DRAFT Strategic Research Plan for Tropical Tuna Stock Structure Research

October 2018

INTRODUCTION

Pacific tuna Fisheries

In the Pacific Ocean, tuna support major industrial fisheries and a variety of small-scale domestic and subsistence fisheries. The principal target species are skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), and albacore tuna (*Thunnus alalunga*). Combined, these four species comprise over 90% of industrial catches in the Pacific and approximately 70% of global catches, with approximately 3.2 million metric tonnes (mt) harvested in 2017 (SPC-OFP 2018a).

The majority of the catches of these four species in the Pacific Ocean comes from the waters of the Western and Central Pacific Ocean (WCPO), with an estimated 2,539,950 mt harvested commercially in 2017 (Figure 1) (SPC-OFP 2018a). Around 60 per cent of this is taken within the Exclusive Economic Zones (EEZs) of Pacific Island Countries and Territories (PICTs; Williams and Reid 2018). Further west, large catches of tuna are also taken in the waters surrounding Indonesia and the Philippines, representing around 35% of the total WCPO catch (SPC-OFP 2018a). Smaller, and in some cases seasonal, catches of the four species are taken in the EEZs of Australia, New Zealand, China, Japan, and Vietnam (SPC-OFP 2018a).

Significant harvests of tuna are also made in the Eastern Pacific Ocean (EPO). Historically, catches in the EPO have been dominated by yellowfin tuna, with catches for this species peaking at around 440,000 t in 2002 (IATTC 2018). However, in recent years, catches of skipjack tuna have exceeded those of yellowfin tuna, with an estimated 320,000 t of skipjack tuna landed in 2017 (IATTC 2018).

Management of tropical tuna stocks in the Pacific, which are assumed to straddle EEZs and the high seas, comes under the auspices of two international conventions: the Convention on the Conservation and Management of High Migratory Fish Stocks in the Western and Central Pacific Ocean; and the Antigua Convention (which revised the Convention for the establishment of an Inter-American Tropical Tuna Commission). These conventions are operationalised by two independent tuna Regional Fisheries Management Organizations (RFMOs): the Western and Central Pacific Fisheries Commission (WCPFC) in the WCPO, and the Inter-American Tropical Tuna Commission (IATTC) in the EPO. There is an overlap in the area of responsibility of the two RFMOs, bounded by 150°W, 130°W, 4°S and 50°S, with this region considered part of the WCPO in catch statistics (the WCPFC Statistical Area).

Relevance of stock structure

Fisheries management in the WCPFC and IATTC aims to achieve maximum production whilst avoiding the overexploitation of the units being harvested. To achieve this outcome knowledge about the number, size and spatial extent of the stock(s) being harvested is required. Stock assessment models applied to Pacific tuna rely on the assumption that the group of individuals being assessed (a unit stock) form an entity, with its own demographics, and fate. Defining the boundaries that characterise each stock helps ensure that the predictions on current levels of stock depletion and how the stock will respond to management decisions are reliable. Failure to recognise stock structure can lead to over-fishing, while for stocks undergoing rebuilding, differential restoration between unidentified stock components can lead to an inability to anticipate future recruitment to those stocks (Begg et al. 1999a).

Definitions of tuna stock for the WCPO

The scientific literature provides varying definitions for stock structure that span from that of a population of individuals that do not interact with any other to units of management that are interconnected. For assessing and managing tuna species in the WCPO the practical definition of a stock is the aggregation of individuals within a spatial domain where recruitment is self replenishing and described by its localised population dynamics. In defining the spatial domain the needs of management, fishing behaviours and the use of space over time by the stock should be consider. As a general principal aggregating to larger spatial domains is considered more precautionary.

Pacific Tuna Stock Assessment

Assessments of bigeye, skipjack and yellowfin tunas have been conducted by the Pacific Community (SPC) in the WCPO, and by the IATTC Secretariat in the EPO. The status of albacore tuna in the South Pacific is assessed by SPC and in the North Pacific by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). Current assessments for skipjack, yellowfin and bigeye tunas assume eastern and western stocks of each species; a split that essentially reflects the jurisdictional boundaries of the two RFMOs. Similarly, regional structures in stock assessment, when present, typically represent the spatial distribution of fishing gears, movement characteristics, tag mixing assumptions, and management regimes.

Stock Structures of Pacific Tuna

To date, modelling has assumed that each species of tuna is a panmictic population across the tropical Pacific basin within the assumed stock boundaries. Pelagic fishes such as tuna can exhibit complex spatial dynamics, owing to a range of biological and environmental processes acting on all life history stages. Past and ongoing studies aiming to identify stock structure for pelagic fish have generally attempted to address one of three main themes: i) the conditions governing spawning (timing, location and behaviour such as natal homing), ii) the extent of individual movement/mixing, and iii) differences in life-history (e.g. growth, maturity, stock recruitment relationships).

Life-history studies on albacore, bigeye, skipjack and yellowfin tuna in the Pacific Ocean indicate spawning in locations where water temperatures generally exceed 24°C, suggesting that the tropical zone may be a common spawning area for all four species. However, there is emerging evidence that the spatial structure and dynamics of populations of the four target tuna species may be more complex than currently assumed. Growth and maturity analyses for bigeye and albacore have detected longitudinal trends with faster growth observed in the eastern Pacific in comparison to the western Pacific. Various genetic studies have also identified evidence of potential differences in allele frequencies between the eastern and western Pacific for yellowfin, bigeye and skipjack. Studies of parasitic composition, isotope and microchemistry signatures in yellowfin and albacore suggest the extent of movement may be more localised which is also supported by estimates of tag mixing rates from conventional tagging information for bigeye, skipjack, and yellowfin. Electronic tagging of bigeye indicates potential for natal homing in the eastern Pacific where an individual was estimated to have twice moved into the central Pacific Ocean. Bigeye movements from the conventional tagging in the central Pacific are proportionally higher for easterly displacements which may support the hypothesis of the central Pacific being a natal area. Similar behaviour has been reported from an electronically tagged albacore in the northern Pacific.

Research Need

The WCPFC Strategic Research Plan (WCPFC-SC7-2011/GN-WP-05) outlines a strategy for obtaining the necessary scientific information to support management decision-making. It identifies four overall research and data collection priorities: (1) collection and validation of data from the fishery; (2) monitoring and assessment of the ecosystem; (3) monitoring and assessment of stocks; and (4) evaluation of management options. The Plan acknowledges the important role of biological studies to reduce structural uncertainty and possible bias in stock assessments. Required studies identified in the plan includes the characterisation of stock structure.

The need to better understand the degree of connectivity between tuna populations in the WCPO has been highlighted in a recent scientific review of the research priorities and opportunities for the Pacific Ocean (Evans et al 2015). This review identifies that if species do not mix rapidly and there is some geographic structure to the population, this spatial structure needs to be taken into account by management frameworks to ensure biological sustainability of populations and economic performance of the dependent fisheries.

Scientists undertaking stock assessments for the WCPFC and IATTC have recognised that movement of bigeye between the WCPFC and IATTC convention areas of competence (from east to west across the 150 longitude line) suggests that bigeye tuna assessments in each RFMO may be only capturing partial components of the stock(s). To date, comparison between WCPFC only assessments and Pacific wide assessments have not detected different conclusions about stock status between the two assessment approaches. It is recognized that information on stock structures would reduce the risk that WCPFC assessments are biased due to the mixing of individuals across the RFMO jurisdictional boundary.

The assessment models in the WCPO are sensitive to the assumed spatial disaggregation that are imposed on the model, in addition to many other uncertainties. In the WCPO, current disaggregation boundaries are not based on assumed stock structure, but attempt to capture the heterogeneity in the fisheries. An improved understanding of stock structure would reduce this uncertainty.

The Forum Fisheries Agency (FFA) and the Parties to the Nauru Agreement Office (PNAO) recognise that improved knowledge on stock structure will facilitate more robust management advice provided by population dynamics, simulation, bio-economic and climate models used to test and guide the formation of management advice for WCPFC tuna stocks, but also ancillary opportunities such as identification of animal provenance for validating catch documentation schemes, sustainability certification requirements, and compliance associated with illegal, unreported and unregulated (IUU) fishing. FFA and PNAO recognize the need to clarify stock structure to appropriate scientific standards as uncertain stock delineation that results in greater spatial disaggregation is likely to be more risk prone (from a management perspective) than assuming fewer stocks.

The benefits of improved understanding of stock structure are supported by Conservation International (CI). Preparing tuna fisheries for climate change effects, evaluating the importance of large scale spatial management, strengthening marketing initiatives, and the development and implementation of precautionary harvest strategies are identified by CI as work areas that improved stock structure would benefit.

Generic Hypotheses on Stock structure

Hypotheses of stock structure that warrant addressing are:

1. Natal Area Homing Hypothesis
    a. juvenile mixing, adult fidelity to spatial boundary or environmental
    b. general mixing adult homing to spawn
    c. Units remain as separate / non-mixing groups outside of spawning period
2. Localised Mixing Hypothesis/Continuous Gradient hypothesis/isolation by distance
3. Vagrants/nomads don't contribute to spawning
4. Panmixia and environmental selection generates a metapopulation

Sampling Design and Approach to Collection

Sampling strategy and design….observers etc, port sampling etc, where, when, who, what.

Samples to be Collected
The application of each of the currently available methods to infer stock structure can be subject to bias due to sampling and/or only measure an aspect of the population dynamics, an approach where multiple methods are simultaneously applied allows opportunity to test the support for alternative hypotheses. Where feasible sampling of a dead individual should include:

1. Tissue for genetic analyses (SNP)
2. Tissue for fatty acid
3. Tissue for stable isotope
4. Hard parts (otoliths, and other inert material) for microchemistry and isotope analyses
5. Otolith Shape
6. Gonad and otolith for life history
7. Gill raker, stomachs for parasite analysis

Given the extent of tuna tagging studies in the Pacific Ocean the collection of biological samples from tag recaptures should be encouraged (particularly those with electronic tags)

Natal Area Homing Hypotheses
Genetics

Preference for sampling adult fish in running ripe condition. Where feasible this should be complemented by newly recruited individuals (i.e.at an age where the probability of movement from spawning location is minimal). Previous genetic studies have sampled individuals in the 3-6 months age and assumed that movements earlier than this would be localised. However that pelagic drift of larvae may violate this assumption. This assumption should be be tested in proposed sampling areas with oceanographic particle simulations and applications of IKAMOANA to describe the plausible spatial area that the individuals in the sample may have originated. Sampling from pole-and-line may yield some small fish (i.e. YFT around 30-35 cm in certain location). Samples should be collected ideally in the same spawning season and across multiple years. .

Examine catch information and expected distribution of adult biomass during peak spawning period in equatorial region to identify potential for restricted spawning sites.

How to get small fish: small yellowfin (30-40 cm) found off Kadavu in spring.

Muscle tissue of x by x by x dimension sampled from y section of the fish, stored frozen or in preservative (……….). Equipment to be sterilised after each time used for sampling.

Infers: Genetic similarity of spawning biomass by location

Isotopes and Otoliths from hard parts
Preference for sampling adult fish in running ripe condition and newly recruited individuals (i.e.at an age where the probability of movement from spawning location is minimal). Previous microchemistry studies have sampled individuals in the 3-6 months age and assumed that movements earlier than this would be localised. However that pelagic drift of larvae may violate this assumption. This assumption should be be tested in proposed sampling areas with oceanographic particle simulations and applications of IKAMOANA to describe the plausible spatial area that the individuals in the sample may have originated.

Left and Right otolith sampled from the fish, stored. other hards-parts (jess farley to update)

Infers:

Parasitic Analyses
Wouldn't be able to show natal homing without a mixed stock design (i.e. first survey young fish in natal areas then adults at spawning sites and attempt to classify adults back - but then this only only be suggestive of natal homing.

Stomach, and gill rakers sampled from the fish
Infers: Whether fish have lived in different water bodies, thus indicating they may be distinct unit stocks.

Localised Mixing Hypothesis

Genetics
No size or maturity preference

Muscle tissue of x by x by x dimension sampled from y section of the fish, stored frozen or in preservative (……….). Equipment to be sterilised after each time used for sampling.

Infers: Genetic similarity of biomass by location (accounting for size)

Fatty Acids
No size or maturity preference

Muscle tissue of x by x by x dimension sampled from y section of the fish, stored frozen or in preservative (……….).

Infers: movement through differential fatty acid composition in liver and muscle (Valerie might be able to expand based on her work with Heidi)

Stable isotope (1)
No size or maturity preference

Muscle tissue of x by x by x dimension sampled from y section of the fish, stored frozen or in preservative (……….).

Infers: movement through isotope presence in muscles. Requires isoscape map. May have limited capacity to detect natal area

Isotopes(2) and Otoliths from hard parts
Requirement for fish to be sampled of same size to be sampled across locations at the same time.

Left and Right otolith sampled from the fish, stored. other hards-parts (jess farley to update)

Infers movement based on isoscape.
Isoscapes by year and tuna age class preferable as deposition of elements can be influenced by fish age, season and year (inter-annual oceanographic effects).

Parasitic Analyses
Brad to describe

Life history
Otolith and gonads across size and age classes

Infers: growth and maturity differences by location

Further Stratification considerations

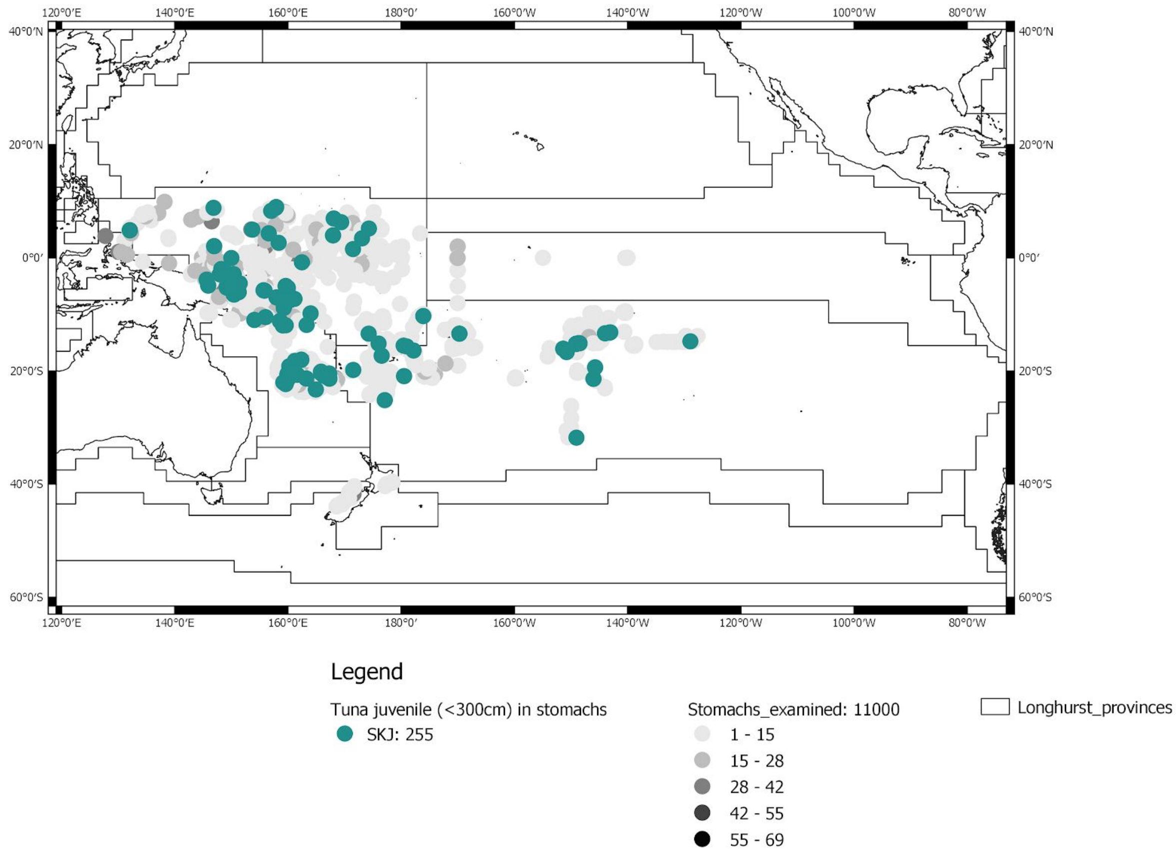
Sex
Sex can influence the ability to discriminate structure. Therefore need to account for sex in sampling design (a biased sex ratio may provide a signal of population structure when it doesn't exist)

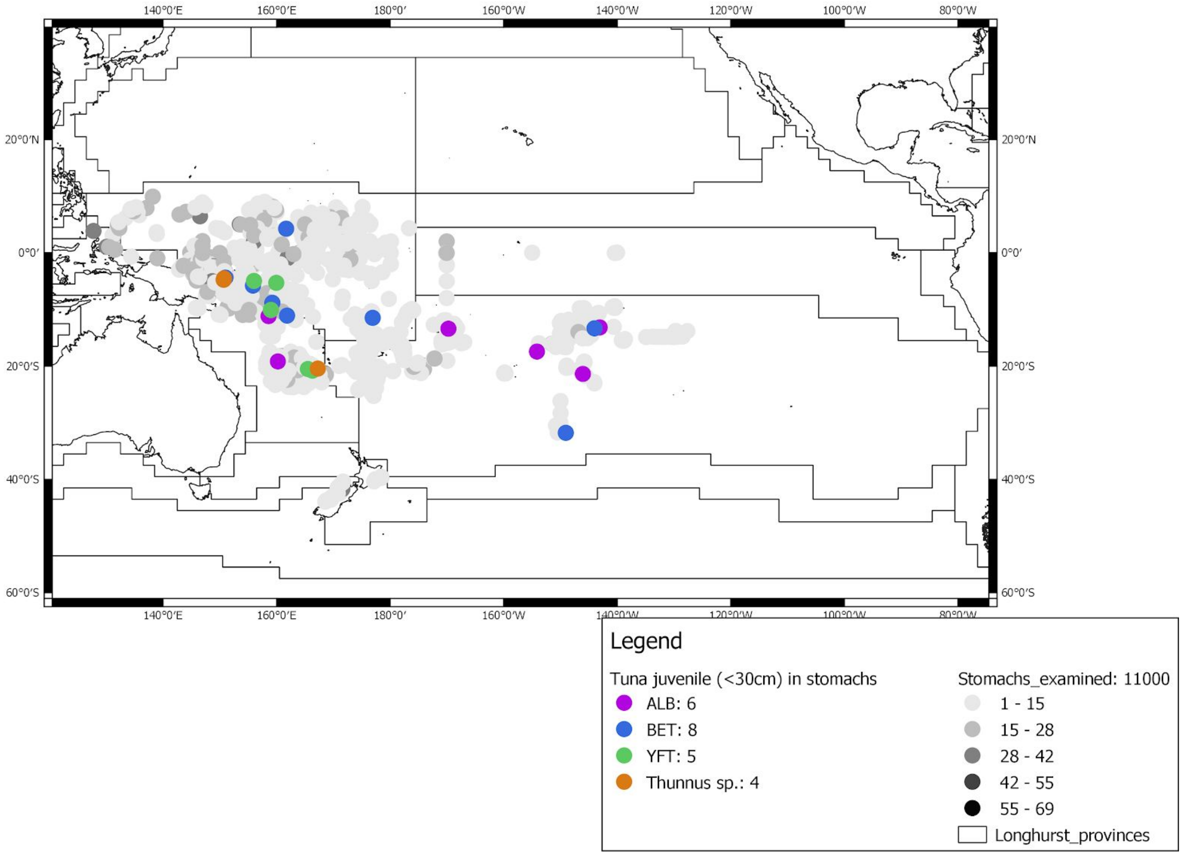
Chaotic Genetic Patchiness hypotheses -
Number of replicate sampling within schools (e.g. within PS sets). Does this need to be tested

Spawning Locations Effects
Spawning area = an area where the fish spawns and the larvae survive. Shifts in time and space with environment - not always a fixed area.

There are areas where larvae aggregate (due to productivity and physical factors) - might want to look at whether you can identify these areas and then focus on sampling from these areas (not sure how feasible this might be). Potential sources of information to determine where larvae aggregate/spawning occurs:

- Observations of running ripe fish from observer data
- Larval distribution surveys e.g. Nishikawa et al. A priority likely
- Observations from stomach contents





Longitudinal and Latitudinal Effects

Size Class Stratification

Sampling Platforms
At Sea and Port Observer

Research Cruises

Vessel self sampling

Deployed samplers

SKIPJACK TUNA

(*Katsuwonus pelamis*)

1. The Fisheries

The total estimated catch of SKJ in WCPFC Statistical Area for 2017 was 1,624,162 mt, including 1,280,311 mt from purse seine 123,132 mt from pole-and-line and 218,175 mt from other gears.

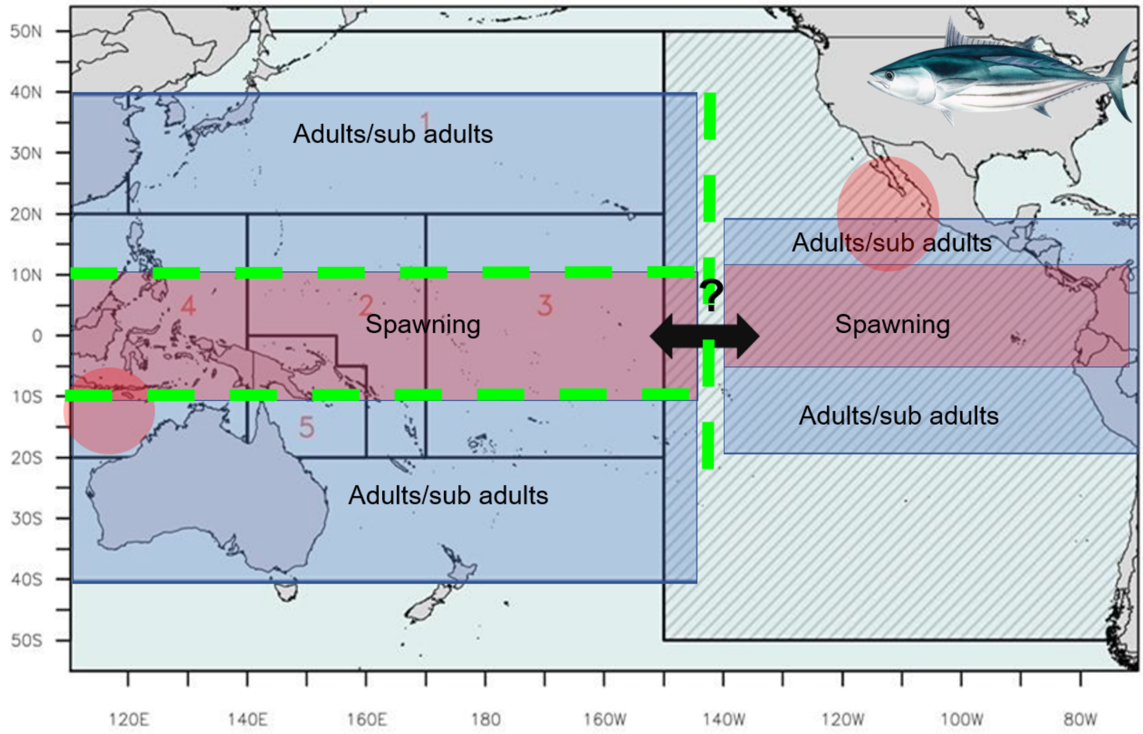
2. Stock Status

The most recent WCPO stock assessment suggests skipjack tuna is not overfished (stock assessed to be above the WCPFC-adopted LRP of 20% $SB_{F=0}$ and around the interim TRP of 50%$SB_{F=0}$) and not subject to overfishing (fishing mortality assessed to be below F_{MSY}; McKechnie et al. 2016). The next WCPO assessment is planned for 2019. There are no recent stock assessment for skipjack tuna in the EPO.

3. Research Approach and Information Requirements

Table X: Skipjack - current approach, information requirements and research needs

	Current approach	Information available	Research needs
Skipjack stock assessment	Considered a single stock	…..	Several components identified 1. refinement of sub-regional boundaries and alignment with fishery impacts and effort distribution 2. need for considering local stock recruitment relationships rather than a regional SR.. SNP best approach from genetics
Skipjack ecosystem modelling			Scaling seapodym projections. Movement parameters are often at or near their boundaries which may be suggesting that the underlying dynamic is not being captured.
Skipjack MSE	Considered a single stock	…..	WCPFC MSE project. Useful to include at least some extreme stock structures (ie each end of the spectrum) and test influence. Noting the IWC experience where stock structure differences are expected to be influential
Skipjack traceability			global analyses required to get this right - i.e. development of an ocean basin ‘library’ to trace individuals back mtDNA species ID SNPs for provenance
……….			



4. Models of life Cycle

The current stock structure assumed for the assessment of skipjack in the Pacific Ocean is a WCPO and EPO stocks. Spawning occurs year-round in surface water temperatures provided water temperatures are generally above 24°C. This results in some seasonal spawning (summer) in higher latitudes. Reported larval densities are higher in WCPO than EPO, suggesting that the main spawning areas is in the WCPO. Immature fish are assumed to be distributed throughout equatorial waters, extending to higher latitudes. Mean length at 50% maturity has been estimated to be ~52cm in the EPO (assumed to) and ~48cm in the WCPO with an assumed age between 9-12 months. Sub-adults and adults are distributed from 35°N to 35°S, extending to 40° in both hemispheres (West of ~145°W) and distributed from 15°N to 15°S, extending to 20° in both hemispheres (East of ~145°W). Skipjack is considered highly mobile with movement in the equatorial region influenced by oceanographic cycles such as ENSO. The median lifetime displacement estimated from conventional tagging data is 420-470 nmi. There is some evidence for spatial structuring of populations from older genetic techniques however the molecular techniques used in these studies are no longer consider state-of-the-art.

Hypotheses of stock structure that warrant addressing are:

1. Continuous (mixed) stock in the equatorial Pacific due to continuous year-round spawning and high exchange longitudinally (i.e. easterly compression of biomass during El Nino and westerly compression of biomass during La Nina)

2. Two or more stocks that demonstrate a "Wahlund Effect" where distinction between stocks may only be readily detectable during an El Nino events (not sure about this)
3. Coastal occurrence of skipjack in Japan EEZ is independent of equatorial stock.

5. Implications for Research

Sustainability

What happens without this……

Management

What happens without this……

6. Sampling Design and Approach to Collection

Sampling strategy and design….observers etc, port sampling etc, where, when, who, what.

7. Medium Term Research Plan for Skipjack Tuna

Bold = research to be proposed for 2019 *Italic* = *multi-year research programme*

Project/Issue	**2019**	**2020**	**2021**	**Annual**
WCPFC Project 35b	Purse seine and ?WP5	…		**Sampling for tuna tissue bank**

Project/Issue	**2022**	**2023**	**2024**	**2025**

8. Chronology of Skipjack Tuna Research

Year	Project	Objectives	Reports
xxxx	yyyyy		
Precis			
Precis			

YELLOWFIN TUNA

(*Thunnus albacares*)

1. The Fisheries

Total yellowfin catch in 2017 was a record 670,890 mt. Purse seine catch was 472,279 mt in 2017, longline catch was 83,399 mt, pole and line catch at 12,219 mt, and other gears (primarily Indonesia and Philippines domestic fisheries) caught 102,993 mt**.**

2. Stock Status

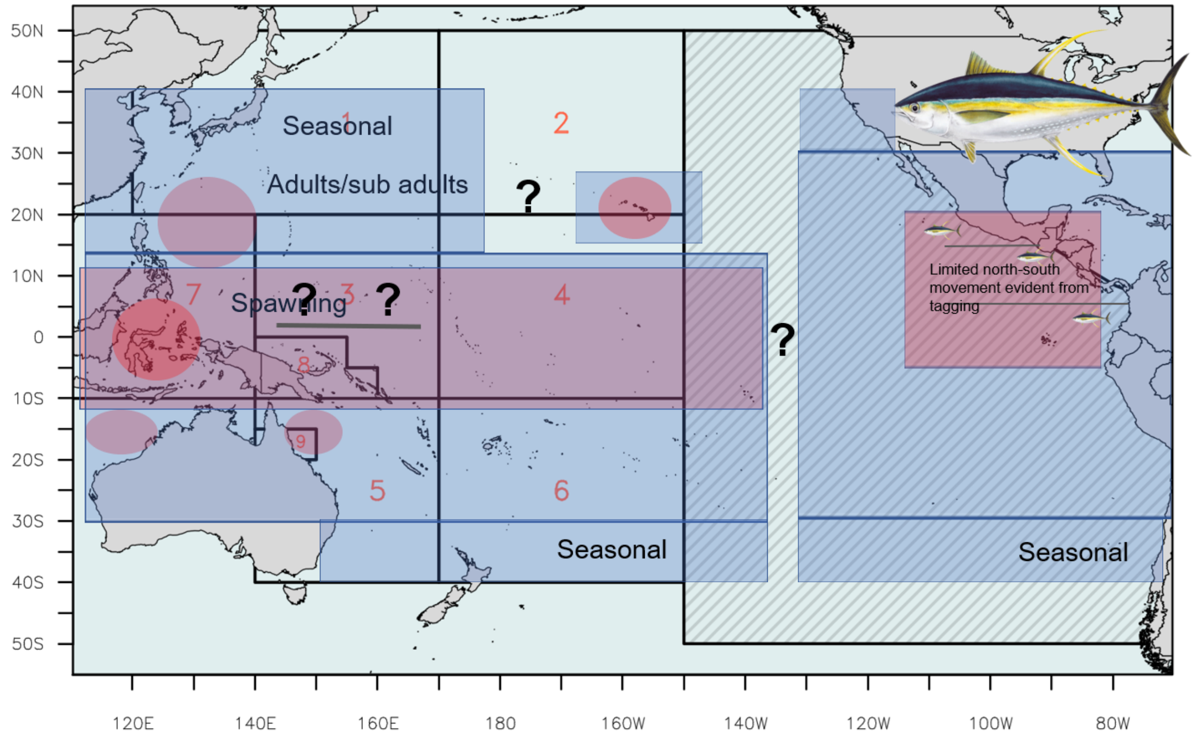
Stock assessments in both the WCPO and EPO suggest yellowfin tuna is not overfished and not subject to overfishing (for the WCPO, stock assessed to be above the WCPFC-adopted LRP of 20% $SB_{F=0}$ and fishing mortality to be below F_{MSY}; Tremblay-Boyer et al. 2017; Minte-Vera et al. 2017). The next assessment in the WCPO is planned for 2020.

3. Research Approach and Information Requirements

The stock structure approach for yellowfin is given in Table x. The proposed…..

Table X: Yellowfin - current approach, information requirements and research needs

	Current approach	Information available	Research needs
Yellowfin stock assessment	Considered a single stock in each of WCPO and EPO	…..	Several components identified 1. refinement of sub-regional boundaries and alignment with fishery impacts and effort distribution 2. need for considering local stock recruitment relationships rather than a regional SR.. SNP best approach from genetics
Yellowfin ecosystem modelling			Scaling seapodym projections. Movement parameters are often at or near their boundaries which may be suggesting that the underlying dynamic is not being captured.
Yellowfin MSE	Considered a single stock	…..	WCPFC MSE project. Useful to include at least some extreme stock structures (ie each end of the spectrum) and test influence. Noting the IWC experience where stock structure differences are expected to be influential
Yellowfin traceability			Global analyses required to get this right - i.e. development of an ocean basin 'library' to trace individuals back mtDNA species ID SNPs for provenance
……….			



4. Models of life cycle

The current stock structure assumed for the assessment of yellowfin in the Pacific Ocean is separate WCPO and EPO stocks. Spawning occurs in areas where water temperatures are generally above 24°C, though Ueyanagi (1969, 1978) stated that 26°C is probably the lower limit for spawning of yellowfin. Several authors reported that the yellowfin tuna spawns throughout the year in tropical waters, but seasonally in subtropical waters in the western and central Pacific Ocean. In the WCPO there is evidence to suggest a peak spawning period between February and June. A number of key spawning areas have been identified, including the Banda Sea in Indonesia, the eastern and southern Philippines, northeast Solomon Islands, the northern Coral Sea and Fiji. Mean length at 50% maturity of females has been estimated to be ~108 cm in the WCPO, and around 92 cm in the EPO. Sub-adults and adults are broadly distributed across the Pacific Ocean, inhabiting tropical to temperate waters from approximately 30°N to 30°S, extending to 40° in both hemispheres seasonally. The median lifetime displacement estimated from conventional tagging data is 330-380 nmi. There is some evidence for spatial structuring of populations from SNPs, with evidence suggesting genetically-distinct populations in the WCPO and EPO.

Hypotheses of stock structure that warrant addressing are:

1. Natal Area Homing Hypothesis (adults use same spawning grounds)
2. Sub-adult fish resulting from different spawning grounds are mixed (the converse being they stay as 'discrete' assemblages

5. Implications for Research

Sustainability

What happens without this……

Management

What happens without this……

6. Sampling Design and Approach to Collection

Sampling strategy and design….observers etc, port sampling etc, where, when, who, what.

Hypothesis 1:

Requires simultaneous sampling of either 1) running ripe fish (preferential) or 2) fish as small as possible (YOY - ideally less than 30 cm but practicalities may limit this). Samples should be collected over multiple years to evaluate whether signal(s) are stable, particularly within ENSO phases. Observer data and the tuna tissue bank should be interrogated to determine areas where running ripe fish occur at the same time to help identify key sampling locations. Samples should be collected from as broad an area as possible, spanning from (at least) indonesia to the EPO.

Ideally, sampling should cover the full suite of material, but priority should be given to material that has multiple uses - 1) muscle (for genetics, fatty acid, stable isotope analyses, 2) otoliths (for age and growth studies, chemistry (elemental and stable isotopes), and shape analyses).

Where: target key areas identified to have running ripe fish (e.g. Coral Sea) but also examine observer data / biodasys / catch data to try to fill in area gaps. Better to over-sample and determine which samples best to use for analyses rather than undersample, but also need to beware observer/sampler fatigue (new tools, incentives may help with this).

How to sample: via observers, samplers on LL vessels. If targeting small fish could potentially sample from brined individuals in wells during transhipment activities (individuals wells still likely to have spatial information). But, will need a rigorous test on the quality of DNA in brined fish. Collaborations with other projects e.g. new ACIAR project on population biology of SKJ, YFT, BET in Indonesia.

Could also use non-genetic approaches to test for natal homing (e.g. otolith chemistry): approach would be to first sample fish as small as possible to try to identify a natal area signature, then sample a few years later when those same fish are adults spawning on the spawning ground and see if they hold the natal area signature characterising that ground.

Sample sizes: 100 fish for genetics, 50 of otolith chemistry / shape analyses, 50 for parasites per sample (spatially or temporally distinct group of fish).

Hypothesis 2: Sub-adult fish resulting from different spawning grounds are mixed (the converse being they stay as 'discrete' assemblages

Similar to above but requires simultaneous sampling of fish outside spawning period in addition to YOY fish as close to natal areas as possible. Mixed stock analysis for genetic or otolith chem could determine whether samples from different natal areas have mixed (by re-classifying back to natal signature determined above)

Ideally, sampling should cover the full suite of material, but priority should be given to material that has multiple uses - 1) muscle (for genetics, fatty acid, stable isotope analyses, 2) otoliths (for age and growth studies, chemistry (elemental and stable isotopes), and shape analyses).

Where: for spawning locations - target key areas identified to have running ripe fish (e.g. Coral Sea) but also examine observer data / biodasys / catch data to try to fill in area gaps. For assemblages outside of spawning - target largest fish possible from purse seine catch. Samples could be spaced along 10° of longitude and latitude in the WCPO, and include at least 2 (ideally three) latitudinally distinct samples in the EPO. Better to over-sample and determine which samples best to use for analyses rather than undersample, but laos need to beware observer/sampler fatigue (new tools, incentives may help with this).

Sample sizes: 100 fish for genetics, 50 of otolith chemistry / shape analyses, 50 for parasites.

7. Medium Term Research Plan for Yellowfin Tuna

Bold = research to be proposed for 2019 *Italic* = *multi-year research programme*

Project/Issue	**2019**	**2020**	**2021**	**Annual**
WCPFC Project 35b	Purse seine and longline	…		**Sampling for tuna tissue bank**

Project/Issue	**2022**	**2023**	**2024**	**2025**

8. Chronology of Yellowfin Tuna Research

Year	Project	Objectives	Reports
xxxx	yyyyy		
Precis			
Precis			

BIGEYE TUNA

(*Thunnus obesus*)

1. The Fisheries

The preliminary estimate of total catch of WCPO bigeye tuna for 2017 was 126,929 mt. Longline gears caught 58,164 mt, purse seine catch was 56,194 mt, pole and line catch was 1,411 mt, and catch by other gears was 11,160 mt.

2. Stock Status

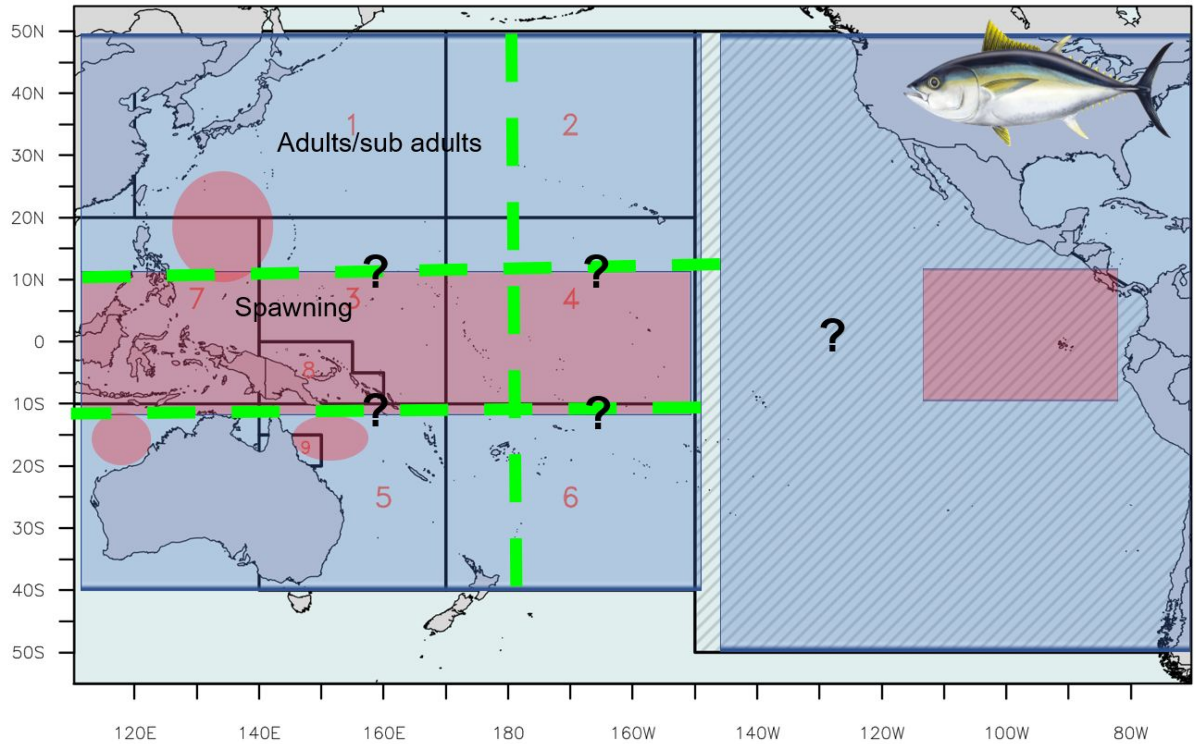
The most recent stock assessment suggests bigeye tuna is not overfished, and not subject to overfishing in both the WCPO ((stock assessed to on average be above the WCPFC-adopted LRP of 20% $SB_{F=0}$ and fishing morality below F_{MSY}; McKechnie et al. 2017a), and EPO (Aires-da-Silva et al. 2017, but see Maunder et al. 2018). The next assessment in the WCPO is planned for 2020.

3. Research Approach and Information Requirements

The stock structure approach for bigeye is given in Table x. The proposed…..

Table X: Bigeye - current approach, information requirements and research needs

	Current approach	**Information available**	**Research needs**
Bigeye stock assessment	Considered a single stock	…..	……..
Bigeye ecosystem modelling			
Bigeye MSE	Considered a single stock	…..	
Bigeye traceability			
……….			



4. Models of life cycle

The current stock structure assumed for the assessment of bigeye tuna in the Pacific Ocean is separate WCPO and EPO stocks.

Farley et al. (2018) observed spawning capable females (only) between 12°N and 12°S and between 137°E and 130°W, in water temperatures between 27.7 and 30.3°C suggesting tropical central equatorial waters may be an important spawning region for bigeye. Additional spawning areas have been reported off the eastern coast of the Philippines and in the Coral Sea. Mean length at 50% maturity of females has been estimated to be ~118 cm in the central and eastern Pacific. Sub-adult and adult bigeye tuna are broadly distributed across the Pacific Ocean, inhabiting tropical to temperate waters from approximately 45°N to 40°S in the western Pacific, and from approximately 40°N to 30°S in the eastern Pacific. Tagging data suggest limited latitudinal movement of fish within 10° of latitude from the equator, and limited westward movement of fish tagged in the EPO. Fish tagged in the CPO show a strong tendency to move eastwards. In the EPO, one electronically individual was estimated to have repeatedly moved in to the central Pacific Ocean, potentially indicative of natal homing. Preliminary genetic studies using SNPs suggest some structuring between the WPO and the EPO.

Hypotheses of stock structure that warrant addressing are:

1. Homing of BET to natal spawning locations;
2. Latitudinal movement and mixing of BET from the equatorial belt (10° of latitude from the equator) to sub-equatorial areas;
3. …..

5. Implications for Research

Sustainability

What happens without this……

Management

What happens without this……

6. Sampling Design and Approach to Collection

Sampling strategy and design….observers etc, port sampling etc, where, when, who, what.

7. Medium Term Research Plan for Bigeye Tuna

Bold = research to be proposed for 2019 *Italic = multi-year research programme*

Project/Issue	2019	2020	2021	Annual
WCPFC Project 35b	Purse seine and longline	…		**Sampling for tuna tissue bank**

Project/Issues	2022	2023	2024	2025

8. Chronology of Bigeye Tuna Research

Year	Project	Objectives	Reports
xxxx	yyyyy		
Precis			
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SOUTH PACIFIC ALBACORE

(*Thunnus alalunga*)

1. The Fisheries

The preliminary estimate of total catch of south Pacific albacore (within the WCPFC Convention Area south of the equator) for 2017 was 75,707mt. The majority was taken by longliners, being 72,785mt, with that from other gears (primarily troll) being 2,896t.

2. Stock Status

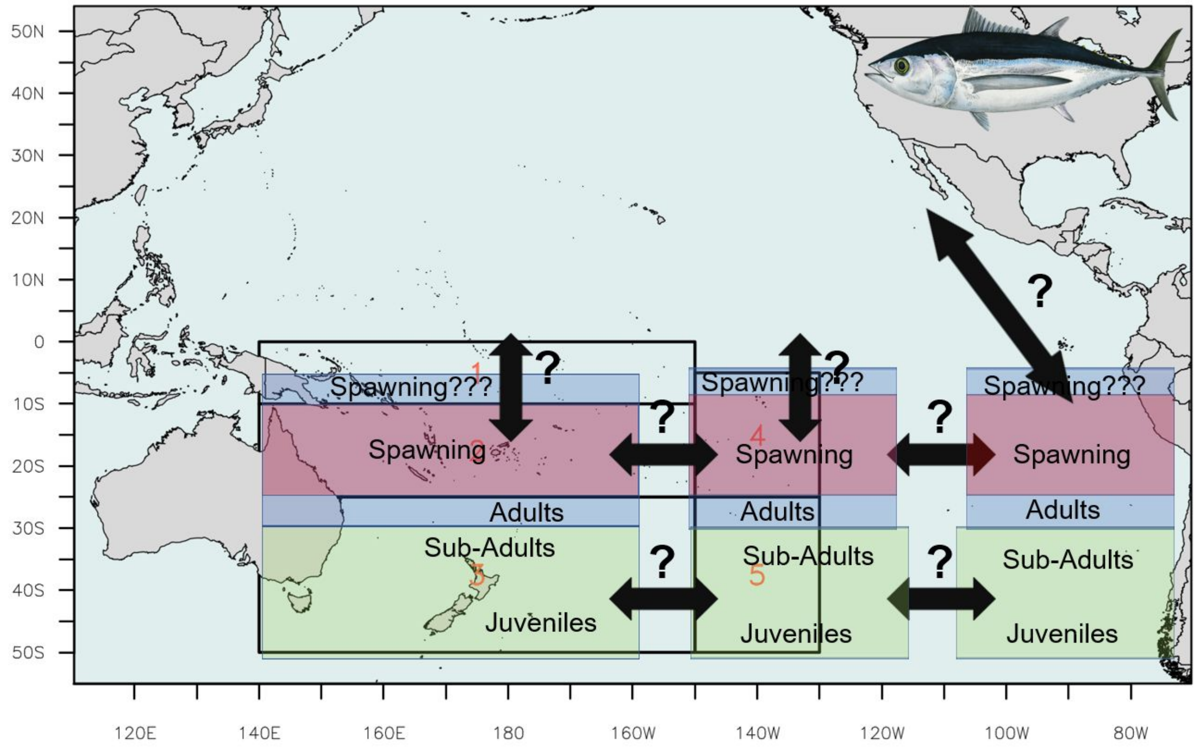
The most recent WCPO stock assessment suggests South Pacific albacore is not overfished (recent adult biomass is above the adopted LRP), and is not subject to overfishing (fishing mortality is below F_{MSY}; Tremblay-Boyer et al. 2018).

3. Research Approach and Information Requirements

The stock structure approach for South Pacific albacore is given in Table x. The proposed…..

Table X: South Pacific albacore - current approach, information requirements and research needs

	Current approach	**Information available**	**Research needs**
South Pacific albacore stock assessment	Considered a single stock	…..	……..
South Pacific albacore ecosystem modelling			
South Pacific albacore MSE	Considered a single stock	…..	
South Pacific albacore traceability			
……….			



4. Implications for Research

Sustainability

What happens without this……

Management

What happens without this……

5. Sampling Design and Approach to Collection

Sampling strategy and design….observers etc, port sampling etc, where, when, who, what.

6. Medium Term Research Plan for South Pacific Albacore

Bold = research to be proposed for 2019 *Italic = multi-year research programme*

Project/Issue	2019	2020	2021	Annual
WCPFC Project 35b	Purse seine and longline	…		**Sampling for tuna tissue bank**

Project/Issue	2022	2023	2024	2025

7. Chronology of South Pacific Albacore Research

Year	Project	Objectives	Reports
xxxx	yyyyy		
Precis			
Precis			

GENERIC ISSUES

This section briefly highlights issues that are of relevance to all of the tuna stock structure research programmes (e.g. cross-cutting issues) and will need to be addressed in future research planning.

Obtaining Efficiencies in Sampling Programmes

Sampling programmes in….

Multi-year Research Programmes

Where a research programme is generally rolled over from year to year, efficiencies can be obtained by funding across a multi-year project. However, in an uncertain medium term planning environment these potential efficiencies may be sacrificed to allow future flexibility. In order to obtain research more efficiently, effectively and economically in future, exploration of the potential for partnerships across multi-year programmes is required.

Other RFMO Projects

For ….. collaborative research projects among interested RFMOS/members of multiple RFMOs……..

review whether fisheries independent indices of abundance can be reasonably obtained.

Artisanal Fishery Implications

For

Postgraduate research opportunities

From