Proposal Detail

Owner: sergio jesus

Moderator:

Submitted: 22-Dec-2021 19:35 CET

Proposal Status: Reviewer Selected

PID19099 - Acoustic particle motion measurements on bluefin tuna in aquaculture tanks

VID: 33028 - Awaiting Scientific Review - Marine site at IEO-ICAR **AQUAEXCEL**

Marine site at IEO-ICAR -

Short study title

TUNAMOTION

Project acronym

TUNAMOTION

Is this application a re-submission?

Yes

If yes, previous application reference

AE160008

Have you sought and received advice from the Orientation Commitee? Yes/No

Yes

Applicant Name

Sergio Jesus

Applicant role

LAV (Lead applicant/Visitor)

Is this person the group leader?

Yes

Is this person a remote user?

No

Organisation Name

Universidade do Algarve

Organisation Unit Name

SiPLAB

Lead Researcher CV

cv_en_res.pdf *Open File*

Applicant Name

Applicant role

Is this person the group leader?

No

Is this person a remote user?

No

Organisation Name

Organisation Unit Name

Names and organisations of other researchers involved in the project

Co-Applicant CV

Number of units of access requested from research installation

2

Requested start date for access to research installation:

06-06-2022

Expected end date for access to research installation

19-06-2022

Is Remote Access required?

Yes

Has the Installation Manager been consulted?

Yes

Have you previously benefitted from access to AQUAEXCEL, AE2020 or AE3?

No

Have you or your research group previously carried out collaborative research with staff of the proposed Research Installation?

No

Have any members of your research group previously accessed this Research Installation?

No

If yes, please give further details

Number of visits to research installation planned by lead applicant

1

Total duration of planned visits by lead applicant (days at installation)

10

Planned start date of first visit by lead applicant*

06-06-2022

Planned end date of last visit by lead applicant*

19-06-2022

Number of visits to research installation planned by co-applicant

Duration of planned visits by co-applicant (days at installation)

Planned start date of first visit by co-applicant

Planned end date of last visit by co-applicant

*If you are planning a complex schedule of visits with more than two trips, please explain it in detail here

Proposal summary

This research aims at planing, executing and monitoring an an acoustic recording experiment in a bluefin tuna aquaculture tank. The analysis of the acoustic recordings, together with other biotic and abiotic data, gathered during the experiment should allow to provide or complement the understanding of the behavior of bluefin tuna in a confined environment. In particular the experiment will provide recordings of the particle motion field at close range and low frequency where it significantly differs from the acoustic field. It is anticipated that bluefin tuna lateral line is highly sensitive to water agitation and therefore to particle motion variations. Whether the knowledge of the particle acceleration field helps to explain part or some of the behavior of this specie, remains an open question, that we would like to address.

Justification

There is significant knowledge gap on the understanding of the hearing and vocalization of fish. Although this may significantly vary with specie, sound pressure waves are generally generated by the action of skeletal muscles compression of internal gas filled cavities, such as the swim bladder, or movement of external body parts. This action produce a mechanical movement of the body that excites water particles close to the body and transmit the mechanical sound wave. Very often this does not implies or requires fish mouth movement. It is well known from general physics that the acoustic field propagates as particle oscillation producing, at long range from source and reflecting walls, sound pressure waves, while at close distance it also includes particle motion which directional field is quite different from the measurable scalar sound pressure field. This is particularly important for marine organisms in general, that heavily rely on estimating water agitation in their vicinity for orientation, for prey detection, or to avoid predators. There is a long list of theoretical as well as experimental studies on the importance of particle motion for marine life, but we only cite here the early study of Banner et al. with measurements and call of attention for the relevance of mechanoreceptors [1], generic fish hearing [2], measurements on some species and locations [3,4], and more recently the work of Popper [5].
It is not known whether tuna reaction is due to sound pressure waves or to water agitation captured by lateral lines, mechanoreceptors or othollits, as in various other species [1,2,5]. Tuna "vocalizations" were identified to take place in the frequency band 20-150 Hz, apparently related to the muscle contraction on the tuna's swim bladder [6]. To the best of our knowledge there is no study relating tunas' behavior to the variation of the particle motion field, which is substantially different of the sound pressure field in the low frequency band of interest for tuna vocalization and close to walls and sound sources. This is particularly important in a confined environment such as a aquaculture tank where individuals navigate

in close proximity and to the tank walls. We must recall that the difference between the particle motion and sound pressure fields embraces one wavelength which for the frequency band of the bluefin tuna means 10 to 75 m or, in practice, the whole tank. Further, machinery (pumps, drum filters, blowers, air extractor fans, etc) and water flow in an aquaculture tank provides a challenging environment for a diverse and intense particle motion field a potentially perturbation for tuna grow as it was identified in other environments [7,8]. May tuna interaction, excitation pattern and behavior be explained by the particle motion field and not by other sensing organs ? This is the question we would like to address in this study.

[1] A. Banner. Measurements of the particle velocity and pressure of the ambient noise in a shallow bay. J. Acoust. Soc. America, 44(6):1741–1742, 1968.
[2] R.R. Fay and A.N. Popper. Comparative hearing: Fish and amphibians. Springer, New York, 1999.
[3] L.E. Wysocki, A. Codarin, F. Ladich, and M. Picciulin. Sound pressure and particle velocity acceleration audiograms in three marine fish species from the adriatic sea. J. Acoust. Soc. America, 126(4):2100–2107, October 2009.
[4] M. Lugli and M.L. Fine. Stream ambient noise, spectrum and propagation of sounds in the goby padogobius martensii: Sound pressure and particle velocity. J. Acoust. Soc. America, 122(5):2881–2892, November 2007.
[5] A.N. Popper and A.D. Hawkins. The importance of particle motion to fishes and invertebrates. J. Acoust. Soc. America, 143(1):470–488, 2018. 44(6):1741–1742, 1968.
[6] S. Allen and D.A. Demer, Detection and characterization of yellowfin and bluefin tuna using passive-acoustical techniques, Fisheries Reasearch, 63 : 393-403, 2003.
[7] G.R. Potty, M. Tazawa, J. Giard, J.H. Miller, Y-T Lin, A. Newhall, and K.J. Vigness-Raposa. Measurements of particle motion near the seafloor during construction and operation of the block island wind farm. In Proc. Meeting Acoust. Soc. America, volume 141, page 3993, 2017.
[8] P.Sigray and M. Andersson. Particle motion measured at an operational wind turbine in relation to hearing sensitivity in fish. J. Acoust. Soc. America, 130(1):200–207, July 2011.

Study objectives

In collaboration with the research installation personnel and researchers, this project aims at developing, implementing and field testing the necessary methodologies to attain the following objectives:
1) to understand the correlation between behavior patterns and acoustic sound generation of bluefin tuna
2) to determine the acoustic particle motion and the sound pressure fields of a bluefin tuna shoal in a confined environment, and understand whether its behavior relies more on the information gathered through sound pressure or particle motion
3) to understand the impact of particle acceleration field generated by environmental noise

Research plans

The proposed research foresees the following procedures to take place:
A - before the visiting period:
A.1 - make a test plan: take water tank dimensions and calculate min and max working frequencies and reverberation level, determine theoretical recording levels using historical or bilbiography relevant levels; produce a detailed test plan with procedures and times.
A.2 - test equipment and prepare for transportation:
B - at the infrastructure site:
B.1 - prepare equipment and data acquisition
Verify water tightness (o-rings, etc) as well as lab data acquisition. This is necessary after every transportation.
Verify and put together cables, ropes, weights, storage, computer, network cables, hub, etc. It also entails the recording of facility other non-acoustical environmental and biological data such as meteorological and water conditions information (temperature, salinity, O2, turbidity, etc) that are assumed to routinely acquired, and include biological data regarding the fish in the tank (fish size, biomass, reproduction stage, feeding, feeding hours, etc).
B.2 - receiver calibration on tank
This aims at defining receiver location, mechanical settings, and adjusting gains and frequency bands for acoustic signal acquisition. It entices the deployment of the sensors on their final location in the tank, through supporting poles or other mechanical fixing procedure that is largely dependent on the existing structure at the facility; once the receivers are fixed it entices test recordings that will last say 24h in order to cover various aspects and activity in the tank for gain and frequency band adjustment in order to avoid out of band noise and either lack of resolution for low signals or overflow producing highly undesirable harmonics and interference.
B.3 - remote monitoring
Setup the possibility for remote monitoring of both sound and image through a remote connection from the tank to the nearby office and also from office to the internet using a protected secure connection access. This greatly depend on the available facilities on site and requires the authorization of site responsible. Remote monitoring should allow to receive and send commands so as to be able to change system configuration when and if needed. It also includes the retrieval of raw data files for preliminary data analysis and checking.
B.4 - preliminary data analysis
This connects to the previous item, but extends to the preliminary analysis of full data sets over periods of one or more days in order to apprehend long time trends or changes of behavior or required recording adjustments. This preliminary data analysis will encompass computing sample power spectral densities (PSD) sprectrograms and power spectra (PS) along time, and detect statistical changes, if any.
B.5 - equipment and data recovery
It includes recovering equipment and any mechanical structure, cables, ropes, etc, washing and preparing for transportation. The infrastructure should be left at least in the condition it was found at arrival. This also includes to make sure that all acoustic and non-acoustic data is checked and properly archived.
C. After the visiting period:
C.1 - preliminary data report
This is an experiment report, that accounts and shows all the data gathered and procedures undertaken during the experiment. It also includes a detailed log of the experiment. The data is shown and quality checked for further processing. Overall data visualization and calibration, both for pressure and acceleration.
C.2 - understand levels, frequency bands and video
This includes a detailed check of the acoustic information and makes the correlation with video and non-acoustic data. It includes checking and extracting directional information as it can be recorded with the vector sensor hydrophone.
Results are extracted and conclusions drawn for discussion and dissemination.
C.3 - organize workshop for discussing results with infrastructure researchers and eventual further dissemination through joint publication either in conferences or through journal papers.

Details of proposed analysis of results

The details of the proposed analysis will encompass, but will not be limited to, the following steps: complete acoustic data check for errors, dropouts, misconfiguration, clock synchronization between acoustic and non acoustic (vision) data; acoustic data calibration and checking for main events (pumps on/off, personnel working, feeding periods, etc); identify periods for further analysis.
Run a simple event detector based on signal energy against an empirical variable threshold drawn from the data. Inspect detected events and attempt for manual classification by checking or correlating with side information (video, external events, etc). Run a supervised and then unsupervised classifiers. Inspect classes and rerun with fixed number of classes. Select video periods based on events' timing for each representative class; draw conclusions by looking at simultaneous images and sounds (or other events). Use separately the sound pressure and the particle acceleration low frequency fields. Draw conclusions on the representation of events and classes of events for both fields.
Extract field directionality using both the horizontal array of hydrophones and the vector sensor hydrophone data using the signal steering capabilities. Compare and conclude for relevant classes of events drawn previously: where do class relevant signals come from ? Are there sequences of events ? What triggers them ?
Extract acoustic pressure equivalent sound pressure from particle velocity and compare with acoustic pressure as measured on closely located hydrophones.
Analyze spectrograms of particle acceleration in the low frequency band and compare with acoustic pressure in the same periods and bands in various configurations and during events (feeding, machines, or other noisy situations). Compare anthropogenic noise intensive or less noise cases, if any.
Many other issues and questions will, hopefully, raise during the analysis. These will most probably foster other research and other experiments. Experience says that the first experiment with a given objective or with a given setup will require at least a second experiment with a refined setup, where objectives are more target and possibly different from those in the first experiment. So, issues may be uncovered and hopefully solved.

Expected knowledge outputs from the research

Expected knowledge outputs of this research may be, but are not limited, to:
- get practical experience and experimental knowledge on how to plan, execute and monitor acoustic and particle motion recordings on big aquaculture tanks;
- how to analyze data during and pos-acquisition in such environment and for such specie;
- to gather information allowing to complement the current understanding of the behavior and excitation of bluefin tuna in a confined environment based on the analysis of sensing data, including low frequency particle acceleration
- the generic understanding on the role of particle motion on fish behavior

Specific Requirements

A complete list of requirements can only be made after the drawn up of the test plan, which is the first task to be carried out during experiment preparation. However, a preliminary list with the major requirements can be made at this stage, which may comprise the following main items:
- the access to a location of the tank have a full 360 degree view of the tank, probably in the middle of the tank. This access may be through a suspended platform or a pole from which the acoustic receiving equipment may be deployed.
- depending on the nature of this platform or pole the equipment may be suspended through a vertical pole immersed in the water at a depth to be determined.
- video camera to be colocated with the sound receiving equipment
- cables to be run to the lab and remote access to the data.
- access to non-acoustic environmental and biological data

Unfunded Requirements

This is not an exhaustive list of equipment provided by the applicant to be used during this research project, but the main items to be available and to be used during this research can be described as follows:
1 - four hydrophone acoustic recorder for azimuth estimation (TP1-4)
2 - double tri-axial accelerometer vector sensor hydrophone (DAVS1)
3 - three axial vector hydrophone (GeoSpectrum M20)
4 - reference hydrophone (Reson)
5 - computer for data archiving
6 - power supply and submarine cables (length TBD)
7 - small equipment for mounting, network, cabling and storage

Total estimated travel cost

420,00

Estimated subsistence expenses

1500,00

Explanation of expected expenses

Travel
Faro - Mazarron distance is 700 km x 0.30 euro = 210 euros x 2 (return) = 420 euros
Subsistance
estimated 100 / day for lodging and food x 15 days = 1500 euros

Describe how you expect to disseminate the results of the research

It is foreseen that this research will produce the following outputs:
- experiment test plan
- logbook of the experiment
- preliminary data report
- final report

- workshop presentation
and depending on the results obtained
- (at least) two conference publications
- (at least) one journal paper
Additionally, and depending on due authorizations, the data gathered may be used in live examples for master students on aquaculture and fisheries or marine biology, at the University of Algarve.

Describe how you expect the results of the research to be exploited

Depending on the results themselves it is expected that the exploitation may include:
- changes on aquaculture management, eventually decreasing or elimination of anthropogenic noises in the facility
- provide recommendations for changes in management policies
- depending on due authorizations, the data gathered may be used in live test case examples for master students on aquaculture and fisheries or marine biology, at the University of Algarve.

Do you expect the research to result in the creation and protection of any IP (Intellectual Property)?

No

If yes, please describe the expected IP and how it will be protected

Does your research involve any procedures likely to cause stress, distress, or lasting harm to experimental animals? If so, please list any relevant procedures and give details if not described fully in section

No

What procedures are necessary to ensure the proposed research is approved under the ethical regulations of the selected Research Infrastructure or national regulatory body? What is the timescale for this and what stage has been reached? Please give reference for approval if already obtained

This project does not involve disturbance for or practices on living animals. The recording of sound is purely passive, this means that there is no energy injection in the water or outside of the water, whatsoever. In that regard the planned actions are fully compliant with descriptor 11 of the MSFD.

Reduction: Please explain any specific procedures you plan to put in place to reduce the number of experimental animals used

N/A

Refinement: Please explain any procedures you plan to put in place to reduce adverse impacts of any procedures used

N/A

Could this work be carried out without conducting experiments or other scientific procedures on living animals?

No

If the proposal is to use vertebrates, could the same questions be answered using invertebrate animals?

No

Please explain any procedures you plan to employ to replace experimental work on live animals

N/A

Behaviour/Welfare

Technology/systems

Other

No

Marine fish (sea bream, sea bass, cod, halibut, others)

Other aquaculture species

Thunnus thynnus

Technology and Systems

Integration with the Environment

Aquatic Animal Health & Welfare

EATIP Justification

The study aims at a using innovative technologies and systems allowing for better monitoring and improving understanding of marine specie welfare and therefore a better resource management.
Regarding the compliance with the EC Agenda for broadening access to infrastructures, this proposal constitutes a first working visit of the applicant to the facility that is not available in his home country. This provides opportunities to scientists that might not otherwise be able to access such

facilities.

In submitting this application you agree you have read and agreed to the terms and conditions for Transnational Access as detailed within the Call for Access

In submitting this application you agree AQUAEXCEL3.0 project partners will be processing your personal data as part of its official activities and the lawful basis for the processing will be that the processing is necessary for a task carried out.

Proposal Team

Principal Investigator	Research Team
sergio jesus	