs were compared to verify that the sensitivity of both units was the same and to confirm that significantly different detection rates should not result from deploying two units at the same site. Further, to investigate differences in echolocation behaviour among sites, the mean Inter-Click Interval (Mean ICI) for each click train was extracted from all C-POD data files. ICI represents the time between adjacent clicks, so faster click trains have smaller ICI values. Mean ICI was calculated as:

$$\text{Mean ICI} = \frac{\text{Train duration } (\mu s)}{(\text{Number of clicks} - 1)}$$

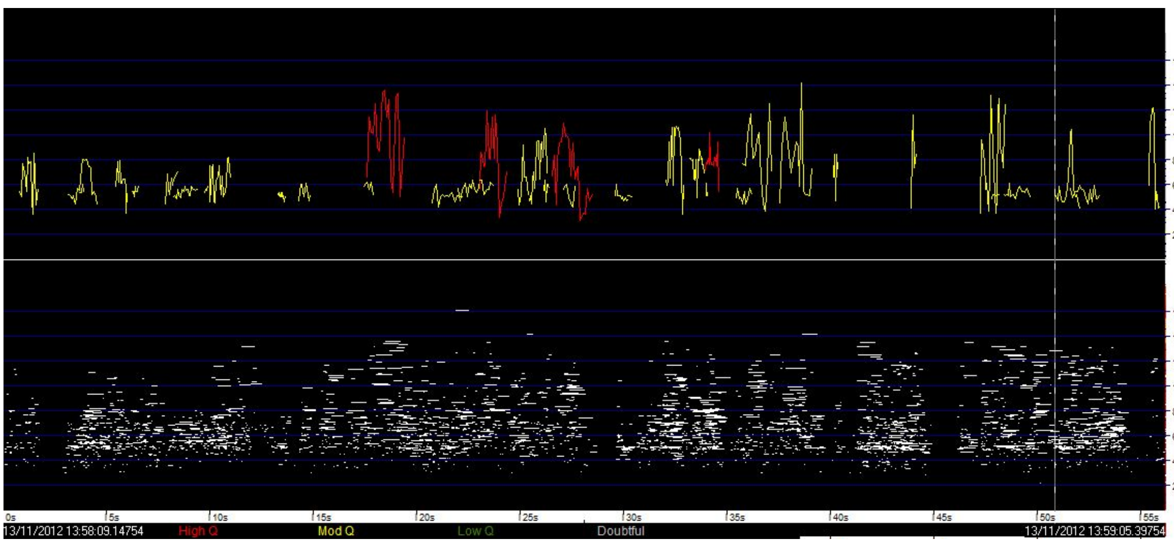


Figure 5: Example spectrogram of click detections at Belelo. Bottom screen shows the CP1 file across time (raw data), Top screen shows the CP3 file across time (algorithm-selected click trains). Red click trains are of 'High Quality', yellow detections are of 'Moderate Quality'. X-axis = Time, Y-axis = Frequency in kHz.

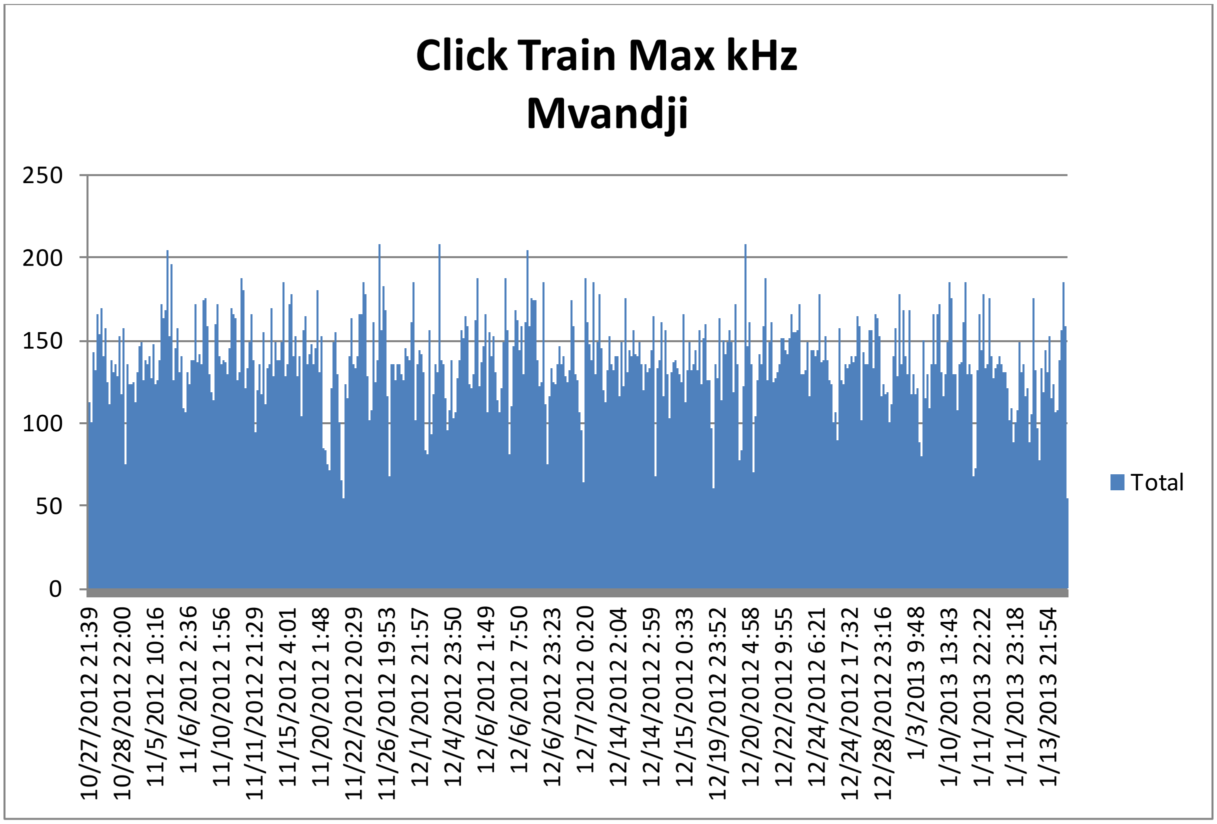


Figure 6: Max kHz of click trains recorded at Mvandji provided as an example to illustrate issues with species classification on CPOD units.

C-POD results

Using data from 75 h for which clicks were detected on at least one of the two units at Bellelo (Fig. 3; 1508 h with no clicks on either unit were removed), a paired t-test was performed on natural log-transformed click counts per hour, for dolphin clicks only (Fig. 8). There was no significant difference between click detection rates on C-POD 2005 and C-POD 2007 (t=0.821, p=0.4).

Hourly detection rates ($DPM.h^{-1}$) appeared to be highest at Mvandji and Niandji (Fig. 9, Table 3), compared to the other sites. Similarly when detection rates are expressed daily, as detection-positive hours per day, averaged for each month (Fig. 10), detection rates at Mvandji and Niandji were high (between 2 and 2.8 $DPH.day^{-1}$) compared to those on C-PODs at other sites, deployed during the same period, particularly from December to January for both sites and also in October, at Mvandji. Detection rates at Bellelo were consistently lower, overall, than at the other sites. These results suggest that when dolphins are present at Mvandji and Niandji, they tend to spend longer there than at the other sites. At a coarser scale, the proportion of detection-positive days (% DPD) at each site was considerably higher at Mvandji and Niandji than at all other deployment sites (Table 4), suggesting that this site is used by dolphins on a more regular basis (more days per month) than other sites.

Table 3: Details of C-POD deployments for which data were available for this report.

File name	Start of data	End of data	Period	Location*
Bellelo North 2012 11 08 POD2007 file01	11/11/2012 06:00	16/01/2013 05:00	65 d 23 h	Bellelo Congo
Bellelo North 2013 01 25 POD2007 file01	26/01/2013 07:00	18/03/2013 08:00	51 d 1 h	Bellelo Congo
Bellelo South 2012 11 08 POD2005 file01	11/11/2012 06:00	16/01/2013 05:00	65 d 23 h	Bellelo Congo
Bellelo South 2013 01 25 POD2005 file01	26/01/2013 07:00	02/03/2013 11:00	35 d 4 h	Bellelo Congo
Niandji 2012 10 26 POD2010 file01	26/10/2012 15:00	07/12/2012 10:00	41 d 19 h	Niandji Congo
Niandji 2012 12 22 POD2010 file01	04/01/2013 13:00	02/03/2013 11:00	56 d 22 h	Niandji Congo
Mvandji 2012 10 27 POD2009 file01	27/10/2012 14:00	14/01/2013 11:00	78 d 21 h	Mvangji Congo
Mvandji 2020 01 22 POD2009	24/01/2013 07:00	01/03/2013 09:00	36 d 2 h	Mvangji Congo
Kouboula 2012 07 17 POD1885 file01	20/07/2012 15:00	11/11/2013 12:00	113 d 21	Kouboula Congo
Nyafessa 2012 07 17 POD1888 file01	21/07/2012 13:00	09/11/2012 08:00	110 d 19 h	Nyafessa Congo

Table 4: Mean detection rates at each site, calculated for the entire deployment period.

Site	N C-POD days (full days only)	Mean $DPH.day^{-1}$	Max $DPH.day^{-1}$	Mean $DPM.h^{-1}$	% DPD
Bellelo South	99	0.83	4	0.26	42.4
Bellelo North	115	0.79	4	0.3	46.1
Mvandji	113	1.9	8	0.92	72.6
Niandji	97	1.9	11	0.74	76.3
Nyafessa	110	1.0	8	0.37	50
Kouboula	113	1.34	8	0.41	58.4

No clear patterns are evident earlier in the deployment period (Jul-Sep), when only the Mayumba C-PODs were deployed, but the mean detection rates on these units are not dissimilar to detection rates in Congolese waters, between about 0.5 and 2 $DPH.day^{-1}$. It is difficult to draw any conclusions regarding spatial and seasonal patterns from these data, given that all C-PODs were not deployed for the same length of time and a full year of data is not available. However, a diel pattern in hourly detections ($DPM.h^{-1}$) does appear to be evident at Mvandji, with higher rates of detection at night and in the early morning, and lower detection rates during the day (Fig. 9).

Mean ICI values were calculated for Mvandji, Niandji, Kouboula and Nyafessa (Fig. 11). There is some suggestion of longer intervals between clicks (i.e. higher Mean ICI values) in the middle of the day than at night, at Mvandji. No patterns in mean ICI were obvious at Niandji, Kouboula or Nyafessa.

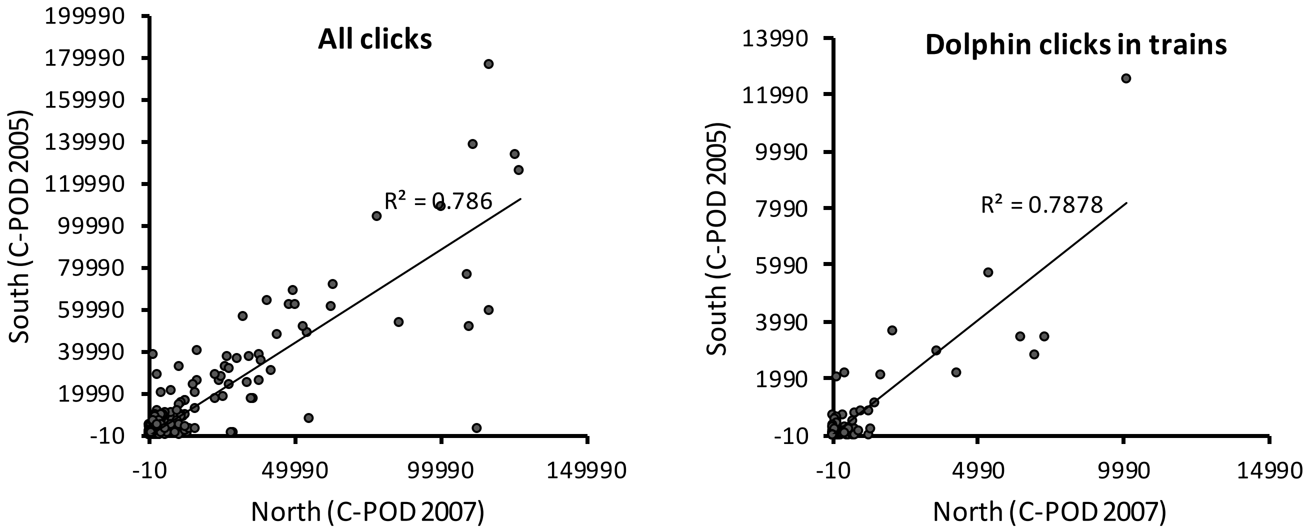


Fig. 7: Comparison of detection rates for all clicks (left) and dolphin clicks in trains (right), for 2 C-PODs at Bellelo.

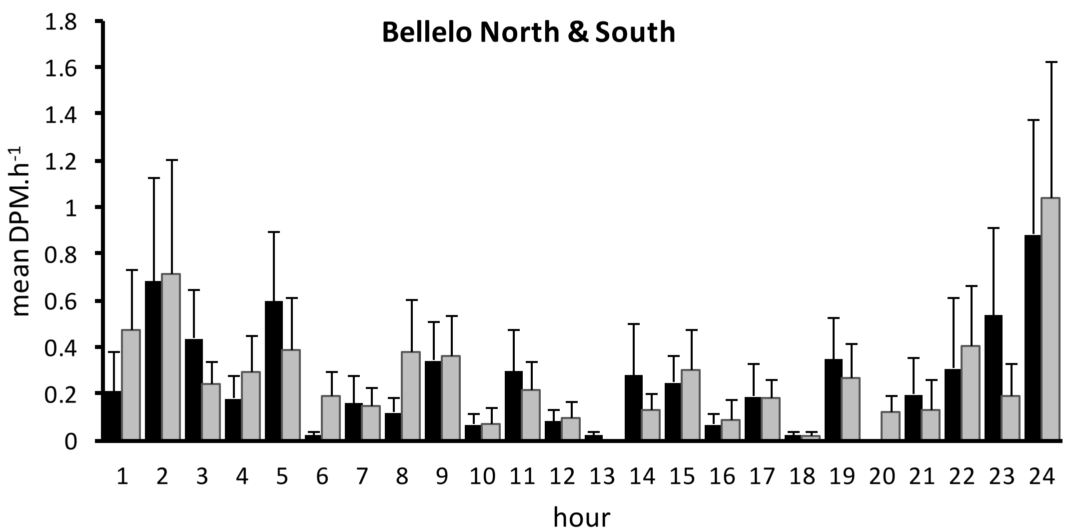


Fig. 8: Comparison of mean hourly detection rates (DPM.h^{-1}) at Bellelo North (n=116-118 replicates for each hour) and Bellelo South (n=100-102 replicates for each hour), for both deployment periods (November 2012 to March 2013).

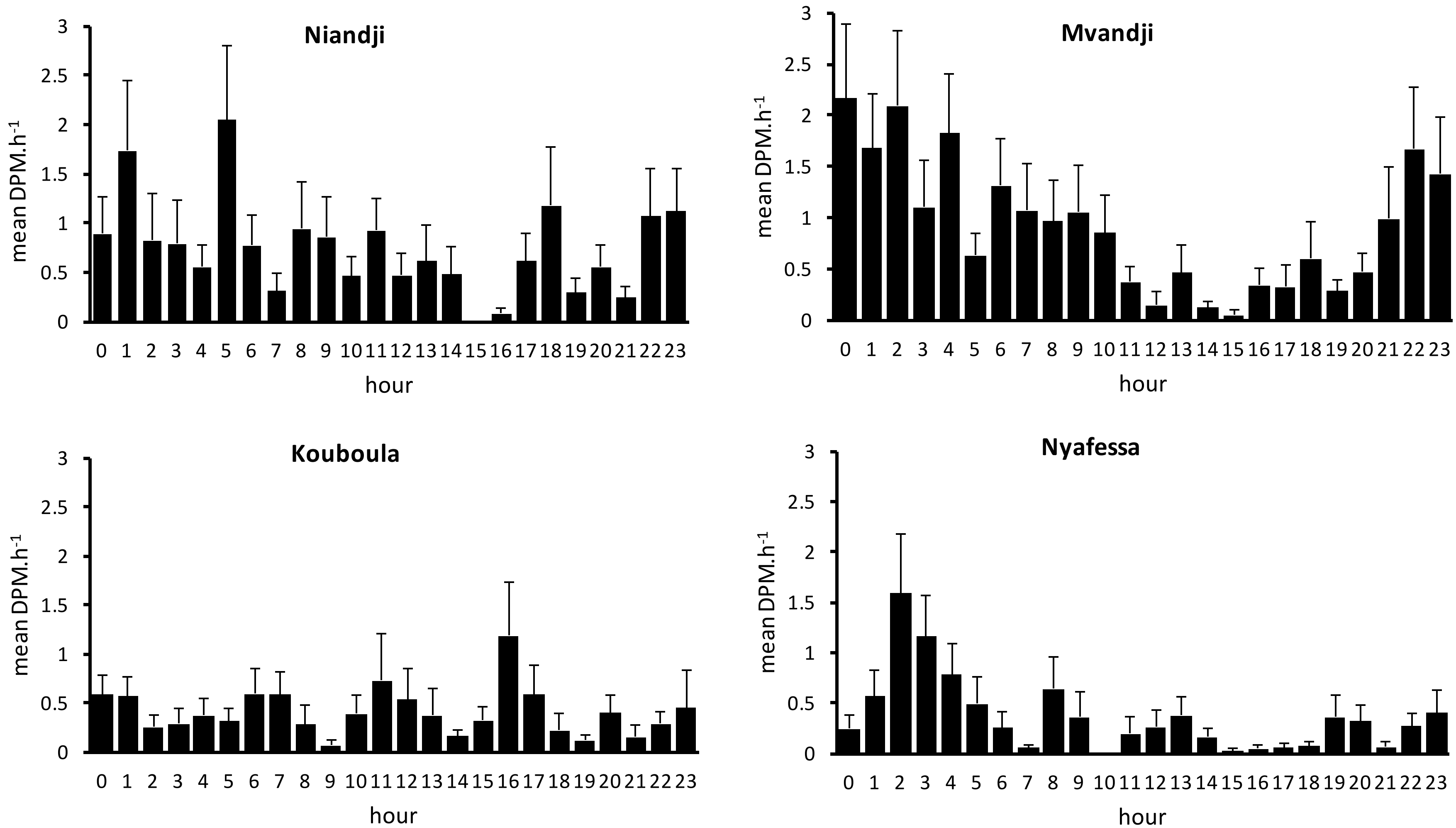


Fig. 9: Mean DPM.h^{-1} at Niandji (26/10/2012 – 07/12/2012 & 04/01/2013 – 02/03/2013, n ≥ 97 for each hour); Mvandji (27/10/2012 – 14/01/2013 & 24/01/2013 – 01/03/2013, n ≥ 114 for each hour); Kouboula (20/07/2012-11/11/2012, n ≥ 113 for each hour) and Nyafessa (21/07/2012-09/11/2012, n ≥ 110 for each hour).

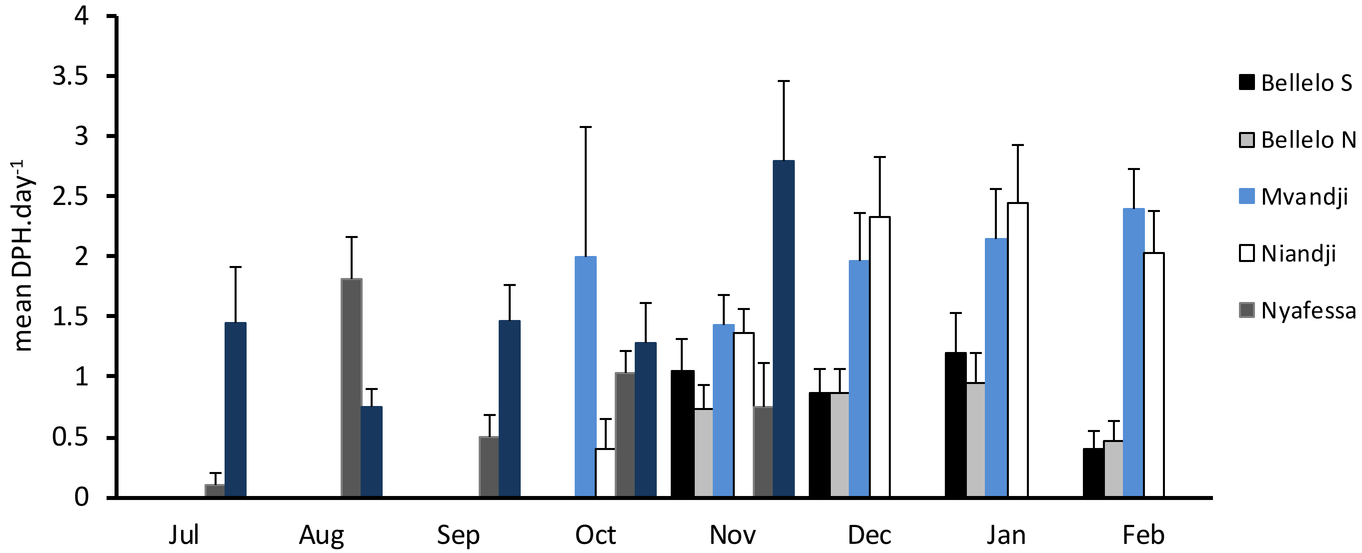


Fig. 10: Monthly mean DPH.day^{-1} between July 2012 and February 2013, at all 5 C-POD sites. Each C-POD was deployed for between 4 and 5 months over this period.

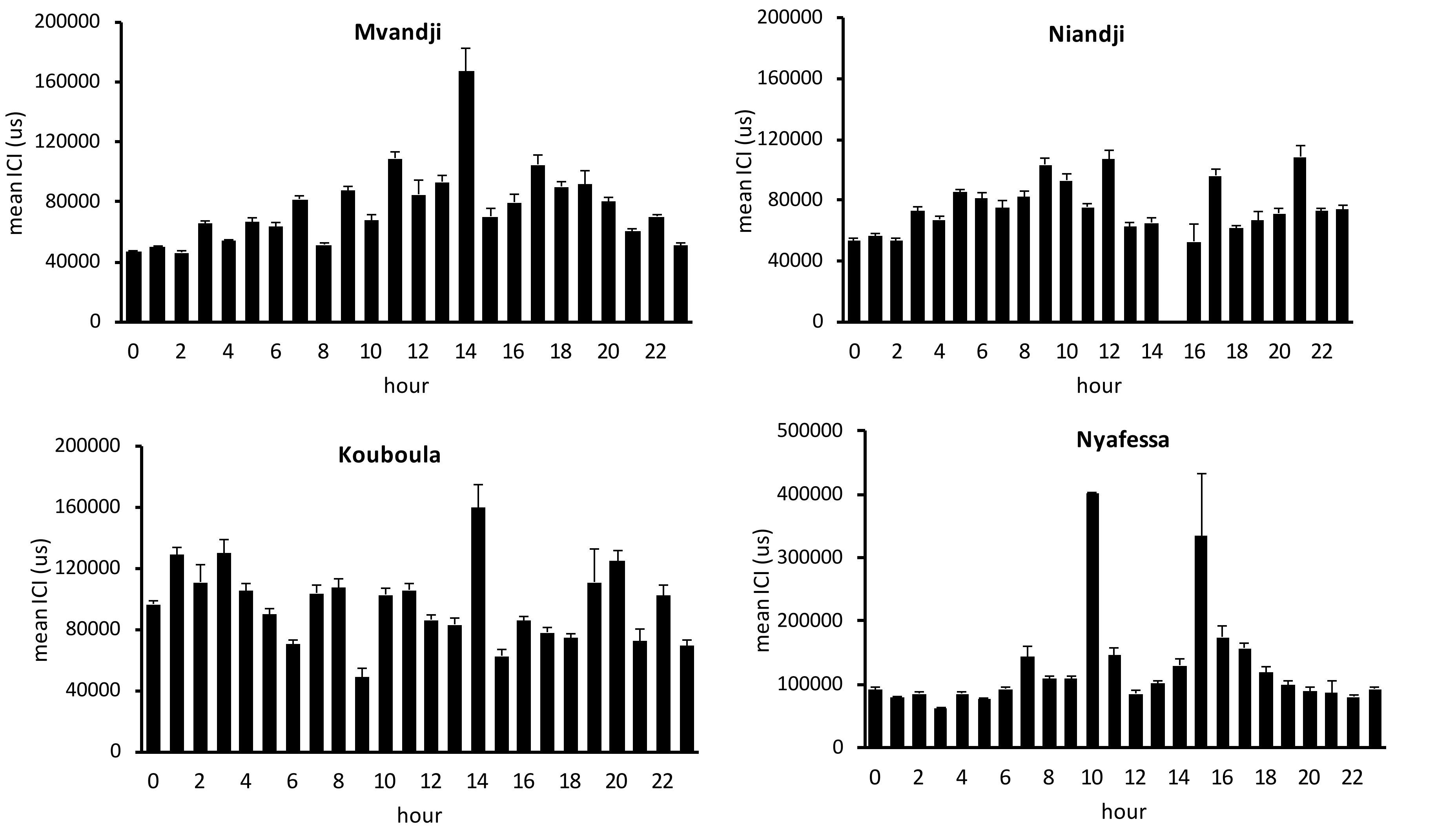


Fig. 11: Mean (+ s.e.) hourly ICI values for Mvandji, Niandji, Kouboula & Nyafessa (note different y-axis scale for Nyafessa). The value for 10:00 at Nyafessa is based on a single value. Time periods from which hourly ICI values were extracted are the same as for Fig. 4.

The C-POD data suggest that dolphins are present more regularly at Mvandji and Niandji than at the other sites monitored, and that they may spend longer time periods at these two sites than elsewhere. Sightings records from Mvandji and Niandji involve primarily Atlantic humpback dolphins and thus it is likely that the majority of detections logged by C-PODs during this study were due to the presence of this species. The project has recently employed two dedicated 'C-POD' observers (trained fishers) to monitor full time C-PODs at two locations during daylight hours. Future work will match sightings of *S.teuszii*, *Tursiops* sp. and any other delphinids, close to each C-POD, with detections on the C-PODs, in order to assess whether detections of *S.teuszii* are distinguishable from other species and also, whether group size can be inferred from detection rate, duration or other features of the acoustic encounter.

Investigating patterns in mean ICI can provide insight into whether the echolocation behaviour of dolphins is different among sites, or differs with time at a given site. Fast click trains have been associated with foraging behaviour at some sites but differences in ICI might also be due to the distance at which dolphins investigate objects in their environment using their sonar (Carlström 2005), which can in turn be related to the turbidity of the water and levels of natural light (i.e. day or night). The broader behaviour of the animals will also determine the ICI values seen; hunting or foraging behaviour involves faster click trains as the predator chases and approaches it prey, whereas resting dolphins are likely to produce fewer fast click trains, for example. No clear patterns in mean ICI were apparent from these analyses, except for a possible diel pattern in mean ICI at Mvandji, which suggests that dolphins are using their sonar at longer range in the middle of the day. This corresponds with the time when detection rates are lowest at Mvandji, thus it could be inferred that the few detections that do occur at this time of day are from dolphins passing by the site at some distance, rather than dolphins clicking on the C-POD at close-range. Carlström (2005) documented porpoise ICI values of 20-80 ms (20,000–80,000 µs) and Philpott *et al.* (2007) described mean ICI values of up to 300 ms (300,000 µs) for bottlenose dolphins in Ireland, although most (90%) of trains had a value <200 ms . The mean ICI values of 40,000-120,000 µs documented in this study are thus in a similar range.

These data provide a preliminary insight into dolphin habitat use at three sites along the Congolese coast and two in southern Gabon. Seasonal patterns cannot be assessed from a limited deployment period such as this. We are hoping to complete at least two years of constant monitoring in order to thoroughly assess seasonal patterns in dolphin habitat use.

3. BYCATCHES AND ASSOCIATED OUTREACH WORK

In SM/64/22 we reported on a spate of humpback dolphin bycatches (n=6) in CDNP during late 2011 and early 2012. The number of reported catches (n=3) has declined in the intervening period but we are uncertain if this reflects a true decline in the number of catches or a change in the frequency of reports (see table 5 below). The pattern remains the same as previously reported with inshore set nets being responsible for all captures. All captures are attended and processed if possible; we have curated eight *S. teuszii* skulls with associated skeletal material and have collected otoliths from six *S. teuszii* stomachs.

The resulting plot suggests that there is some relationship between fishing effort and the risk of bycatch. We wish to explore this idea further with a view to implementing (perhaps) pingers on nets (Dawson *et al.* 2013). Given the number nets and the cost of pingers we want to target the effort towards areas that represent a greater risk. This has been discussed at least preliminarily with some fishers and reactions to the idea of pingers are mixed, with many anxious about the effects of pingers on their catches. Some fishers however are willing to participate and thus we are keen to try.

Date	LatinName	SS	Sex	L (m)	Closest Village	Latitude	Longitude	By Catch Evidence
10/30/2008	Sousa teuszii	2	M		Paris	-4.11205	11.34780	Dolphin captured in coastal gillnet.
1/1/2009	Tursiops sp.	2	?	3.28	Kondi	-4.17161	11.37514	Dolphin captured in coastal gillnet.
8/27/2009	Tursiops sp.	3	?	3.65	Tchibota	-4.27099	11.46839	Recovered from landing site, dorsal mass removed
9/12/2009	Tursiops sp.	4	M		Longobondi	-4.24300	11.43300	Recovered from landing site
9/9/2009	Tursiops sp.	4	M	1.65	Mikoundji	-3.96016	11.15319	Dolphin severed in two
7/10/2011	Sousa teuszii	5	?		Longobondi	-4.29526	11.49901	Dolphin captured in coastal gillnet.
8/4/2011	Tursiops sp.	2	?		Longobondi	-4.30908	11.51604	Dolphin captured in coastal gillnet.
8/13/2011	Tursiops sp.	2	?		Longobondi	-4.30908	11.51604	Tourists watched animal landed and butchered.
9/27/2011	Sousa teuszii	3	?		Bondi	-4.22956	11.41654	Proximity to landing sites, machete scar left parietal
10/20/2011	Sousa teuszii	2	?	2.38	Lifelo	-4.04064	11.26732	Dolphin captured in coastal gillnet.
12/6/2011	Sousa teuszii	2	F		Conkouati	-4.01887	11.23885	Dolphin captured in coastal gillnet.
1/26/2012	Sousa teuszii	3	M	238. 00	Bondi	-4.22240	11.40755	Dolphin captured in coastal gillnet.
2/29/2012	D. capensis	5	?		Longobondi	-4.29418	11.49741	Proximity to fishing camp
5/6/2012	Sousa teuszii	2	M	2.66	Noumbi	-4.12354	11.35600	Dolphin captured in coastal gillnet.
10/15/2010	D. capensis	5	?		Mikoundji	-3.96016	11.15297	None
10/15/2010	D. capensis	5	?		Lifelo	-4.02511	11.24715	Proximity to fishing camp
1/31/2013	Sousa teuszii	2	F	1.65	Kondi	-4.17272	11.37346	Dolphin captured in coastal gillnet.
10/18/2012	Sousa teuszii	3	M	2.26	Lifelo	-4.02645	11.24917	Dolphin captured in coastal gillnet.
5/18/2013	Sousa teuszii	3	F	2.50	Kondi	-4.15237	11.37644	Dolphin captured in coastal gillnet.. Lactating

Table 5: Recorded strandings and bycatches in CDNP since 2008.

In order to improve our assessment of possible mitigation for the artisanal fishery we have begun a comprehensive assessment of fishers and landing sites. Preliminary ‘effort data’ data for the artisanal fishery are presented below in Figure 12. Effort data are very preliminary and represent the exploration of an idea that needs further development but something we hope will inform several aspects of work. The effort layer was developed using the following steps:

- identifying the number of fishing vessels (pirogues) at each fishing site in 2013.
- buffering each site by 5 km for each vessel (if a site had 5 vessels it would be buffered 5 times)
- identifying the fishing effort buffer overlaps by performing a union
- converting the union output into a raster and clipping to the study region

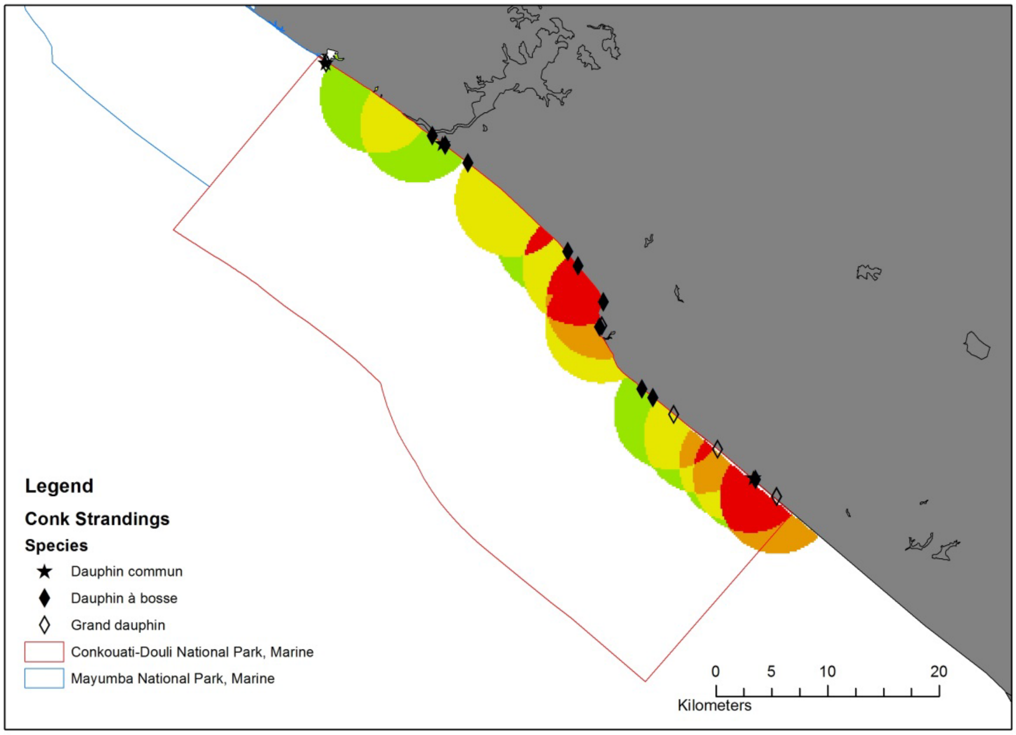


Figure 12: Artisanal fisheries effort in Conkouati overlaid with bycatches recorded since 2008. The effort scale is a relative measure with green being least effort and red the greatest. The scale reflects the number of boats (and thus an average number of nets per boat) at each landing site within CDNP.

4. FUTURE PLANS AND FUNDING

The project will continue for the foreseeable future. Funding has been secured from a variety of sources (foundations, private donors and industry sources) to help support project activities for at least 18 more months. Industry funds are in fact particularly welcome; as well as being a local source for work that is at times difficult to fund, they also represent something of a shift (albeit haphazard) in local perceptions and willingness to mitigate impacts to coastal species. Funding for C-PODs for instance was sourced from a private mining company developing a jetty just south of CDNP, and given this projects dependence on World Bank funding, the IFC critical habitat criteria (performance standard six) have been applied to the assessment of potential risks. Vessels are functional in both Gabon and Congo and thus boat based survey elements identified in the original proposal will be attempted in coming months. We have also secured sufficient funding to support boat based patrols by park enforcement officials in order to free CDNP of illegal trawlers. The associated effects of these trawlers were discussed in SC/64/SM22.

Work in Gabon will benefit from a recent and large scale shift in government level management of marine resources. This includes a complete reassessment of fisheries and fisheries licensing, an improvement in the mitigation of impacts associated with offshore industry and development of marine protected areas. The humpback dolphin figures in these plans, and the project is working to actively promote the development of a nearshore fisheries exclusion area in key areas for both fisheries and endangered species (particularly dolphins and turtles).

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Figure 13: Coauthors and co-investigators Justin Thonio and Ema Dilambaka. Researchers walk the entire coastline of CDNP at least once a month, some sections being covered more than once. Focal fisheries work is also completed in two villages, allowing for assessment of catches (species, yields, seasonality).

Figure 14: Local fishers at 6 different landing sites in CDNP were engaged to help with CPOD deployments and recoveries, as well as to help with surveillance of the units whilst they are in the water. Here a village meeting (Niandji) is held prior to deployment in order to explain the units function and to assure terms.

Figure 15: The most recent humpback dolphin captured in CDNP (Kondi), a lactating female in otherwise excellent health. Fishers reported the dolphin captured in a coastal gillnet to project researchers on the 18th of May 2013, but held off on butchery until the 19th of May and the arrival of TC. The meat was shared amongst many villagers post-necropsy, the authors recovered skeletal material, stomach and tissue samples. This represents a major shift in the way catches were handled in the past

Figure 16: The first juvenile *S.teuszii* (another female) that the project has documented captured in CDNP (January 31st, 2013). The project maintains a comprehensive database of all sightings and strandings records that spans the entire Gabon-Congo project area.