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Incorporating industry knowledge to understand purse seine effort creep and evolution of fishing strategies in the WCPO

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Executive Summary

Fishery-dependent catch and effort data are critical in underpinning the assessments of tuna stocks and fishery conditions that inform effective management. In the purse seine fishery many things have changed over the last 10-15 years, e.g. technological advances, increased reliance on FADs, and the management arrangements such as the Vessel Days Scheme. The flow on effects of these changes to fishery operations, as they adapt, can have both positive and negative consequences for the fishing operations and the stocks. It is important to understand how fishing operations have changed overtime so that any changes are factored into decisions on how information is gathered, analysed and interpreted to inform management decisions for the good of the stock and fishery.

We developed an industry-based survey complete with 37 questions to better incorporate fisher knowledge into the scientific process related to effort creep and technological change in the tropical tuna purse seine fishery in the western and central Pacific Ocean (WCPO). Due to COVID-19 restrictions, 176 industry contacts were emailed the survey, as opposed to pursuing in-person interviews. We received responses relating to approximately 20+ vessels, as some of the respondents were fleet managers and not individual skippers or fishing masters, which was the original intent. Although the response rate was much lower than we hoped for, the feedback we received offered valuable insight into the changes in the fishery and fishing strategies over time.

There were notable trends in the importance of technologies for sets on fish aggregating devices (FADs) as well as on free-schooling tuna. For FAD sets, vessel-based characteristics and FAD materials were important factors for catch rates 15-20 years ago, but more recently FAD-mounted echosounder buoys were ranked as the most important technology for improving FAD catch rates. For free-school sets, on the other hand, helicopter use has become increasingly important, although it has always ranked high, and remote oceanographic sensing tools has increased in importance over time. In general, the responses suggested an overall reliance on information technology in the contemporary fishery, as opposed to the more physical technologies they relied on a decade or two prior. Looking to the future, it was expected that drones, helicopters, oceanographic and weather monitoring, as well as communication will all be important to fishers. In addition to sharing information about changes in fishing practices, almost all respondents noted concerns over climate change and potential shifts in the distribution of tunas.

Here, we summarize the results from this survey attempt, and note the challenges and limitations that were faced due to the global pandemic. Even so, we have obtained valuable information that can assist in the generation of hypotheses and refining of analyses related to effort creep and fishing efficiency in the purse seine fishery.

We invite the Scientific Committee to:

- note the importance of engaging with the industry on issues of effort creep and enhanced understanding of changes in fishing strategies;
- note the results highlighting the importance of information technologies on perceived catch rates and fishing efficiency; and
- to support future efforts to further engage with the industry in a broader, more comprehensive manner, to develop ways to better define effort, quantify effort creep, and improve modeling efforts aimed at monitoring abundance trends in the purse seine fishery.

1 Introduction

Fishery statistics are an important, and often the primary means, to measure the performance of a fishery, whether it be quantity of harvest, duration of fishing operations and economic costs and returns of fish and the distribution in time and space (Stamatopoulos, 2002). We have therefore worked with the Pacific Islands Regional Fisheries Observer Program, fishing industry, and scientists to develop an exploratory questionnaire aimed at better understanding changes in the purse seine fishery, from an industry perspectives. The questions were intended to provide descriptive summaries of changes in the fishery, especially with respect to the period since implementation of the vessel day scheme (VDS) era, and to aid in the development of more informed hypotheses for statistical modelling. Additionally, the aim is to further engage industry and foster more collaborative approaches associated with potential future research.

The information collected through this survey will potentially address limitations identified in previous work on effort creep in the western and central Pacific Ocean (WCPO) (Vidal et al., 2020), including explaining how fishing behaviours and strategies affect catchability. The survey responses should enhance our understanding of short-term tactical fishing decisions, those which generally influence when and where to fish, and longer term fishing strategies influenced by fuel prices, markets, and status of stocks (Tidd et al., 2017). In addition, enhanced skill and experience of the skipper and crew may be important drivers of catch rates, and yet, we have very little information to quantitatively address such variables with respect to effort creep and standardization of catch-per-unit-effort CPUE for input into stock assessments.

We hypothesized that crew experience, skill sets, and decisions making processes are insufficiently understood when attempting to account for technological advancements. We believe that addressing these important data gaps is essential to further our understanding of CPUE hyper-stability and to more effectively control for effort creep in CPUE standardization models. The survey has been designed to focus on the technology changes on FAD sets and unassociated free school sets. We identify areas considered important for FAD effort distribution by industry and discuss future concerns about the stocks in the WCPO. This report attempts to highlight the industry perspective of the tropical tuna purse seine fishery, the associated management framework, and utilisation of the tuna resource.

2 Method

2.1 Survey design

Quantitative survey preparation often involves a semi-structured interview stage aimed at enhancing questionnaire designs (Jarratt, 1996). It was intended that this survey adopts an interview type approach, where target questions are vetted by industry representatives, trained observers and other related specialists to ensure the appropriateness of questions and design of the survey for

purse seine skippers and fishing masters. These interview methods provide an opportunity to gather new data as a means to explore perceived technology improvements over time in a way that takes into account respondents' knowledge, attitude, perception, and fishing practices.

Due to COVID-19, restrictions subsequently impacted the demographics of the survey participants as it was not possible to conduct in-country face to face interviews. We investigated the possibility of conducting small focus groups in trans-shipment ports by carrying out virtual interviews with skippers while in port. However, given the volatile nature of state controls and scheduling of vessels and crew, such focus groups were not possible. Instead, an email approach to distribute the questionnaire was taken.

Generating the contact list of companies was done with the assistance of the Pacific Islands Forum Fisheries Agency (FFA) vessels of good standing database. A resulting list of 92 registered companies were identified with 176 contact email addresses supplied; contacts spanning the entire 'good standing' fleet. One of the difficulties with the registered contact emails were several accounts had delivery issues, which was considered to be no longer active or invalid accounts for this purposes of this study. A mail merge via Microsoft Word was used to send personalised batch email invitations to companies which had multiple registered contact details. An initial letter was sent on the 7th September 2020, followed by a reminder email sent on the 14th October 2020 indicating the survey link would be closed on the 23rd October 2020. The mail merge email explained how information from the fishing industry is critical in underpinning the assessments of tuna stocks and fishery conditions that inform effective management. Participation was voluntary with surveys administered via the Survey Monkey[2] platform and responses were later downloaded for analysis. It was requested that the registered contacts make practical arrangements to provide the Survey Monkey links to their respective skippers, with information from responses being securely stored on SOC2 accredited data centres that adhere to international security and technical practices as well as SPC privacy standards. This was considered to be important to add a layer of anonymity and privacy to encourage honest responses.

2.2 Survey content

The survey included 37 questions in total, the full survey can be viewed in the Appendix. Questions ranged from general demographics including current position held within the industry, years of experience fishing in the purse seine sector, and the number of vessels in the company's fleet to specifics about which technologies have been most important for FAD and free-school sets over time, how do perceived FAD densities influence their fishing strategies, most influential oceanographic variables, and concerns about future management and environmental variability. Most questions were multiple choice or drop-down style responses, with options to write in custom responses when applicable. These data were intended to cover aspects of the fishery that may be challenging to gauge from logsheet or observer data alone, and were intended to inform not only our interpretation and modeling of the data we have, but to consider how modifications to data collection procedures could be modified or supplemented in the future.

[2]https://www.surveymonkey.com

3 Results

3.1 Characteristics of respondents

In total, we received completed surveys from 11 respondents by the 23rd October 2020 deadline. 45% of the respondents were identified as fleet managers and 54% identified as being 'other' comprising of either fleet manager assistants or having some form of at-sea observer experience. It was estimated that this sample is representative of approximately 20+ purse seine vessels operating in the WCPO, based on the number of vessels individual fleet managers and assistants were representing. The level of fishing experience within the respective role of the respondents varied from 0 years to over 12 years of service; however, only 55% of the respondents had registered fishing experience on a purse seiner. Eighty percent of the respondents identified their respective fleets as having a range of 0-4 vessels, indicating that these were relatively small companies compared to the remaining 20% of the respondents that indicated 6+ vessels operating in their fleets (i.e a medium to large company in the context of this survey). The size of fleets and communication among the vessels could offer significant advantages in the modern fishery as satellite communication capabilities have been greatly enhanced. Approximately 60% of the respondents indicated that they share information about productive fishing areas with other vessels within their overarching company, while only 30% share information with vessels from other companies.

As indicated in the demographics, most of the respondents were fleet managers or assistants, and therefore, their responses likely represent general trends across the vessels in the fleets they are associated with. Therefore, individual vessel size is not known, but when asked about the processing capabilities per day, responses ranged from 10 mt of fish to 350 mt, with about 67% of the responses indicating 200 mt or more and 33% indicating 350 mt. Two responses suggested a daily capacity of less than 50 mt.

3.2 Fishing technologies

The role of technology is perceived as one of the greatest changes and potential sources of efficiency gains within the purse seine fleet. When asked about the technologies or tools that have been most important through time (in 5 year time blocks ranging from 2000-2020) for FAD fishing and improving catch rates for FAD sets, there was a notable shift from physical characteristics perceived as most important in the early part of the time series (e.g. vessel horsepower, winches, FAD materials, and net configuration) to more information-based technologies including oceanographic sensing tools and FAD-mounted echo-sounders (Figure 1). Over the last 15 years, the use of echo-sounder FAD buoys was rated as the most important technology, followed by a mixture of tools/technologies with relatively equal weight.

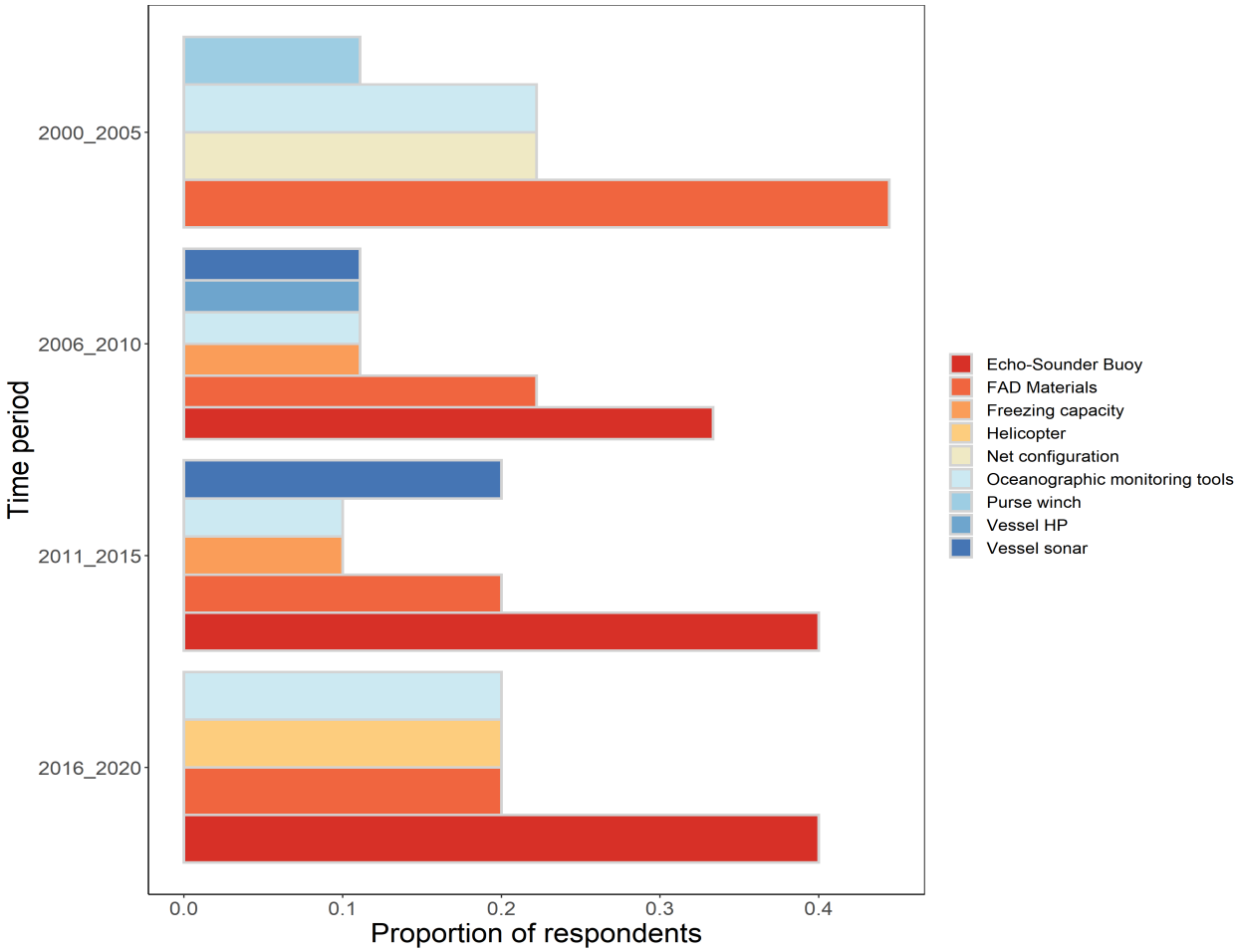

Figure 1: Tools/technologies/information have been most important for improving catch rates through time for FAD sets

3.2.1 FAD set fishing

With respect to FAD fishing in the WCPO, the current Tropical Tuna Measure (paragraph 23[3]) restricts the number of FADs with activated instrument buoys that can be monitored at any given time per vessel; however it does not restrict the number of FADs deployed nor does it provide incentives for vessels to retrieve deployed FADs. There have been questions regarding the relevance and efficacy of that limit as sufficient FAD monitoring have not yet been available fully evaluate that measure. Recently, Escalle et al. (2021) estimated that on average vessels are monitoring about 50 FADs, with the vast majority monitoring fewer than 150 and most monitoring 25-75. Almost no

[3]A flag CCM shall ensure that each of its purse seine vessels shall have deployed at sea, at any one time, no more than 350 drifting Fish Aggregating Devices (FADs) with activated instrumented buoys. An instrumented buoy is defined as a buoy with a clearly marked reference number allowing its identification and equipped with a satellite tracking system to monitor its position. The buoy shall be activated exclusively on board the vessel. A flag CCM shall ensure that its vessels operating in the waters of a coastal State comply with the laws of that coastal State relating to FAD management, including FAD tracking.

vessels monitored close to the limit of 350 FADs.

The responses from this survey indicated that fleets were deploying less FADs per year on average; with 10% of fleets deploying between 200-350+ FADs per year from 2000-2010 and later deploying less than 200 FADs per year from 2011-2020. There was a notable increase (40% to 60%) in respondents indicting they were deploying less than 50 FADs on an annual basis between 2000-2020. Overall FAD use in the WCPO has increased since the 1990s, with sets on FADs surpassing sets made on natural logs and in particular a sharp increase with the use of FADs over the past decade. This is linked to new technologies such as satellite buoys and more recently echo-sounder satellite buoys (Escalle et al., 2020). This may suggest that some fleets are investing in small numbers of FADs with technology which allows the ability to estimate the quantity of tuna aggregated beneath the FAD rather than large quantities of less advanced FADs, noting this small dataset appears to be in contrast to the literature. The survey also investigated the relationship between the distance vessels are willing to steam to FADs and the known biomass which aided in the decision making process for fishers. Satellite buoys were considered to be revolutionary in the sense that it allowed fishers to keep track of FADs in real time and at great distances (Torres-Irineo et al., 2014) . This ability was further amplified by attaching satellite-linked echo-sounder buoys which has improved efficiencies by informing fishers as to which FADs might have large fish biomass beneath them to justify further investigation (Dagorn et al., 2013). This is supported with 50% of respondents indicating that high biomass on FAD echo-sounder, increasing biomass shown on FADs echo-sounder and sea conditions being the top three considerations given to the decision to investigate.

Satellite-linked buoys were an early, but powerful technology, and 30% indicated they had adopted this technology by 2000. The remaining respondents incorporated this technology between 2001 and 2011 at which point 100% were using satellite buoys. Over the past two decades or so there has been a notable increase in the use of echo-sounders on FAD buoys to relay real-time information about relative biomass below a FAD along with the specific GPS location. According to the respondents, adoption of this technology was gradual, spanning 2000-2016, with 35% adopting it by 2014. More recently, fishers have begun using dual and multi-frequency echo-sounders to better predict the species composition of the biomass below a FAD (70% are currently using multi-frequency buoys). When asked how many echo-sounder buoys a vessel was deploying through time, the proportions didn't change substantially, but there appeared to be a minor switch from deploying more (50-100/year range) in the earlier part of the time series, to generally deploying less than 50 per year (40% of responses), with 30% deploying 50-100 per year and 10% deploying 100-200 per year. Relative to the participants' ability to determine species composition of a set prior to setting the net, the responses were quite varied ranging from 5% confidence to 90%, with an average confidence level at abut 44%.

3.2.2 Unassociated free school set fishing

For free-school sets the results suggested that helicopter use has been one of, if not the most important factors for improving free school catch rates through time (Figure 2). Interestingly, the

use of land-based analysts was indicated as being more important in years past than in recent years. We hypothesized that land-based analysts have become increasingly important, so this result was surprising. Many of the same technologies have been relatively important over the entire time series, including vessel sonar, vessel horsepower, purse winches, and net configuration, but increasingly respondents indicated that oceanographic monitoring tools have become the second more important tool for free school sets in recent years. There were a couple responses that suggested FAD materials and echo-sounder buoys were important. It is unclear whether these responses stem from confusion regarding the questions, an error in the response, or if FAD-related tools do in fact influence decisions surrounding free school setting strategies and ultimately catch rates.

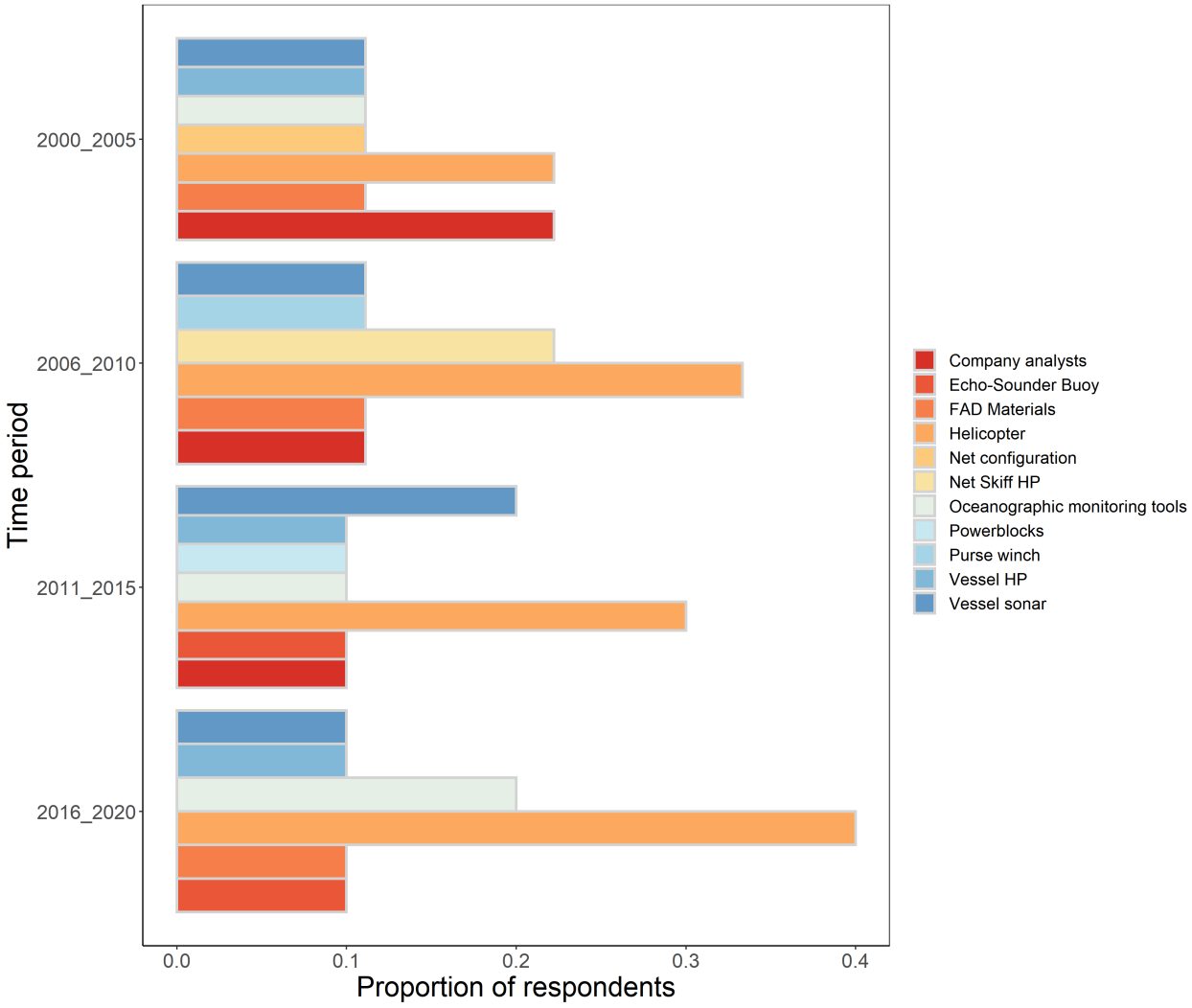

Figure 2: Tools/technologies/information have been most important for improving catch rates through time for free-school sets

Generally, fishers indicated that despite advances in technology, their search time for free schooling tunas has either increased or stayed the same (40% each), while only 20% believe it has decreased

over time. This was surprising, as given the advances in oceanographic sensing software, more sophisticated bird radars and sonars, and enhanced communication with other vessels, one might think that search times would have been reduced over time, but that has not been the experience of the survey respondents. Meanwhile, 50% suggested that the time to locate a productive FAD has been reduced, whereas only 30% said it has increased. Efficiency of harvest is a combination of locating and then harvesting tuna school. Harvest success rate for FAD sets is relatively high, about 75-80% on average; however the success rate for free school sets is only about 50%, and hasn't shown substantial change over time. When asked about the factors contributing to sets where zero catch or low value catch was recorded (i.e. failed or 'skunk' sets in the context of this survey), the majority of fleets indicated that fish movement was the primary factor followed by oceanographic conditions, in particular the sea currents and the effectiveness of gear deployed. Fishing master experience and moon phase were also identified by some fleets as important factors.

3.3 Spatial distribution of effort

Through time, there has been an increase in the reliance on FAD-fishing, and along with that reliance there has been an increase in the deployment of man-made fish aggregating devices (Escalle et al., 2021). As a result, we were interested to know whether changes in drifting FAD dynamics have changed the spatial distribution of individual vessel behavior. When asked about where FAD-related fishing effort has been concentrated over time, there was little contrast. Most respondents indicated that A3 is where most of their current and more historical FAD effort has been directed, followed by A4 and A2 (Figure 3). These behaviors are not surprising, as many of the drifting FADs are deployed in the east and then subsequently drift westward, with A3 largely representing the center of the spatial domain of the fishery. It seems with increased deployments, the spatial distribution of effort has not been impacted.

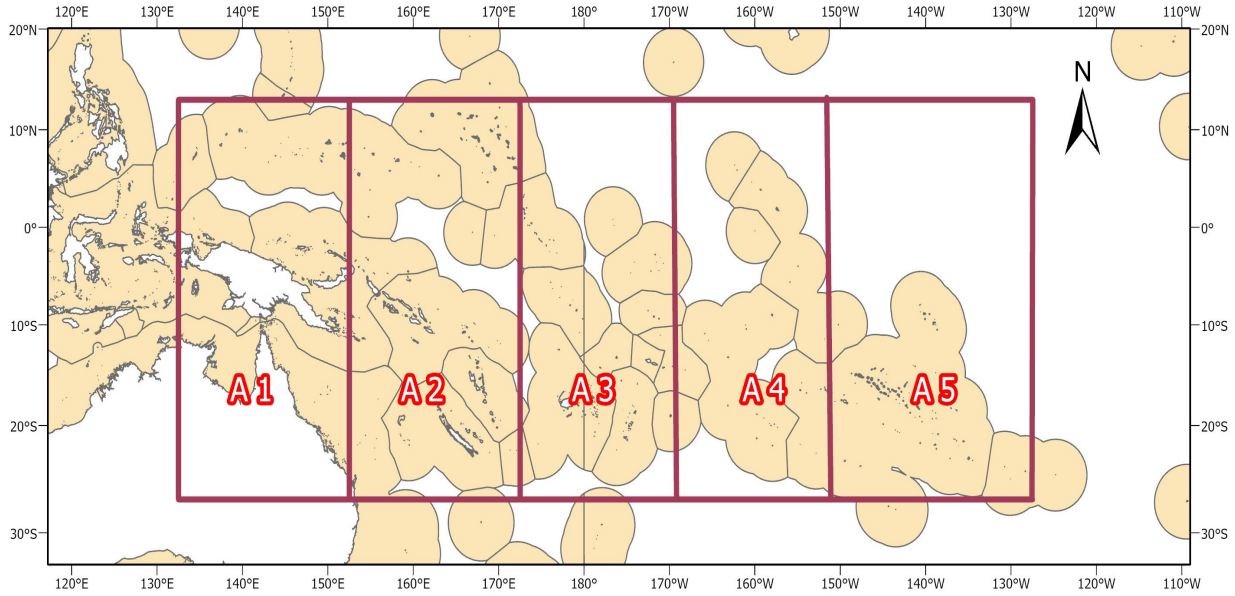

Figure 3: Regional Map showing sub zones for FAD use

There has been conflicting anecdotal evidence that fishers perceive FAD density differently. Whereas some fishers think high FAD density is advantageous, others maintain that there is a threshold above which FAD density may be too high. We were curious about the broader fleet's perceptions. It should be noted that FAD density is difficult to estimate for both fishers and scientists. The question was posed, in what we hope, was a meaningful context. We asked how likely (with four categories ranging from 'Not at all' to 'Might fish' to 'Likely to fish', with an 'Unsure' option) fishers were to fish an area where 1 FAD is encountered within 20 miles, 15 miles, and 10 miles. 60% were *likely to fish* the low FAD density area, with 10% indicating they "would not" or "might fish". At higher FAD densities, 50% were *likely to fish*, while there was increase (40%) in those that were *unsure*.

There was a positive correlation between increasing biomass under FADs and the level of risk fishers would take to investigate a FAD with increasing distance. Figure 4 shows that from their current vessel position, 100% of respondents are likely or would definitely investigate FADs showing some level of tuna biomass aggregating beneath it. There was however some caution with 37% of respondents not wanting to investigate FADs which were between 15-50nm from current vessel position with less than 10 tonnes of tuna aggregating beneath it. In contrast, 71% of fleets would definitely investigate FADs which indicated 50+ tonnes of tuna at the same distance. As distance increased, variability among responses also increased with 50% of respondents not wanting to investigate FADs with less than 10 tonnes of tuna where FADs were 50+nm from the vessel's current position. There was a slight decrease in the number of fleets (62%) that would definitely investigate FADs with 50+ tonnes of tuna at 50-100nm distance. When asked about FADs which were 100+nm from current vessel position, 42% of respondents would definitely investigate FADs which showed biomass between 50-100 tonnes of tuna however this proportion

of respondents increased to 72% if 100+ tonnes of tuna was present. Overall it appeared that the distance respondents were willing travel increased with the biomass estimated from the FAD.

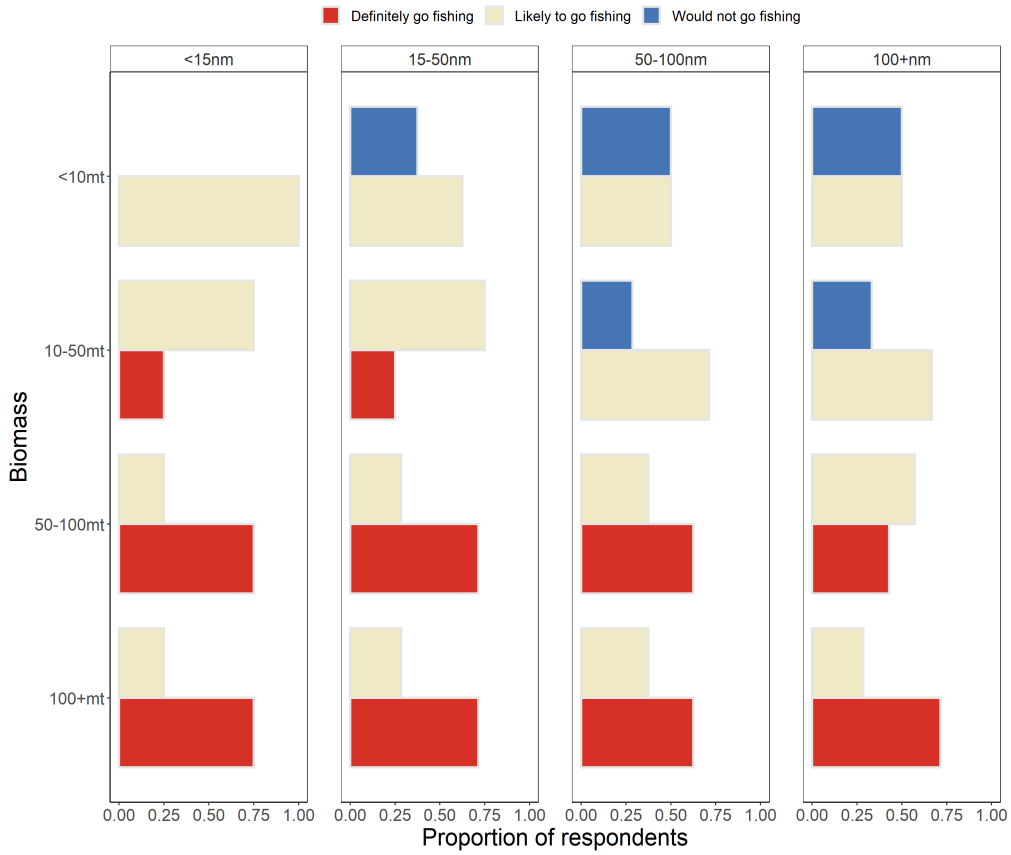

Figure 4: Distance respondents would travel to make a set on a FAD based on the associated biomass estimate.

Oceanography can influence the distribution and densities of tunas. It is well established that the El Niño Southern Oscillation (ENSO) can shift the distribution of tropical tunas along an east-west gradient as the location of the important convergence zone between colder waters upwelled from the east and the western warm pool moves (Lehodey et al., 1997; Yen et al., 2017). Survey participants were asked about which environmental factors are most important in predicting locations of productive fishing grounds. The responses were largely mixed, without any one factor standing out as being significantly more important than the others, and included temperature, phytoplankton concentrations, sea surface conditions and height, time of the day, and ENSO phase. Another factor indicated was the known bathymetry with seamounts being important for conducting both the biological and physical patchiness from the surrounding ocean that provide suitable environment for schools of tuna. Boehlert and Genin (1987) conducted three hydrographic surveys in the northwest Pacific, which found that the seamounts had associated concentrations of chlorophyll and cooler temperature domes were observed around seamounts. The higher levels of chlorophyll resulted in high phytoplankton and zooplankton densities around seamount tops which is consistent to environmental conditions considered important by fleets. 75% of the respondents

indicated that they currently have the tools to monitor the environmental variables of importance to them, whereas those that didn't indicated more advanced electronics are desired.

3.4 Landing port

How fishers decide which ports to land at and which to avoid can influence transit times and fuel consumption, as well as costs and availability of goods and services. The survey results indicated that 60% of respondents indicated proximity to the fishing grounds as most influential factor followed by transshipment facilities and port fees and port facilities being influential factors. Seto et al. (2020) support this result with the article indicating that at-sea transshipment extensively occurs in the WCPFC, with activity concentrated in the tropical region to allow vessels to remain in the fishing grounds for longer periods and supports having close proximity to the fishing grounds. This may justify why the majority of fleets indicated close proximity as being the most important factor when considering transshipment ports. Seto et al. (2020) also explains that where in-port transhipment activity occurs, vessels are subject to strict rules and regulations of coastal or port states as well as inferred transshipment costs which appears to also have weighted influence on the decision to trans-ship in ports. Other factors were identified as important when a deciding to come to port, including the need to replenish food stock supplies, onshore stevedores availability and family or partners present in particular ports.

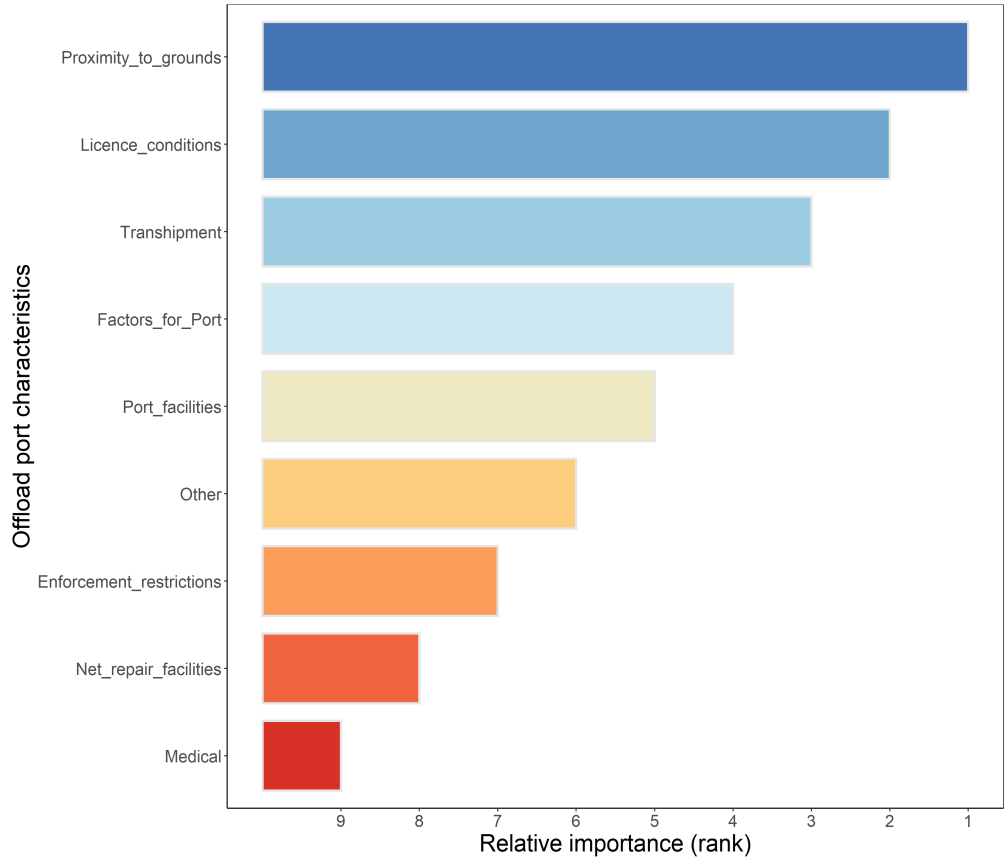

Figure 5: Factors are most important when choosing a port to offload catch

3.5 Future of the fishery

When asked about the future of the fishery, and which technologies respondents perceived would be most important, the majority indicated information technologies. Drones and helicopters were expected to be important search tools, while sonar, weather and oceanographic monitoring tools, and information sharing were all highlighted as top factors in addition to the continuation of FAD fishing. Second-tier variables focused largely on FADs and FAD technologies, but licensing arrangements were also reported as being important. Lastly, there was mixture of gear mounted electronics, helicopters, and communication with land-based analysts as the third-tier of important factors when looking to the future of purse seine fishing. With respect to the environment, almost all the participants raised concerns over climate change and shifting distributions of tunas, while one raised concern over the ecological impacts of non-biodegradable FADs.

The remaining questions focused on future concerns of the fishery. There was a juxtaposition of opinions with regard to future concerns with tuna stocks in the WCPO, with several fleets having little to no concern, one respondent indicated that there was "too much stock", while other fleets expressed the need to monitor the stocks that were under threat, including enhanced data collection programs to better inform science and management. Here, the responses varied ranging

from too much stock available and a dissatisfactions with the VDS pricing framework, while others expressed concerns about needs to increase catch rates to compensate for rising costs. Still others expressed concerns of overcapacity in the fishery, and a desire to raise fees in an effort to reduce participation. When asked specifically about how the VDS has changed their fishing practices, the overwhelming response was that the VDS has encouraged, and even necessitated increases in efficiency due to the costs of fishing days, as well as the spatial restrictions. Vessels must more intentionally target productive fishing grounds, and some indicated that there is a need to conduct more sets within a fishing day, while some expressed concerns over costs and the challenges with recovering those costs through catch revenue.

4 Discussion

The intention of this industry survey was to better understand changes in the purse seine fishery over time from the industry's perspective. It is not possible to collect complete information on fisher dynamics, as the decision making process is inherently variable and often unmeasurable. We can however, strive to build better collaborations with industry and incorporate their first-hand knowledge of the fishery dynamics to better inform how we model, interpret, and ultimately use fishery-dependent data to assess and manage tropical tuna stocks. An important aim of this survey was to better understand the main tools and technologies that have influenced fishing efficiency over time, for both free school and FAD/associated sets. Overwhelmingly, there appeared to be a shift from more physical vessel-based tools and characteristics towards information/technology based tools. In the early part of the time series we have evaluated, things like vessel horsepower and purse winches were important factors for fishing efficiency, whereas most recently there is heightened importance of oceanographic monitoring and FAD-mounted echo-sounder buoys. Interestingly, there appeared to be less reliance on land-based analysts as compared to the 2000s, perhaps an indication that fishers themselves have become more adept at using the advanced technologies that inform their fishing decisions.

The underlying interest in more fully understanding the factors that fishers perceive as affecting their fishing efficiency is to more appropriately standardize CPUE trends to account for changes in effective effort over time, and to better evaluate effort creep as it related to the effort-based management regime. To the first objective, the data obtained here offer some new insights and confirm others. Specifically, the developments in FADs and FAD fishing were almost universally important, with the use of echo-sounder FAD technology weighted heavily. It was noted here that 70% of respondents are already using multi-frequency echo-sounder buoys, a tool that should further help fishers elucidate species composition and more effectively direct their efforts to tuna schools. It may be possible to further use this technology to discriminate tunas with (bigeye and yellowfin) and without a swim bladder (skipjack), as those signals have been reliably differentiated in a previous study (Moreno et al., 2019). Not only may this technology improve fisher productivity, it could also be used to avoid unwanted bycatch. The harvest of juvenile bigeye and to a lesser degree yellowfin in FAD sets is a priority management concern, especially as those stocks have declined over the past couple decades (Ducharme-Barth et al., 2020; Vincent et al., 2020). It may be

possible to adjust effort in a stepwise or incremental fashion, based on relative importance and relative efficiency of different technologies. These types of surveys assist in those decisions, and will help to guide quantitative assessments.

In addition to reconsidering how to use the data we already have, important research questions have been identified through the industry input. Specifically, fishers have indicated that FAD density affects their catch rates, and was also noted in their willingness to fish certain areas. Having said that, there appears to be a general decline or leveling off of FAD deployments and not a continual increase. This observation could be directly related to costs, as fully-equipped FADs can costs tens of thousands of USD per unit, but it may also be that there is a threshold of FADs, per vessel that is no longer feasible or beneficial to monitor. It will be imperative in the coming years to improve FAD data collection to better understand how FAD density influences fishing effort and catch rates, and also tuna behaviour. FAD echo-sounder data may serve as a valuable data source, not only for when sets are made, but also while drifting around the Pacific. Developing a pathway for these data to be made available to scientists would have great benefit.

With respect to free school fishing, better monitoring of oceanographic conditions has increased in importance, likely in relation to the increased quality and availability of monitoring tools and software. This is an important area of research, not just for understanding fisher behavior in response to the environment but to also better understand how the environment influences tuna behavior, relative density, and population dynamics (e.g. recruitment). Although much focus has been directed to FAD fishing, given the relatively rapid advancements, it should be noted that free school harvest still comprises about half of the purse seine landings in the WCPO. This is in contrast to some of the other oceans where FAD fishing makes up the overwhelming majority of fishing effort and landings (Floch et al., 2019). In response to how the management regime has altered fishing practices, it was indicated that vessels are making more sets per day. There is obviously an upper limit on what is possible, but it should be noted that there is typically only one FAD set made per day (pre-dawn) followed by subsequent free school sets. Therefore, if fishers are able to make substantial efficiency gains on free school sets in addition to FAD sets, it could represent a dramatic impact on the resource.

Gavaris (2009) explains how poor fisheries management practices may favour immediate economic, social or cultural benefits at the expense of longer term conservation. The survey responses regarding stock status and attitudes towards the management framework seemed to highlight a disconnect between the assessment and management advice and fleet managers' perspectives. This potentially suggests that awareness to scientific information fishery managers rely on for developing conservation management measures is not extended to fishers who have an important and direct role in the sustainability of tuna stocks. Achieving economically viable and ecologically sustainable fisheries requires an understanding of the role fishers play with respect to ecosystem dynamics and fishery production. Salomon et al. (2011) suggests that there is general agreement between fishery managers and fishers on the overall status of fish stocks (overfishing is not occurring, stocks are not to be overfished, reduction in bycatch and habitat impacts) however there appear to be disputes over specific objectives and how best to achieve them. This is evident with fishing fleets raising concerns with increasing licensing conditions, fees and thus making the fishery too restrictive and costly to operate. Bridging this divide can aid in the illumination of the

process and navigate the trade-offs between competing interests for sustainable food security for the resource owners and profitable margins for those that fish it.

5 Conclusion

This survey has provided us with some valuable insight into the dynamics of the WCPO purse seine fishery over the past 20 years. The response rate was much lower than we would have liked and the demographics of the survey respondents was not necessarily the target. There have been many challenges and unexpected consequences of the global pandemic, and therefore we had to adapt to what was possible given the tremendous logistical constraints we faced with such an endeavour. It is our hope and intention to more fully explore these broad questions about the fishery dynamics and to attempt to engage with fishers directly, once such opportunities are safe and available. It seems there is an important bidirectional need to engage with the industry, with potentially mutual benefits to be realized from greater communication and collaboration.

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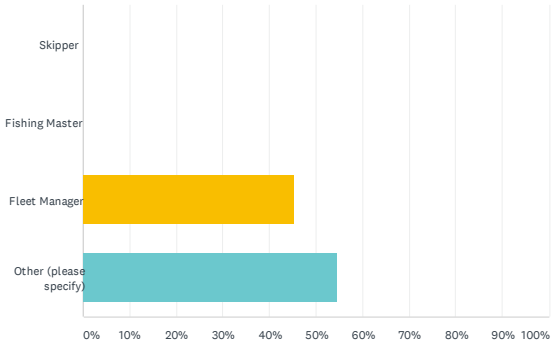
7 Appendix

The survey administered to the fishing industry is provided below for reference.

Industry interview program to understand purse seine effort creep and evolution of fishing strategies

Q1 What position do you currently hold?

Answered: 11 Skipped: 0

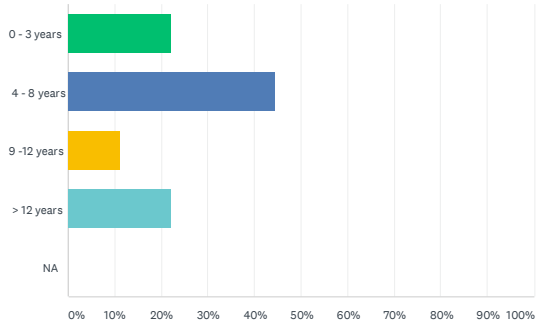


ANSWER CHOICES	RESPONSES	
Skipper	0.00%	0
Fishing Master	0.00%	0
Fleet Manager	45.45%	5
Other (please specify)	54.55%	6
TOTAL		11

#	OTHER (PLEASE SPECIFY)	DATE
1	Staff	10/14/2020 12:20 PM
2	fleet manager assistant	10/5/2020 1:58 PM
3	fleet manager assistant	10/5/2020 1:48 PM
4	Observer	6/19/2020 2:07 PM
5	Fisheries Observer Manager (former Observer/Debriefer/Trainer)	6/4/2020 3:44 PM
6	Obsever Trainer	6/4/2020 2:47 PM

Q2 How long have you worked on a purse seine fishing vessel in this position?

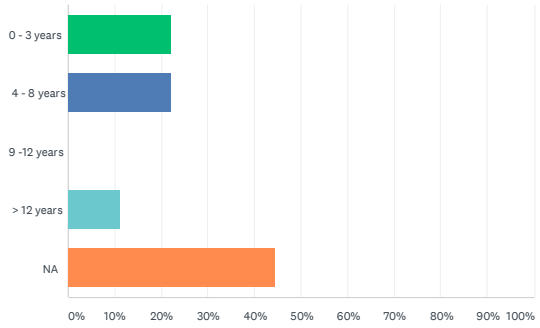
Answered: 9 Skipped: 2



ANSWER CHOICES	RESPONSES	
0 - 3 years	22.22%	2
4 - 8 years	44.44%	4
9 -12 years	11.11%	1
> 12 years	22.22%	2
NA	0.00%	0
TOTAL		9

Q3 How long have you been fishing on a purse seiner, in any role?

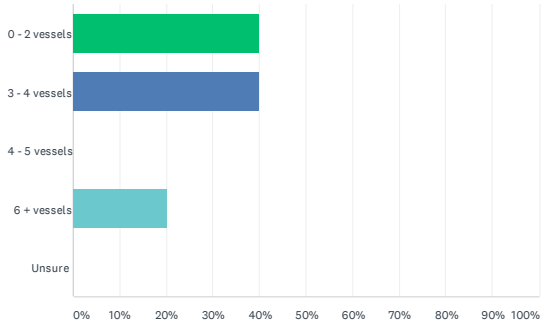
Answered: 9 Skipped: 2



ANSWER CHOICES	RESPONSES	
0 - 3 years	22.22%	2
4 - 8 years	22.22%	2
9 -12 years	0.00%	0
> 12 years	11.11%	1
NA	44.44%	4
TOTAL		9

Q4 How many vessels, operating in the WCPO, are owned by the company that owns the vessel that you fish on?

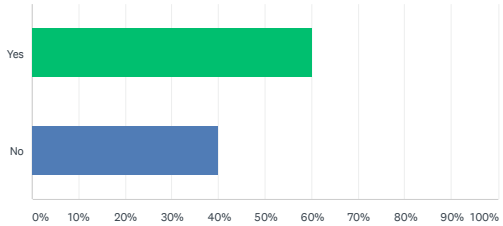
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
0 - 2 vessels	40.00%	4
3 - 4 vessels	40.00%	4
4 - 5 vessels	0.00%	0
6 + vessels	20.00%	2
Unsure	0.00%	0
TOTAL		10

Q5 Do you share information about the location of productive fishing areas for tuna with other vessels from your company?

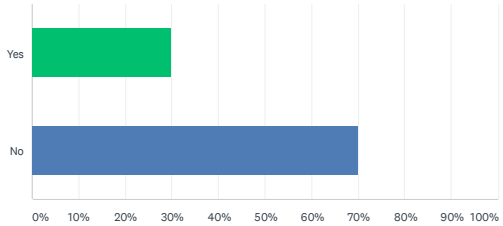
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	60.00%	6
No	40.00%	4
TOTAL		10

Q6 Do you share information about the location of productive fishing areas for tuna with vessels from other companies?

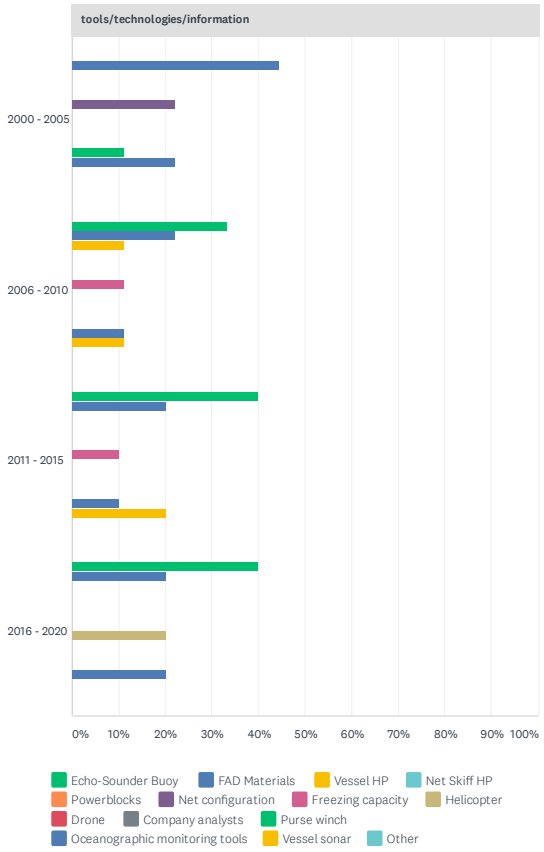
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	30.00%	3
No	70.00%	7
TOTAL		10

Q7 Which tools/technologies/information have been most important for improving catch rates through time for FAD sets? Please indicate one tool for each period

Answered: 10 Skipped: 1



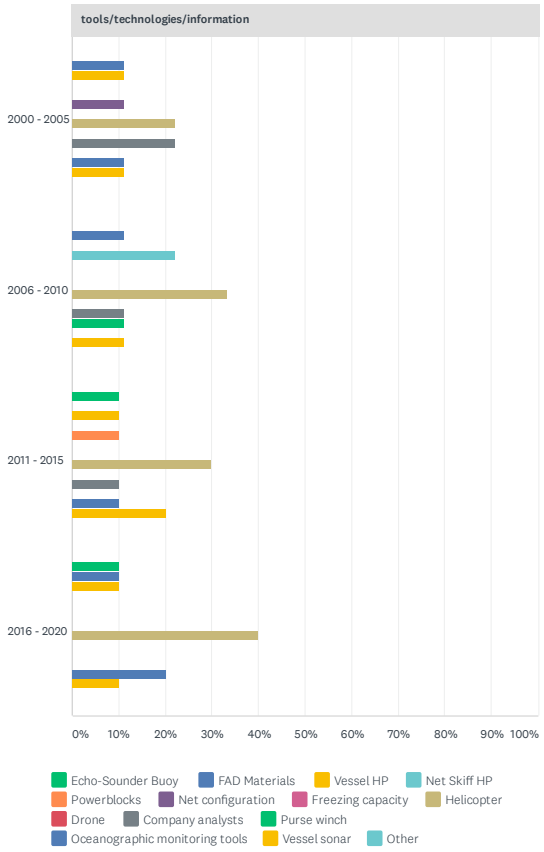
tools/technologies/information

	ECHO-SOUNDER BUOY	FAD MATERIALS	VESSEL HP	NET SKIFF HP	POWERBLOCKS	NET CONFIGURATION	FREEZING CAPACITY	HELICOPTER	DRONE	COMPANY ANALYSTS	PU WI
2000 - 2005	0.00% 0	44.44% 4	0.00% 0	0.00% 0	0.00% 0	22.22% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	11.
2006 - 2010	33.33% 3	22.22% 2	11.11% 1	0.00% 0	0.00% 0	0.00% 0	11.11% 1	0.00% 0	0.00% 0	0.00% 0	0.
2011 - 2015	40.00% 4	20.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	10.00% 1	0.00% 0	0.00% 0	0.00% 0	0.
2016 - 2020	40.00% 4	20.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	20.00% 2	0.00% 0	0.00% 0	0.

#	OTHER (PLEASE SPECIFY)	DATE
1	Information from friends from different nationalities (between Captains or Masters)	6/4/2020 3:44 PM

Q8 Which tools/technologies/information have been most important for improving catch rates through time for free school sets? Please indicate one tool for each period

Answered: 10 Skipped: 1



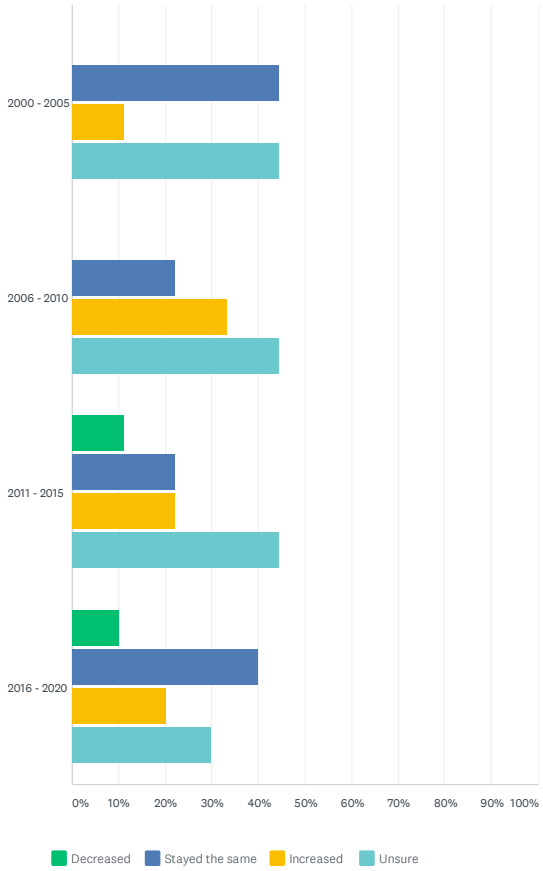
tools/technologies/information

	ECHO-SOUNDER BUOY	FAD MATERIALS	VESSEL HP	NET SKIFF HP	POWERBLOCKS	NET CONFIGURATION	FREEZING CAPACITY	HELICOPTER	DRONE	COMPANY ANALYSTS	PU WI
2000 - 2005	0.00% 0	11.11% 1	11.11% 1	0.00% 0	0.00% 0	11.11% 1	0.00% 0	22.22% 2	0.00% 0	22.22% 2	0
2006 - 2010	0.00% 0	11.11% 1	0.00% 0	22.22% 2	0.00% 0	0.00% 0	0.00% 0	33.33% 3	0.00% 0	11.11% 1	11
2011 - 2015	10.00% 1	0.00% 0	10.00% 1	0.00% 0	10.00% 1	0.00% 0	0.00% 0	30.00% 3	0.00% 0	10.00% 1	0
2016 - 2020	10.00% 1	10.00% 1	10.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	40.00% 4	0.00% 0	0.00% 0	0

#	OTHER (PLEASE SPECIFY)	DATE
1	Information from friends from different nationalities (between Captains or Masters)	6/4/2020 3:44 PM

Q9 How has your helicopter use changed through time?

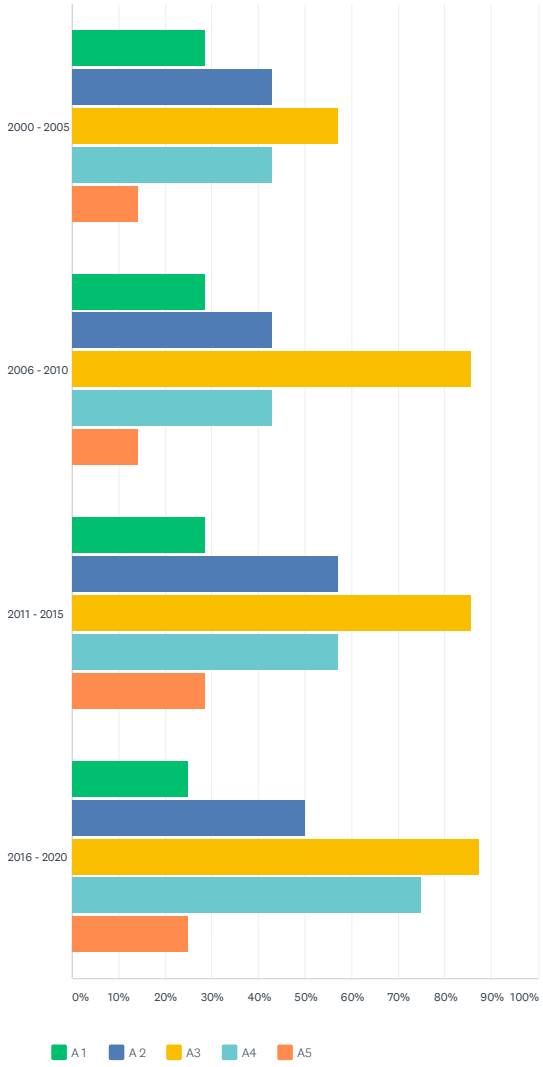
Answered: 10 Skipped: 1



	DECREASED	STAYED THE SAME	INCREASED	UNSURE	TOTAL
2000 - 2005	0.00% 0	44.44% 4	11.11% 1	44.44% 4	9
2006 - 2010	0.00% 0	22.22% 2	33.33% 3	44.44% 4	9
2011 - 2015	11.11% 1	22.22% 2	22.22% 2	44.44% 4	9
2016 - 2020	10.00% 1	40.00% 4	20.00% 2	30.00% 3	10

Q10 Which zone(s) were you fishing FADs through time? (refer to map below, tick more than one zone where applicable)

Answered: 8 Skipped: 3



	A 1	A 2	A3	A4	A5	TOTAL RESPONDENTS
2000 - 2005	28.57% 2	42.86% 3	57.14% 4	42.86% 3	14.29% 1	7
2006 - 2010	28.57% 2	42.86% 3	85.71% 6	42.86% 3	14.29% 1	7
2011 - 2015	28.57% 2	57.14% 4	85.71% 6	57.14% 4	28.57% 2	7
2016 - 2020	25.00% 2	50.00% 4	87.50% 7	75.00% 6	25.00% 2	8

Q11 Which tools/technologies/information do you think will influence your fishing in the future?

Answered: 10 Skipped: 1

ANSWER CHOICES	RESPONSES	
1	100.00%	10
2	30.00%	3
3	30.00%	3
Other	10.00%	1

#	1	DATE
1	FAD	10/16/2020 3:29 PM
2	Helicopter	10/14/2020 12:20 PM
3	Weather and Sea technologies	10/14/2020 11:59 AM
4	share information	10/13/2020 1:56 PM
5	sonar	10/5/2020 1:58 PM
6	sonar	10/5/2020 1:48 PM
7	Fad fishing	9/30/2020 6:36 PM
8	Drones	6/19/2020 2:07 PM
9	Oceanographic monitoring tools	6/4/2020 3:44 PM
10	Oceanic Environment features	6/4/2020 2:47 PM

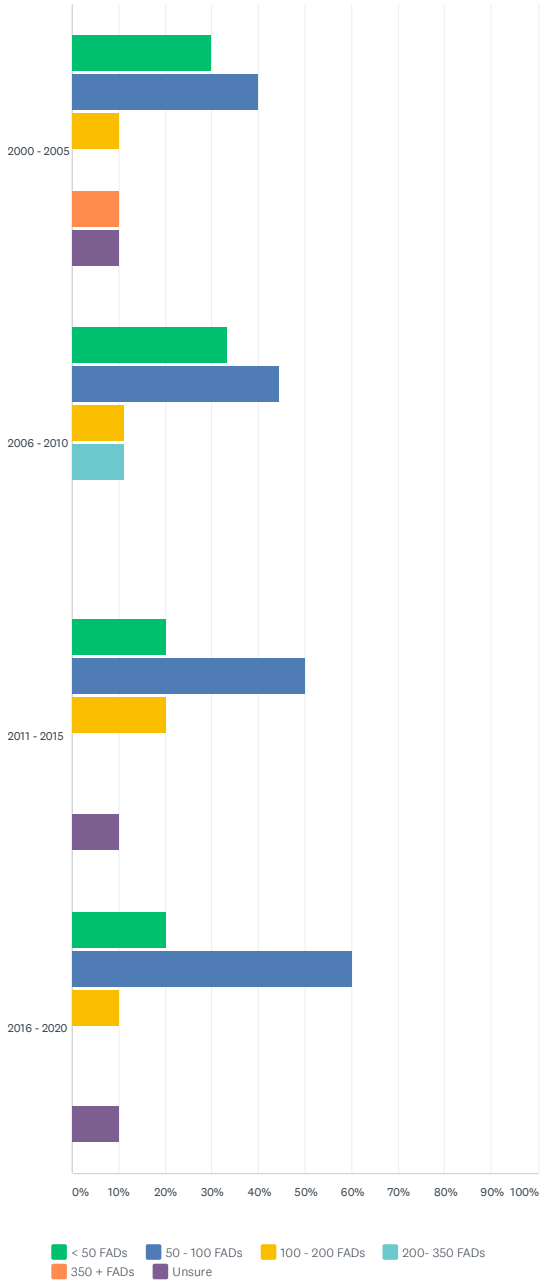
#	2	DATE
1	FADs	6/19/2020 2:07 PM
2	Echo-Sounder Buoy	6/4/2020 3:44 PM
3	Licensing arrangements	6/4/2020 2:47 PM

#	3	DATE
1	Helicopters	6/19/2020 2:07 PM
2	Company Analysts	6/4/2020 3:44 PM
3	Fishing gear & electronics technologu	6/4/2020 2:47 PM

#	OTHER	DATE
1	Verbal communication (use of satellite phones, radios, etc)	6/4/2020 3:44 PM

Q12 How many FADs were your vessel deploying per year during these periods?

Answered: 10 Skipped: 1

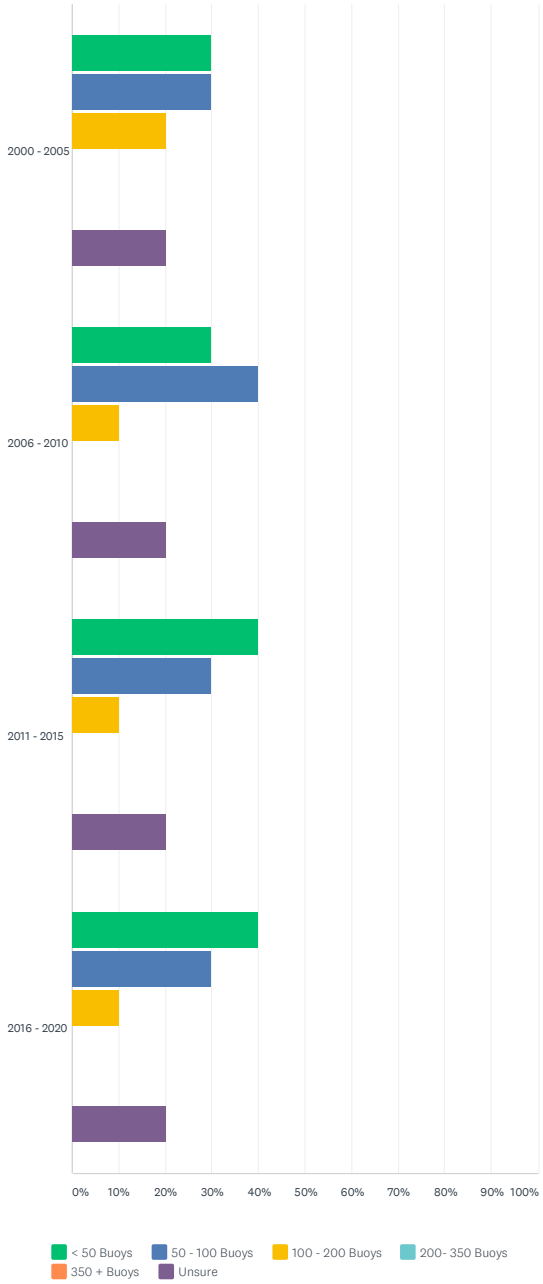


Industry interview program to understand purse seine effort creep and evolution of fishing strategies

	< 50 FADS	50 - 100 FADS	100 - 200 FADS	200- 350 FADS	350 + FADS	UNSURE	TOTAL
2000 - 2005	30.00% 3	40.00% 4	10.00% 1	0.00% 0	10.00% 1	10.00% 1	10
2006 - 2010	33.33% 3	44.44% 4	11.11% 1	11.11% 1	0.00% 0	0.00% 0	9
2011 - 2015	20.00% 2	50.00% 5	20.00% 2	0.00% 0	0.00% 0	10.00% 1	10
2016 - 2020	20.00% 2	60.00% 6	10.00% 1	0.00% 0	0.00% 0	10.00% 1	10

Q13 How many echo-sounder buoys were your vessel deploying per year during these periods?

Answered: 10 Skipped: 1

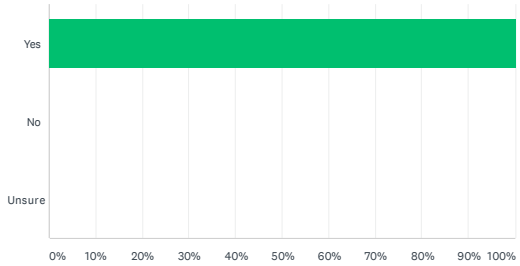


Industry interview program to understand purse seine effort creep and evolution of fishing strategies

	< 50 BUOYS	50 - 100 BUOYS	100 - 200 BUOYS	200- 350 BUOYS	350 + BUOYS	UNSURE	TOTAL
2000 - 2005	30.00% 3	30.00% 3	20.00% 2	0.00% 0	0.00% 0	20.00% 2	10
2006 - 2010	30.00% 3	40.00% 4	10.00% 1	0.00% 0	0.00% 0	20.00% 2	10
2011 - 2015	40.00% 4	30.00% 3	10.00% 1	0.00% 0	0.00% 0	20.00% 2	10
2016 - 2020	40.00% 4	30.00% 3	10.00% 1	0.00% 0	0.00% 0	20.00% 2	10

Q14 In your opinion, does the number of FADs in an area influence catch rates?

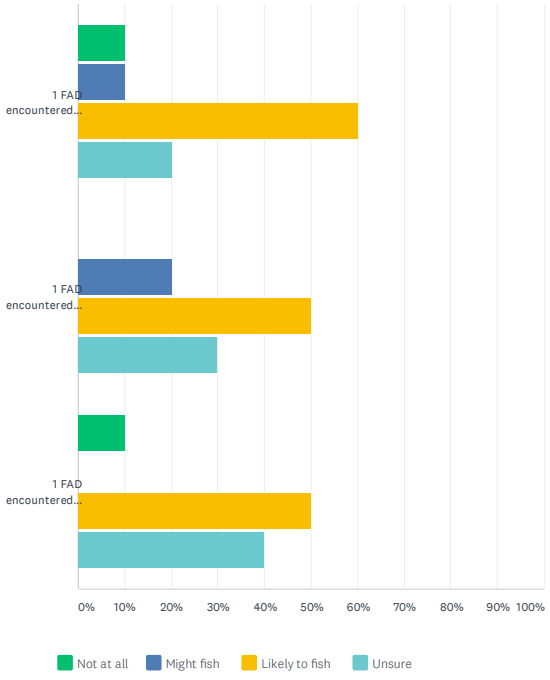
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	100.00%	10
No	0.00%	0
Unsure	0.00%	0
TOTAL		10

Q15 How likely are you to fish an area with the following FAD densities below?

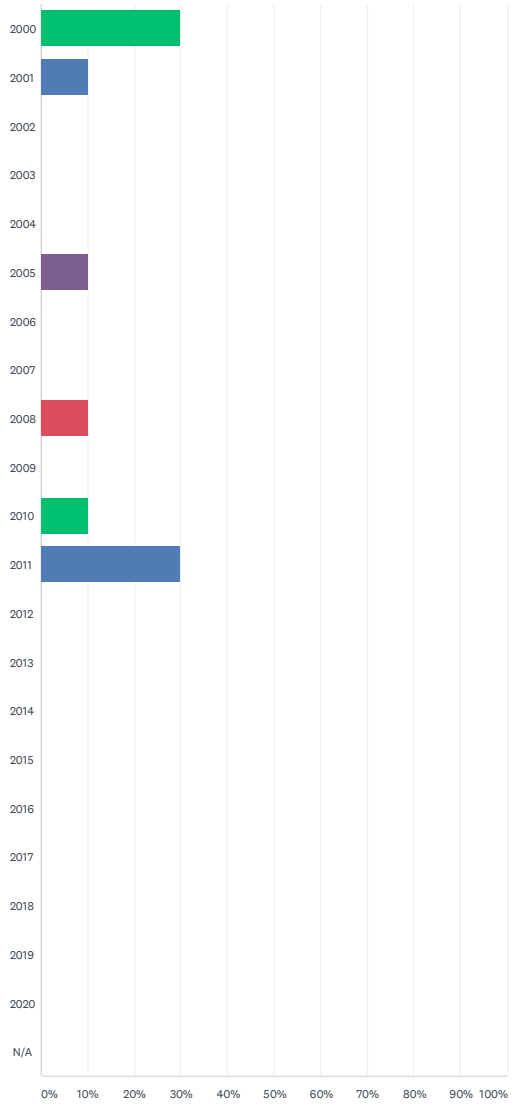
Answered: 10 Skipped: 1



	NOT AT ALL	MIGHT FISH	LIKELY TO FISH	UNSURE	TOTAL
1 FAD encountered within 20 miles	10.00% 1	10.00% 1	60.00% 6	20.00% 2	10
1 FAD encountered within 15 miles	0.00% 0	20.00% 2	50.00% 5	30.00% 3	10
1 FAD encountered within 10 miles	10.00% 1	0.00% 0	50.00% 5	40.00% 4	10

Q16 When did your vessel start using FADs equipped with satellite buoys? (select year in the drop down box)

Answered: 10 Skipped: 1

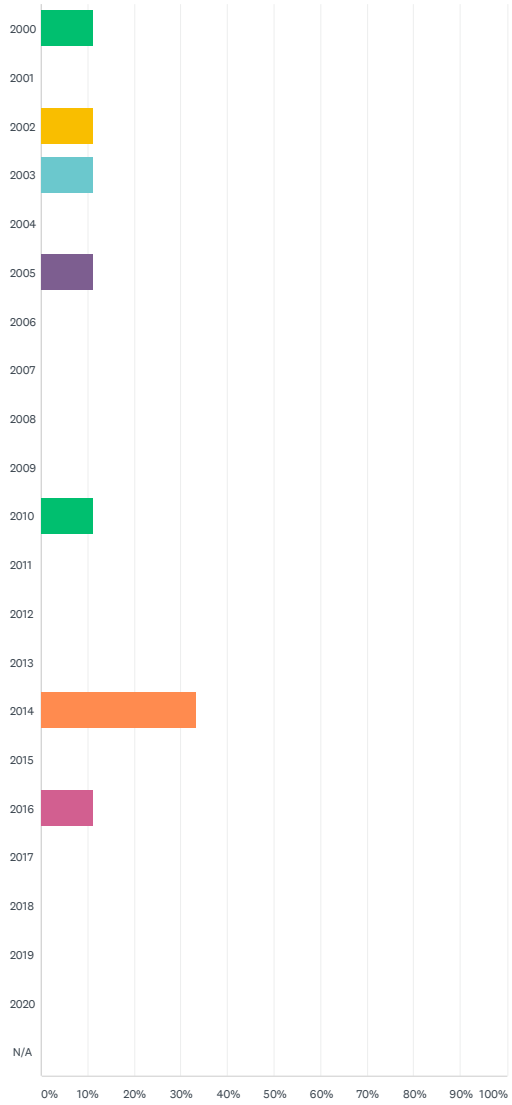


Industry interview program to understand purse seine effort creep and evolution of fishing strategies

ANSWER CHOICES	RESPONSES	
2000	30.00%	3
2001	10.00%	1
2002	0.00%	0
2003	0.00%	0
2004	0.00%	0
2005	10.00%	1
2006	0.00%	0
2007	0.00%	0
2008	10.00%	1
2009	0.00%	0
2010	10.00%	1
2011	30.00%	3
2012	0.00%	0
2013	0.00%	0
2014	0.00%	0
2015	0.00%	0
2016	0.00%	0
2017	0.00%	0
2018	0.00%	0
2019	0.00%	0
2020	0.00%	0
N/A	0.00%	0
TOTAL		10

Q17 When did your vessel start using FADs equipped with satellite echo-sounder buoys? (select from the drop down box)

Answered: 9 Skipped: 2

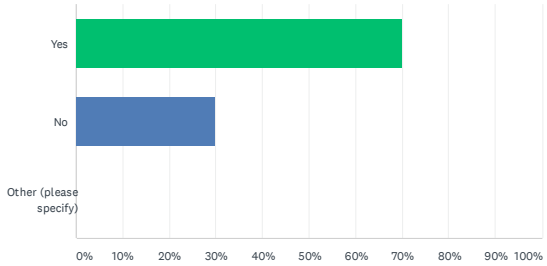


Industry interview program to understand purse seine effort creep and evolution of fishing strategies

ANSWER CHOICES	RESPONSES	
2000	11.11%	1
2001	0.00%	0
2002	11.11%	1
2003	11.11%	1
2004	0.00%	0
2005	11.11%	1
2006	0.00%	0
2007	0.00%	0
2008	0.00%	0
2009	0.00%	0
2010	11.11%	1
2011	0.00%	0
2012	0.00%	0
2013	0.00%	0
2014	33.33%	3
2015	0.00%	0
2016	11.11%	1
2017	0.00%	0
2018	0.00%	0
2019	0.00%	0
2020	0.00%	0
N/A	0.00%	0
TOTAL		9

Q18 Are you using FADs equipped with satellite multi frequency echo-sounder buoys?

Answered: 10 Skipped: 1

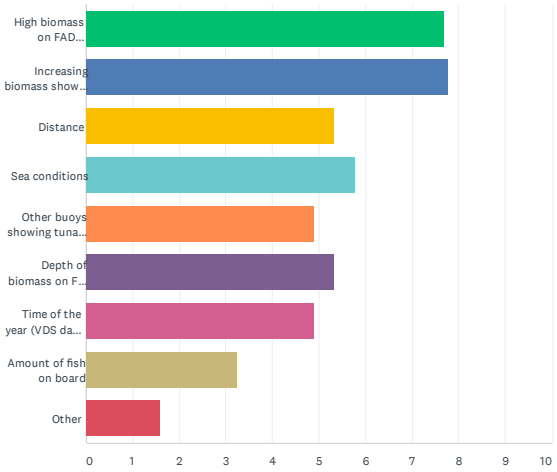


ANSWER CHOICES	RESPONSES	
Yes	70.00%	7
No	30.00%	3
Other (please specify)	0.00%	0
TOTAL		10

#	OTHER (PLEASE SPECIFY)	DATE
	There are no responses.	

Q19 What factors influence your decision to steam to a FAD? (Place in descending order, drag and drop with 1 being the most important factor and 9 the least important factor)

Answered: 10 Skipped: 1



	1	2	3	4	5	6	7	8	9	N/A	TOTAL	SCORE
High biomass on FAD echo-sounder	50.00% 5	10.00% 1	10.00% 1	0.00% 0	10.00% 1	10.00% 1	0.00% 0	0.00% 0	0.00% 0	10.00% 1	10	7.67
Increasing biomass shown on FAD echo-sounder	20.00% 2	50.00% 5	10.00% 1	0.00% 0	10.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	10.00% 1	10	7.78
Distance	0.00% 0	10.00% 1	20.00% 2	10.00% 1	30.00% 3	10.00% 1	0.00% 0	0.00% 0	10.00% 1	10.00% 1	10	5.33
Sea conditions	30.00% 3	0.00% 0	0.00% 0	20.00% 2	10.00% 1	0.00% 0	20.00% 2	10.00% 1	0.00% 0	10.00% 1	10	5.78
Other buoys showing tuna biomass	0.00% 0	10.00% 1	10.00% 1	20.00% 2	0.00% 0	20.00% 2	30.00% 3	0.00% 0	0.00% 0	10.00% 1	10	4.89
Depth of biomass on FAD echo-sounder	0.00% 0	10.00% 1	20.00% 2	20.00% 2	10.00% 1	10.00% 1	10.00% 1	10.00% 1	0.00% 0	10.00% 1	10	5.33
Time of the year (VDS days left over)	0.00% 0	10.00% 1	20.00% 2	0.00% 0	20.00% 2	10.00% 1	20.00% 2	10.00% 1	0.00% 0	10.00% 1	10	4.89
Amount of fish on board	0.00% 0	0.00% 0	0.00% 0	20.00% 2	0.00% 0	10.00% 1	0.00% 0	50.00% 5	0.00% 0	20.00% 2	10	3.25
Other	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	16.67% 1	0.00% 0	0.00% 0	66.67% 4	16.67% 1	6	1.60

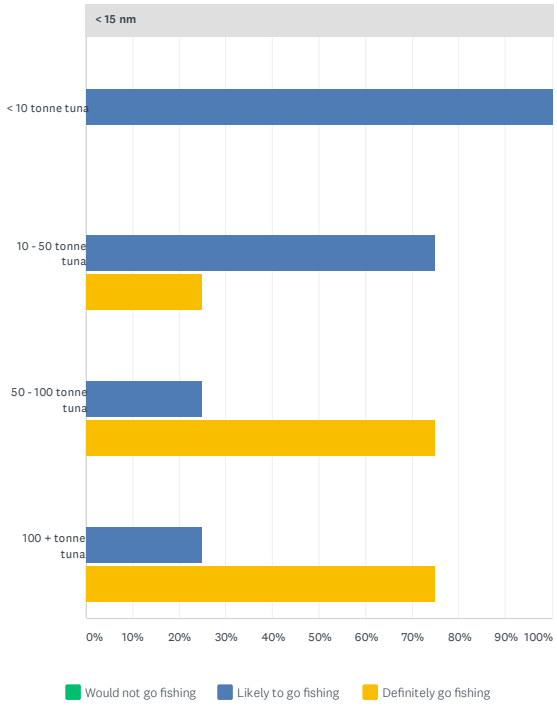
Q20 If 'Other' was selected in Q.19 as being important, please specify below.

Answered: 2 Skipped: 9

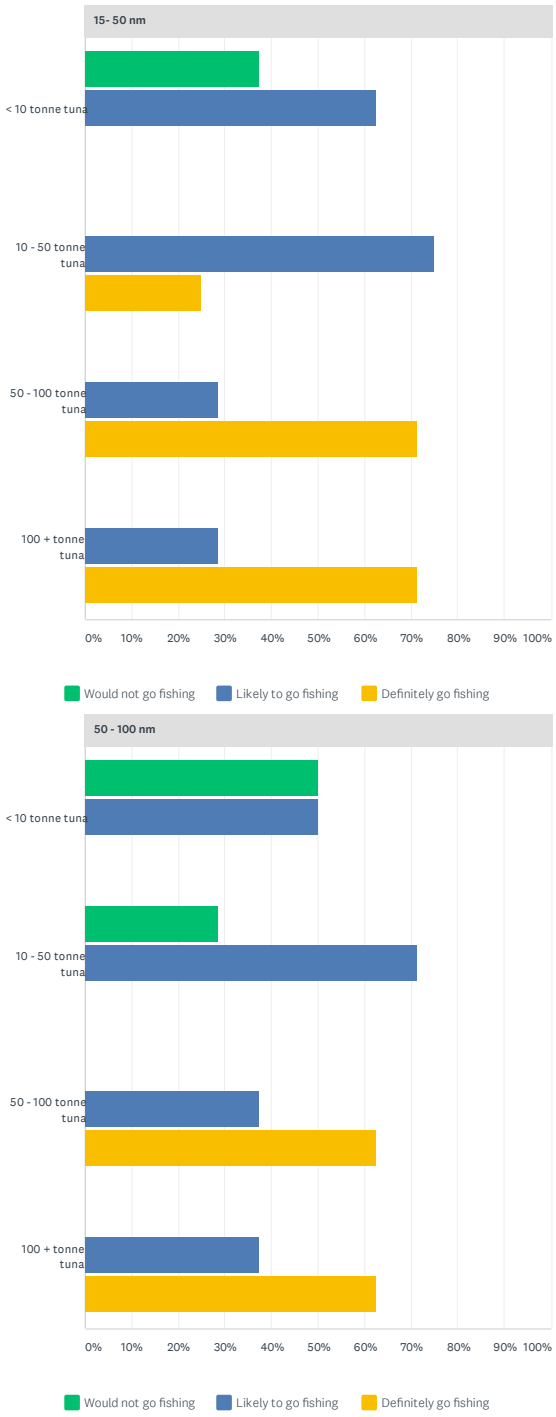
#	RESPONSES	DATE
1	Information from sister vessel	6/19/2020 2:07 PM
2	Fish might scatter during the day and aggregate so well during the night.	6/4/2020 3:44 PM

Q21 Assuming you have an empty hold and calm weather conditions, how far (nautical miles) will you be willing to travel to make a set on a FAD that has indicated the biomass estimates (in metric tonnes) below?

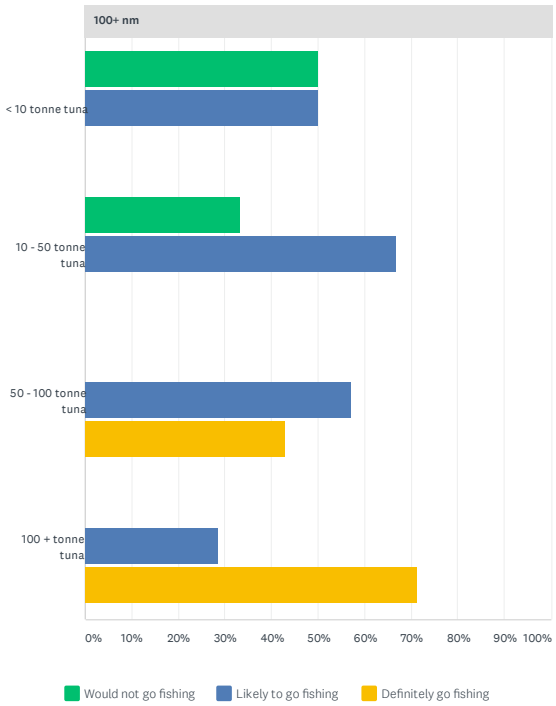
Answered: 10 Skipped: 1



Industry interview program to understand purse seine effort creep and evolution of fishing strategies



Industry interview program to understand purse seine effort creep and evolution of fishing strategies



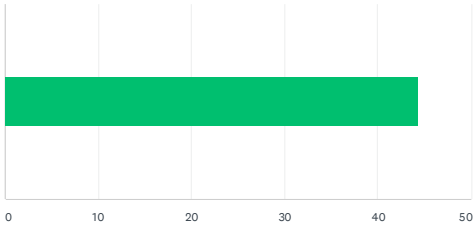
< 15 nm				
	WOULD NOT GO FISHING	LIKELY TO GO FISHING	DEFINITELY GO FISHING	TOTAL
< 10 tonne tuna	0.00% 0	100.00% 9	0.00% 0	9
10 - 50 tonne tuna	0.00% 0	75.00% 6	25.00% 2	8
50 - 100 tonne tuna	0.00% 0	25.00% 2	75.00% 6	8
100 + tonne tuna	0.00% 0	25.00% 2	75.00% 6	8
15- 50 nm				
	WOULD NOT GO FISHING	LIKELY TO GO FISHING	DEFINITELY GO FISHING	TOTAL
< 10 tonne tuna	37.50% 3	62.50% 5	0.00% 0	8
10 - 50 tonne tuna	0.00% 0	75.00% 6	25.00% 2	8
50 - 100 tonne tuna	0.00% 0	28.57% 2	71.43% 5	7
100 + tonne tuna	0.00% 0	28.57% 2	71.43% 5	7
50 - 100 nm				
	WOULD NOT GO FISHING	LIKELY TO GO FISHING	DEFINITELY GO FISHING	TOTAL
< 10 tonne tuna	50.00% 3	50.00% 3	0.00% 0	6
10 - 50 tonne tuna	28.57% 2	71.43% 5	0.00% 0	7
50 - 100 tonne tuna	0.00% 0	37.50% 3	62.50% 5	8
100 + tonne tuna	0.00% 0	37.50% 3	62.50% 5	8

Industry interview program to understand purse seine effort creep and evolution of fishing strategies

100+ nm				
	WOULD NOT GO FISHING	LIKELY TO GO FISHING	DEFINITELY GO FISHING	TOTAL
< 10 tonne tuna	50.00% 3	50.00% 3	0.00% 0	6
10 - 50 tonne tuna	33.33% 2	66.67% 4	0.00% 0	6
50 - 100 tonne tuna	0.00% 0	57.14% 4	42.86% 3	7
100 + tonne tuna	0.00% 0	28.57% 2	71.43% 5	7

Q22 How confident are you to determine species and catch composition prior to setting the net, as a percentage between 0 - 100%

Answered: 10 Skipped: 1

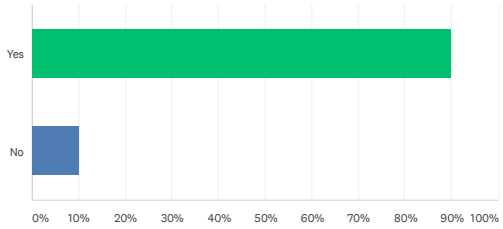


ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	44	443	10
Total Respondents: 10			

#		DATE
1	50	10/16/2020 3:29 PM
2	0	10/14/2020 12:20 PM
3	80	10/14/2020 11:59 AM
4	50	10/13/2020 1:56 PM
5	29	10/5/2020 1:58 PM
6	29	10/5/2020 1:48 PM
7	5	9/30/2020 6:36 PM
8	90	6/19/2020 2:07 PM
9	75	6/4/2020 3:44 PM
10	35	6/4/2020 2:47 PM

Q23 Does the price of fuel influence your fishing decisions?

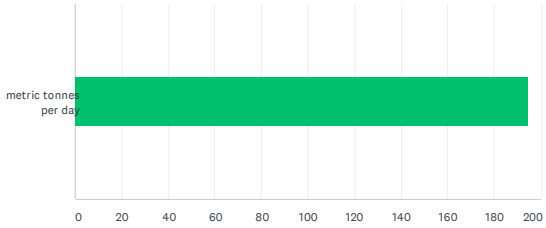
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	90.00%	9
No	10.00%	1
TOTAL		10

Q24 What is your maximum capacity (in metric tonnes) for processing fish per day?

Answered: 9 Skipped: 2

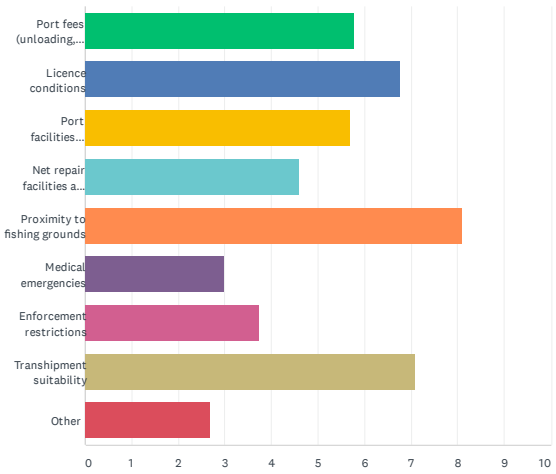


ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
metric tonnes per day	194	1,750	9
Total Respondents: 9			

#	METRIC TONNES PER DAY	DATE
1	350	10/16/2020 3:29 PM
2	300	10/14/2020 12:20 PM
3	350	10/13/2020 1:56 PM
4	200	10/5/2020 1:58 PM
5	200	10/5/2020 1:48 PM
6	200	9/30/2020 6:36 PM
7	10	6/19/2020 2:07 PM
8	40	6/4/2020 3:44 PM
9	100	6/4/2020 2:47 PM

Q25 What factors are most important when choosing a port to offload your catch? (Place in descending order, drag and drop with the 1 being the most important factor and 9 the least important factor)

Answered: 10 Skipped: 1



	1	2	3	4	5	6	7	8	9	N/A	TOTAL	SCORE
Port fees (unloading, provisioning)	10.00% 1	0.00% 0	30.00% 3	10.00% 1	10.00% 1	20.00% 2	10.00% 1	0.00% 0	0.00% 0	10.00% 1	10	5.78
Licence conditions	25.00% 2	25.00% 2	12.50% 1	0.00% 0	25.00% 2	0.00% 0	12.50% 1	0.00% 0	0.00% 0	0.00% 0	8	6.75
Port facilities (accommodation,restaurants, entertainment)	0.00% 0	10.00% 1	30.00% 3	20.00% 2	30.00% 3	0.00% 0	0.00% 0	0.00% 0	10.00% 1	0.00% 0	10	5.70
Net repair facilities and expertise	0.00% 0	10.00% 1	0.00% 0	10.00% 1	30.00% 3	20.00% 2	30.00% 3	0.00% 0	0.00% 0	0.00% 0	10	4.60
Proximity to fishing grounds	60.00% 6	10.00% 1	10.00% 1	20.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	10	8.10
Medical emergencies	0.00% 0	0.00% 0	0.00% 0	10.00% 1	0.00% 0	30.00% 3	10.00% 1	40.00% 4	10.00% 1	0.00% 0	10	3.00
Enforcement restrictions	0.00% 0	0.00% 0	11.11% 1	0.00% 0	11.11% 1	22.22% 2	22.22% 2	22.22% 2	0.00% 0	11.11% 1	9	3.75
Transhipment suitability	10.00% 1	50.00% 5	0.00% 0	30.00% 3	0.00% 0	10.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	10	7.10
Other	0.00% 0	0.00% 0	14.29% 1	0.00% 0	0.00% 0	0.00% 0	14.29% 1	28.57% 2	28.57% 2	14.29% 1	7	2.67

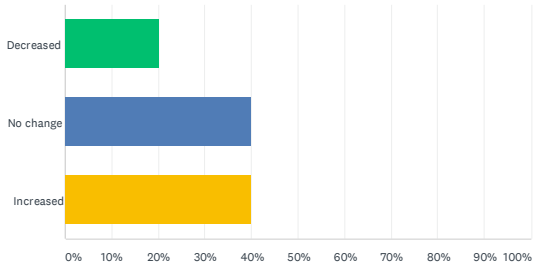
Q26 If 'Other' was selected in Q.25 as being important, please specify below.

Answered: 3 Skipped: 8

#	RESPONSES	DATE
1	Stevedores availability	9/30/2020 6:36 PM
2	Food and water supply	6/19/2020 2:07 PM
3	Have wife or girlfriend or family in that particular port.	6/4/2020 3:44 PM

Q27 Has your search time for free school sets changed over time?

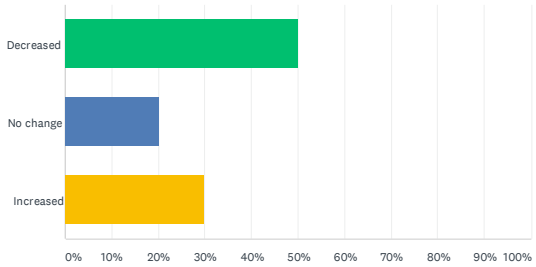
Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Decreased	20.00%	2
No change	40.00%	4
Increased	40.00%	4
TOTAL		10

Q28 Has the time required to find a productive FAD changed over time?

Answered: 10 Skipped: 1



ANSWER CHOICES	RESPONSES	
Decreased	50.00%	5
No change	20.00%	2
Increased	30.00%	3
TOTAL		10

Q29 What are the three biggest factor that contributes to a failed/skunk set?

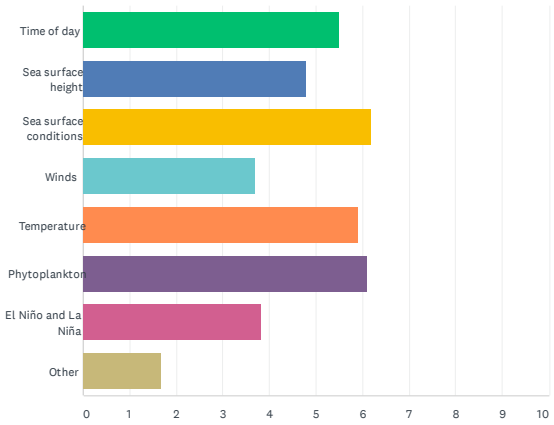
Answered: 9 Skipped: 2

ANSWER CHOICES	RESPONSES	
Factor 1	100.00%	9
Factor 2	77.78%	7
Factor 3	66.67%	6

#	FACTOR 1	DATE
1	Mobility of Tuna	10/14/2020 12:20 PM
2	Current	10/14/2020 11:59 AM
3	SET CONDITION	10/13/2020 1:56 PM
4	weahter	10/5/2020 1:58 PM
5	weahter	10/5/2020 1:48 PM
6	Current	9/30/2020 6:36 PM
7	Movement of school	6/19/2020 2:07 PM
8	Movement of fish	6/4/2020 3:44 PM
9	Movement of tuna	6/4/2020 2:47 PM
#	FACTOR 2	DATE
1	Tool	10/14/2020 12:20 PM
2	Purse Problems	10/14/2020 11:59 AM
3	FISHING MASTER EXPERIENCE	10/13/2020 1:56 PM
4	Fish dynamics	9/30/2020 6:36 PM
5	Strength of current	6/19/2020 2:07 PM
6	Moon Phase	6/4/2020 3:44 PM
7	Effectiveness of gear & crafts	6/4/2020 2:47 PM
#	FACTOR 3	DATE
1	Speed	10/14/2020 12:20 PM
2	Net Problems	10/14/2020 11:59 AM
3	THE STATE OF FISH MOVEMENT	10/13/2020 1:56 PM
4	timing of start of set	6/19/2020 2:07 PM
5	Sea surface temperature	6/4/2020 3:44 PM
6	Weather conditions	6/4/2020 2:47 PM

Q30 What environmental factors do you think are most important in predicting locations of productive fishing grounds? (Place in descending order, drag and drop with the 1 being the most important factor and 7 the least important factor)

Answered: 10 Skipped: 1



	1	2	3	4	5	6	7	8	N/A	TOTAL	SCORE
Time of day	30.00% 3	0.00% 0	20.00% 2	10.00% 1	20.00% 2	20.00% 2	0.00% 0	0.00% 0	0.00% 0	10	5.50
Sea surface height	0.00% 0	10.00% 1	20.00% 2	40.00% 4	10.00% 1	10.00% 1	10.00% 1	0.00% 0	0.00% 0	10	4.80
Sea surface conditions	20.00% 2	20.00% 2	30.00% 3	20.00% 2	10.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	10	6.20
Winds	0.00% 0	0.00% 0	20.00% 2	10.00% 1	10.00% 1	40.00% 4	20.00% 2	0.00% 0	0.00% 0	10	3.70
Temperature	30.00% 3	30.00% 3	0.00% 0	10.00% 1	10.00% 1	10.00% 1	10.00% 1	0.00% 0	0.00% 0	10	5.90
Phytoplankton	20.00% 2	40.00% 4	0.00% 0	0.00% 0	20.00% 2	10.00% 1	0.00% 0	0.00% 0	10.00% 1	10	6.11
El Niño and La Niña	0.00% 0	0.00% 0	14.29% 1	14.29% 1	28.57% 2	0.00% 0	28.57% 2	0.00% 0	14.29% 1	7	3.83
Other	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	28.57% 2	14.29% 1	57.14% 4	7	1.67

Q31 If 'Other' was selected in Q.30 as being important, please specify below.

Answered: 1 Skipped: 10

#	RESPONSES	DATE
1	Presence of seamounts on sea bed	6/4/2020 3:44 PM

Q32 Do you have the tools to monitor these environmental variables?

Answered: 7 Skipped: 4

ANSWER CHOICES	RESPONSES	
Yes (please list)	71.43%	5
No (what would you like)	14.29%	1
Other	28.57%	2

#	YES (PLEASE LIST)	DATE
1	Traking System	10/14/2020 11:59 AM
2	CATSAT	10/13/2020 1:56 PM
3	Oceanographic software	9/30/2020 6:36 PM
4	sst gauge, weather updates daily, ocean distribution	6/19/2020 2:07 PM
5	Electronics onboard	6/4/2020 2:47 PM

#	NO (WHAT WOULD YOU LIKE)	DATE
1	Advanced electronics	6/4/2020 2:47 PM

#	OTHER	DATE
1	Sea Temperature analyize	10/14/2020 12:20 PM
2	This is a secret.	6/4/2020 3:44 PM

Q33 How does knowledge of El Niño conditions influence your fishing?

Answered: 7 Skipped: 4

#	RESPONSES	DATE
1	Sea Temperature change	10/14/2020 12:20 PM
2	Very Much	10/14/2020 11:59 AM
3	SAE SURFACE TEMPERATURE CHANGE	10/13/2020 1:56 PM
4	Water temperature	9/30/2020 6:36 PM
5	Water too warm, fsihing, concentrated elsewhere	6/19/2020 2:07 PM
6	Has a great impact.	6/4/2020 3:44 PM
7	Not so much.	6/4/2020 2:47 PM

Q34 What are your concerns for future changes to the environment with respect to the tuna fishery?

Answered: 7 Skipped: 4

#	RESPONSES	DATE
1	Sea Temperature and Tuna Diving and moving	10/14/2020 12:20 PM
2	Eco and Friendly Fads	10/14/2020 11:59 AM
3	weather	10/5/2020 1:58 PM
4	Fish moving to west Pacific	9/30/2020 6:36 PM
5	Sea becoming warmer resulting in tuna movement unpredictable	6/19/2020 2:07 PM
6	Very huge with regards to global warming and weather patterns.	6/4/2020 3:44 PM
7	Sea may become warmer and tuna moves further north or south of the equator	6/4/2020 2:47 PM

Q35 What are your concerns for the future of the tuna stocks in the WCPO?

Answered: 7 Skipped: 4

#	RESPONSES	DATE
1	Too much stock	10/14/2020 12:20 PM
2	No concerns	10/14/2020 11:59 AM
3	IF THE ENTERPRISE LOSES MONEY,IT IS NECESSARY TO INCREASE CATCH,THE STOCKS WILL FALL INTO A VICIOUS CIRCLE.	10/13/2020 1:56 PM
4	Biased management pushed fishing to VDS areas to charge shipowners	9/30/2020 6:36 PM
5	Need to monitor closely the tuna species under threats	6/19/2020 2:07 PM
6	Current data collection areas must increase in order to make correct decisions by leaders (Science and Management work hand in hand)	6/4/2020 3:44 PM
7	Decrease number of fishing fleets or increase licensing fees.	6/4/2020 2:47 PM

Q36 How has the Vessel Day Scheme changed how you fish? Please describe the three most important changes below.

Answered: 7 Skipped: 4

ANSWER CHOICES	RESPONSES	
Change 1	100.00%	7
Change 2	85.71%	6
Change 3	71.43%	5

#	CHANGE 1	DATE
1	Price	10/14/2020 12:20 PM
2	Weather conditions	10/14/2020 11:59 AM
3	TOO HIGH A COST	10/13/2020 1:56 PM
4	Move to an extremely efficient carching	9/30/2020 6:36 PM
5	Target fishing ground where more productive	6/19/2020 2:07 PM
6	Vessel targets high biomass areas	6/4/2020 3:44 PM
7	Limited fishing days	6/4/2020 2:47 PM
#	CHANGE 2	DATE
1	NFD denied	10/14/2020 12:20 PM
2	Fishing gears conditions	10/14/2020 11:59 AM
3	INCREASE IN LOSSES	10/13/2020 1:56 PM
4	Restricted movement between fishing ground	6/19/2020 2:07 PM
5	Vessel now use satellite information	6/4/2020 3:44 PM
6	Added Pressure to effectively catch	6/4/2020 2:47 PM
#	CHANGE 3	DATE
1	Vessel conditions	10/14/2020 11:59 AM
2	UNREASONABLE USE OF DAYS	10/13/2020 1:56 PM
3	Need to conduct more sets as possible daily	6/19/2020 2:07 PM
4	Use of echo sounders increasing	6/4/2020 3:44 PM
5	Increasec fishing fees	6/4/2020 2:47 PM

Q37 Please provide your vessel details.

Answered: 7 Skipped: 4

ANSWER CHOICES	RESPONSES	
Vessel Length (meters)	100.00%	7
Vessel Tonnage (GRT)	100.00%	7
FishHold Capacity (CuM)	100.00%	7
Freezing Capacity (tonnes per day)	100.00%	7

#	VESSEL LENGTH (METERS)	DATE
1	70	10/14/2020 12:20 PM
2	61.2	10/14/2020 11:59 AM
3	70.59	10/13/2020 1:56 PM
4	2185	10/5/2020 1:58 PM
5	2185	10/5/2020 1:48 PM
6	78	9/30/2020 6:36 PM
7	69.15	6/19/2020 2:07 PM
#	VESSEL TONNAGE (GRT)	DATE
1	1467	10/14/2020 12:20 PM
2	1160	10/14/2020 11:59 AM
3	1284.00	10/13/2020 1:56 PM
4	1052	10/5/2020 1:58 PM
5	996	10/5/2020 1:48 PM
6	1980	9/30/2020 6:36 PM
7	780 mT	6/19/2020 2:07 PM
#	FISHHOLD CAPACITY (CUM)	DATE
1	1600	10/14/2020 12:20 PM
2	1309	10/14/2020 11:59 AM
3	1476	10/13/2020 1:56 PM
4	800	10/5/2020 1:58 PM
5	800	10/5/2020 1:48 PM
6	1700	9/30/2020 6:36 PM
7	50mT	6/19/2020 2:07 PM
#	FREEZING CAPACITY (TONNES PER DAY)	DATE
1	300	10/14/2020 12:20 PM
2	150	10/14/2020 11:59 AM
3	350	10/13/2020 1:56 PM
4	150	10/5/2020 1:58 PM
5	150	10/5/2020 1:48 PM
6	200	9/30/2020 6:36 PM
7	200 mT	6/19/2020 2:07 PM