Creation of an Autonomous System on Moored Fish Aggregating Device (FAD) for a Permanent Acoustic Monitoring of Marine Mammals and other Perspectives for Marine Environment Attention, Guadeloupe, F.W.I.

NADÈGE GANDILHON[1], CEDRIC MILLON[1], PAUL GERVAIN[3], GILLES NOLIBE[4], MAX LOUIS[1], and OLIVIER ADAM[2]*

*[1]Laboratoire Dynamique des écosystèmes Caraïbes (DYNECAR), Université des Antilles et de la Guyane, BP 592, 97159 Pointe-à-Pitre Cedex, Guadeloupe. *nadege.gandilhon@univ-ag.fr. [2]Centre de Neurosciences Paris-Sud, UMR 8195, Bâtiments 440-447, Université Paris-Sud, 91405 Orsay cedex France/Institut Jean le Rond d'Alembert, Equipe LAM, 11 rue de Lourmel 75015 Paris, France. [3]PLK Marine, Allée des Cocotiers 97 120 St-Claude, Guadeloupe. [4] Ce Sigma, ActiClub Bât. A1, 1576 Chemin de La Planquette, 83 130 LA GARDE, France.*

ABSTRACT

Our field of research is focused on cetacean observations in order to propose some answers about the diversity, abundance and distribution of this marine biodiversity. Hence, we are leading since 2008 an inventory of cetaceans in Guadeloupe, in the French West Indies, which includes the AGOA Marine mammals French Sanctuary (www.agoa.fr), concerned by cetacean conservation priorities. To complete our scientific purposes we assessed a concept of a passive acoustic permanent observatory. Thus, the use of a fixed buoy as a support for a hydrophone has led to the creation of a customized prototype: GUALIBA I. This system merges the high technology of an autonomous acoustic system with a powerful FAD revised with a new design . The Fish Aggregating Devices (FADs) are widely used in pelagic fisheries. The intensifying use of these semi-submersible artificial floating objects in the Caribbean Sea is due to their heavy contribution to fishing activities in coastal areas. In the archipelago of Guadeloupe, their mutualisation through the deployment of a fleet of moored FADs, monitored and maintained since January 2008, aims to ensure reliable and sustainable long term fishing devices. Funded on triptych collaborative skills (Biology - Fisheries - Technologies), our results highlight here the formalization of a new technological answer and preliminary recordings results. The choice of implementation considered priority our cetacean biodiversity first results, environmental features (currents, distance from the coast) and technological constraints (power autonomy, large storage needs data recovery). The system has been deployed at 22km from the Leeward coast of Guadeloupe the 25 November 2010 on a moored FAD at ± 1450 meters of depth. The perspective of this work could be the creation of a synchronized network of FADs as instruments for cetaceans monitoring.

KEY WORDS: Acoustics, FADs, cetacean

Creación de un nuevo Sistema Autónomo sobre un Dispositivo de Concentración de Peces Pelágicos Anclado para el Control Acústico Permanente de los Mamíferos Marineros y otras Perspectivas de Viligencia del Medio Marino, Guadalupe, Antillas Francesas

PALABRAS CLAVE: Acústico, dispositivo de concentración de peces, mamíferos marineros

Création d'un Système Autonome Installé sur un Dispositif de Concentration de Poissons Ancré (D.C.P) pour le Suivi Acoustique Permanent des Mammifères Marins et autres Perspectives pour la Surveillance du Milieu Marin, Guadeloupe, Petites Antilles Françaises.

MOTS CLÉS: Acoustique, DCP, mammifères marins

INTRODUCTION

Fish Aggregating Devices (hereafter FADs), were deployed in the French West Indies first in Martinique off the Atlantic coast in 1983 by the ISTPM - Institut Scientifique et Technique des Pêches Maritimes, now IFREMER (French Institute of Research for Ocean Development) and gradually, widespread use in the rest of the Caribbean (Doray et al. 2002). The objective is to ensure reliability and sustainability for a long term fisheries with for moorings a longer lifespan and resistance (Leproux and Desurmont 1996, Taquet et al. 1998). FADs reduce the costs for professional sea fishermen by decreasing the travels but also by improving the conditions of safety by a better knowledge of the places of fishing (Diaz et al. 2001). FADS is mainly considered to improve the aggregation or attraction especially for the big pelagic fishes because of an increasing presence or abundance noticed around floating or immersed objects (Kogima (1956), Galea (1961) Matsumoto (1981) Lagin et Ledouble (1994), Higashi (1994), Freon and Dagorn (2000), Reynal et al. (2000), Dempster et al. (2003), Nelson et al. (2003), Doray et al. (2006). Mainly anchored in the coastal area of Guadeloupe, 40 collective FADs are currently monitored and maintained. Our topic was to consider FADs to fit with another scientific use, without changing its initial role. Indeed, our research project focuses on abundance and distribution of cetaceans in order to characterize species and the dynamics of resident or semi-resident populations in the coastal area of Guadeloupe. Moreover, in a context of marine mammal's sanctuary of Exclusive Economic Zone (EEZ) of the French West Indies, the knowledge of this biodiversity is a concern for administrators of protected marine areas. Various methods for observing marine mammals exist and it is possible to employ more that one method simultaneously as these methods are complementary: visual observations, observations using satellite tags or robotics and use of passive acoustics. In order to complete our results of cetacean visually observed in several ship-based surveys, we considered this last method as very attractive for marine mammals which are vocally active animals (Gandilhon et al. 2010). In the passive acoustics approach, the concept of permanent observatory permits continuous research effort with deeper time-scale results and thus, is more suitable for long-term acoustic monitoring for marine mammals. Our first goal is to complement our visual results for a range of at least 28 different species of cetaceans present in theory (Ward and Moscrop, 1999), with at least 18 of them observed in the Leeward coast of Guadeloupe (Gandilhon, unpublished data, 2007 to 2011). Note that the sounds emitted (narrowband e.g. wheezing or broadband e.g. clicks) are very various depending on the species but also for individual animal within the same specie. Our second main objective aims to complete our previous results in the status trends of residence or semi-residence for particular populations and the characterization of ecological parameters of their habitats (e.g. the ambient noise). To reach these requirements, we built a permanent passive acoustic prototype, with high technology features, able to continuously records various sounds emissions of different marine mammals, 24h/24 and 7days/7, with a regularly datasets download. We fixed it on a customized moored FAD, as a very cost-effective and existing, tropical weather resistant support.

MATERIAL AND METHODS

The GUALIBA passive acoustics system is designed in two parts: one part at the sea surface, composed by the FAD floating buoy (customized to integrate acoustic processors) and one part underwater, with an hydrophone located at ±55 meters.

The Buoy Part

PLK Marine (http://plkmarine.com) has totally re-engineered the surface Buoy part of the FAD, in order to integrate the computerized part of the processing module of the hydrophone built by Ce Sigma (http://www.cesigma.com).

Building of specific turret at the superior step, hosting the voltage regulators (Low voltage alarm and power supply to WIFI) and the housing external hard drives, here 2 SSD 6 - Solid State Drives- version of the SSD hard KINGSTONE 512MB and 256 MB (3 1 / 2 inches) ;

Reinforcement of the waterproof inside the buoy to welcome two gel batteries (Optima Blue Top, 75Ah) and a computer (Mini ITX board with integrated low-power processor Atom D510 (1.6 GHz, dual core and 1 GB of RAM)) for the processing and storage of data from the hydrophone (Figure 1). This computer is coupled with a map of receipt of the connection to the hydro with a connection to 125 Mbit / s in synchronous mode) and is included in a waterproof container.

The Hydrophone Part

Considering the diversity of cetacean species with various frequencies range, the hydrophone was built to simultaneously record large cetaceans like humpback whales (*Megaptera novaeangliae*) or sperm whales (*Physeter macrocephalus*), as well as beaked whales (Ziphiidae) or dolphins (Delphinidae) families with spectrum of their sounds presenting more energy in high frequencies. The hydrophone (Cetacean CR55 (omni-directional bandwidth: 10Hz to 40 kHz + / - 1 dB) 12 V for onboard preamp) is linked to a waterproof container including an acquisition card (card developed by CAPNG CeSigma, 4 channels, 24 bits to 250 kHz (configurable in steps of 2 Hz). Each channel has a gain adjustable between -95 and 31.5 dB (0.5 dB steps) and a regulated 12V power supply for active hydrophones, but only channel 0 is used and frequency of scanning is set at 65 kHz. This set, fixed in a cage, is integrated into an cylinder of 80 mm in diameter and 180 mm of height, including anodes and a subconn grip in 15 points (Figure 2).

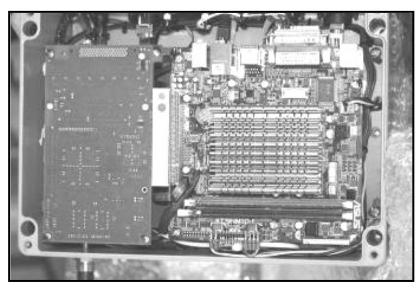

Figure 1. Low-power processor Atom D510 .

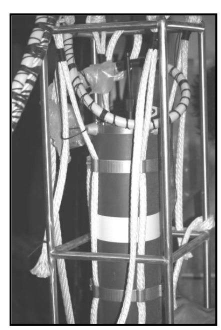

Figure 2. Omnidirectional hydrophone

The FAD Customization

Additionally, the mast was equipped by guy wires and equipped with a lightning protection system as well as WIFI (802.11n router Hercules, operating up to 300 Mbps (HWNAP-300)) for communication with the computer and a sink load of battery. A pin has been added for the stability of the buoy vis-à-vis the overhead of adding equipment, and trained by balancing the weight of the wind.

RESULTS

Design and Engineering of the GUALIBA Passive Acoustic Aystem (Figure 3.)

The whole system weights around 400 kilograms with around four meters height between the top of the mast and the bottom of the buoy.

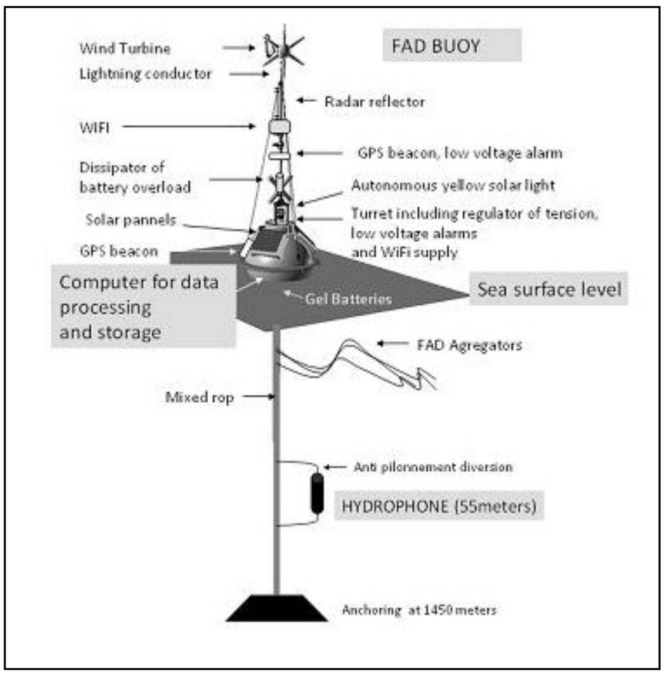

Figure 3. Gualiba system and re-engineering of the of the FAD buoy

Deployment of the Gualiba System

We based the choice of the location for Gualiba priory beyond the marine mammal's diversity observed during five years by ship-based campaigns around Guadeloupe. The currents average direction and celerity, the bathymetry and distance from the coast were considered to definitely choose to implement the permanent acoustic system on the Leeward coast, at the DCP Number 5 (Depth: ±1450m) off -shore Pointe Noire (16 ° 13,271 'N, 62 ° 0205 "W, turning radius: 1155m) (Figure 4). In that area, fifteen species have been documented and/or observed, including observations of rare specimens like *Kogiidae or Ziphiidae.*

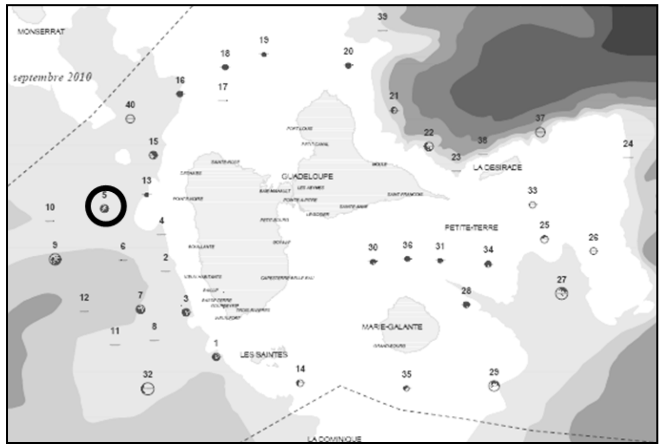

Figure 4. 2010 Map of Guadeloupian FAD's network with N°5 Location showed in the bold circle *(source http:// plkmarine.com)*.

Operational GUALIBA Passive Acoustics System

After several *ex-situ* validation tests on the material (sensitive of the sensor, electronic connections, energy load, waterproof reinforcement…), artificial sounds (human voice, applauses) and ambient noises were also recorded in air environment. All these controls permitted to check the data acquisitions, the energy capacity and to adjust the recording channel and its regulations. The system has been deployed on the 25th of November 2010 on the 5 FAD's location (Figure 5). The physical immersion took several hours, first because of the delicate manipulation from the Engineering workshop to the fishing boat and secondly, linked to the technicality of these marine operations to concretely implement it directly in the water (swell ± 1.7 meters). The PLK Marine Company replaced the old N°5 FAD by Gualiba buoy, keeping the same anchored system. Wi-Fi tests at sea indicated a reach until 850 meters from the buoy and remote computer access tests were compliant. To recover the recorded data, each week a team is planned to retrieve the external hard disk (Fig.6) and exchange it by a new one (SSD KINGSTONE 512MB and 256 MB). The DRS maintenance Software specifically built by Ce Sigma company (Figure 7) was used remotely to close the in-progress records, stop the system, save the configuration and check several recording tests. Since that implementation, several breakdowns of the system occurred, with identified failures by iterative diagnosis and gradually resolved by new series of tests and technical adjustments. We also noticed the positive and robust points of this prototype conception. Nevertheless five days of sounds data were recorded, showing that the system is able to perform a part of our scientific purposes. The analysis of the recordings extracted and the sound characteristics of some species are presented in another work.

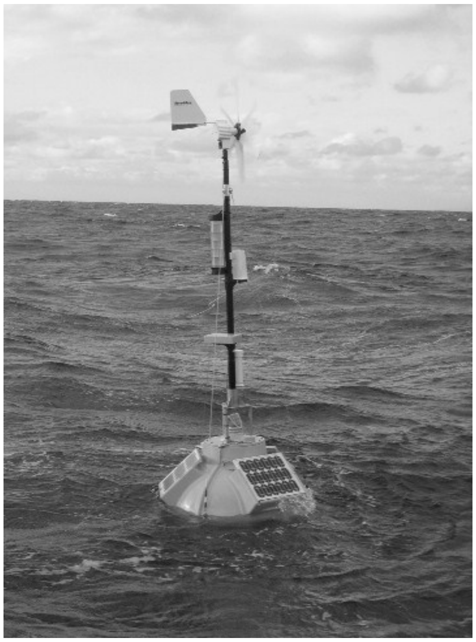

Figure 5. Gualiba *in situ*

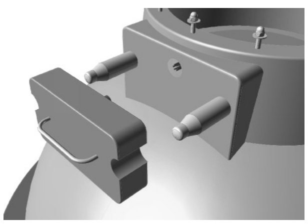

Figure 6. External Data disk

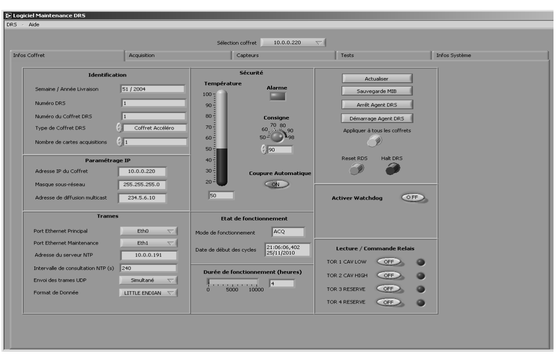

Figure 7. Main interface of the Gualiba remote software

DISCUSSION

In the world, several projects exist or are under construction on cetacean permanent observatories using multi- levels sensors including passive acoustics technology. Today, few projects are permanent and perennial devoted to the cetacean observations. The motivation of these projects is that the conventional seafloor sensors are cut off from the surface and require battery and their own data storage (Gandilhon et al. 2010). Scientists don't even know if their instruments are working properly until they try to recover their equipment at the end of an experiment. It is why for the Observatory of the St Lawrence Estuary for e.g. at the initiative of Simard et al. (2006), multiple sonobuoys for recording sounds emitted by whales were installed with a real-time transmission via satellite communications.

The solution to use radio waves can be used instead of a cable as a transmission medium to connect stations, especially when the buoy is far from the coast. In our prototype conception, we integrate low-cost, unregulated point-to-point computer network connections with Wi-Fi (*Wireless Fidelity*) technology to retrieve our data as an alternative solution for the on-sea recovery of each external hard disk. We also considered first the HYPER LAN (**HI**gh **PER**formance **R**adio **LAN**) standard developed by the European Telecommunications Standards Institute (ETSI) which allows transmitting data with a high speed Ethernet wireless link between for e.g. the Antenna of the FAD's buoy and a land Antenna. This "ideal" solution implies a vertical and horizontal alignment of the Antennas, which is not very suitable with the gyrating movements of the buoy. Moreover, an equipped basis at land is necessary and the maximum data rate depends on the distance of the communications stations and the land topography.

Several technical points have been revisited during the conception of the system, like the underwater placement of the hydrophone cage in order to run correct sounds acquisitions. We should care of solutions to make a deviation (with perfect symmetry in length, geometry and weight around the cage) or even to ballast the cage, to conserve a perfect verticality, despite of the currents effects. However, records disks should not work (effective transfers - heads in position work and not rest) during shocks. It appears that FAD's on-surface buoy is subjected to this type of shocks. In spite of insulating elements, we were not able to cross the tests of submarine shocks and vibration.

For the critical question of energy consumption of the GUALIBA system, at this time focused on a continuous 24h/24 and 7/7 days of recordings, we used tools compliant with sustainable development (solar panels and wind turbine). We can notice that new industrial component as alginates material (extracted from brown algae) can supply energy for a battery, eight times greater than that of todays best graphite electrodes. Utilisation of different levels of salinity of sea water and fresh water can also generate electricity to charge batteries that not only could boost energy storage, but also eliminate the use of toxic compounds now used to manufacture the components (Yi Cui et al. 2011).

As a final remark, we should note that several improvements of GUALIBA prototype have already be noticed like: an efficient number and curvature of connections, a lower energy consumption of the system by the improvement of the ranges of recordings, a faster real-time transmission of the data to the land with for e.g. by WIMAX (**Worldwide Interoperability for Microwave Access**) and a better waterproof protection with the integration of an optic fibre in the main cable for a more reliable connection between the hydrophone part and the Buoy part. Our monitoring acoustics efforts are focused in Gualiba to first detect, classify and analyse the signal processing of the local marine mammal's populations on biological or ambient sounds sources, but as a second objective, to assess, the anthropogenic activities around the FAD. That means that our system has been chosen obligatory as passive itself, mitigating *a priori* any new perturbation impacts like those recognized on the marine mammals by the use of active acoustics systems. We should nevertheless consider in our future analysis the noise made by the coaxial cable of the FAD and other material frictions.

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