FADIO (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems): a European Union funded project on development of new observational instruments and the behavior of fish around drifting FADs

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Abstract

Associative behavior is a major component of the life of pelagic fish. Tropical tuna and other species are often found in association with floating objects, with other animals, and with topographic features such as seamounts. Because fish are more abundant, occur in larger schools, or are easier to catch when aggregated, fishermen extensively use these associations to increase their catches. More than 50% of the world tuna catches are made from schools associated with floating objects.

There is a clear need for new technologies to study these associations and to propose innovative methods of management. The European Union has funded a project to study the requirements of future assessment tools and to develop prototypes. The project: FADIO[1] (Fish Aggregating Devices as Instrumented Observatories of pelagic ecosystems) has conducted five extensive field surveys of the Western Indian Ocean in conjunction with the large-scale purse seine fishery operating on drifting FADs that operates in this region.

The objectives of FADIO are to develop new observation and assessment tools and collect data on the behavior of pelagic fish around drifting FADs. Two categories of instruments are being developed in collaboration with manufacturers: (1) autonomous buoys equipped with 360º sonar and cameras to observe aggregations, acoustic receivers to detect individuals carrying electronic tags and satellite uplinks for both, (2) new electronic tags with ecological sensors. Various field experiments are conducted to assist in the development of these prototypes. During these scientific cruises, different instruments and methods are used to document the behavior of associated species concurrently resident on the same FAD, including: fishing and acoustic tagging, passive and active acoustic surveys, and underwater visual census. Those observations, combined together, provide valuable insights in the dynamics of FAD aggregations.

These instruments can be used in the future (i) to build the foundation for future observatories of pelagic ecosystems, using FADs as scientific platforms for observation and data collection, (ii) to understand the effects of FADs on tuna and other associated species, even in remote areas, (iii) to find methods to reduce by-catch around FADs.

[1] http://www.fadio.ird.fr/

Why FADIO?

More than half of the world catch of tropical tuna (yellowfin tuna, *Thunnus albacares*, bigeye tuna, *T. obsesus*, skipjack tuna, *Katsuwonus pelamis*) come from fish associated to floating objects, usually refered to as fish aggregating devices (FADs). Large quantities of juvenile tuna as well as non target species (dolphinfish, *Coryphaena hippurus*, wahoo, *Acanthocybium solandr*i, silky shark, *Carcharinus falciformis*, etc.) are captured around drifting FADs, which has raised ecological and ethical concerns. The international tuna commissions (Indian Ocean Tuna Commission - IOTC, International Commission for the Conservation of Atlantic Tuna - ICCAT, Inter-American Tropical Tuna Commission - IATTC, Western and Central Pacific Fisheries Commission - WCPFC) and the Secretariat of the Pacific Community (SPC) have underlined the need for better understanding of the effects of FADs on the behavior of tuna, to improve stock assessment of these species.
In order to better understand the behavior of fish around drifting FADs, which are usually located in remote areas difficult to access and monitor, a first prerequesite to future studies was to develop scientific tools and methods adapted to the conditions of this environment.

FADIO objectives

The objective of FADIO (www.fadio.ird.fr) is to develop prototypes of innovative autonomous instruments (electronic tags and instrumented buoys) to create autonomous observatories of pelagic life.
In the same way that oceanographers have historically used instrumented buoys to study the physical dynamics of the oceans, fishery scientists need instrumented buoys able to observe pelagic communities. FADIO has two main objectives:

- Development of prototypes: new electronic tags and instrumented buoys to observe fish aggregations around FADs
- Improving knowledge on behavior of pelagic fish around FADs

FADIO team

The FADIO team is composed of a multi-disciplinary consortium of 10 partners from Europe, the U.S.A. and the Seychelles. More than 30 researchers and technicians, including 4 PhD students, have been involved in this project in field and lab research:

- Institut de Recherche pour le Développement - IRD (France) : L. Dagorn, E. Josse, C. Girard (PhD student), P. Brehmer, P. Dewals, C. Peignon, C. Vrignaud
- University of Hawaii – UH (U.S.A.) : K. Holland, D. Itano, C. Meyer, Y. Papastamatiou (PhD student)
- Instituto Tecnológico Pesquero y Alimentario - AZTI (Spain): E. Puente, G. Moreno (PhD student), I. Mosqueira, G. Sancho (sub-contractor from the College of Charleston)
- Institut français de recherche pour l'exploitation de la mer – IFREMER (France) : M. Taquet, O. Dugornay
- University of Las Palmas de Gran Canaria – ULPGC (Spain): A. Ramos
- MARTEC (France): E. Filliol, P. Brault, R. Degois
- Institute of Marine research – IMR (Norway) : L. Nøttestad, J. Dalen, J.O. Krakstad, I. Svellingen
- University of the Aegean – UA (Greece) : S. Georgakarakos, V. Trygonis (PhD student), T. Karambas, M. Pantelelis, J. Dimon
- Université Libre de Bruxelles – ULB (Belgium): J.L. Deneubourg
- Seychelles Fishing Authority (Seychelles) : R. Aumeeruddy, V. Lucas, G. Burke

FADIO work

Except a co-ordination/management work package (WP), the research activities of the project are distributed within 8 work packages, including a final WP concerning the documentation and dissemination of results.

WP2: Development of new electronic tags
WP3: Fish tracking around FADs (determination of orientation distance)
WP4: Residence time of fish around drifting FADs
WP5: Species composition and biomass around drifting FADs
WP6: Fishermen knowledge
WP7: Models of aggregation processes
WP8: Development of instrumented buoys
WP9: Dissemination of results

FADIO has performed 5 offshore cruises from the Seychelles in the Western Indian Ocean, using various technologies/methods to observe fish around drifting FADs on the high seas fishing grounds: electronic tags, acoustic receivers, hydrophones, echo-sounders, sonars, cameras. FADIO began in 2003 and will end in Oct. 2006, with an exposition and workshop at the Oceanographic Museum in Monaco.
Main FADIO results are summarized below:

Objective 1
Development of prototypes: new electronic tags and instrumented buoys to observe fish aggregations around FADs

- Promoted and accelerated the development of novel "modular" architecture for electronic (acoustic) tags. Tested and evaluated four new types of electronic tags that are designed to measure various aspects of the ecology and physiology (eg., feeding events) of fishes. Development of a new acoustic tag with integrated pH sensor, and research/development of a new acoustic tag with accelerometer sensor (2007)
- Contributed to the development and successfully tested the first satellite-linked acoustic receiver (listening station) that allows remote, real-time monitoring of open ocean-fish implanted with sonic transmitters
- Developed and tested an autonomous 360° sweeping sonar buoy with cameras and satellite links designed to monitor FAD-associated fish communities
- Developed and tested state of the art software for the quantitative analysis of sonar data, thereby facilitating analysis of school structure and dynamics

Objective 2
Improving knowledge on behavior of pelagic fish around FADs

- Obtained the first *in situ* scientific descriptions of the species that comprise the community of animals associated with drifting FADs
- Obtained first observations of residence times and vertical behavior of tuna and other pelagic fish around drifting FADs
- Obtained first quantitative measurements of the distribution of tuna schools around drifting FADs.
- Established excellent rapport with the commercial fishing fleets of the western Indian Ocean and conducted in depth surveys of the perceptions of commercial fishermen
- Developed theoretical models linking the size and distribution of FAD-associated tuna aggregations to the size of the regional tuna population.

Conclusion

Thanks to the new instruments and methods developed during FADIO, as well as newly acquired insights into the behavior of fish around drifting FADs, innovative and necessary studies on drifting FADs can be designed. Three priorities should be considered in the near future:

- Study of the effects of FADs on the behavior of tuna and by-catch species
- Find methods to reduce by-catch around FADs
- Using instrumented FADs as observatories of pelagic ecosystems (fishery-independent methods for stock assessment, monitoring the biodiversity)