Darwin Initiative Innovation Annual Report

To be completed with reference to the "Project Reporting Information Note":
(https://www.darwininitiative.org.uk/resources/information-notes/)

It is expected that this report will be a maximum of 20 pages in length, excluding annexes)

Submission Deadline: 30th April 2024

Submit to: BCF-Reports@niras.com including your project ref in the subject line

Darwin Initiative Project Information

Project reference	DARNV002
Project title	Innovation of Bait Fisheries for Live-bait Conservation
Country/ies	Indonesia
Lead Partner	International Pole and Line Foundation
Project partner(s)	Safety Net Technologies (SNTech)
Darwin Initiative grant value	£177,792.00
Start/end dates of project	01st April 2022 - 30th September 2024*
Reporting period (e.g. Apr 2023 – Mar 2024) and number (e.g. Annual Report 1, 2, 3)	April 2023 - March 2024 (Annual Report 2)
Project Leader name	Craig Turley
Project website/blog/social media	https://ipnlf.org/unlocking-a-huge-potential-for-ocean-conservation-and-climate-change-ipnlf-maldives-and-sntechs-innovation-seeks-to-limit-wild-caught-bait-fish-in-pole-and-line-tuna-fishing/ https://www.darwininitiative.org.uk/news/2024/01/30/sustainable-food-system-case-study/ https://www.instagram.com/p/C0lst5aKAXx/ https://www.instagram.com/p/CzdUTmZK96U/?img_index=1 https://www.instagram.com/p/CyAq4Q-ICrO/?img_index=4 https://www.instagram.com/p/CzdbgBHq1FL/?img_index=4 https://www.instagram.com/p/CyA1YgzuQsh/?img_index=3
Report author(s) and date	Craig Turley, Martin Purves, Helena Gey Van Pittius 22/04/2023

1. Project summary

Pole-and-line fishers are highly dependent on livebait to attract schools of tuna. Livebait resources are becoming increasingly scarce from over-exploitation, climate change, and other anthropogenic impacts to coral reefs, which can lead to the collapse of these tuna fisheries.

This Darwin Innovation project experiments with alternative stimuli to livebait (e.g. programmable LED lights, playback of recorded sounds and use of olfactory stimuli and lures) to induce skipjack into a feeding frenzy.

Programmable LED lights and Artificial Intelligence integrated cameras are cutting-edge technologies, and their application, as proposed in this project, are entirely novel.

Exploring alternatives to livebait fish is also relatively unexplored with few published studies with limited success As such the proposed experiments are innovative and will contribute to novel scientific knowledge.

If successful the innovations have potential to positively disrupt traditional pole and line fishing methods by reducing the dependency on livebait which could have poverty reduction and biodiversity protection benefits across one-by-one tuna fisheries globally.

Forage fish species, referred to as baitfish, are a critical component of marine food webs (4). Globally, they are currently targeted in huge quantities by several different fisheries, including for human consumption, as well as for fish meal and fish oil processing. This has meant that baitfish stocks in many geographies are subject to overfishing and have become depleted. In the short term this has the potential to undermine the livelihoods of one-by-one fishing communities who are reliant on baitfish, whilst continued harvesting despite being overfished has the potential to undermine the sustainability credentials of one-by-one fisheries. In the longer term, unchecked overharvesting of baitfish could result in a trophic cascade leading to ecosystem collapse.

Therefore this project is designed to reduce the extractive use, and dependency of the pole and line fisheries on baitfish, in order to allow for conservation of baitfish species which can support a healthier more resilient marine ecosystem.

The conservation of baitfish is important for all who are reliant on the ocean ecosystem as a source of livelihood and protein. In the case of this project the direct beneficiaries of our technological experiments are the Indonesian pole and line fishers, whom, by reducing their baitfish consumption and reliance on livebait, help protect marine food chains and secure their own livelihoods.

Coastal communities in Indonesia and elsewhere throughout the world are dependent on the productivity of pole and line fisheries as well as the baitfish stocks, both as a source of livelihood and a key source of affordable protein. The pole and line fisheries also support a vast ecosystem of jobs and livelihoods for both men and women in the primary and secondary processing sectors and associated value chains and supply affordable protein to consumers all around the world. Therefore, the continuation of these fisheries is extremely important to the social and economic wellbeing of coastal communities, both in Indonesia and globally.

In many places the issues related to baitfish over-extraction have already materialised, resulting in dangerous and ever riskier bait-fishing practices with diminishing returns; or even closure of once thriving pole and line fisheries such as in Cabo Verde or Senegal. In other geographies issues regarding baitfish are foreseeable in the future where the effects of climate change and species range shifts are likely to impact the sensitive baitfish species.

The livebait issue in both Indonesia and the Maldives is complicated and multifaceted. Livebait resources inhabit coral reefs and associated environments which are becoming increasingly impacted by climate change (e.g. periodic episodes of coral bleaching, resource depletion, anthropogenic activities and competing human factors on resource allocation (between tourism and fisheries). Fishermen are having to spend more time and use more fuel in search of live-bait, increasing their overheads and carbon footprint (IPNLF, unpublished data).

2. Project stakeholders/partners

This project is a partnership between the International Pole and Line Foundation (IPNLF), our regional office based in Indonesia, Yayasan IPNLF Indonesia (YII), and technology partner, Safety Net Technologies (SNTech).

The project was originally located in the Maldives, and partnered with IPNLF's regional office, IPNLF Maldives. However, due to unforeseen political issues, the project was relocated to Indonesia, where IPNLF are engaged with our other regional office Yayasan IPNLF Indonesia (YII).

SNTech were approached as technology partners prior to this project inception because of their work on precision fishing gears using programmable LED lights with the use of cameras.

In addition, to the original partners, several organisations have become key stakeholders in the project development and implementation since the relocation to Indonesia. These stakeholders include tuna fishing and processing company PT. Samudra Mandiri Sentosa (PT. SMS) who are based in Bitung, North Suluwesi, and their subsidiary PT. Fajar Flores Flamboyan Fishindo (PT. F4) based in Maumere, Flores. During this recent reporting period from October 2023 to March 2024, PT. SMS have kindly assisted in chartering two of their fishing vessels and crews for two rounds of experimental trials, conducted from both Bitung and Maumere. A further experimental trial period is being conducted as this report is being prepared.

Additional project stakeholders have included IPNLF commercial members, and seafood brand, Fish Tales, based in the Netherlands (email exchanges included in Annexes), and retailer, Woolworths based in South Africa. Gert Le Roux, the Aquaculture and Fisheries Specialist of Woolworth's, South Africa, and Abrizal Ang, CEO from PT Samudra Mandiri Sentosa, Indonesia, have provided specialist technical input based on their respective previous experience regarding baitfish and the potential for innovation. Abrizal was previously involved in efforts to cultivate milkfish livebait in aquaculture facilities for use as baitfish in pole and line operations. Gert Le Roux previously helped pioneer tuna aquaculture cages and tuna husbandry.

Further technical expertise has been contributed by Craig Syms of Ecological Analytics (previously with SNTech) who has provided ongoing consultancy on scientifically robust experimental design (some experimental designs included in Annex 4C and 4D). Craig also has experience with marine acoustics and ecological acoustic design that has been invaluable to designing experimental protocols with marine acoustics in this project design.

All formal partners have been involved in communication with project planning, monitoring, and decision making throughout the project and on a continuous basis; which has included a series of email exchanges, scheduled and ad-hoc meetings, either in person or online. There have been 4 of these meetings between all partners to-date.

Two fishing vessels in the Maldives (Sea Sun and Daafa 3) were involved in the baseline data collection, whilst the project was located in the Maldives, and were provided with a small financial incentive to compensate for potential lost fishing opportunities, as a result of helping IPNLF collect the baseline data. Both crews provided invaluable feedback regarding camera rig design and potential experimental set-ups to trial the lights and sounds.

MIFCO provided the IPNLF team with free accomodation in Koodoo, before they departed for baseline data collection onboard Sea Sun vessel, whilst the project was located in the Maldives.

Since relocating the project to Indonesia in August 2023, two local vessels, provided by Abrizal Ang from PT.SMS have been engaged in experimental trials and data collection activities in Bitung and Maumere. These vessels were provided with a nominal chartering cost in order to compensate for lost fishing effort, crew salaries, and opportunity cost whilst participating in the experimental trials.

In addition, two Indonesian government entities, the Agency for Marine and Fisheries Extension and Human Resources Development (BPPSDM) of the Ministry of Marine Affairs, the Republic of Indonesia (MMAF) and National Research and Innovation Agency (BRIN) have been engaged in order to see whether experimental trials can be expanded to take place in sea cages which are located in the north of Bali, Indonesia. These sea cages provide an opportunity to test some of the technologies in a more controlled environment on captive populations of tuna.

Experimentation in sea cages would limit the number of variables that are prevalent when doing sea trials. It would allow us to further refine the technology and implementation to be more suitable for application in a real world fisheries setting. An initial meeting was conducted in Gondol in North Bali to discuss collaboration and the use of the fish cages. The initial engagement was positive, with a willingness from all parties to cooperate and share data. However, as per Indonesian government protocol, IPNLF, BPPSDM and BRIN will have to enter into a formal cooperation agreement which can be a lengthy process to complete. The experimentation in sea cages will likely be the future direction of the research beyond the Darwin Innovation grant funding, and this process has already begun to ensure continuity and a continued legacy of the project.

3. Project progress

3.1 Progress in carrying out project Activities

The project was successfully moved to Indonesia, and two rounds of experimental trials were conducted in September and November 2023, with a third round of experimental trials being conducted in late April/ early May 2024.

Baseline data collection was completed in year 1 in the Maldives and submitted with the previous annual report.

The first round of experimental trials were conducted in Bitung, North Sulawesi, where a small day boat was chartered with the help of Abrizal Ang from PT. SMS, in order to trial the deployment methodology and run the first experimental trials. On the first day, the rig was deployed in shallow water, in a depth from which the rig could be retrieved in order to safely test the set-up. Over the following three days a total of 5 experimental trials were conducted around anchored FADs (aFADs). However, the experimental trials were frequently being disrupted by extremely strong currents and adverse weather conditions, which caused the skipper to cut short the experimental trials for safety concerns on all three days. On one occasion, the experimental team actually lost sight of the experimental rig as it was drifting so quickly in the current and the marker buoy was being obscured by the waves. Thankfully the rig was finally spotted after over an hour of anxious searching, thanks to the keen eyesight and skilled use of binoculars from one of the fishers. After this it was decided to postpone the experimental trials for better weather and fishing conditions.

In the interim, between the first and second round of experimental trials, it was discussed with Abrizal Ang from PT. SMS whether it would be possible to charter a multi-day fishing vessel in order to make the experimental trials more efficient and eliminate the need to return to shore each evening. Abrizal suggested that we conduct the next trials in Maumere, Flores, where he owned several pole-and-line and purse-seine vessels, and the multi-day fishing trips were conducted around aFADs that were just 12 hours from port as opposed to 2-3 days steaming from the port in Bitung. It was therefore decided to courier the experimental rigs to Maumere and wait for the fishing season to begin there in November.

The second round of experimental trials were therefore conducted in November 2023 from Maumere, Flores. The team chartered a 30 metre purse seine vessel, which was set-up for multi-day fishing trips. The vessel departed shore and travelled overnight to an aFAD around 14 hours from shore. Two full days of experimental trials were conducted, this time in much calmer conditions. Over the two days a total of 14 experimental trials were conducted, bringing the total experimental trials to 19.

The third round of experimental trials are currently being conducted as this report is being drafted in late April and early May 2024, with an aim to conduct a minimum of 20 trials.

A third, separate fishing trip was conducted to attempt to record various seascape sounds associated with successful fishing events using a hydrophone in March 2024. The field team spent three nights onboard a pole and line fishing vessel and recorded sounds from bait fishing, tuna fishing and other associated activities. The plan was to isolate some of the sounds using a python script to create short sound bites that we could playback using the underwater speaker to observe the reaction of tuna to different sounds.

The sound recordings from the field trip were somewhat distorted due to interference from the cable of the hydrophone. To mitigate this in future trials a potential solution could be to record sounds in a static environment rather than towing the hydrophone behind the boat. The sound bites recorded during the trip remain on the project google drive. Project partner Craig Syms has been tasked with developing a sound library that can be used in future experiments and this will be made available as an output of this project. A second field trip to record and generate sounds will be conducted in May 2024.

3.2 Progress towards project Outputs

Output 1 Observe and document the existing tuna feeding response to live-bait as a control treatment to advance scientific knowledge

The target for baseline data collection has been completed in February 2023 (22 out of 20 baseline fishing events recorded) and the videos have been uploaded to a shared google drive and analysed to determine likely indicators of the voracity of skipjack feeding behaviour (e.g. darting vertically, rapid changes in pace and direction and mouth flaring/gaping).

Output 2 Develop experimental treatments to test as an alternative to live-bait including innovative use of alternative technologies

The experimental rigs were shipped from Maldives to Indonesia.

The experimental rigs have been designed, built, tested and further refined for phase 1 experimental trials which utilise a combination of programmable LED lights and reflective materials to imitate the visual effect of schooling fish and underwater playback of seascape sounds which are hypothesised to attract tuna from a distance beyond visual range.

The rigs are deployed in a paired trial, with the experimental and control rigs (identical frame without the programmable LED lights and underwater speakers) deployed 300 - 500 metres apart. The order of deployment and retrieval of the experimental and control rigs has been alternated between trials to mitigate any sensitization that fish might develop over time to the sound of the rigs entering the water. The rigs are then left for 1 - 1.5 hours to drift down current past an aFAD. The logic for deploying the rigs around aFADs, is that these structures naturally attract tuna species, and can therefore help the team identify whether tuna are present when conducting trials, either through visual observation of tuna schools or indicated by the presence of other fishing vessels catching fish. However, in practice, verifying the presence of tuna schools has been quite challenging.

The experimental rigs and control rigs were constructed of stainless steel square tubing as a 1 metre x 1 metre x 1 metre cube. These cubes were then wrapped in netting to allow the SNtech lights to be attached around the rig in different positions. SNtech's programmable LED lights, a 'disco ball reflector', used to divert as much of the light downwards into the water column, the underwater speaker set-up from Lubell Labs and gopros for recording fish behaviour underwater were all attached to the experimental rig. The control rig was an identical set-up without the SNTech programmable LED lights or the underwater speaker. The set up was first trialled on dry land to ensure all the electronic components were fully functional.

For at-sea deployments, the cages were suspended 2 metres below the water surface by a larger marker buoy with a marker flag and a secondary buoy as a back-up in the unlikely event that the first buoy/rope failed. The experimental rig also required the speaker to be powered by a dual battery and amplifier set-up which needed to be housed in a water-tight container at the water's surface. For this purpose, we used a polystyrene fish cooler, housed on a bamboo raft. This set-up allowed the rigs to be deployed independently without being tethered to the fishing vessel.

To date, 19 out of 40 trials have been conducted and further experimental trials are being conducted as this report is being drafted. More than 40 deployments of the experimental rigs will be completed before the end of the project.

The lack of tuna sightings during the experimental trials has raised the questions whether the the results of the experimental trials are due to ineffectiveness of the alternative stimuli to attract tuna or simply the lack of tuna presence in the surrounding waters. In Indonesia, tuna fishers are reliant on the use of aFADs for fishing and rarely chase free-schools of tuna in the open ocean.

The review of the video footage from the trials do not currently indicate that the experimental trials are effective. No tuna can be seen on the camera footage on either the experimental or control rigs on any of the 19 experimental trials conducted to date.

However, in both rounds of experimental trials to-date, there has been very little pole-and-line fishing observed around the aFADS during the trial period. This raises the question whether there has actually been any tuna in the immediate vicinity when the trials have been conducted. Unfortunately, pole-and-line vessels in Indonesia do not have fish-finder or sonar technology onboard, and therefore sighting of a tuna school by eye, or the presence of a fishing vessel that is successfully catching are the only indicators of the presence of tuna in the surrounding waters. To address this, the project team have looked into the possibility of using a downward/side-scan sonar to verify the presence/absence of tuna during the experimental trials, although costs may be prohibitive.

A key discussion among the project team is whether the experimental design could be adapted to trial the innovative stimuli in a more controlled setting, such as aquaculture sea cages. This would allow the project team to directly observe the reaction of tuna species to different stimuli. The most promising treatments could then be taken to an open water environment for further trials. Project team member, Craig Syms, has begun the development of an experimental protocol for such controlled treatments, as a potential future phase of the project. These experimental designs will be a valuable output of this project (see Annex 4.D).

Output 3 Establish standard protocols for testing feeding response in tuna to a range of alternative stimuli that is replicable in commercial tuna fisheries to contribute to scientific methodology.

The experimental trials for at-sea testing of innovative stimuli are run in paired trials (see description in Output 2). Underwater cameras are currently being used on both the experimental and control rigs, with the widest possible field of view to detect the presence/absence of feeding tuna in response to the alternative stimuli.

However, to date no tuna have been detected by the cameras during the two rounds of experimental trials conducted in September and November 2023.

To determine whether the alternative stimuli are effective or ineffective in (1) attracting tuna, (2) Initiating a feeding frenzy and (3) maintaining a feeding frenzy, we must first determine whether tuna is actually present in the vicinity of the rig when conducting experimental trials.

Originally these trials were going to be conducted in the Maldives where fishing vessels are equipped with bird radars and fish finding technology such as side-scan/downwards facing sonar which can verify the presence of schools of tuna. However, in Indonesia, the pole-and-line vessels do not have fish finding technology onboard and primarily fish around aFADs. It was hoped that schools of tuna would be visually sighted and/or the presence of pole-and-line vessels visually catching tuna would verify the presence of tuna around a particular aFAD. However, in practice during the two rounds of experimental trials around aFADS, there has been no visual indication of tuna schools and the presence of fishing pole-and-line vessels have been very fleeting, lasting no more than 20 minutes before moving on.

Purchasing a sidescan/downward facing sonar could help determine the presence of tuna schools before conducting experimental trials, although costs vary greatly between different specifications, and a sonar suitable for this application could be cost-prohibitive (potentially GBP 30,000 - 100,000).

Alternatively, conducting the experimental trials in the more controlled environment of an aquaculture sea cage with captive tuna could allow the direct observation of tuna response to different alternative baitfish stimuli. Whilst testing on captive populations of tuna could present many confounding variables which would not necessarily translate to a real world fishing situation, it would at least provide a strong indication of which stimuli could produce a positive response and allow refinement of the at-sea experimental process. IPNLF are currently in the process of exploring the feasibility of conducting some experimental trials in sea-cages, as a future phase of research, either during or beyond the period of this Darwin Innovation Grant.

Output 4 Produce video, photographic and written communication outputs to promote project activities and outputs through social media websites and relevant public fora.

One blogpost was published in October 2023 and was well received resulting in several of our supply chain members reaching out to IPNLF to ask how they can support the project.

A second blog post was published by the Darwin Initiative in January 2023 when IPNLF contributed a case study on sustainable food systems to the Darwin Initiative newsletter. The blogpost discussed how a positive outcome of this project could result in sustainable food systems change, by reducing baitfish consumption in pole-and-line fisheries and making pole-and-line fishing even more low-impact.

A Total of 5 social media posts have been published on instagram.

Video and photographic content has been continuously captured by project staff during all project activities and will eventually contribute to two videos being produced towards the end of the project. A professional videographer will be engaged to film experimental trials being conducted towards the third quarter of 2024.

3.3 Progress towards the project Outcome

Outcome: Dependency of pole-and-line fisheries in *Indonesia on livebait is reduced by developing innovative technologies as an alternative to live bait resources

Experimental trials are yet to indicate whether the innovative technologies are effective in (1) attracting tuna, (2) initiating a feeding response in tuna and (3) maintaining the feeding response in tuna.

More replications and further refinement of the experimental protocol are required to rule out the possibility of a false negative, by determining whether tuna are present in the immediate vicinity of the experimental trials.

Indicator 0.1 By the end of the project at least three alternatives to livebait have been prototyped and trialled in the *Indonesian pole and line tuna fishery.

The three alternative stimuli to livebait that have been identified include:

1. Programmable LED lights, combined with reflective materials to simulate the visual effect of schooling bait fish
2. The underwater playback of a range of seascape sounds including but not limited to, tuna feeding frenzies and associated noises e.g. birds diving, dolphins, baitfish schools as well as more isolated sounds such as baitfish schooling over a reef or specific frequencies that appear to elicit a reaction and;
3. Olfactory stimuli that are harvested from the byproducts of the fish processing industry, which will include, dried fish scales and fish skin, frozen blood, fish oil, and other offal.

The programmable LED lights and underwater playback of sound are currently being trialled in an at-sea setting. To date, the trials have not indicated that tuna are attracted to the stimuli, although it is possible this is a false negative and is because there was no tuna present in the surrounding waters when the alternative stimuli was trialled. More replications and further refinement of the methodological approach is required as well.

The olfactory stimuli will only be trialled once the other stimuli (light and sounds), which are designed to attract tuna to within a catching range of the vessel have shown a positive indication.

Indicator 0.2 By the end of the project at least one developed baitfish alternative is able to elicit a feeding response in tuna significant enough to justify reduced use of livebait.

As above, the alternative stimuli are yet to show a positive indication of attracting tuna to within catching range of the vessel. However these results still need to be validated through further trials and refinement of the methodology.

Indicator 0.3 By the end of the project, pole and line fishers on the trial vessels are using less livebait to catch similar quantities of tuna resulting from use of developed livebait alternatives.

The baseline of the amount of tuna caught during a regular fishing event utilising livebait will be extracted from the data sets of pole and line observer data that IPNLF has been collecting through our observer program in both the Maldives and Indonesia.

At present, the innovative experimental treatments have not indicated that a reduction in livebait will currently be possible. However, it is still very early in the development of these experimental trials, and more trials, as well as further refinement of the experimental protocol is required.

As indicated by the desk study, this is a truly innovative field of research with little prior knowledge.

3.4 Monitoring of assumptions

0.1 All important variables are identified and observable.

This assumption remains partially true - The variables that indicate success of an experimental trial would be an observed feeding response in tuna similar to that of a live-bait fishing event. This can be quantitatively determined by the observed catch by weight of tuna and qualitatively by surveying the fishing crew on their opinions as to how the livebait alternatives performed.

The underwater cameras attached to the experimental rigs also allow the feeding behaviour of the tuna to be directly observed.

However, determining the presence of tuna in the vicinity, prior to the experimental trials has proved more difficult than initially expected. IPNLF are currently looking to address this through two potential strategies. (1) buy a fish/finder/ sonar to identify the presence of tuna, or; (2) conduct some experimental trials in sea-cages with captive tuna to ensure that tuna are present. Both these approaches also have challenges and potentially significant cost implications. Alternatively, replicating more trials may help overcome this as more fishing conditions and trials throughout the fishing season provide more confidence in the observed results.

0.2 Stakeholders are willing to trust IPNLF to experiment with alternatives, new research published and accessible, experimental inputs are readily available.

This assumption remains true.

IPNLF has a standing Cooperation agreement or Perjanjian Kerja Sama (PKS) with the Indonesian Ministry of Maritime Affairs and Fisheries (Kementerian Kelautan dan Perikanan, KKP), which includes the trialling of innovative technologies and ways to improve livebait utilisation in Indonesian pole-and-line fisheries. It was therefore determined that this project falls within the scope of this MoU. The project has been discussed at in-person meetings, with various departments of KKP, and there is an active interest in its outcomes.

IPNLF are also in the process of establishing a Cooperation Agreement or Perjanjian Kerja Sama (PKS) with the National Research and Innovation Agency (Badan Riset dan Innovasi Nasional (BRIN)), who could support the project by allowing use of their sea cages in the north of Bali.

Support from Indonesian tuna industry and fishers, as well as international market partners has been very good throughout the project. PT SMS, and PT F4, have provided ongoing support through vessel charter arrangements and logistics. Woolworths (South Africa), Sainsbury's (UK)

and Fish Tales (Netherlands) have maintained an active interest in the outcome of this project and indicated an interest to fund future research.

0.3 Live bait alternatives are successful to elicit a sufficient tuna feeding frenzy so that fishermen and stakeholders replicate it on fishing vessels

This assumption is yet to be verified through further experimental trials. However, the innovative nature of the project means this assumption is not certain.

1.1. Cameras are able to record every activity

This assumption remains true. The cameras have been able to capture the underwater feeding behaviour of skipjack at a sufficiently high-resolution to be able to determine individual skipjack and school behaviour during baseline data collection. To our surprise, the cameras are also able to detect the live bait that is being thrown from the vessel during baseline data collection.

So far with the experimental trials, tuna schools are yet to be sighted by the underwater cameras attached to the control and experimental rig. However, during the trials, the visibility has been in excess of 30 metres, so if tuna were present, they should have been detected by the camera.

1.2 All the variables are observable and recorded.

This assumption remains true. The key variables we require to determine the success or failure of a feeding response in skipjack tuna are captured by the underwater cameras. In addition, these variables can be corroborated by the actual catch rates of skipjack tuna during the phase 2 experimental trials on a working pole and line boat.

2.1 New research is documented and published

Very little research was found on the subject with much of the available research dating back to the 1970s. However, the research did indicate that this is a promising area of research that remains relatively unexplored, confirming that this indeed novel and innovative research.

The desk research remains an active document and is updated with references as and when the team comes across them (see annex 4.A.)

2.2 Experimental inputs are available for development or procurement

This holds true. All the materials required for experimental trials have already been procured.

2.3 Stakeholders are willing to trust IPNLF to experiment with alternatives on their vessels

This assumption remains true. Vessel owners and crew have shown a willingness to participate in the trials and IPNLF offer a small but reasonable compensation in order to compensate for the opportunity cost of disruption to fishing and subsequent loss of income due to experimental trials. This compensation is negotiated on a vessel by vessel basis, depending on the relationship held with the vessel and is lower depending on whether it is a baseline data collection event, with lower disruption to fishing events, or higher for experimental trials, which may cause complete disruption to a fishing event.

3.2 Stakeholders are willing and interested to read new research on alternatives to livebait.

This assumption holds true. IPNLF's first blog post was distributed to our member network and was well received with multiple supply chain members reaching out to ask how they can support the project, including Marks & Spencers and Sainsbury's in the UK, Fish Tales in the Netherlands, PT Samudra in Indonesia and Woolworths in South Africa. There has also been interest from

stakeholders in other fisheries including the Azores pole-and-line fishery and the Brazilian pole-and-line fishery who have requested to stay up-to-date with the outcomes of the project. The potential for this project to have a significant impact on the future sustainability of pole-and-line fisheries is well recognised and understood.

3.3 Stakeholders are receptive to engage with the findings and the protocol

This assumption remains true. All the stakeholders above have shown an active interest in the outcomes of this project.

3.5 Impact: achievement of positive impact on biodiversity and poverty reduction

Impact: Reduce reliance on livebait in pole-and-line tuna fisheries through the use of innovative alternatives, thereby enhancing fisheries sustainability, operational efficiency, reduction of carbon footprint and conservation of vulnerable baitfish resources

If experimental treatments are successful in eliciting a tuna feeding response comparable to livebait, it could reduce or remove the need for livebait in one-by-one fisheries. The reduced usage of live bait can have transformative longer term benefits for both biodiversity and poverty reduction in many low and middle income developing coastal states, in which development of low impact, sustainable fisheries could provide dignified and even lucrative livelihoods in a sustainable blue economy.

Furthermore, reduced reliance on baitfish would increase the operational efficiency and reduce the carbon footprint of existing pole-and-line fisheries by reducing the time and fuel spent searching for baitfish resources.

Lastly, reducing or removing dependency on live-bait in one-by-one tuna fisheries means that those forage fish can remain in the ocean to reproduce, fulfilling their ecosystem function as the prey fish that underpin the marine food web. Healthier more abundant stocks of forage fish contributes to better overall ecosystem health and resilience in the face of climate change and the biodiversity crisis.

If successful, the research from this project will strengthen the capability of low impact one-by-one tuna fishers to sustainably harvest their marine resources and further minimise their ecosystem impacts, by removing the need for baitfish. This in turn enhances the capacity of coastal fishers in low and middle income developing countries to participate in sustainable fisheries which have a low barrier to entry and can offer dignified, sustainable and potentially lucrative employment and livelihoods.

4. Project support to the Conventions, Treaties or Agreements

At this stage, the project has not directly contributed to national policy or the development of conventions, treaties or agreements that Indonesia is signatory of.

IPNLF and project partners have also not had any direct interaction with the convention focal points over the last 12 months.

5. Project support for multidimensional poverty reduction

If successful the research from this project will strengthen the capability of low impact one-by-one tuna fishers to sustainably harvest their marine resources and further minimise their ecosystem impacts, by removing the need for baitfish. This in turn enhances the capacity of coastal fishers in low and middle income developing countries to participate in sustainable fisheries which have a low barrier to entry and can offer dignified, sustainable and potentially lucrative employment and livelihoods.

Furthermore, reduced reliance on baitfish would increase the operational efficiency and reduce the carbon footprint of pole and line fisheries by reducing the time and fuel spent searching for baitfish resources, which would have significant time and cost savings for fishers.

By openly publishing the data and reports and widely disseminating the outputs via digital communications outputs, the research conducted in Indonesia can help lower barriers to experimentation in other one-by-one fisheries and research institutions, catalysing a new frontier of research in one-by-one fisheries. The research will also provide insight for fisheries management authorities into potential ways to proactively address baitfish issues.

As the alternative baitfish stimuli are still currently in their early experimental stages, no direct progress towards poverty reduction has been made, and poverty reduction outcomes are dependent on successfully identifying and alternative stimuli that can reliably elicit a feeding frenzy response in tuna.

6. Gender Equality and Social Inclusion (GESI)

Please quantify the proportion of women on the Project Board[1].	25%
Please quantify the proportion of project partners that are led by women, or which have a senior leadership team consisting of at least 50% women[2].	0%

GESI Scale	Description	Put X where you think your project is on the scale
Not yet sensitive	The GESI context may have been considered but the project isn't quite meeting the requirements of a 'sensitive' approach	
Sensitive	The GESI context has been considered and project activities take this into account in their design and implementation. The project addresses basic needs and vulnerabilities of women and marginalised groups and the project will not contribute to or create further inequalities.	
Empowering	The project has all the characteristics of a 'sensitive' approach whilst also increasing equal access to assets, resources and capabilities for women and marginalised groups	X
Transformative	The project has all the characteristics of an 'empowering' approach whilst also addressing unequal power relationships and seeking institutional and societal change	

Coastal communities and small-scale fisher groups are intended to be the beneficiaries of the project outcomes and impacts. These same communities are frequently marginalised in decision making processes and excluded from initiatives to improve sustainability and operational efficiency. This often results in them being outcompeted and thus economically disadvantaged by highly capitalised and politically influential industrial fisheries, who can pay for expensive sustainability initiatives and gain increased market access.

Should the project be successful in reducing the utilisation of live bait in pole-and-line fisheries, this would provide small-scale fishers with a significant cost-saving which would lower the barrier of participation in the fishery. Furthermore, the improved sustainability of the fishery through reduced use of live bait, if well evidenced and promoted, could provide a market advantage over industrial fisheries and incentivise preferential sourcing from pole-and-line fisheries from sustainability concerned markets. As such, the project is designed with the intent to empower coastal communities, and therefore can be classified as 'empowering' on the GESI scale.

The project doesn't make any specific actions to differentiate engagement between specific genders, especially as the primary harvesting sector in Indonesia is exclusively male. At present both trial vessels engaged in baseline data collection have entirely male crews. However, women are an important part of the post-harvest value chain in Indonesia and make up over 75% of the

[1] A Project Board has overall authority for the project, is accountable for its success or failure, and supports the senior project manager to successfully deliver the project.

[2] Partners that have formal governance role in the project, and a formal relationship with the project that may involve staff costs and/or budget management responsibilities.

employment and small-business owners. Therefore both men and women who rely on one-by-one fisheries value chains are beneficiaries of the project outcomes. To this end, the project has considered gender roles in the fishery, but does not take any active actions to rebalance the gender inequity in the primary harvesting sector and could therefore be considered 'sensitive' on the GESI scale.

Fishers and small-scale fisheries representatives have been an integral part of project implementation and development. So far during this Darwin Innovation project five different vessels and their crews (two from Maldives and three from Indonesia) have been engaged in project implementation through baseline data collection and experimental trials.

As the project develops through this Darwin Innovation project as well as in the future, IPNLF will endeavour to ensure the outcomes remain accessible to the small-scale fisheries and coastal communities we work with and promote. Ensuring the benefits from sustainably managed fisheries flow equitably back to coastal communities is a key part of IPNLF's mission and vision of a world with thriving fisheries through catching one fish at a time.

7. Monitoring and evaluation

Monitoring of project activities and progress against the agreed deliverables in the logframe has been a very simple process, as progress is measured in the number of baseline fishing events and experimental trials conducted. Each baseline fishing event and experimental trial has a set of video recordings associated with it, so there is tangible evidence of progress towards the agreed deliverables.

As data collection involves directly recording fishing events from underwater, whilst recording other variables relating to baitfish utilisation above water, the video generated is a very tangible way to record progress towards our data collection targets. As of the time of writing, 22 baseline fishing events and 19 experimental trials have been recorded and are shared with all project partners on a shared google drive.

Progress towards the outcomes is largely dependent on successful results from the trialling of innovative alternative stimuli to attract tuna, with reduced utilisation of baitfish. This will be conclusively determined by comparing live bait utilisation and tuna catch rates with and without the alternative live bait technologies. However, before this can be conducted, at least one of the alternative live bait stimuli needs to indicate a positive result of attracting tuna/ initiating a feeding frenzy. To date, the experimental trials have shown no evidence of attracting tuna, however, it is still very early in the experimental process and more trials and refinement is required. This is expected with highly innovative projects of this nature.

Project monitoring is conducted by IPNLF.

Monitoring and evaluation also includes financial monitoring and has been conducted by updating two spreadsheets on a regular basis 1) Financial forecasting spreadsheet and 2) Actual expenditure spreadsheet. This process is managed between the Project Manager and IPNLF's Financial Manager. Detailed expense reports from fieldwork are provided by IPNLF Indonesian field staff.

8. Lessons learnt

Trialling the projects in an open ocean environment has been one of the most challenging aspects of the project. Firstly there is the logistical complexity of conducting at-sea trials. And secondly, locating schools of tuna in a vicinity in which to conduct the experimental trials has proved very difficult without appropriate fish finding technology. In the future, we would recommend that the first attempts of innovative trials such as trials being conducted in this project are conducted in a more controlled environment with fewer dynamic variables, such as in tanks or sea-cages, before more promising treatments are trialled in a real-world fisheries setting.

Flexibility in the plans has also been a key component of the project so far. As our project works with fisheries, which are notoriously hard to forecast and plan as activities are entirely dependent

on weather and fishing conditions, which are factors beyond our control. This has meant that we have had to frequently pivot our plans in order to achieve the desired outcomes for project activities. Building contingencies in the project plan and activity schedule helps when trying to plan for field trips which involve international staff or project partners who may have limited time and incur additional costs, to ensure that the time is used cost-effectively. For example, back-up plans when fishing conditions or weather conditions do not allow for baseline data collection or experimental trials. Often flexibility in timelines and a willingness to change plans at a moment's notice are the most important factors. As such, in the future we would build longer field trips into the project plan so that it allows for as much flexibility as possible.

9. Actions taken in response to previous reviews (if applicable)

Below are the repsonses from the Year 1 end of Year Report that requied a response from the reviewers:

1. The AR mentions that the project was aware of the licensing requirement, but did not consider it a risk. It was only added to the risk register in October 2022. The application M&E section mentions Situational/ Context Monitoring and Compliance Monitoring, either or both of which could be expected to have identified the licensing requirement as a risk and therefore to have taken steps to establish formal support from the Ministry. Comment on how these aspects of M&E are implemented by the project and why they failed to identify this risk at an earlier stage. Has the project taken steps to ensure a similar situation does not arise in Indonesia?

In Indonesia, the work under this Darwin Innovation project falls within the scope of the standing Cooperation agreement or Perjanjian Kerja Sama (PKS) that Yaysan IPNLF Indonesia have with the Ministry of Maritime Affairs and Fisheries (*Kementerian Kelautan dan Perikanan*, *KKP*). The MoU covers the topic of technological innovation in fisheries and improvements in the utilisation of livebait resources.

2. Please include as wide a range of evidence as possible with future reports. Minutes of project management meetings should be provided. The AR included abstracts from 2 desk analyses - the reports themselves could have been provided. Datasets e.g. as Excel files would be useful to see. Photos of purchased equipment, especially in use. The current version of the standard protocols could have been provided. A link to the blog post should be included in the publications annex. Example emails and letters of support from stakeholders. Almost every MoV should be capable of generating an output that can be included (either in its entirety, or as representative examples) e.g. MoV 1.2 (trip reports), MoV 1.3 (observer datasheets).

The desk analysis reports have been included as annex 4.A and 4B (attached in the email). Photos of the equipment used for experimental trials have also been included under annex 4 Additional Materials. The blogpost publications have been included in the publications annex. Example email exchanges have been included in Annex E-H).

10. Risk Management

The potential for weather and fishing conditions to disrupt experimental trials still remains a risk. However, IPNLF have been extending the field work periods to account for potential weather disruptions. We also switched from using day boats (capable of only one day at sea, before having to return to shore) to multi-day boats, which allow us to do up to 2-3 days of experimental trials before being required to return to shore. This has made experimental trials much more efficient.

There remains a risk that due to the novel and innovative nature of this project, the experimental stimuli fail to produce the desired outcomes of (1) attracting tuna to within catching range of a vessel (2) eliciting a feeding frenzy response in the tuna, and (3) ultimately improving the utilisation of livebait onboard pole-and-line fishing vessels, during the timeframe of this Darwin Innovation project.

IPNLF are committed to exploring this topic until potential options have been exhausted and therefore plan to develop alternative experimental protocols, including in a more controlled environment such as aquaculture sea cages, to narrow down the stimuli that could lead to a positive outcome. If these experimental trials can still be conducted within the scope of this Darwin Innovation Project, then IPNLF will endeavour to do so. If not, IPNLF will seek additional funding in the future to continue this research stream.

11. Sustainability and legacy

Indonesia is an ideal location for this project for several reasons:

(1) IPNLF has a longstanding relationship with fisheries stakeholders from across the value chain, from individual vessels through to commercial processors, brands and distributors.

(2) Baitfish in Indonesia cannot be fished by pole-and-line fishing vessels and have to be purchased from *bagan* fisheries. This makes baitfish one of the largest operational expenses and constraints of the pole-and-line fishery. Reduction in baitfish utilisation could significantly improve the operational efficiency, fuel consumption, carbon footprint and overall sustainability of the fishery.

(3) IPNLF has a permanent staff component in the Maldives, and a locally registered entity: Yayasan IPNLF Indonesia.

(4) Indonesia is is a middle-income country as per the ODA list, however, the coastal communities which are crews onboard the pole-and-line fishing vessels represent a low-income sector of society, that would experience significant increases in income and therefore poverty alleviation if the operational costs of fishing were improved by improving baitfish utilisation.

There has been great support and interest in the project outcomes from many external stakeholders including seafood brand Fish Tales in the Netherlands, and retailers Sainbury's and Marks and Spencers in the UK, and Woolworths in South Africa. Additionally, fisheries stakeholders from the Azores pole-and-line fishery and the Brazilian pole-and-line fishery have shown an active interest in the outcome of the project after reading the first IPNLF blogpost.

The outcomes of the experimental research conducted through this project will be presented in an open access scientific report and will contribute to novel scientific research. The methodologies and results for outputs 1, 2 and 3 all aim to be replicable by other scientists and fisheries and will allow others to advance the research into live bait alternatives.

Should an experimental treatment trialled through this project be successful in cost-effectively eliciting a feeding response in tuna, whilst reducing or eliminating need for baitfish, IPNLF will widely promote the results through our global network, and seek funding to cost-effectively replicate the project results in other fisheries and countries that can benefit from the innovation.

If the result is linked to technology provided by project partner, SNTech (e.g. Pisces programmable LED system), SNtech may explore commercialising the solution and explore making the technology more affordable as a cost -effective solution for fishers in low and middle income countries. However the theory behind the LED light frequencies will be openly published and will therefore be replicable by market competitors.

Regardless of the results of this Darwin Innovation project, IPNLF is committed to further exploring baitfish reduction and innovation and will continue to actively raise funds to conduct further research and experimental trials.

12. Darwin Initiative identity

IPNLF released the first blog post and newsletter in October 2022 announcing the beginning of the control trials in which it was explicitly stated that this was a Darwin funded project.

IPNLF also contributed to a Darwin case study on Sustainable Food Systems, which was published on the Darwin website.

6 Social media posts have been published on Instagram and have resulted in several emails from interested stakeholders to the project lead (see Annex 4 E - H: Email exchanges)

The project is primarily funded by Darwin but with matched funding from IPNLF's core funding generated by commercial membership. The fact that the project is funded by Darwin is explicitly mentioned in conversations with any project stakeholders, including interested IPNLF members.

It is one of the outputs of the project to produce a short promotional video in which it will be made explicitly clear that this is a Darwin funded project and we would hope to use the Darwin logo in that video. This output is scheduled for the final quarter of the project in the third quarter of 2024. This video will hopefully form part of the legacy of the project.

13. Safeguarding

Biodiversity Challenge Funds are committed to supporting projects develop and strengthen their safeguarding capabilities and capacity to prevent, listen, respond and learn. Defra will not automatically penalise projects where safeguarding concerns are identified, but will help projects respond and learn from the experience. We are committed to helping project strengthen their safeguarding approach and if you have any sensitive questions around safeguarding please contact NIRAS separately.

Has your Safeguarding Policy been updated in the past 12 months?	No
Have any concerns been reported in the past 12 months	No
Does your project have a Safeguarding focal point?	No
Has the focal point attended any formal training in the last 12 months?	No
What proportion (and number) of project staff have received formal training on Safeguarding?	Past: 0% Planned: 0%
Has there been any lessons learnt or challenges on Safeguarding in the past 12 months? Please ensure no sensitive data is included within responses. There have been no issues related to safeguarding in the past 12 months.	
Does the project have any developments or activities planned around Safeguarding in the coming 12 months? If so please specify. No specific developments or activities planned. We have safeguarding policies to which all recruited staff to IPNLF are familiarised with during the onboarding process as well as sections in our IPNLF staff handbook.	
Please describe any community sensitisation that has taken place over the past 12 months; include topics covered and number of participants. No community sensitiation has taken place over tha past 12 months.	
Have there been any concerns around Health, Safety and Security of your project over the past year? If yes, please outline how this was resolved. There have been no specific regards regarding health, safety and security over the past 12 months.	

14. Project expenditure

Table 1: Project expenditure during the reporting period (1 April 2023 – 31 March 2024)

Project spend (indicative) since last Annual Report	2023/24 Grant (£)	2023/24 Total Darwin Initiative Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)	[redacted]			
Consultancy costs				
Overhead Costs				
Travel and subsistence				See detailed explanation below.
Operating Costs				See detailed explanation below.
Capital items (see below)				See detailed explanation below.
Monitoring & Evaluation (M&E)				
Others (see below)				See detailed explanation below.
TOTAL	**£107,200**	**£65,509**		

Table 2: Project mobilised or matched funding during the reporting period (1 April 2023 – 31 March 2024)

Due to the previous significant change request and the transition of the project from the Maldives to Indonesia, a no-cost extension was granted by Defra until 30 September 2024.

Several of the budget lines including staff costs, travel and subsistence, operating costs and others (which includes the financial audit, communication outputs and project supplies) have significant variance in the 2023-23 budget, as these budget lines will carry over into the no-cost extension period (April 1st - September 30th 2024).

Operating costs for vessel chartering are also considerably lower in Indonesia, compared to what was budgeted for The Maldives. This has resulted in a cost-saving that will allow for additional experimental trials to be conducted.

	Secured to date	Expected by end of project	Sources
Matched funding leveraged by the partners to deliver the project (£)	Maldives Consultant [redacted] Gert Le Roux, time in Indo [redacted]		IPNLF Core Funds

Total additional finance mobilised for new activities occurring outside of the project, building on evidence, best practices and the project (£)	Baitfish Best Practices in Indonesia [redacted]		Walton Tuna Consortium Phase 2

15. Other comments on progress not covered elsewhere

Due to the challenges of testing the alternative stimuli in open -water settings, IPNLF and project partners have began to explore the viability of testing the alternative stimuli in a more controlled environment, of aquaculture sea-cages in order to directly observe tunas response to different stimuli and narrow down the range of stimuli that could be effectively tested in the open-water environment. This will be a likely the direction of future phases of the project, beyond Darwin Innovation funding.IPNLF have began the experimental design phase and are exploring the cost and viability of the experimental design. We believe this could be an additional valuable output of this Darwin Innovation project.

IPNLF have also began to compile a ‘sound library’ of sounds to test, to observe if certain seascape sounds or frequencies can elicit a feeding response in tuna.

16. OPTIONAL: Outstanding achievements or progress of your project so far (300-400 words maximum). This section may be used for publicity purposes

File Type (Image / Video / Graphic)	File Name or File Location	Caption including description, country and credit	Social media accounts and websites to be tagged (leave blank if none)	Consent of subjects received (delete as necessary)
				Yes / No
				Yes / No
				Yes / No
				Yes / No
				Yes / No

Annex 1: Report of progress and achievements against logframe for Financial Year 2023-2024

Project summary	SMART Indicators	Progress and Achievements April 2022 - March 2023	Actions required/planned for next period
Impact **Reduce reliance on livebait in pole-and-line tuna fisheries through the use of innovative alternatives, thereby enhancing fisheries sustainability, operational efficiency, reduction of carbon footprint and conservation of vulnerable baitfish resources.**		With the project still in trial phases, no direct impact on biodiversity or poverty alleviation can yet be reported.	
Outcome **Dependency of pole-and-line fisheries in the *Indonesia* on livebait is reduced by developing innovative technologies as an alternative to live bait resources**	0.1 By the end of the project at least three alternatives to livebait have been prototyped and trialled in the *Indonesian* pole and line tuna fishery. 0.2 By the end of the project at least one developed baitfish alternative is able to elicit a feeding response in tuna significant enough to justify reduced use of livebait. 0.3 By the end of the project, pole and line fishers on the trial vessels are using less livebait to catch similar quantities of tuna resulting from use of developed livebait alternatives.	1. 2 alternative stimuli (programmable LEDs and underwater sound) have begun to be trialled and tested in the open water environment. The third stimuli (olfactory stimuli), will be trialled once tuna have been seen within catching range of the experimental rigs. 2. Experimental trials are currently being conducted, but have yet to be seen to elicit a feeding response in tuna. 3. As above	*1.* Livebait alternatives will continue to be trialled and refined to attempt to meet the objective of the project. 2. Continued experimental trials will determine if one of/ a combination of the livebait alternatives can elicit a feeding response in tuna significant enough to justify reduced livebait. 3. Continued at-sea experimental trials will assess the efficacy of the innovative technologies.
Output 1. Observe and document the existing tuna feeding response to live-bait as a control treatment to advance scientific knowledge	1.1 In the first year, at least 20 successful fishing events in which livebait are utilised are recorded and observed using AI integrated underwater cameras to determine a baseline control treatment against which experimental treatments can be compared. 1.2 At least 3 key variables to determine the voracity of tuna feeding response determined in the first year.	*1.1 22 fishing events and skipjack feeding behaviour has been recorded using underwater cameras. The AI component is still being developed by SNTech.* *These footage are available on a shared google drive.* *1.2 The 3 key variables of skipjack feeding behaviour have been identified through tentative review of the baseline footage, but will be further verified during the experimental trials.*	

Activity 1.1 Observe fishing conditions, and baitfish utilisation on commercial Maldivian pole-and-line fishing vessels AI integrated using underwater cameras to capture control conditions.		22 baseline fishing events recorded	Activity complete
Activity 1.2, Assess different behaviours of skipjack from underwater footage to determine measures of voracity of feeding response		The 3 key variables to determine the voracity of skipjack feeding behaviours have been tentatively determined from preliminary review of the baseline footage, but will be verified during experimental trials in the next phase of the project.	Voracity will be determined through comparison between baseline conditions and experimental conditions - Likely looking firstly at the underwater behaviour in phase 1 trials, and by looking at actual catch rates of skipjack tuna in phase 2 trials.
Activity 1.3 Experiment with different variables in eliciting feeding responses in order to isolate effects of the experiments, record and standardise them		Two experimental stimuli (programmable light and sound) have been trialled in an open water setting (with 19 trials conducted to date)	Different sounds need to be trialled to see whether (1) tuna can be attracted to the experimental rig from a distance and, (2) whether a feeding frenzy response can be elicited in the tuna, in combination with other stimuli (light and olfactory stimuli).
Output 2. Develop experimental treatments to test as an alternative to live-bait including innovative use of alternative technologies.	2.1 minimum 3 case studies of existing and new research are identified during desk study 2.2 Experimental treatments using alternative stimuli including LED lights, byproducts of fish processing/artificial bait pods and artificial lures are co-developed with relevant stakeholders and LED lights are procured by end of second quarter. 2.3 At least 40 at-sea trials conducted on a pole and line vessel using a combination of programmable LED lights, byproducts of fish processing/artificial bait pods and artificial lures to elicit a feeding frenzy response in tuna over the project period.	*2.1 Desk study further refined with >3 referenced studies. This remains an active document that will continue to be updated throughout the project as additional research or studies come to light. The desk study resulted in including the use of underwater playback of sound (auditory stimuli) in the project.* *2.2 A paired experimental design rig for phase 1 experimental trials has been designed and built and includes programmable LED lights, underwater cameras, auditory playback of seascape sounds, reflective materials and will later include olfactory stimuli from the byproducts of the fishing industry. All equipment has been tested and 19 trials have been completed.* *2.3 19 out of 40 experimental trials have been conducted, with an additional 20 trials planned for late April/Early May.*	
Activity 2.1 Conduct desk study to compile case studies of new technology and alternative techniques to live-bait in other countries/fisheries		Desk study is complete but remains an active document. Several new studies were added in the last quarter and the document's references have been updated.	The document will continue to be updated until the close of the project.

Activity 2.2. In consultation with fisheries stakeholders, codevelop alternative stimuli to livebait which have potential to elicit a feeding frenzy response in skipjack tuna.		Experimental rigs have been designed, built and tested using both programable LED lights and underwater sound.	Further variations on the experimental treatment (different combinations of sounds and olfactory stimuli) need to be trialled.
Activity 2.3 Test novel alternative external stimuli such as programmable LED lights, byproducts from fish processing/ artificial bait pods and artificial lures to elicit and maintain a feeding frenzy in skipjack schools		Experimental trials of novel alternative stimuli have begun with 19 out of 40 trials conducted. However, the stimuli are yet to elicit a feeding frenzy response in tuna schools.	Different combinations of stimuli need to be trialled in order to try and elicit a feeding frenzy in skipjack
Output 3. Establish standard protocols for testing feeding response in tuna to a range of alternative stimuli that is replicable in commercial tuna fisheries to contribute to scientific methodology	3.1 By the end of the project, experimental protocols are developed standardised, and recorded in a scientific report 3.2 By the end of the project experimental Protocols are widely shared with stakeholders both in Maldives through stakeholder workshops and abroad through communication outputs (output 4).	3.1 Standard protocols for baseline data collection have been established and kept on an active document. Standard protocols for experimental data collection will be refined and documented during the experimental trial phase and recorded in a scientific report. 3.2 A paired experimental protocol has been designed and continues to undergo refinement and experimentation during the experimental trials. This will be documented and described as a project output.	
Activity 3.1 Create a report documenting the trials and standard protocols developed Indonesia, and analysing the potential for scalability and impact in low and middle income countries		Standard protocols for baseline data collection established through a refinement process. A working document on the experimental trial process has been developed and will be adapted for the final output.	Experiential trials protocols will continue to be developed and refined until the end of the project period in September 2024
Activity 3.2 Increase stakeholder buy-in and replication using awareness and communications		See activity 4.4	Final report will be widely publicised in IPNLF's member network and through our website and newsletter.
Output 4. Produce video, photographic and written communication outputs to promote project activities and outputs through social media websites and relevant public fora.	4.1 By the end of the project produce at least 4 written articles/blog posts to promote project activities and outcomes. 4.2 By the end of the project an informational video is produced documenting the experimental protocol 4.3 By the end of the project a high-quality promotional film is produced to promote project activities and outcomes. 4.4 Photos and captions regularly posted on IPNLF Maldives and IPNLF	4.1 2 of 4 written blog posts have been completed. 4.2 Informational video was due to be recorded in March 2023, but has been delayed, pending change request (see section 3.1). 4.3 Same as above. 4.4 Darwin posts have been scheduled for regular release on our IPNLF Maldives Instagram channel - but currently paused and dependent on pending change requests.	

	social media channels (instagram and facebook)		
Activity 4.1 Throughout project, project staff will capture high resolution pictures and footage of project activities, stakeholder engagement and experimental trials for promotional film		Pictures and footage have been captured from baseline footage and the first experimental trials.	Professional videographer will be engaged in this final quarter of the project.
Activity 4.2 Publish a 2-3 minute video experimental methodology and variables required for analysis, which can be used for further scientific study		The experimental trials have been recorded and a short 2-3 video will be produced.	Professional videographer will be engaged in this final quarter of the project.
Activity 4.3 Promotional film edited and produced using footage captured during the project period.		Experimental trials have been filmed by project staff for potential inclusion in the final promotional film	Professional videographer will be engaged in this final quarter of the project.
Activity 4.4 4 Blog posts/articles written bi-quarterly		1 of 4 blog posts released in October 2022.Blogpost 2 of 4 was published in January 2024.	A further 2 blog posts will be scheduled over the following 5 months.

Annex 2: Project's full current logframe as presented in the application form (unless changes have been agreed)

Project Summary	SMART Indicators	Means of Verification	Important Assumptions
Impact: Reduce reliance on livebait in pole-and-line tuna fisheries through the use of innovative alternatives, thereby enhancing fisheries sustainability, operational efficiency, reduction of carbon footprint and conservation of vulnerable baitfish resources. (Max 30 words)			
Outcome: **Dependency of pole-and-line fisheries in the Maldives on livebait is reduced by developing innovative technologies as an alternative to live bait resources**	0.1 By the end of the project at least three alternatives to livebait have been prototyped and trialled in the Maldivian pole and line tuna fishery. 0.2 By the end of the project at least one developed baitfish alternative is able to elicit a feeding response in tuna significant enough to justify reduced use of livebait. 0.3 By the end of the project, pole and line fishers on the trial vessels are using less livebait to catch similar quantities of tuna resulting from use of developed livebait alternatives.	0.1 Scientific reports and video and photographic evidence of livebait alternatives being trialled in Maldivian pole and line fisheries. 0.2 Significant tuna feeding response recorded and analysed using sophisticated AI-integrated underwater cameras (Helios) 0.3 At-sea observations verify significant reductions in use of live-bait, detailed in a scientific report and communications outputs.	0.1 All important variables are identified and observable. 0.2 stakeholders are willing trust IPNLF to experiment with alternatives, new research published and accessible, experimental inputs are readily available 0.3 live bait alternatives are successful to elicit a sufficient tuna feeding frenzy so that fishermen and stakeholders replicate it on fishing vessels
Outputs: **1**. Observe and document the existing tuna feeding response to live-bait as a control treatment to advance scientific knowledge	1.1 In the first year, at least 20 successful fishing events in which livebait are utilised are recorded and observed using AI integrated underwater cameras to determine a baseline control treatment against which experimental treatments can be compared. 1.2 At least 3 key variables to determine the voracity of tuna feeding response determined in the first year.	1.1 Cameras are procured and installed on the fishing vessel 1.2 Trip reports from each fishing trip **1.3** Observer datasheets with variables and experiments recorded 1.4 AI integrated video is analysed 1.5 Results presented in a scientific report.	1.1. Cameras are able to record every activity 1.2 All the variables are observable and recorded.
2. Develop experimental treatments to test as an alternative to live-bait including innovative use of alternative technologies.	2.1 minimum 3 case studies of existing and new research are identified during desk study 2.2 Experimental treatments using alternative stimuli including LED lights, byproducts of fish processing/artificial bait pods and artificial lures are co-developed with relevant stakeholders	2. desk reports 2.2. procurement reports 2.3 fishing trips, trip reports	2.1 new research is documented and published 2.2 experimental inputs are available for development or procurement

	and LED lights are procured by end of second quarter. 2.3 At least 40 at-sea trials conducted on a pole and line vessel using a combination of programmable LED lights, byproducts of fish processing/artificial bait pods and artificial lures to elicit a feeding frenzy response in tuna over the project period.	2.4 Results presented in scientific report	2.3 stakeholders are willing to trust IPNLF to experiment with alternatives on their vessels
3. Establish standard protocols for testing feeding response in tuna to a range of alternative stimuli that is replicable in commercial tuna fisheries to contribute to scientific methodology.	3.1 By the end of the project, experimental protocols are developed standardised, and recorded in a scientific report 3.2 By the end of the project experimental Protocols are widely shared with stakeholders both in Maldives through stakeholder workshops and abroad through communication outputs (output 4).	3.1 Report is published on IPNLF website and shared with stakeholders 3.2 Results presented in scientific report 3.3 Number of stakeholders validated and replicate the protocol on their vessels	3.2 Stakeholders are willing and interested to read new research on alternatives to livebait 3.3 Stakeholders are receptive to engage with the findings and the protocol
4. Produce video, photographic and written communication outputs to promote project activities and outputs through social media websites and relevant public fora.	4.1 By the end of the project produce at least 4 written articles/blog posts to promote project activities and outcomes. 4.2 By the end of the project an informational video is produced documenting the experimental protocol 4.3 By the end of the project a high-quality promotional film is produced to promote project activities and outcomes. 4.4 Photos and captions regularly posted on IPNLF Maldives and IPNLF social media channels (instagram and facebook)	4.1 Blog posts published 4.2 Informational video published on IPNLF Youtube and promoted 4.3 High quality promotional film published on IPNLF Youtube 4.4 Social Media posts.	

Activities

Activity 1.1. Observe fishing conditions, and baitfish utilisation on commercial Maldivian pole-and-line fishing vessels AI integrated using underwater cameras to capture control conditions.

Activity 1.2 Assess different behaviours of skipjack from underwater footage to determine measures of voracity of feeding response

Activity 1.3 Experiment with different variables in eliciting feeding responses in order to isolate effects of the experiments, record and standardise them

Examples of the variables include: type of fishing event, sea state, visibility, time of day, locality, size of school, stomach fullness at start of event, school interactions and depredation events. The standard methodology will be developed during the experimental design phase.

Activity 2.1 Conduct desk study to compile case studies of new technology and alternative techniques to live-bait in other countries/fisheries

Activity 2.2 In consultation with fisheries stakeholders, codevelop alternative stimuli to livebait which have potential to elicit a feeding frenzy response in skipjack tuna..

Activity 2.3 Test novel alternative external stimuli such as programmable LED lights, byproducts from fish processing/ artificial bait pods and artificial lures to elicit and maintain a feeding frenzy in skipjack schools.

Activity 3.1 Create a report documenting the trials and standard protocols developed in Maldives, and analysing the potential for scalability and impact in low and middle income countries
Activity 3.2 Increase stakeholder buy-in and replication using awareness and communications
Activity 4.1 Throughout project, project staff will capture high resolution pictures and footage of project activities, stakeholder engagement and experimental trials for promotional film
Activity 4.2 Publish a 2-3 minute video experimental methodology and variables required for analysis, which can be used for further scientific study
Activity 4.3 Promotional film edited and produced using footage captured during the project period.
Activity 4.4. 4 Blogposts/articles written bi-quarterly

Annex 3: Standard Indicators

Note: It was difficult to retroactively fit the Darwin Standard Indicators to this Darwin Innovation project. Project partners will reach out to Darwin in the next quarter to see how we can better fit our project indicators to the standard indicator framework.

Table 1 Project Standard Indicators

DI Indicator number	Name of indicator using original wording	Name of Indicator after adjusting wording to align with DI Standard Indicators	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
DIA03	Number of local/national organisations4 with improved capability and capacity as a result of project.	Number of local/national organisations involved in baseline/experimental data collection	Number of organisations	Organisation Type.	2 pole and line vessels 2 Processors providing input National Marine Science Insitute providing support	3 Fishing vessels 2 Processors providing input and logistic support Support from BRIN		11	N/A
DIC01	Number of best practice guides and knowledge products10 published and endorsed11 .	Number of new data collection protocols developed and published	Number	Knowledge area.	0.5 Baseline data collection established	0.5 Experimental protocol developed and being refined		1	1