

Developing ecosystem understanding for Ecosystem-Based Fisheries Management (EBFM) of fish resources



AFS Webinar 2: 24th September 2024

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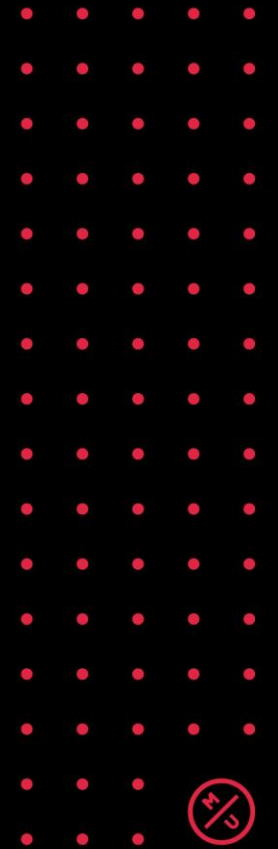
Acknowledgement of Country



We acknowledge that Murdoch University is situated on the lands of the Whadjuk and Binjareb Noongar people.

We pay our respect to their enduring and dynamic culture and the leadership of Noongar elders past and present.

The boodjar (country) on which Murdoch University is located has for thousands of years, been a place of learning. We at Murdoch University are proud to continue this long tradition.



Outline

1. Global, Asian and Australian fisheries
2. Assessment of Asian Fish stocks and the importance of a strong Asian Fisheries Society
3. Evolution of Fisheries Management to reach Ecosystem Based Fisheries Management
4. Developing ecosystem understanding using models
 - conceptual, qualitative, quantitative models
 - a) Example of fished species and a habitat (Australia)
 - b) Example of grouper species in Asia (Saleh Bay, Indonesia)

An Australian perspective





2015 Fisheries assessment
workshop
IBP ICC

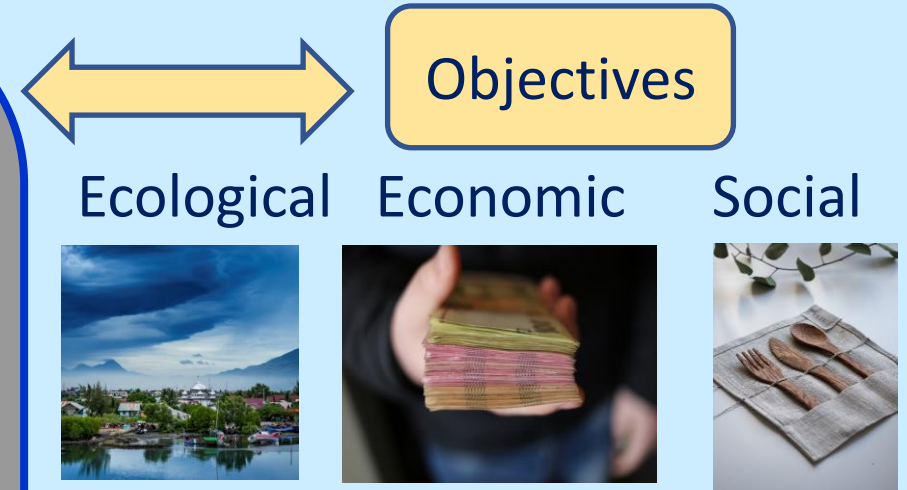
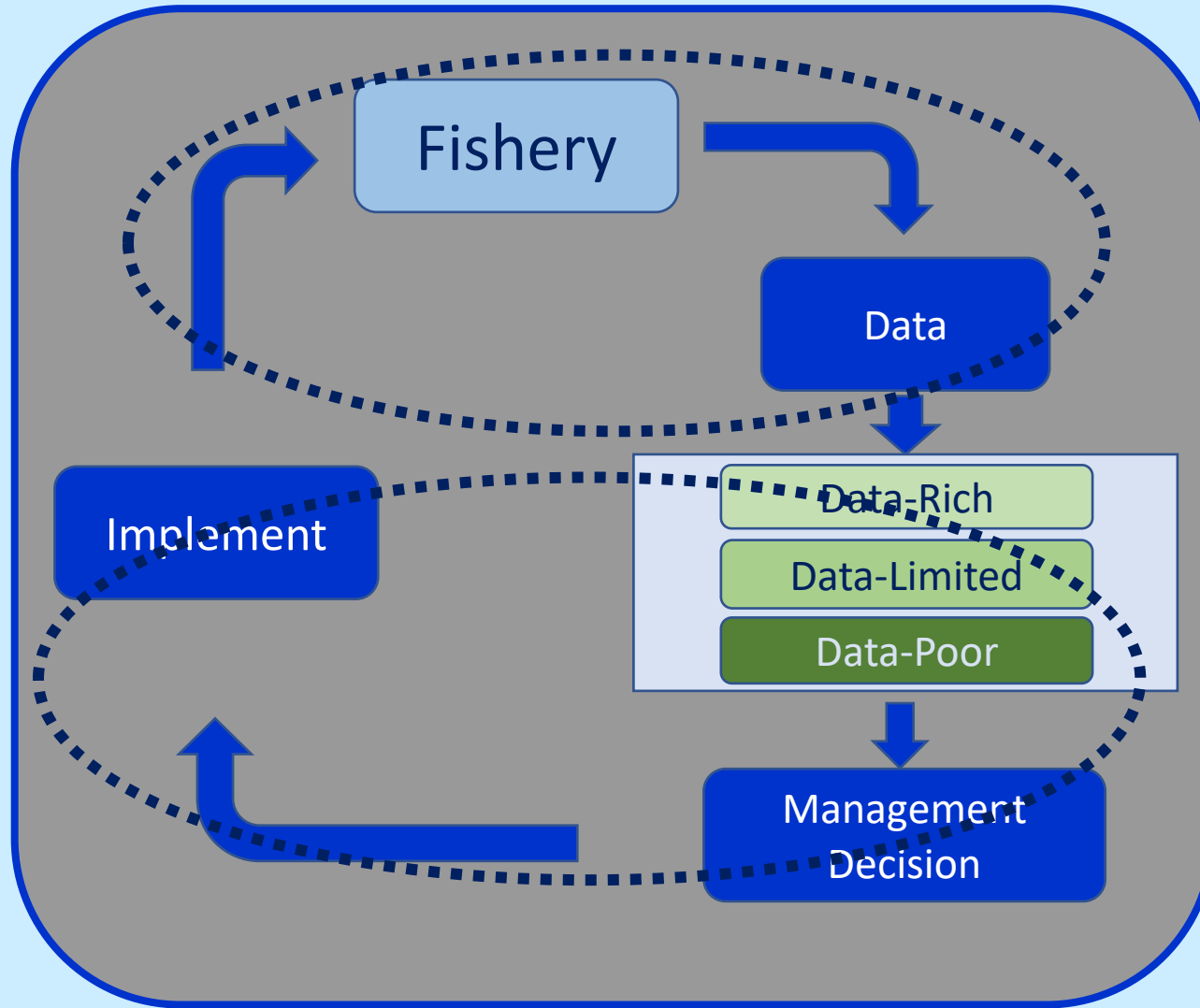
2019 Data-limited
fisheries workshops
IBP Techno Park



2023 Ecosystem
modelling (Lenfest)
Bogor



Fisheries Management System



Trans-disciplinary approach

- People, culture & fisheries
- Biology and ecology
- Data, statistics & models
- Communication

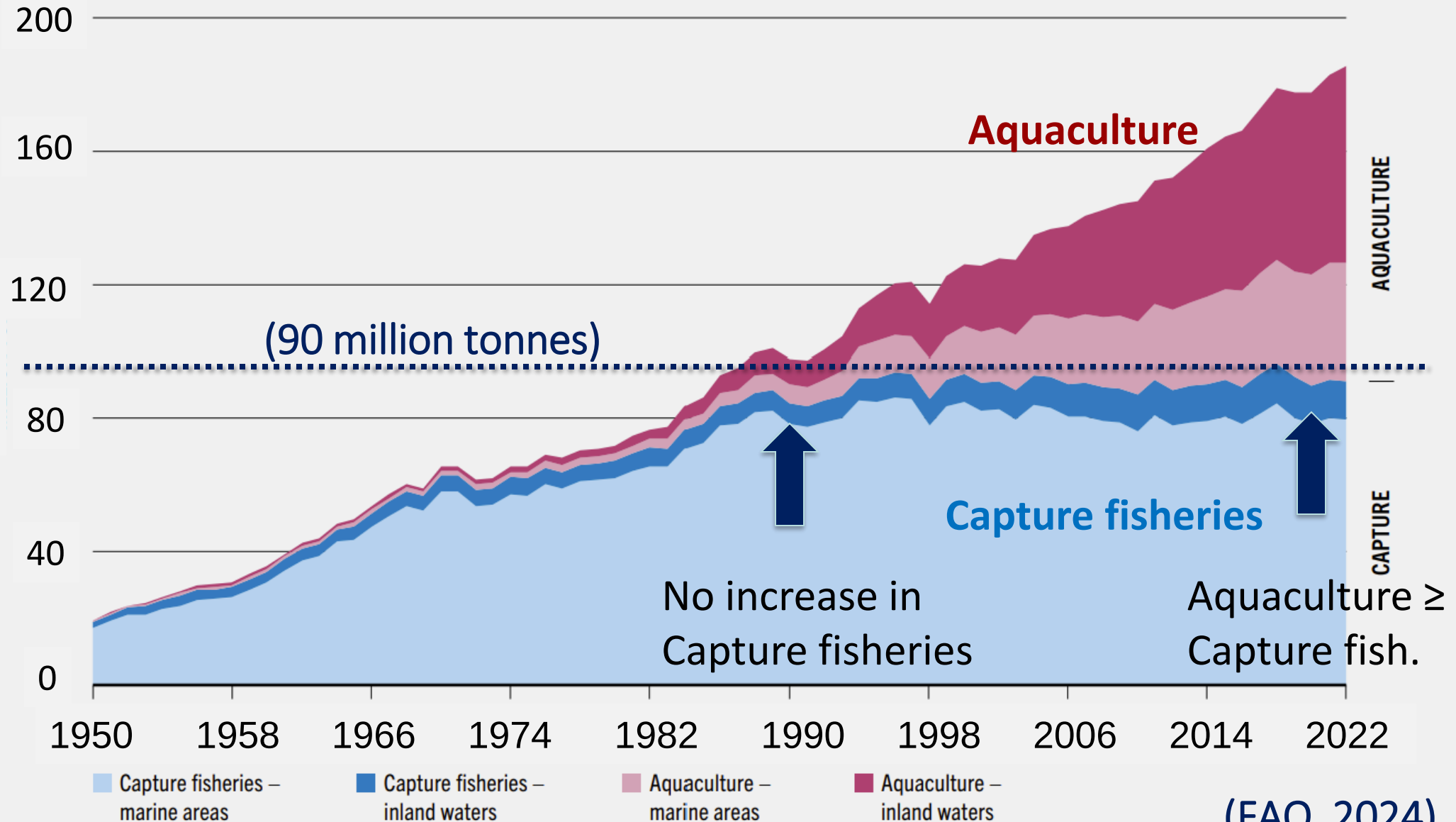
(design by Dr Adrian Hordyk)

World Fisheries and Aquaculture production of aquatic animals

(FAO, 2024)

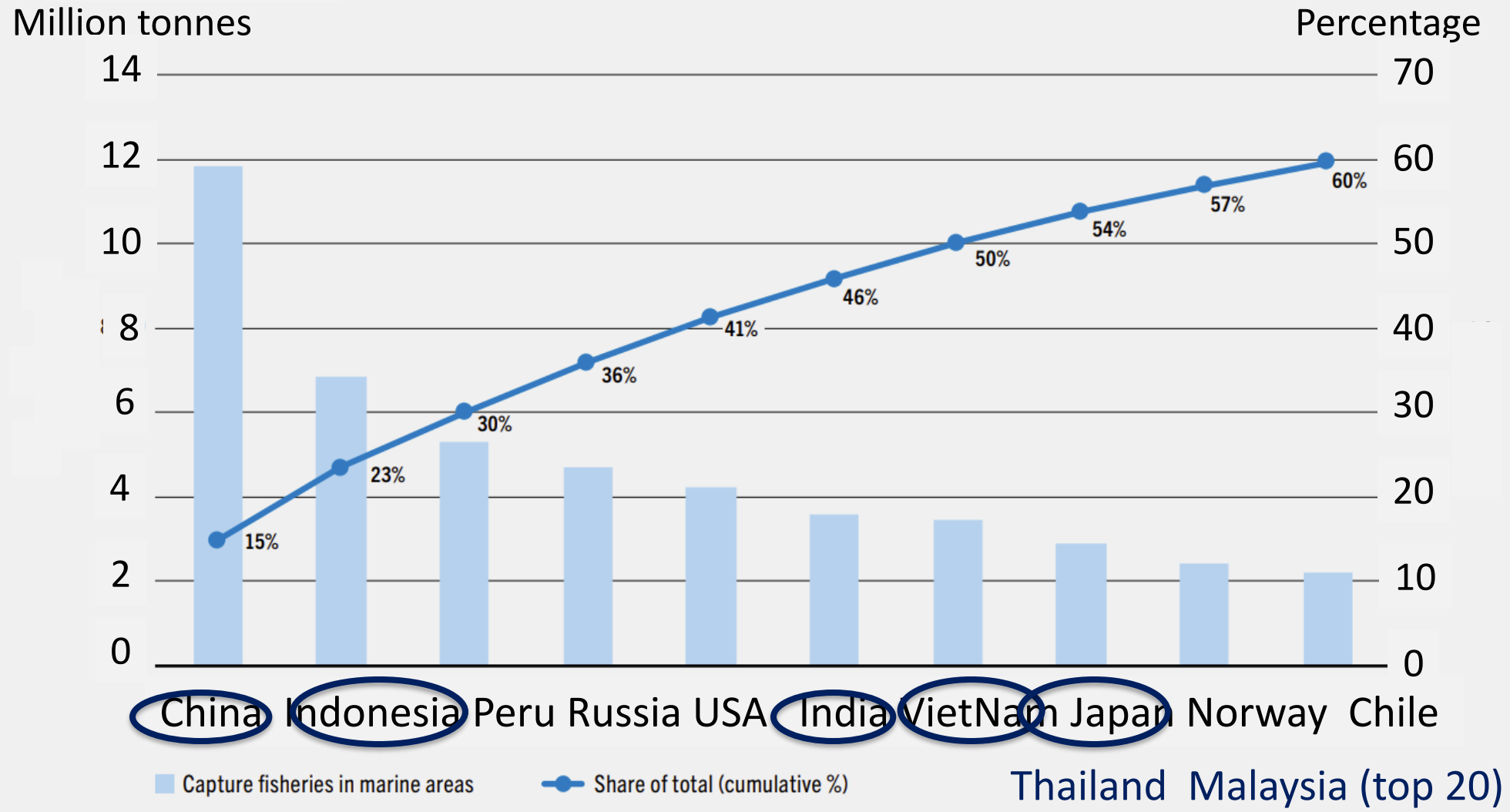
World Fisheries and Aquaculture production of aquatic animals

Million tonnes



(FAO, 2024)

Top ten marine capture fisheries nations (FAO, 2024)

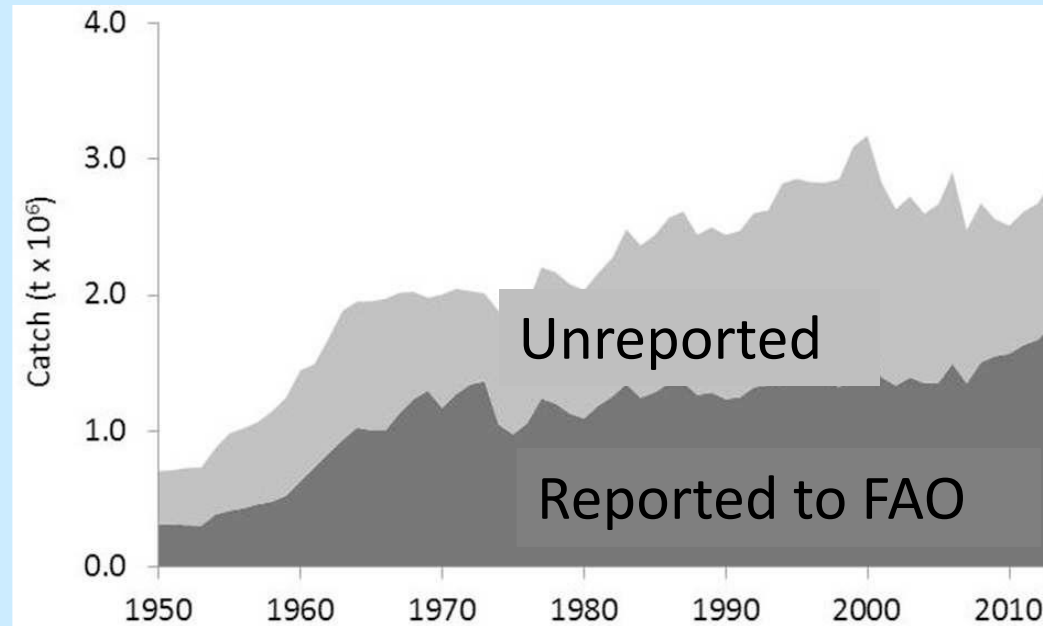


Asia: largest fleet in the world – 3.5 million vessels, 75% of the global fleet

Small scale fisheries



- These fisheries are very significant for livelihoods and nutrition - many fishers, many fishing methods
- Catches and fishing effort in SSF are often under-reported

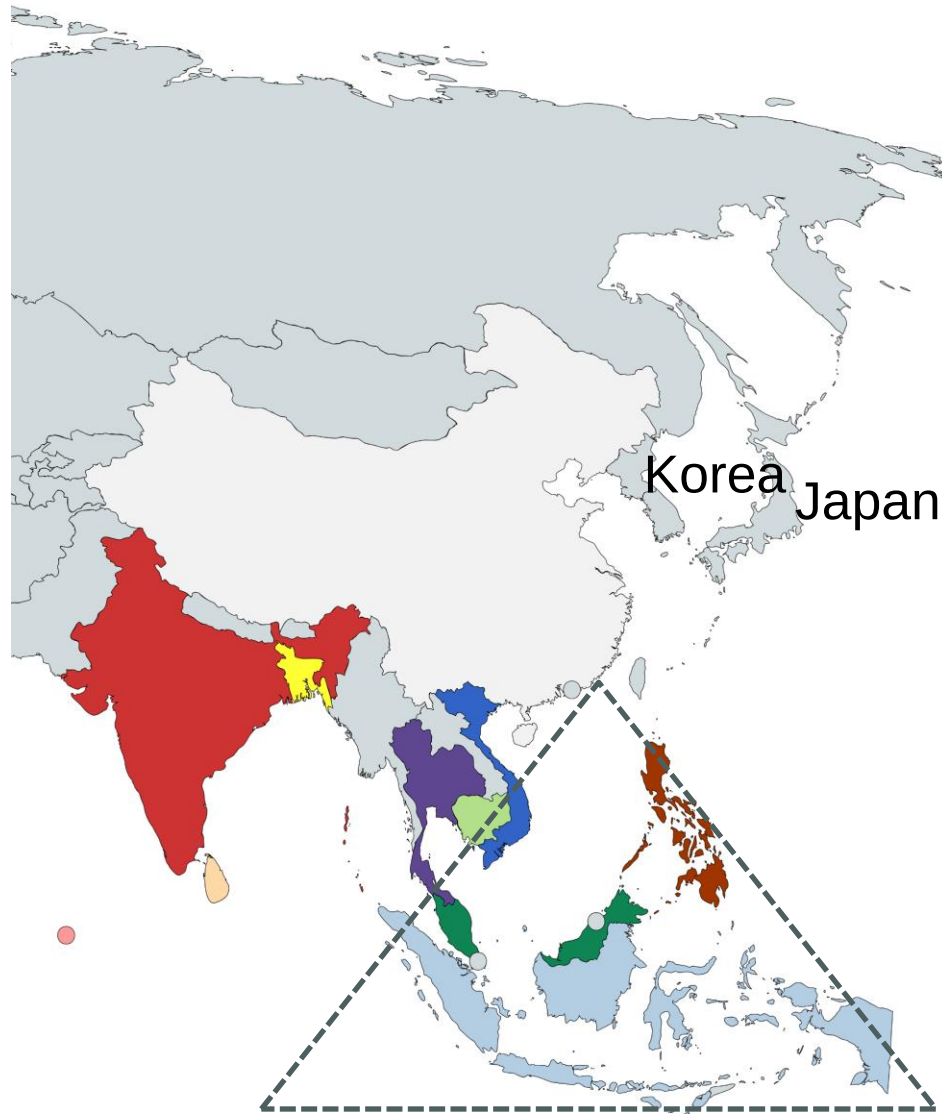


Reconstructed catches for:
Cambodia
Malaysia
Thailand
Vietnam

(Teh and Pauly, 2018)

- Assessment and management of SSF are challenging

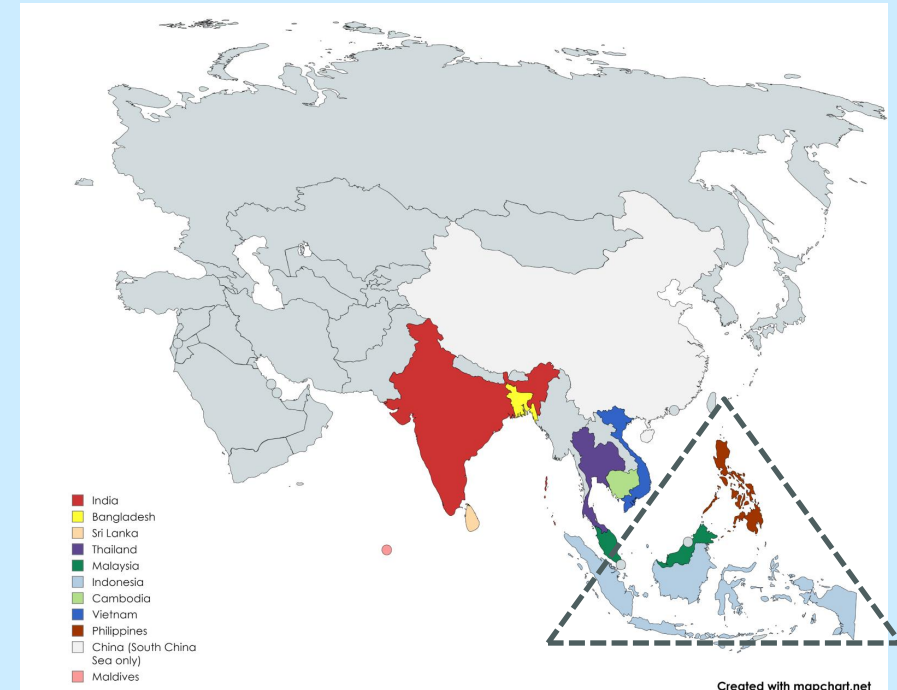
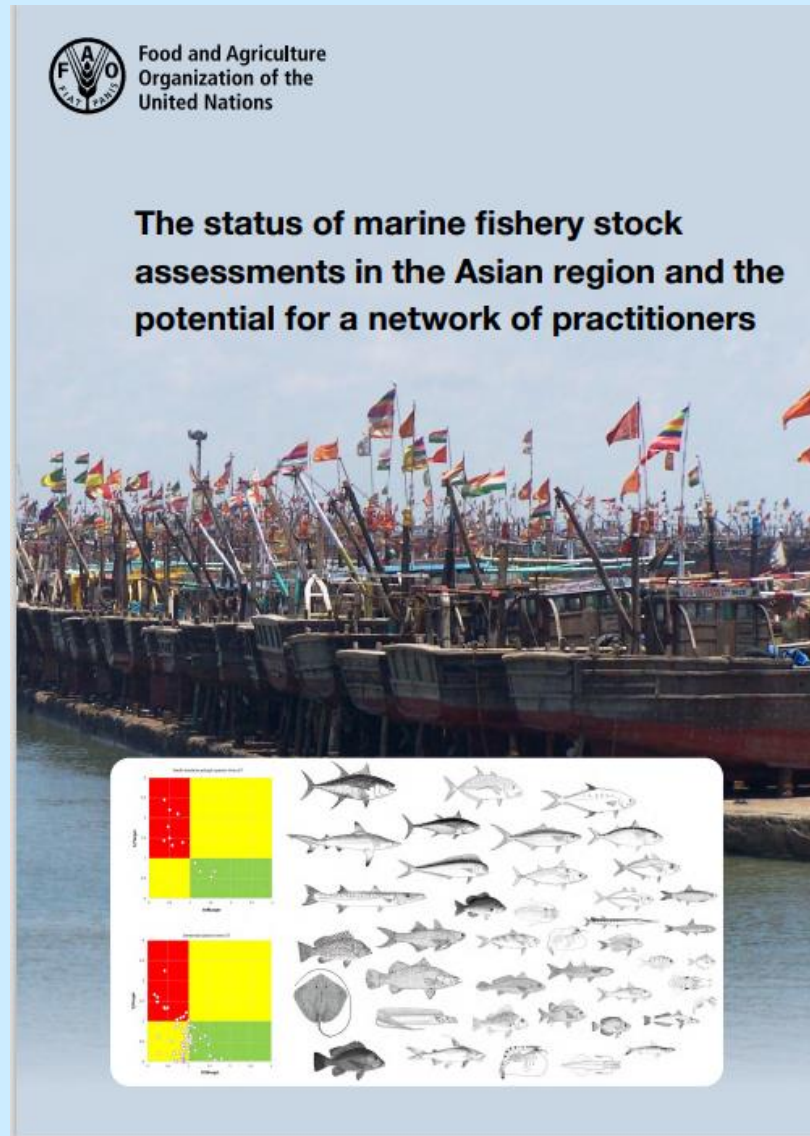
Asian Fisheries and Aquaculture – Asia-Pacific region



1. Largest marine capture fisheries landings globally
 2. Largest aquaculture production globally
 3. Millions of livelihoods supported
 4. Marine biodiversity hotspot (Coral Triangle)
- >70% of global seafood**

Asian fish stocks and their assessment

FAO Bangkok workshop January 2023, <https://doi.org/10.4060/cc9002en>



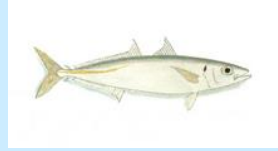
- 10 country assessments
- 10 localized assessments
- Pelagic, reef, and demersal species working groups

Findings FAO Workshop

Small-medium pelagics



Hilsa

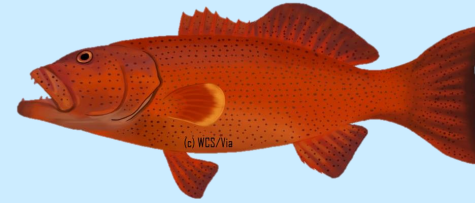


Mackerel
Scad



Bali sardine

Reef



Coral leopard
Grouper

Demersal



Blue Swimmer
Crab (BSC)

- Virtually all stocks fully or over-exploited (similar to FAO assessments)
- Data collection and measurement programs are impressive
- People are applying past, current and emerging methods – good technical capacity, some success stories – BSC in Sri Lanka

Gaps, areas where assessments can be enhanced

- No ecosystem assessments, No social indicators for fisheries
- Little discussion on sampling design, data limitations, model assumptions ...
- Improved communication is needed with:
managers, policy makers, politicians, fishers, ...

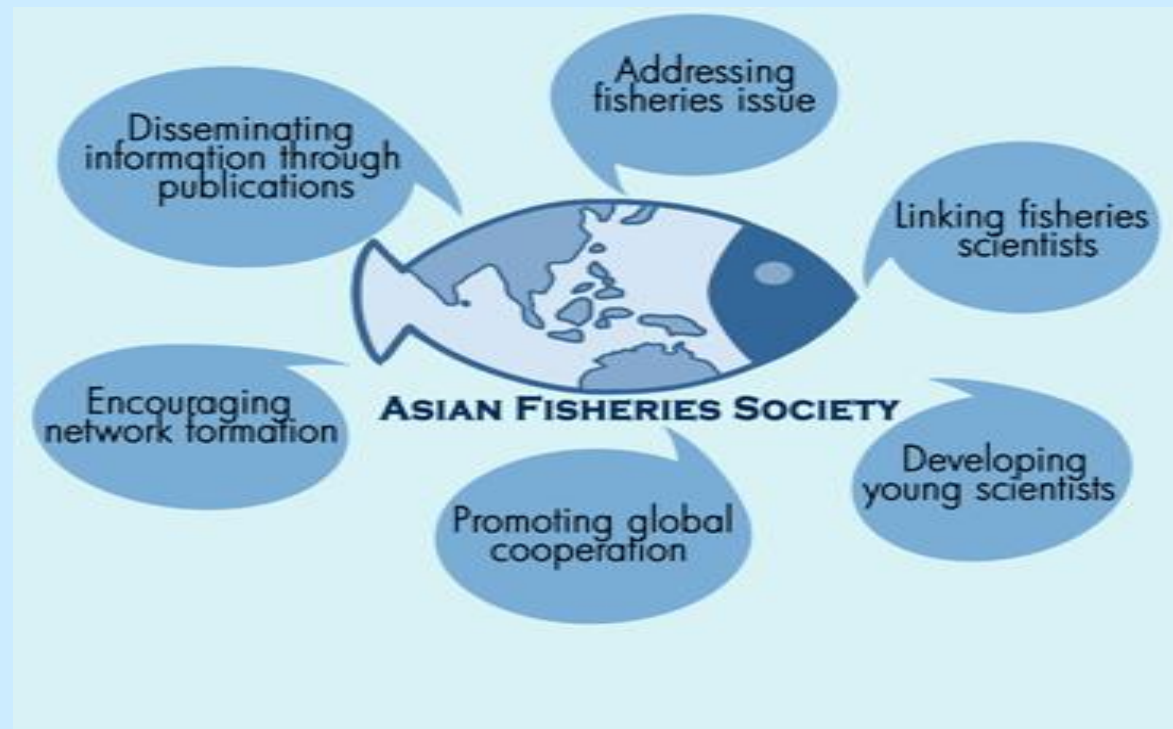
The Asian Fisheries Society

Established in 1984 – now 40 years old



Vision

“A vibrant Asia-Pacific society of researchers and other stakeholders that is valued by members for its ability to provide **opportunities** for **communication, collaboration** and **capacity development** in fisheries and aquaculture science.”

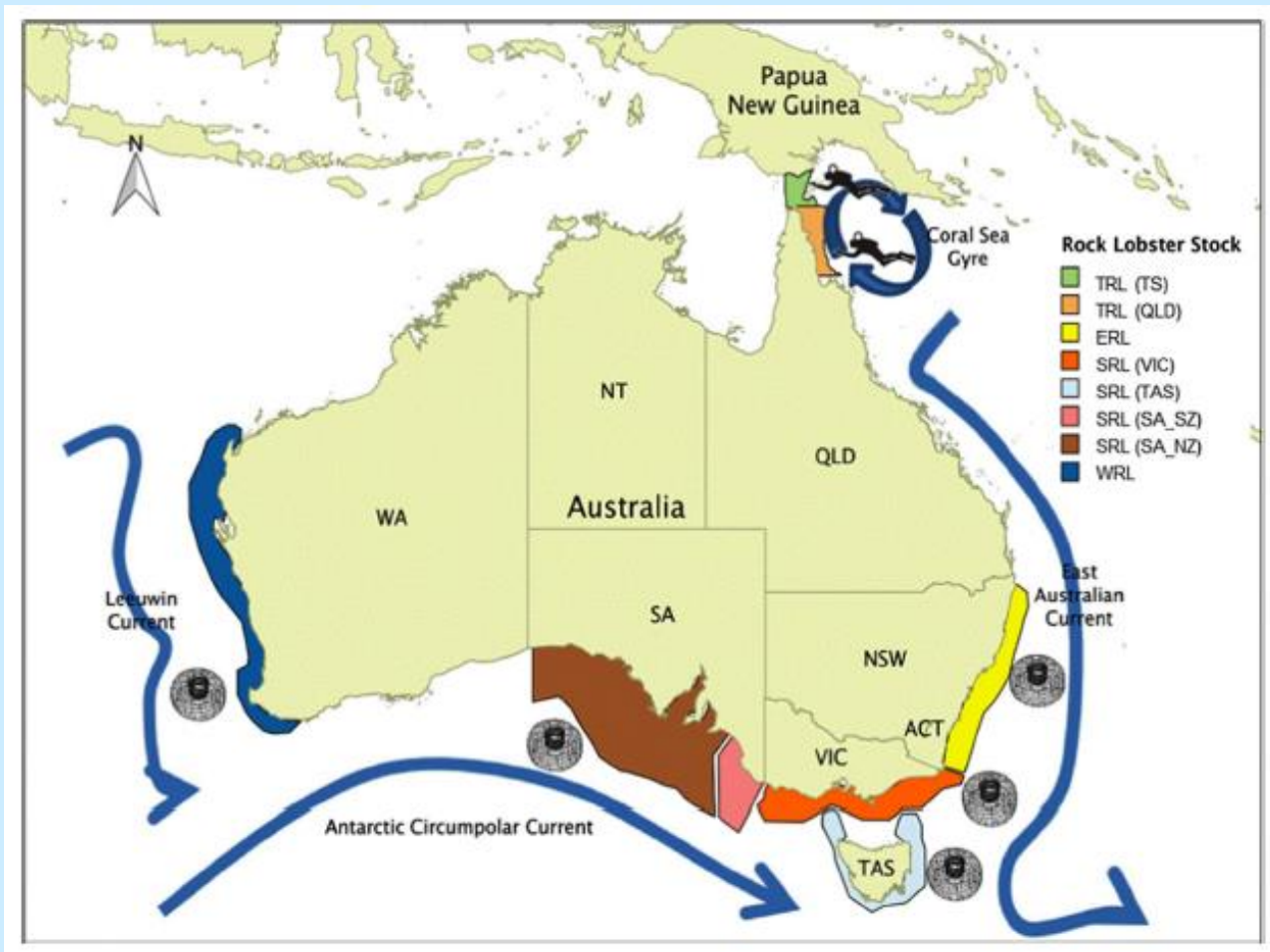


Council

- 14 Councillors (max. of 2 per country)
- 7 Countries
- Secretariate at University Putra Malaysia

Australian /West Australian fisheries

Fisheries and marine environment of Australia



(Figure 1, Plaganyi et al., 2017)

EEZ covers 10 million km²
3rd largest EEZ (Indonesia ~#6)

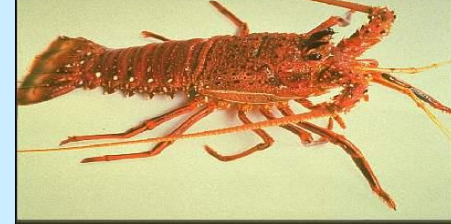
Fisheries rank by weight < top 50 (IND. #2), very high value

Employment = 21,000 (direct)
(Indonesia 3-6 million, SSF)

Low nutrient environment
Low fisheries productivity

Commercial Fisheries – Australia

total capture fisheries ~175,000 tonnes



Panulirus cygnus

Western rock lobster fishery

800 km of coastline, WA (1 state)

230 boats

~6,800 tonnes 2023 (export)

US ~\$200 million



Northern Prawn Fishery

6,000 km of coastline (3 states)

~ 50 trawlers in 2023

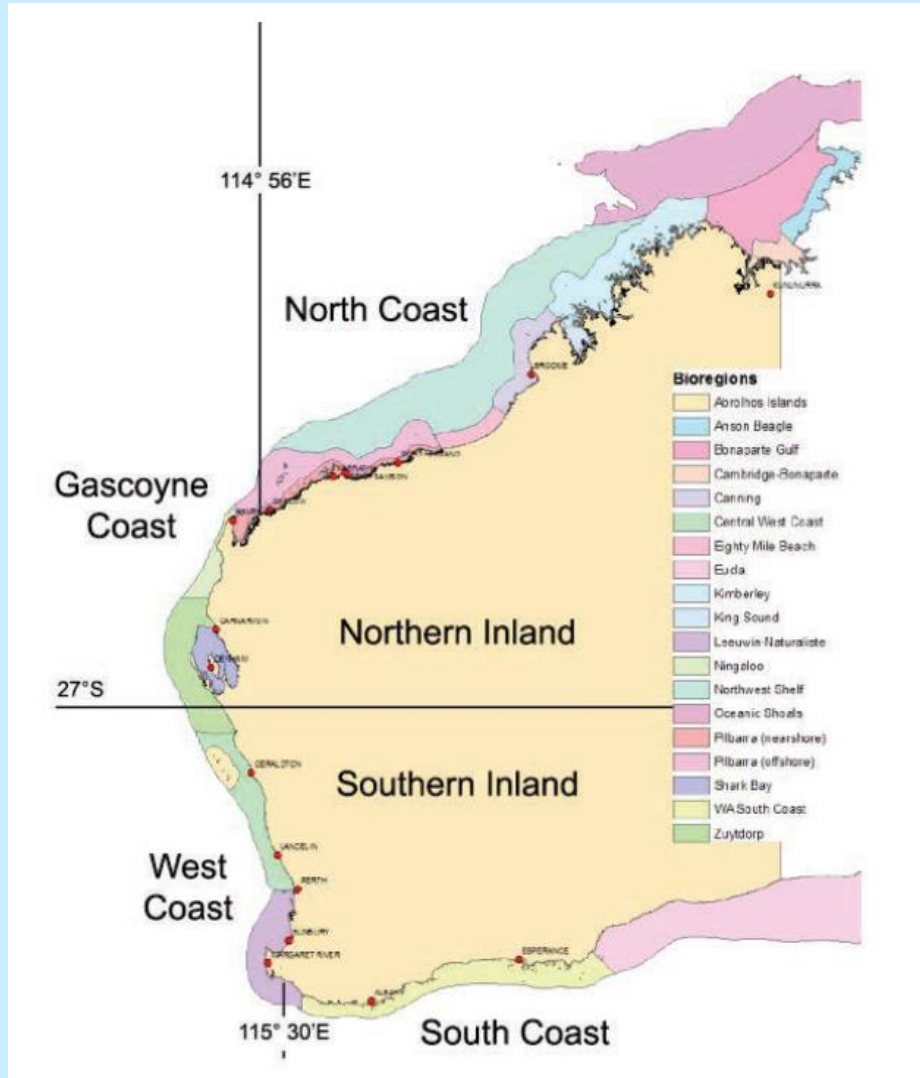
6 to 10,000 tonnes of prawns (export)

US ~\$70 million



Data Rich; Fisheries cover large areas, **few boats, small catch but high value**

Data-limited fisheries in Western Australian



1/3 of Australia 2,500,000 km²
population ~3 million people

Extensive geographic region –
~ 12,800 km of coastline, 568,677 km² shelf

~50 managed fisheries, 40 assessed,
some are data-limited

- estuaries, remote regions, some non-target
species, **recreational fisheries**

~30% of people in WA fish at least once/year

~900,000 fishers

(Figure 2, Fletcher et al. 2017
www.fish.wa.gov.au)

Goals of fisheries management

Maximum sustainable yield (MSY)

“any species each year produces a harvestable surplus, and if you can take that much, and no more, you go on getting it for ever (AMEN!)”

(Larkin 1977, 1978)

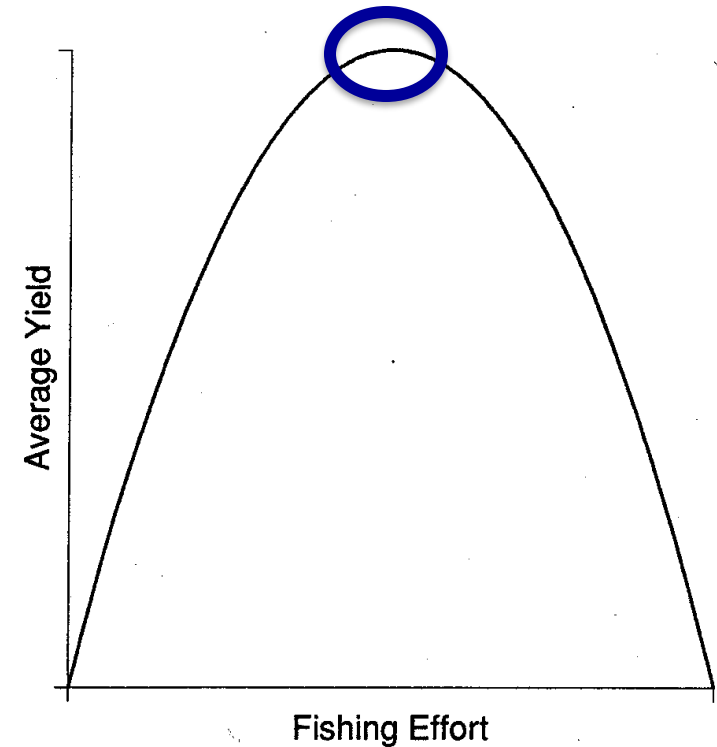


Figure 1.2. The assumed relationship between fishing effort and average catch. Perhaps the most commonly printed illustration in fisheries textbooks, and the most dangerous.

(from Hilborn and Walters 1992)

Goals of fisheries management

Maximum sustainable yield (MSY)

“any species each year produces a **harvestable surplus**, and if you can take that much, and no more, you go on getting it for ever (AMEN!)” (Larkin)

Goal of fisheries management

“to ensure **sustainable** production over time from fish stocks, preferably through regulatory and enhancement actions that promote **economic** and **social** well-being of the **fishermen** and **industries** that use the production”

(Hilborn and Walters, 1992)

Ecologically sustainable development (ESD) in Australian Fisheries (1991/92)

“**using**, conserving and enhancing the **community's** resources so that **ecological processes**, on which life depends, are maintained, and the total quality of life, **now and in the future**, can be increased”

Now - Ecosystem Based Fisheries Management (EBFM)

Goals of fisheries management

1960s: Maximising harvest – Maximum Sustainable Yield (**MSY**)

1980s: Sustainable production – fisheries and fishing industry

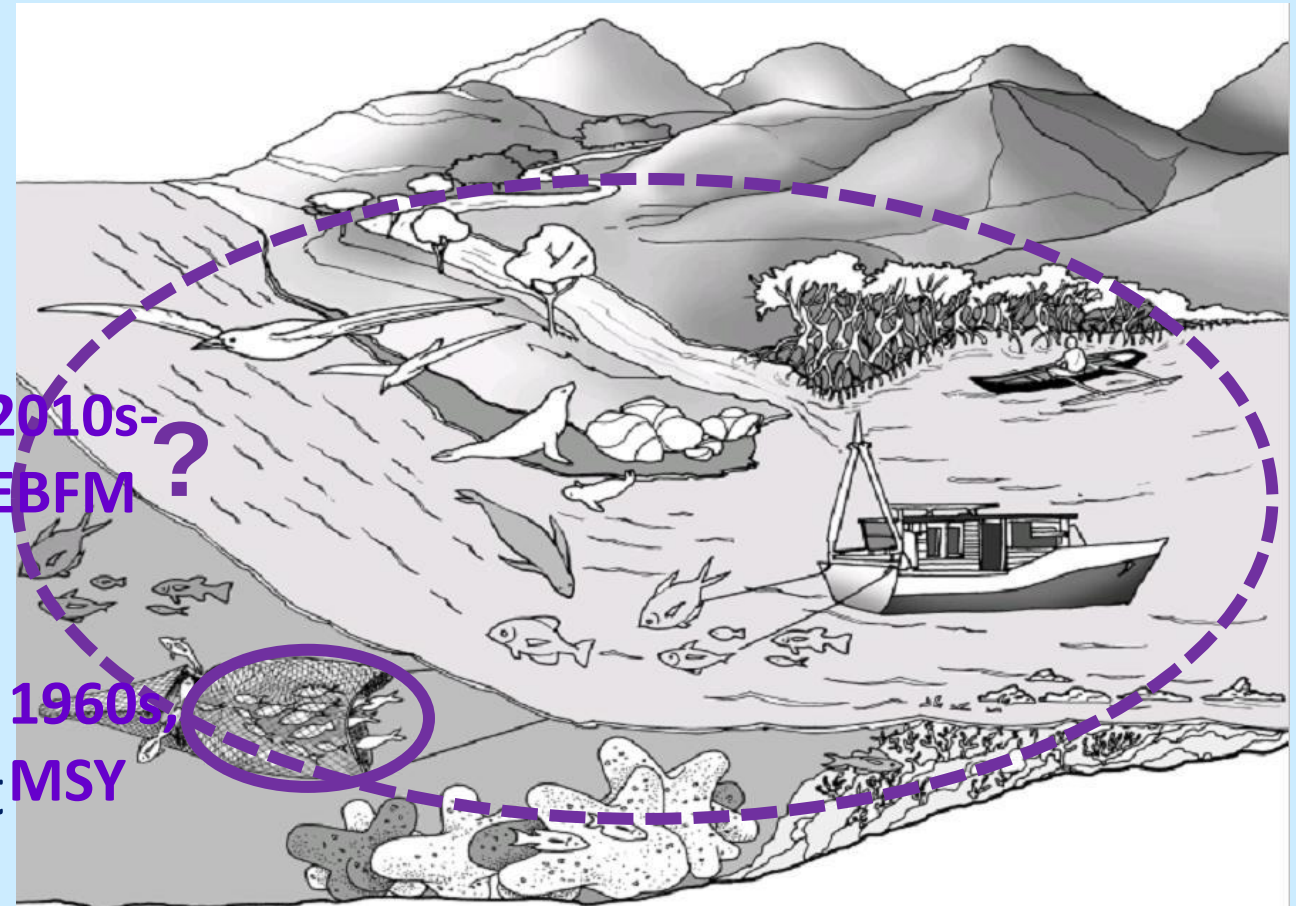
1990s: Ecologically sustainable development – sustainable fisheries extending to ecology (**ESD**)

2000s Ecosystem approaches to fisheries and Ecosystem Based Fisheries Management (**EBFM**)

Ecosystem based fisheries management (EBFM)

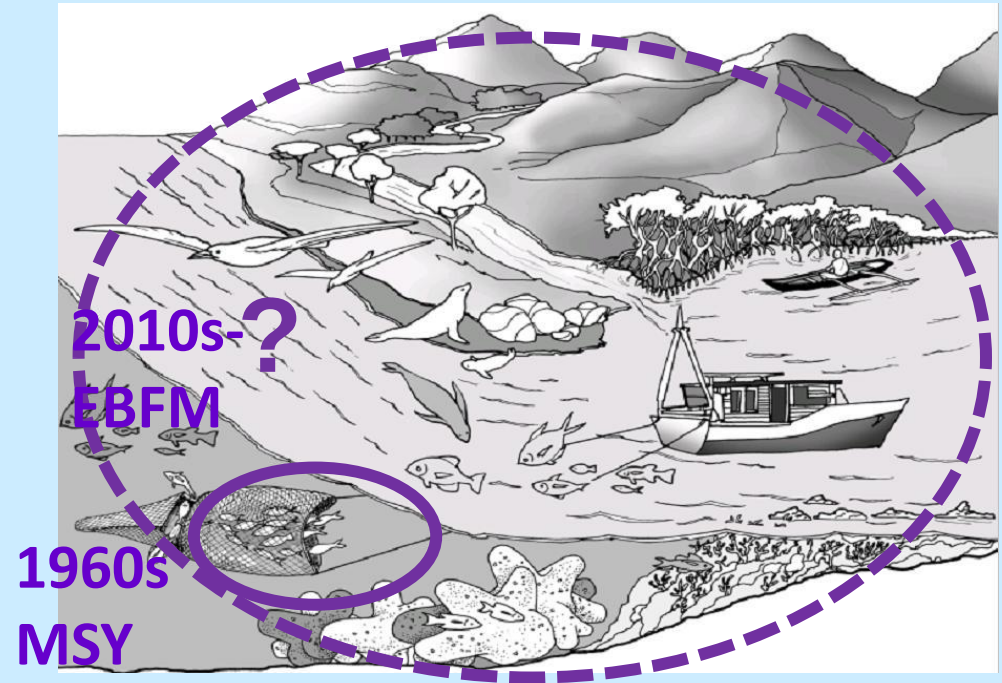
- Requirement for certification e.g. Marine Stewardship Council
- Fishery improvement plans
- UN Sustainable Development Goals 14:

Conserve and sustainably use the oceans, seas and marine resources for sustainable development



Ecosystem based fisheries management (EBFM)

- Requirement for certification e.g. Marine Stewardship Council
- Fishery improvement plans
- UN Sustainable Development Goals 14: Sustainably use the oceans, seas and marine resources



Components of EBFM

1. Ecological

a) Target b) non-target, ecosystem

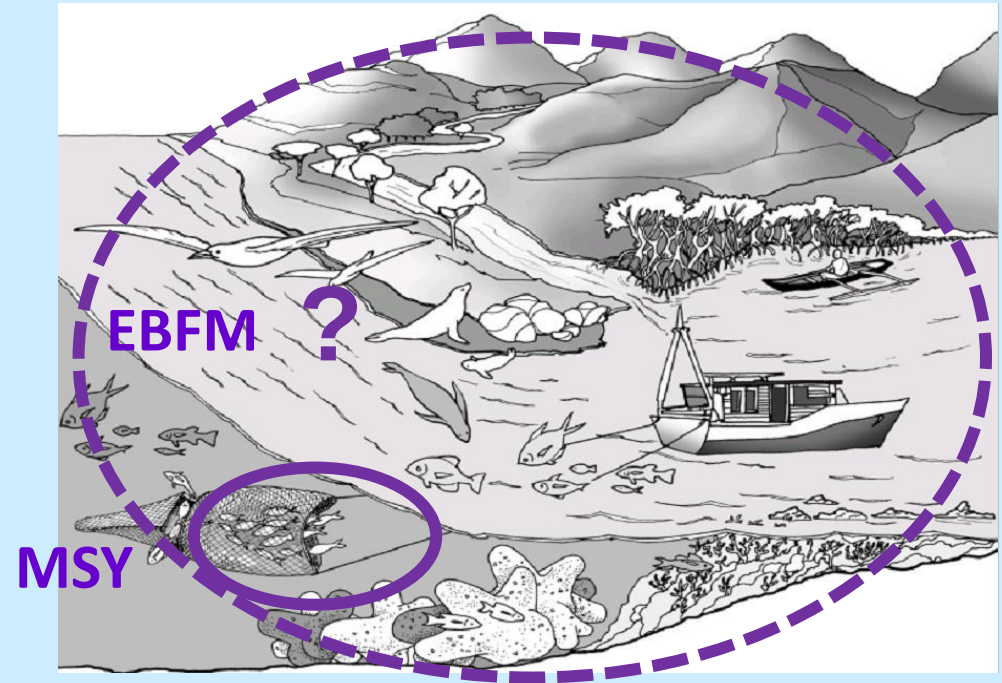
2. Socio-economic outcomes

3. Governance – ability to achieve

Ecosystem approaches to fisheries/EBFM

(EBFM, also Ecosystem approaches to fisheries)

- Requirement for certification
e.g. Marine Stewardship Council
- Fishery improvement plans
- UN Sustainable Development Goals 14: Sustainably use the oceans, seas and marine resources



Components of EBFM

1. Ecological
a) Target b) non-target, ecosystem biology
Stock assessment

2. Socio-economic

3. Governance

Ecology, Ecological Modellers, Social Science,
Economics, Policy and Law

Shifting to EBFM

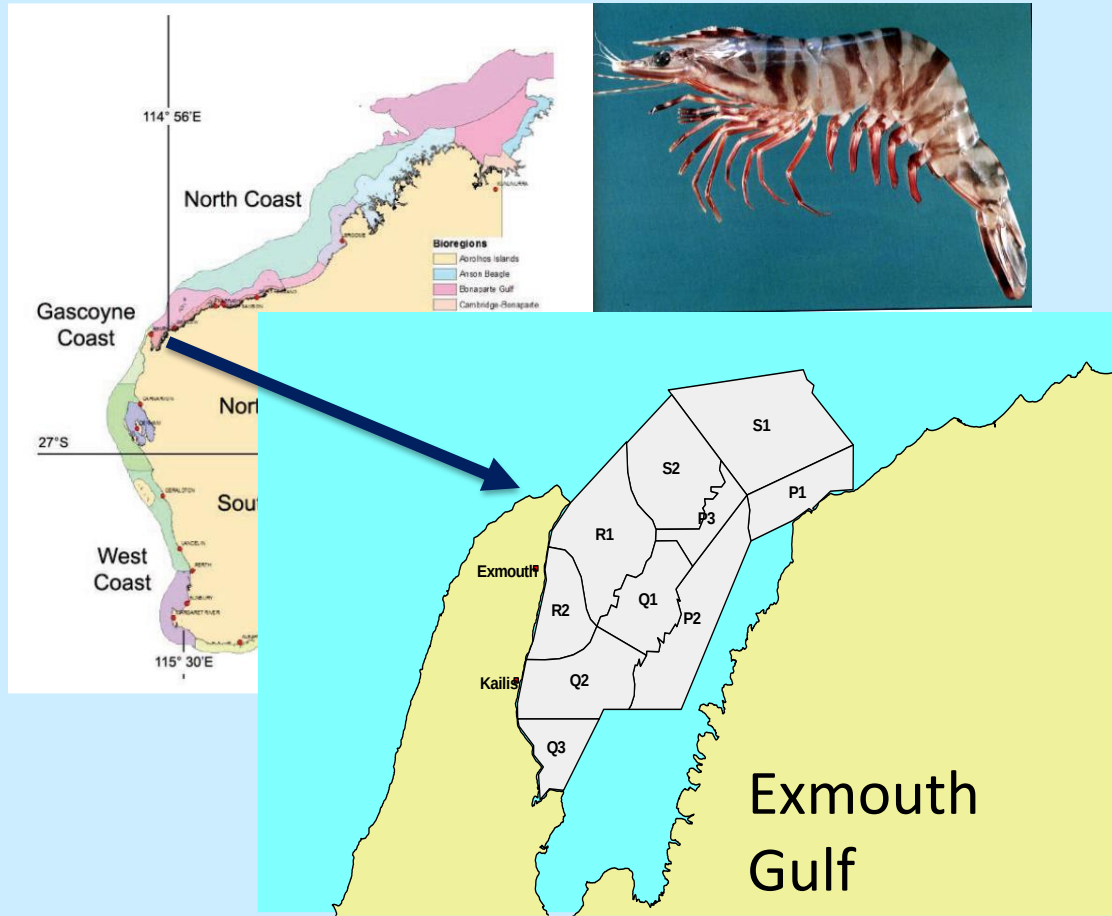
Targeted fish species and habitats

Exmouth Gulf Prawn Fishery

- Limited entry – licenses
- Gear – trawl mesh size
- Closed areas recruits (small prawns)
- Closed seasons to protect spawners

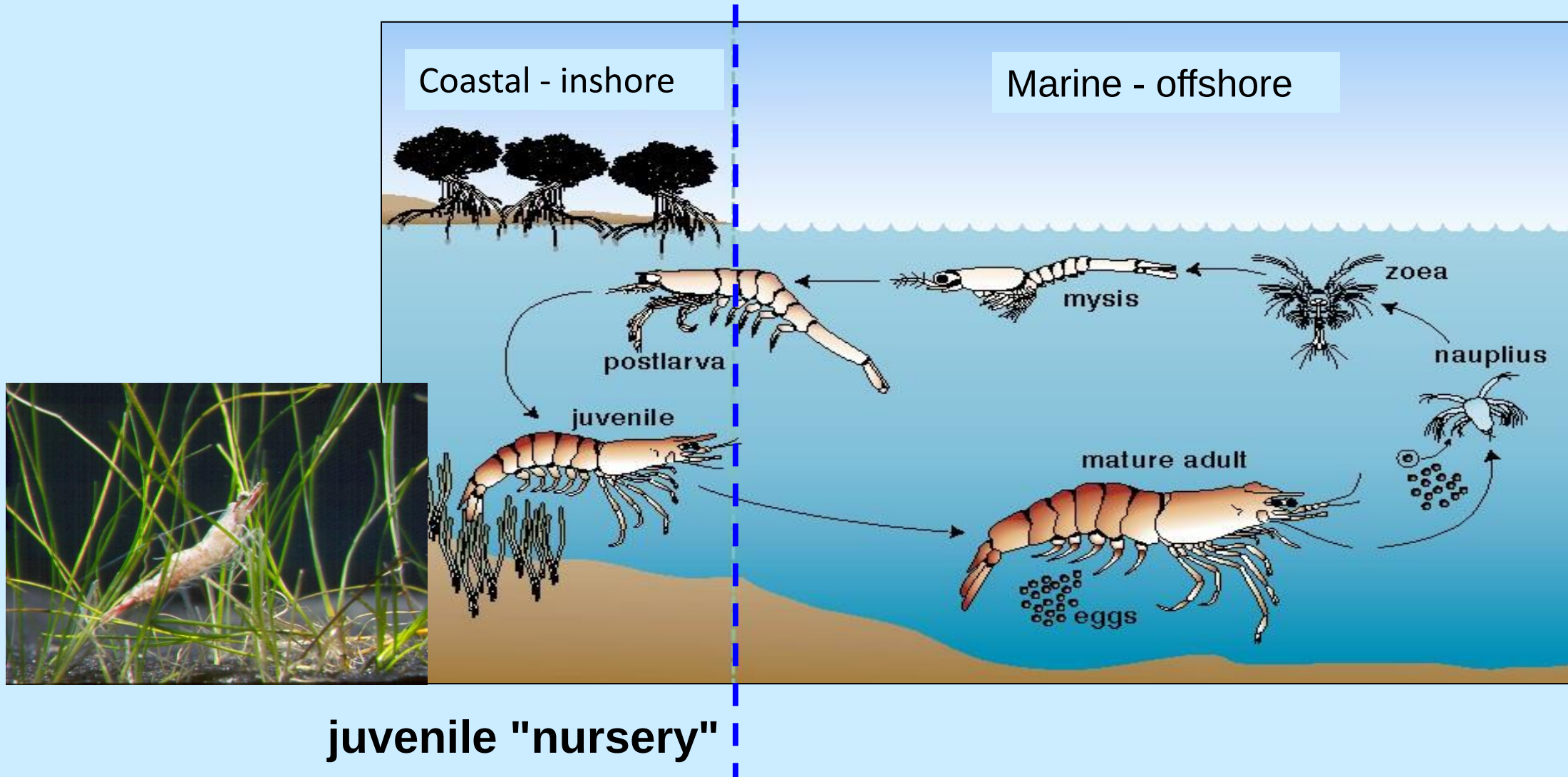
A Data Rich Fishery

- Data from fishery - logbooks
- Fishery-independent data
 - Recruits (small prawns)
 - Spawners (large prawns)
 - Habitats (juveniles)



Shifting to EBFM, an example

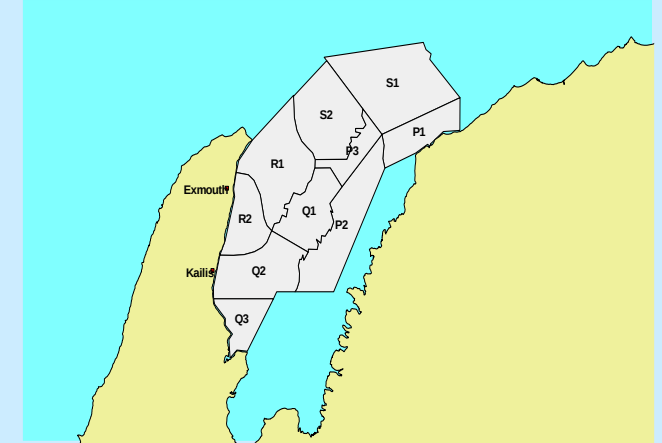
Life cycle of Tiger prawns *Penaeus esculentus*



(Graphic design by Louise Bell, CSIRO Hobart)

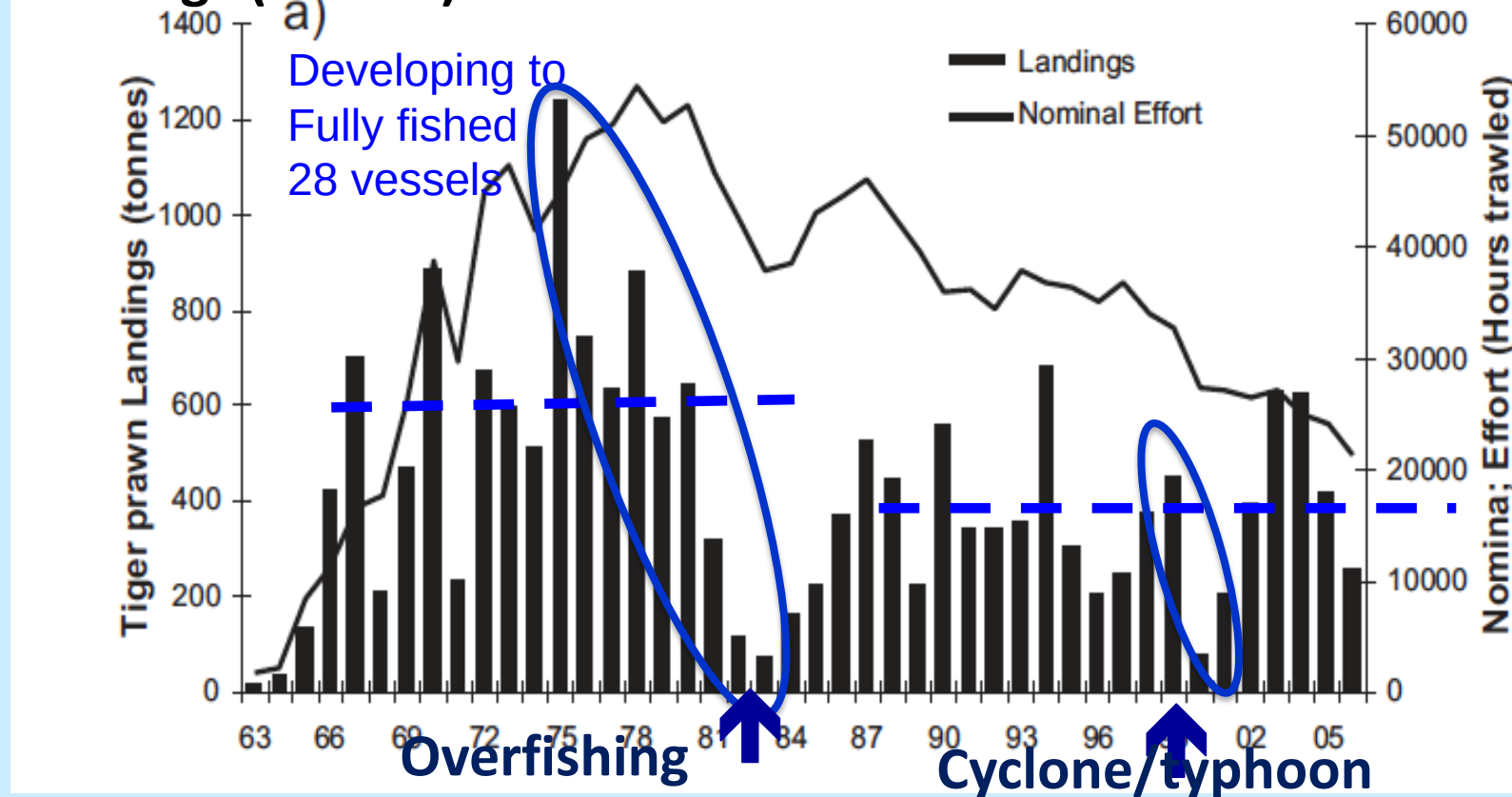


Data Rich Fishery Exmouth Gulf Trawl



Fishery Dependent Data
Landings (tonnes)

Fishing Effort
Hours trawled

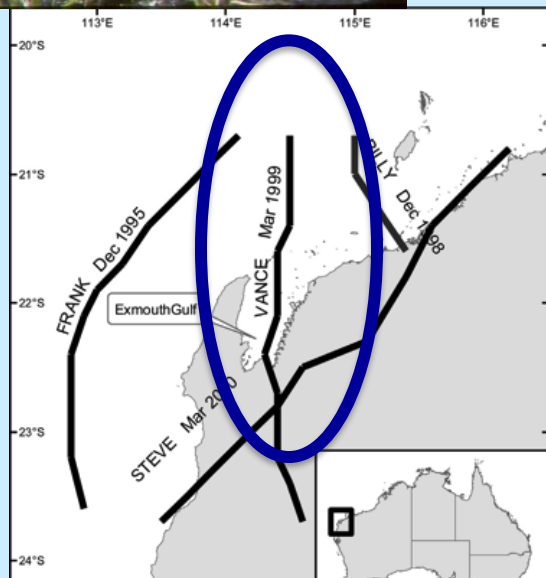


5-10 vessels,
Now 5



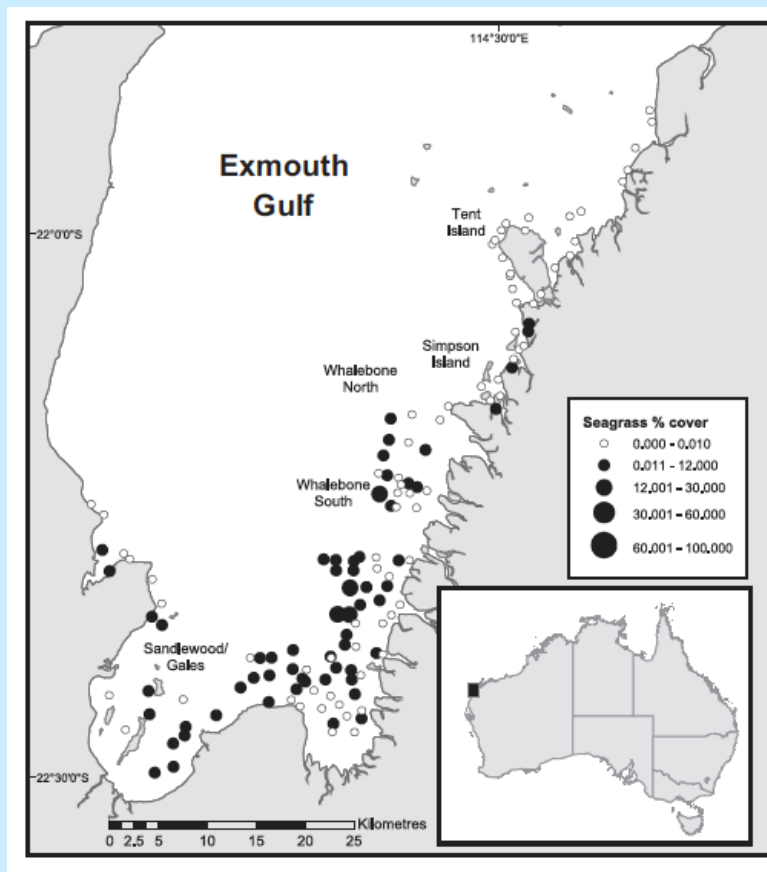
Seagrass cover (% cover)

Loneragan et al. 2013

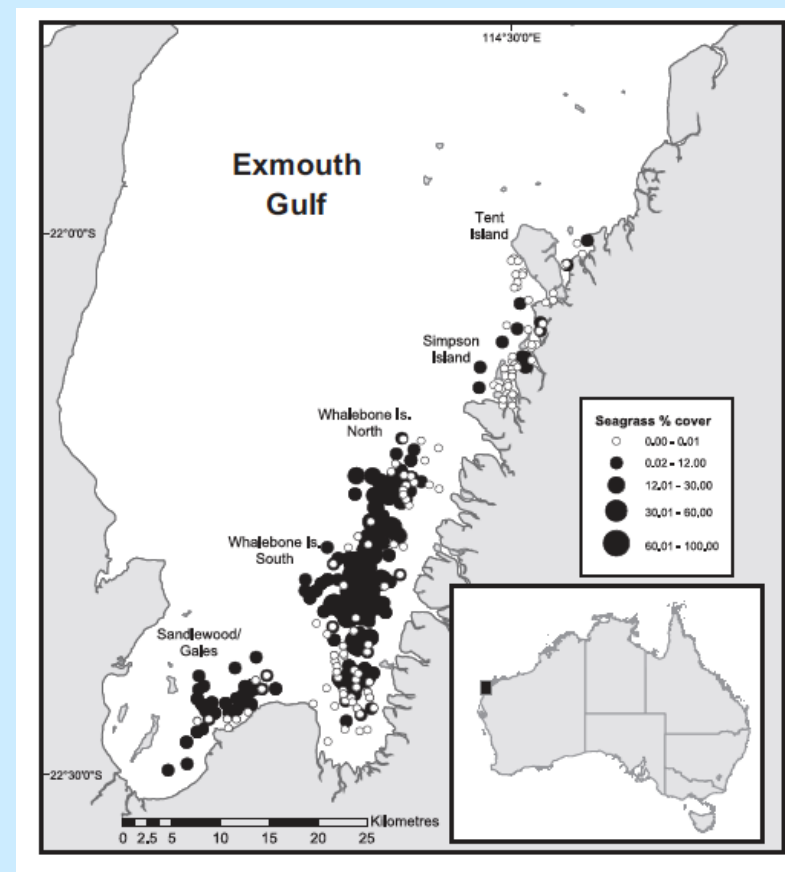


Cyclone paths
Exmouth Gulf

Cyclone Vance
270 km h⁻¹ winds



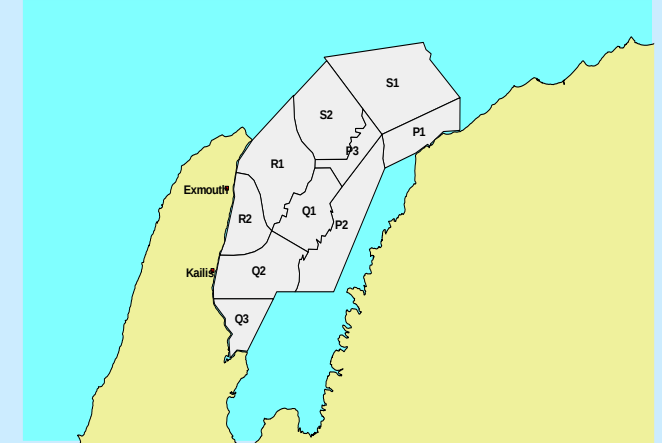
November 1999 <2% cover
7 months post-cyclone



November 2000 >20% cover
19 months post-cyclone

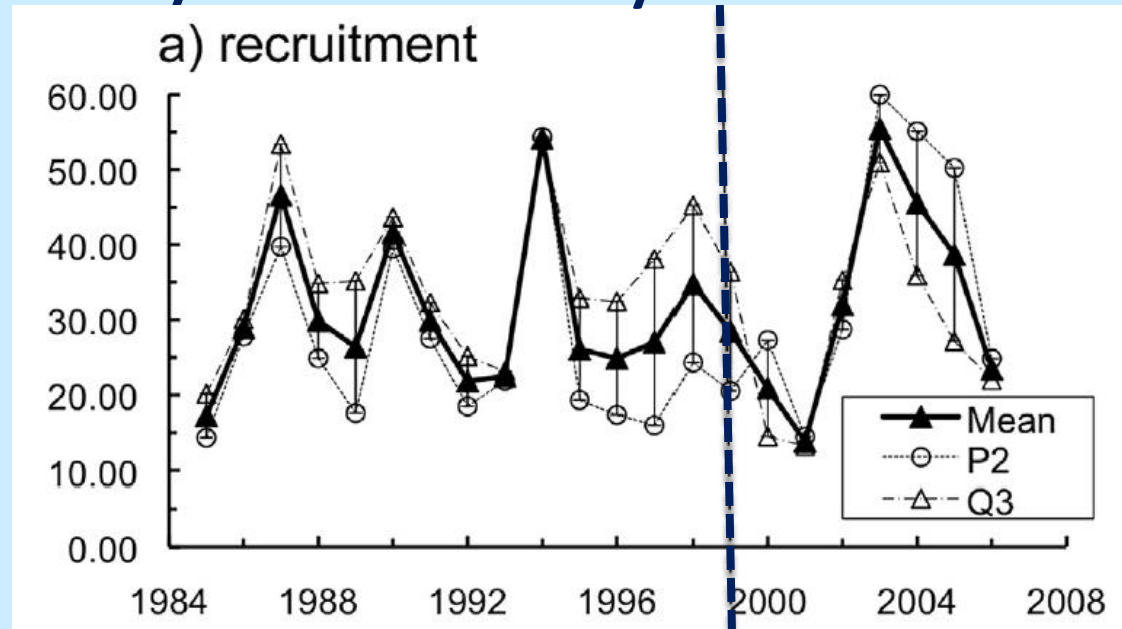


Data Rich Fishery Exmouth Gulf Trawl



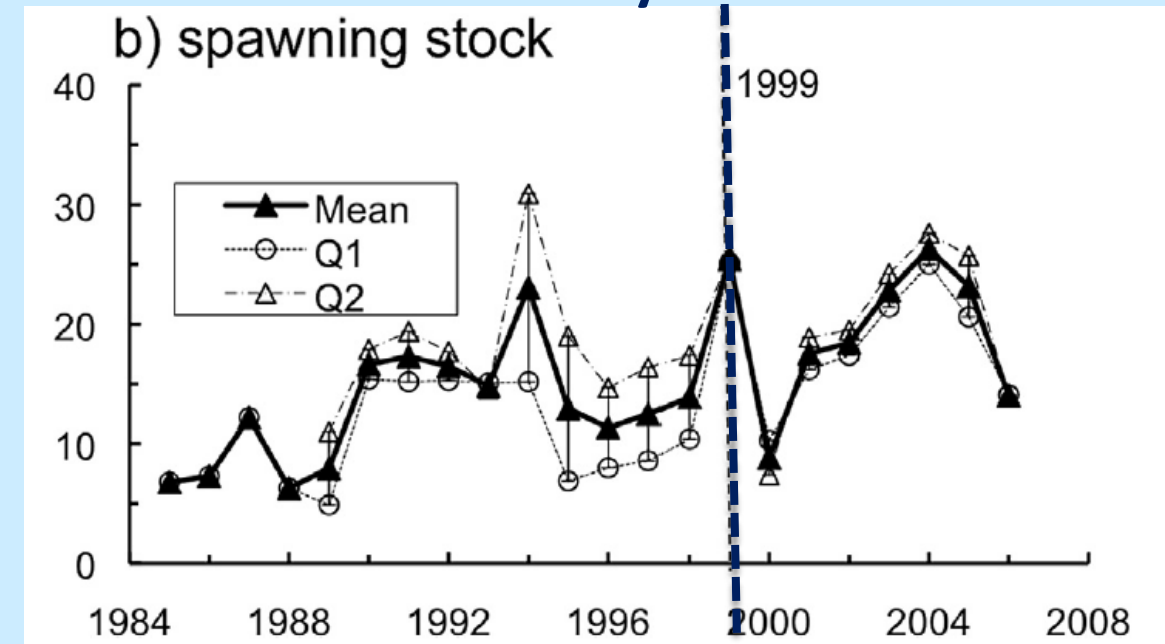
Fishery independent data Surveys

Cyclone Vance



March/April - Opening of season

Cyclone Vance



August - Closing of season

Extending to food webs and ecosystem understanding

Exmouth Gulf example

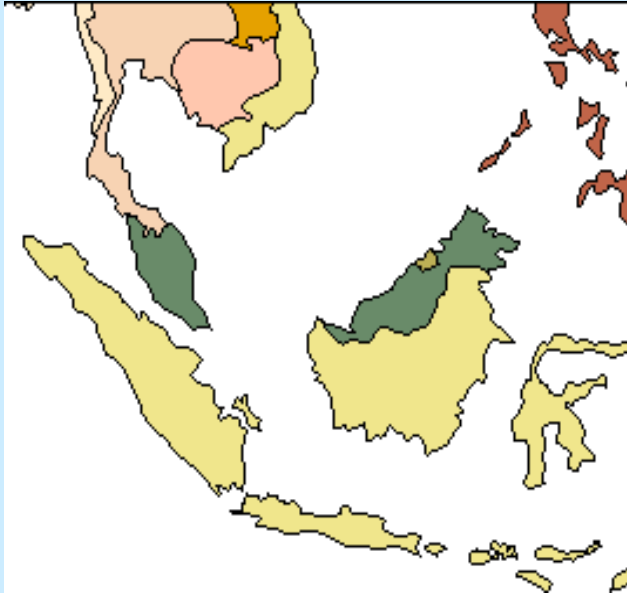
- Focus on the fishery, and significant habitat for postlarvae and juveniles
- Data sources
 - Commercial catch log book
 - Fishery independent indices of recruits and spawners
 - Research data on seagrass



How do we gain an understanding on food webs in the ecosystem?

What other information is needed for EBFM of this fishery?

Fishing – Asia – the people dimension



Malaysia

Western Peninsular Malaysia **WPM**

Eastern Malaysia



Trawlers – 2,000 boats

200 km of coastline WPM

Push nets -illegal



**Nets set on tide
“bag nets” –
10,000 fishers**



The Indonesian Archipelago - ~18,000 islands



Fishers, fishing industry and community knowledge

Shark fishers – data collection



Shark fisher knowledge – interviews



Shark fisheries
of eastern
Indonesia

**Dr Vanessa
Jaiteh**

Processor
Sumbawa
Besar



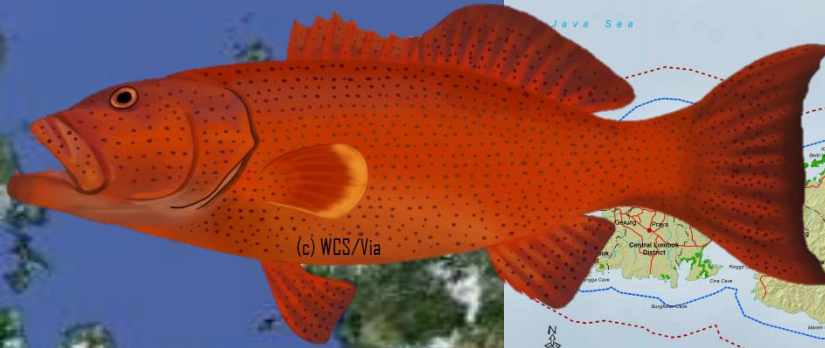
Fisher
cooperative
Saleh Bay



Small-scale
grouper and
snapper
fisheries

Dr Abdul Halim

Saleh Bay – demersal and reef fisheries



Jakarta

Handlines, speargun,
longlines ... 8 gears

Bali



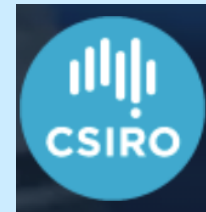
What is the Ecosystem status of grouper/snapper fisheries in Saleh Bay?



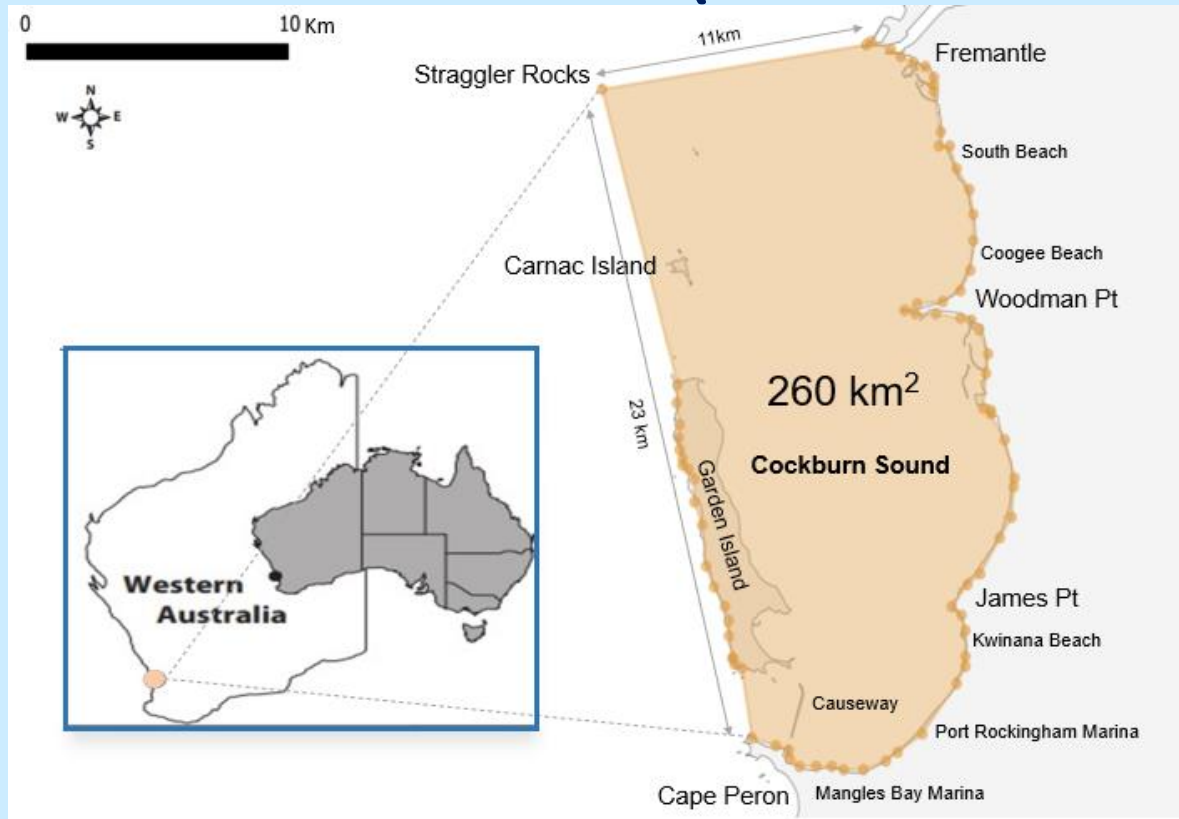
How do we build ecosystem understanding?
What data and information for we need for EBFM?



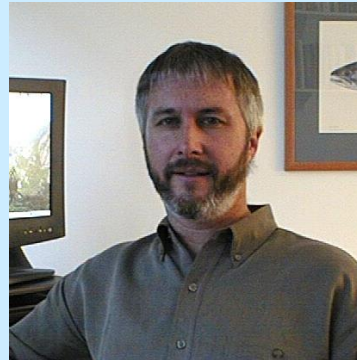
An Example: Cockburn Sound, Western Australia



Cockburn Sound (Derbal Nara)



- Area for industrial development e.g. cement plant, oil and nickel refineries, grain port, ...
- proposed new container port
- **Valued for its aquatic resources - fisheries and recreation**



Hector Lozano Beth Fulton Jeff Dambacher

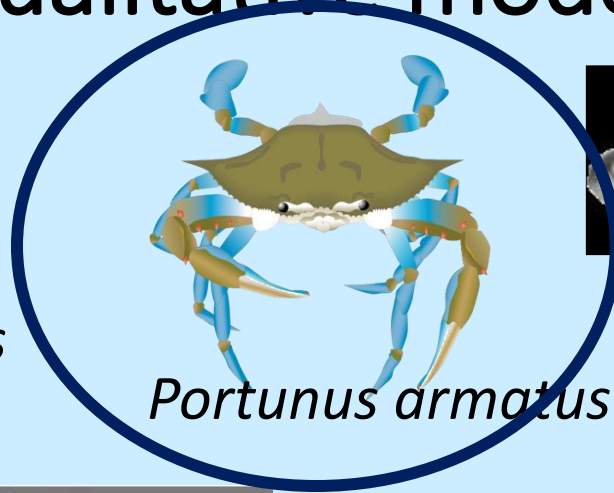


Conceptual and qualitative models

- Fished species –



Chrysophrys auratus
Snapper



Portunus armatus



Sardinella lemuru
Scaly Mackerel

- Conservation species –

Little Penguin
Eudyptula minor



Seagrass – *Posidonia sinuosa*

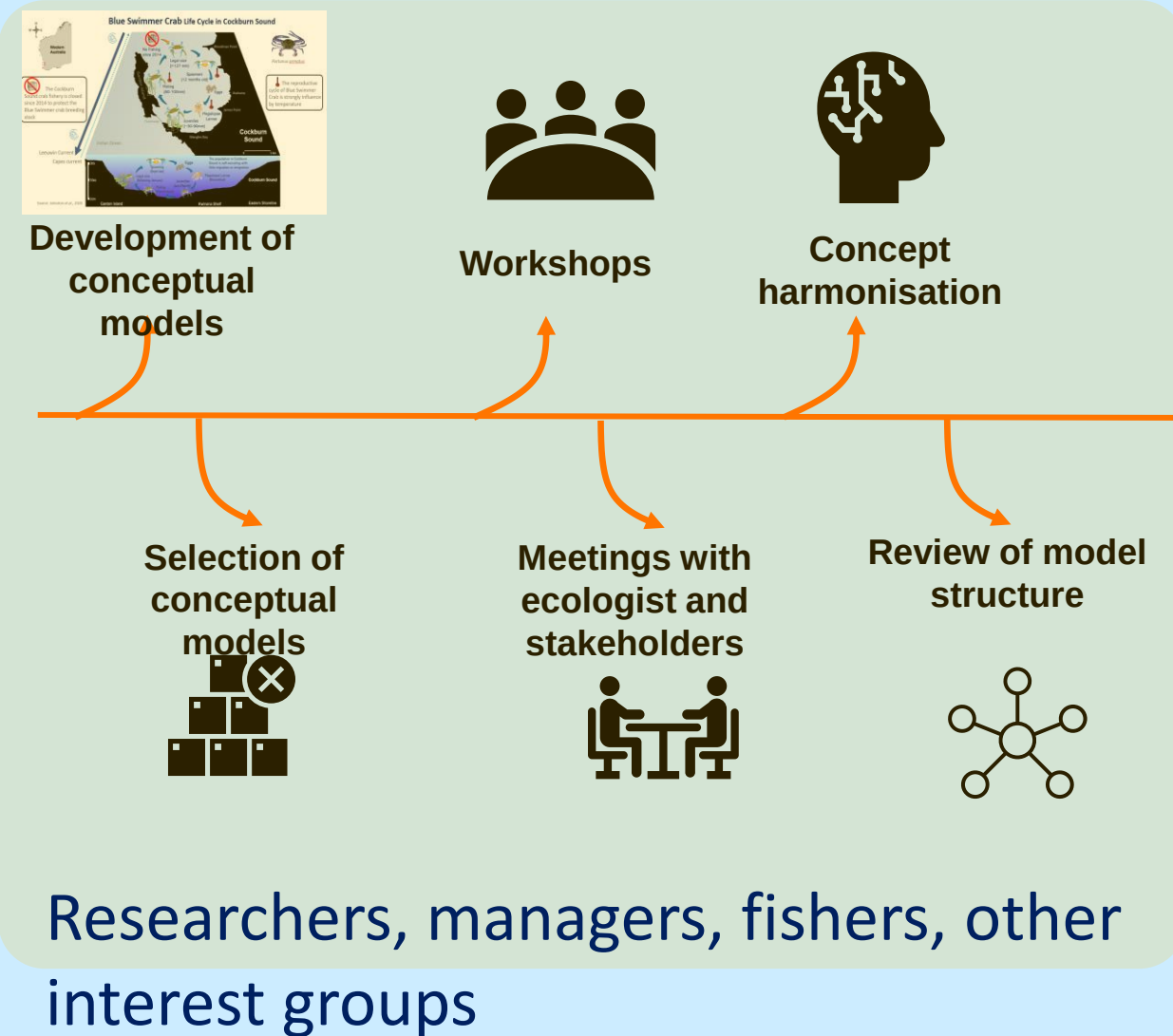
- Major influencing factors

- climate, dredging, fishing, low oxygen, increasing temperature

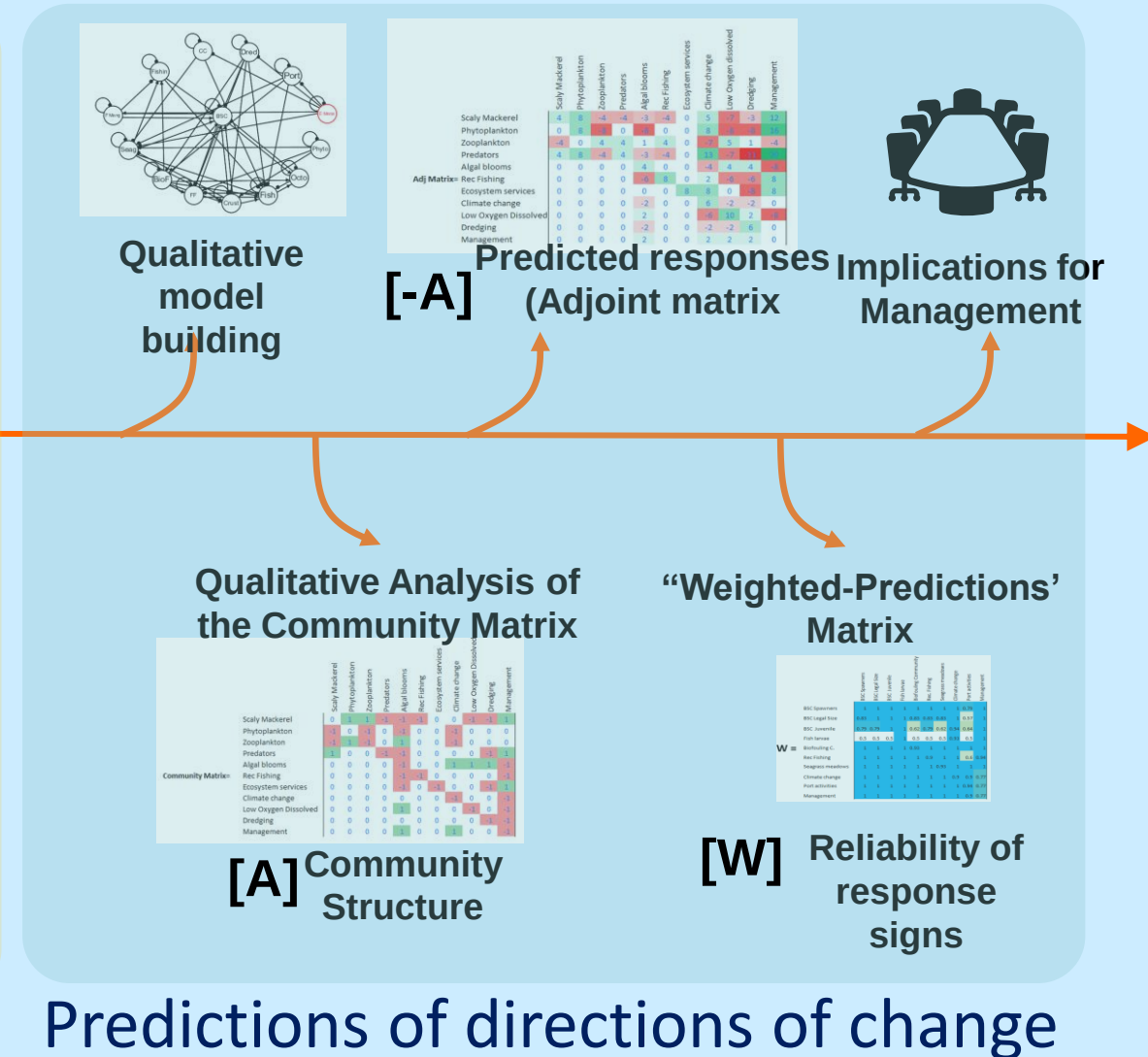
- Ecosystem processes

Building Conceptual and Qualitative models

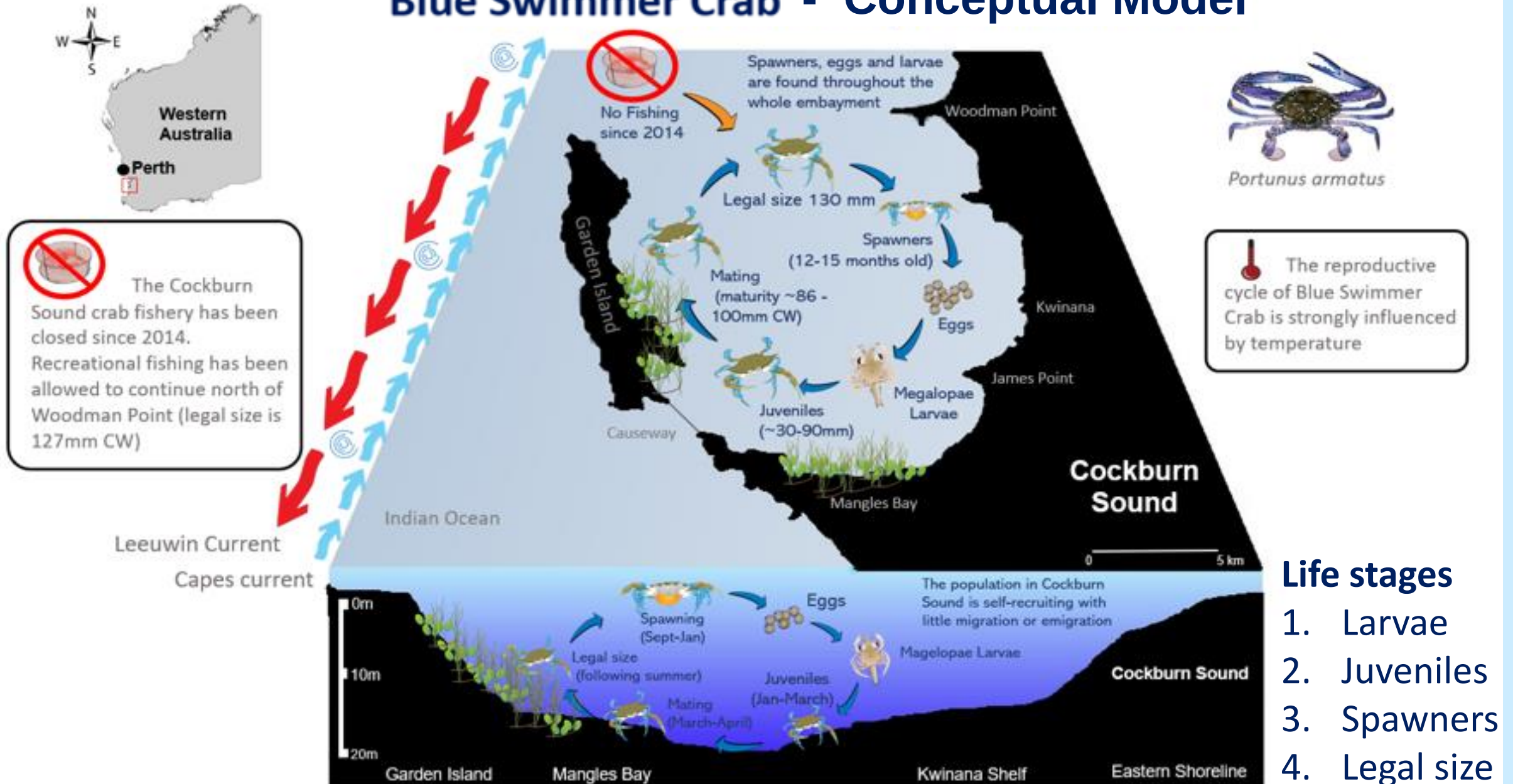
Conceptual models (3 workshops)



Qualitative models

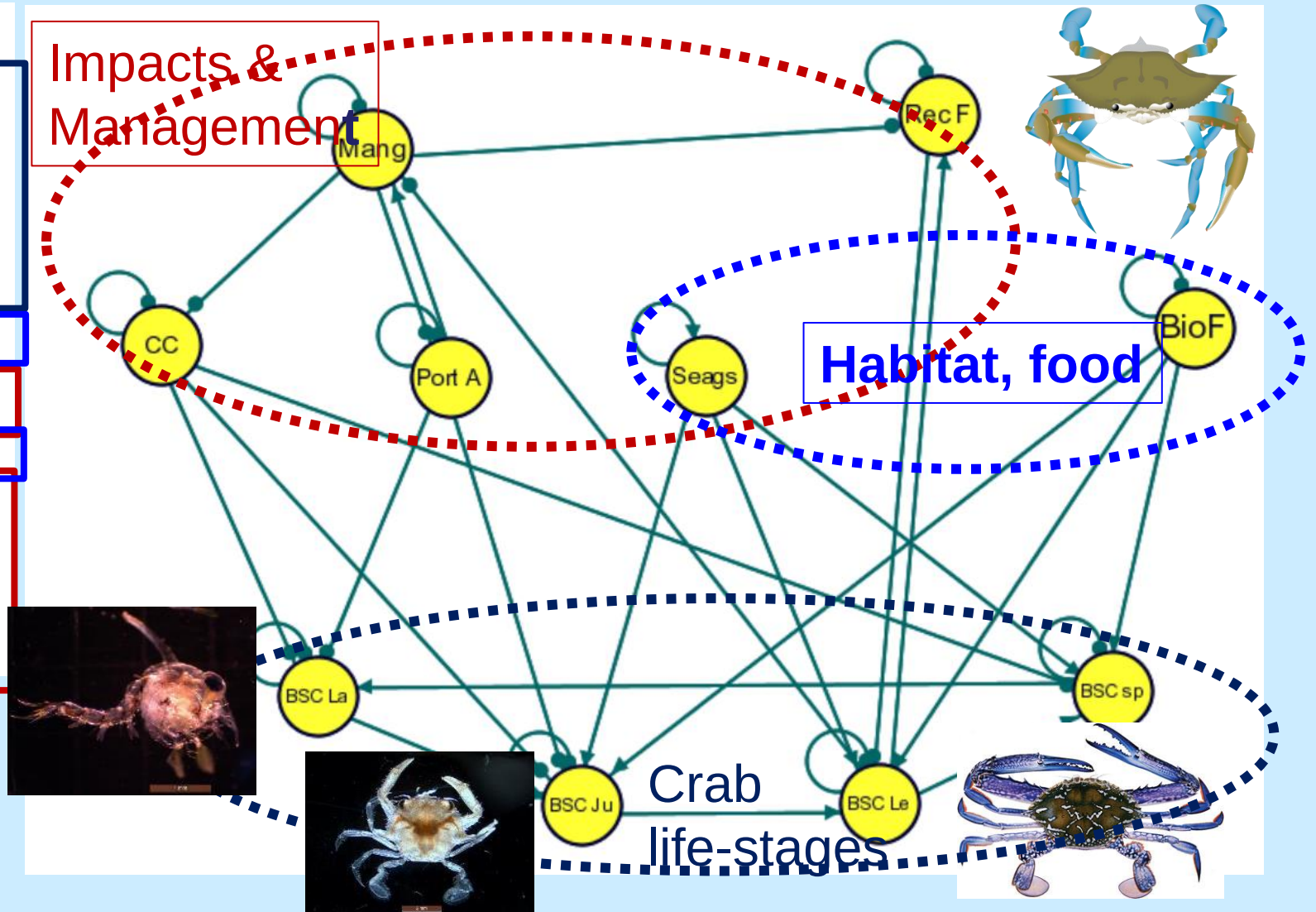


Blue Swimmer Crab - Conceptual Model



→ = positive effect; • = negative effect

Node	Group
BSC Leg	BSC Legal Size
BSC Spw	BSC spawners
BSC Juv	BSC Juvenile
BSC L	BSC larvae
BioF	Biofouling community
Rec F	Rec Fishing
Seags	Seagrass meadows
CC	Climate change
Port A	Port activities
Mang	Management

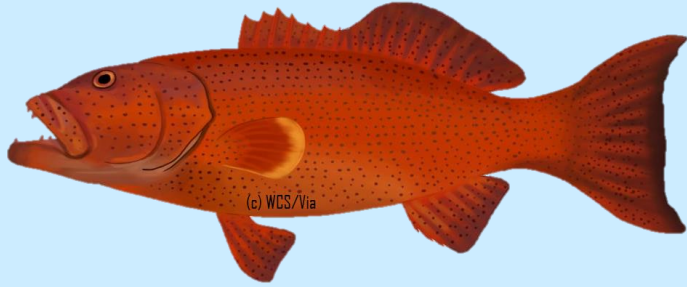


Ecosystem status of fisheries in Saleh Bay?

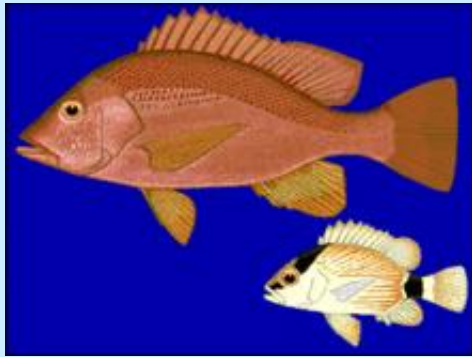


1. What are the key species, key groups of species, habitats and processes?
2. What are the sources of data and knowledge?
3. What management is in place and what might be possible?
4. How have the fisheries and ecosystem changed over time?
5. What information do we need for an EBFM approach?

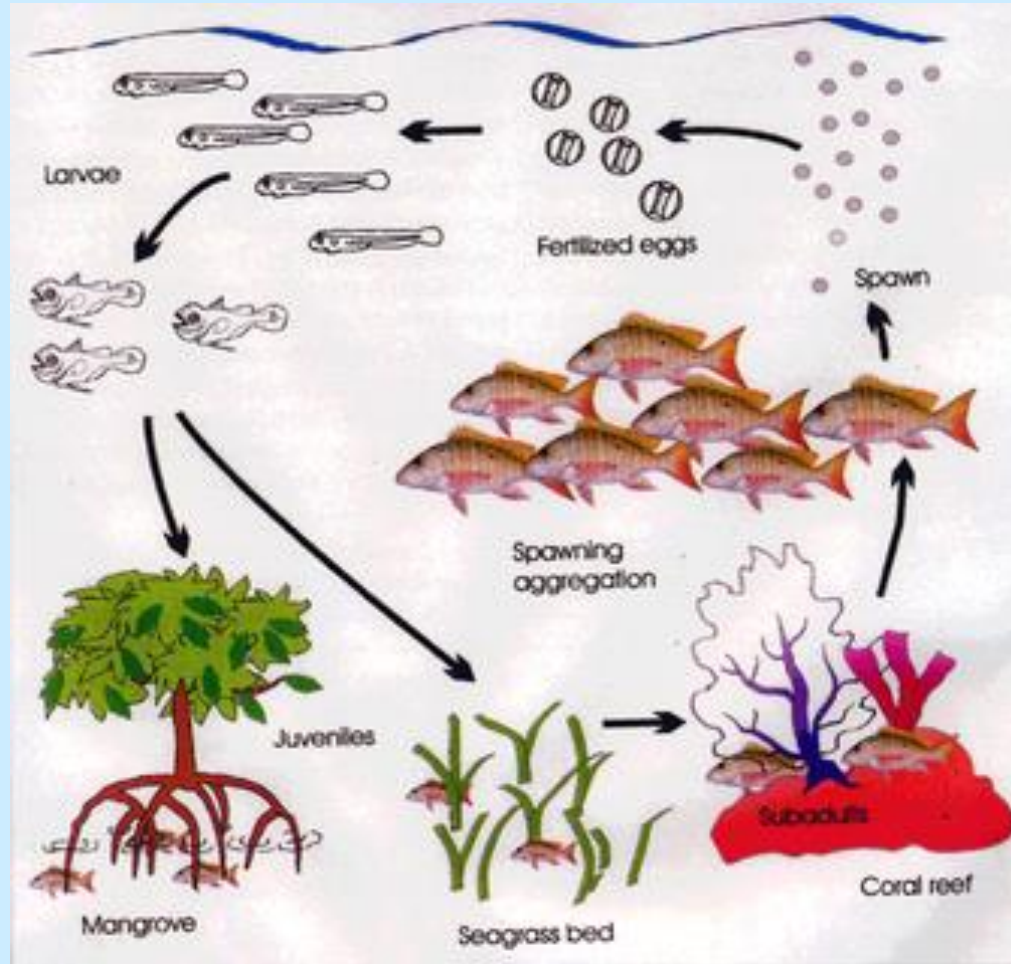
Saleh Bay conceptual/qualitative models for: fish, habitats and processes



Leopard Coral Grouper
Plectropomus leopardus



Malabar Blood Snapper
Lutjanus malabaricus



Which species, what
behaviour?

What is the life-cycle?

Which habitats are
important?

What are the
threats to species and
habitats?

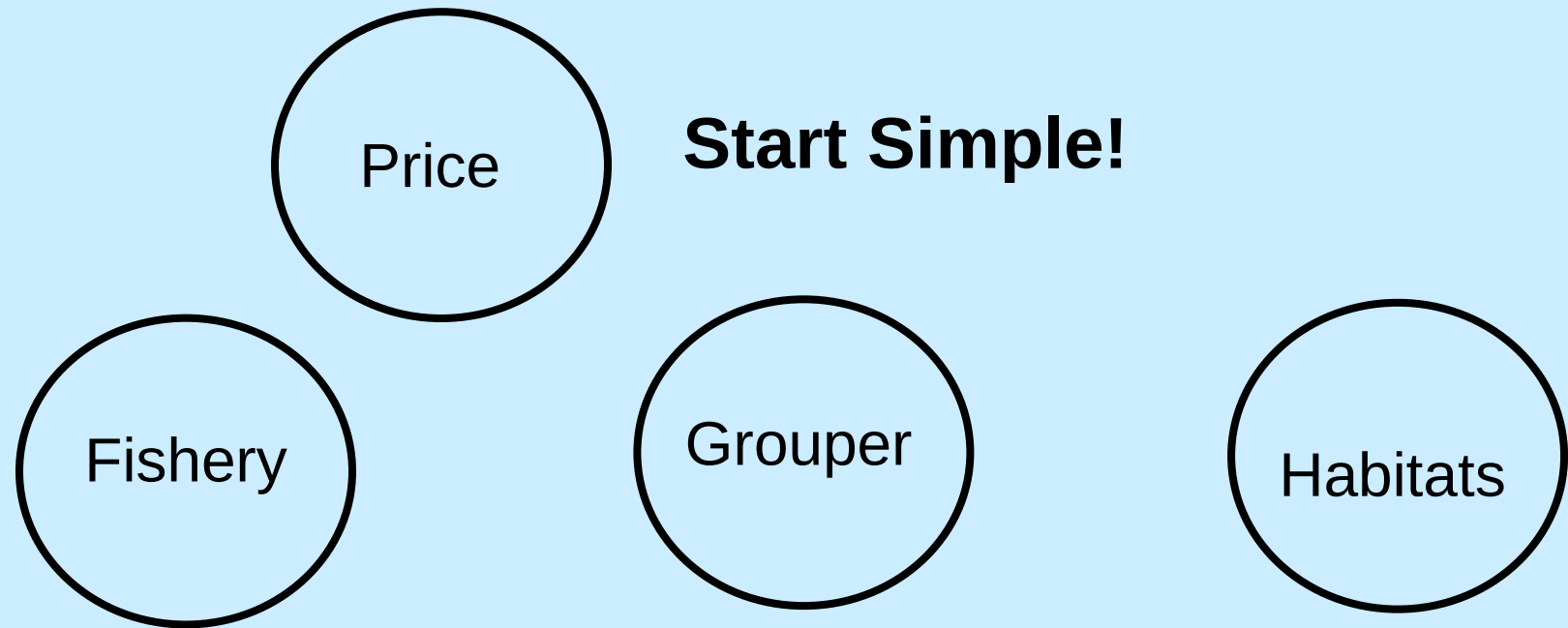
Changes with time?

FSU Coastal and Marine Laboratory

<http://emilymarinescience.weebly.com/grouper-life-cycle.html>

Conceptual and qualitative models

1. Develop the conceptual model of the focus species
2. Identify Nodes (components) of interest
3. Relationships between Nodes



Price and grouper fisheries system:

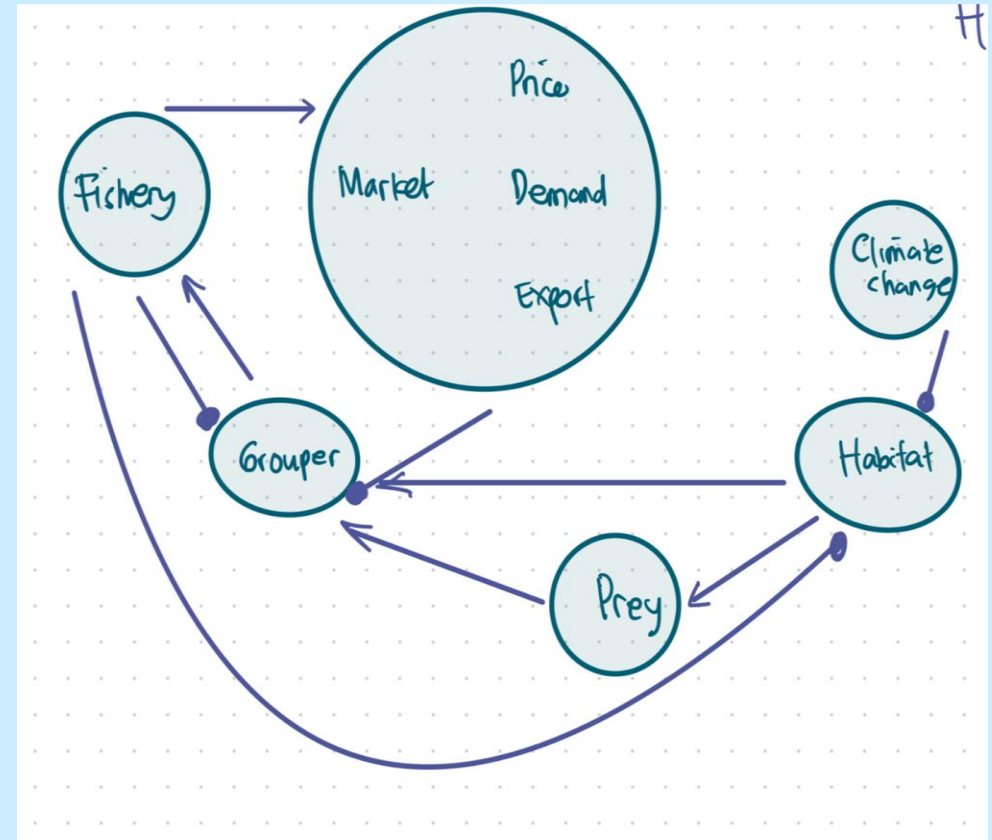
H_0 : Price affects fishing and grouper stocks

Grouper Fishery Habitat System

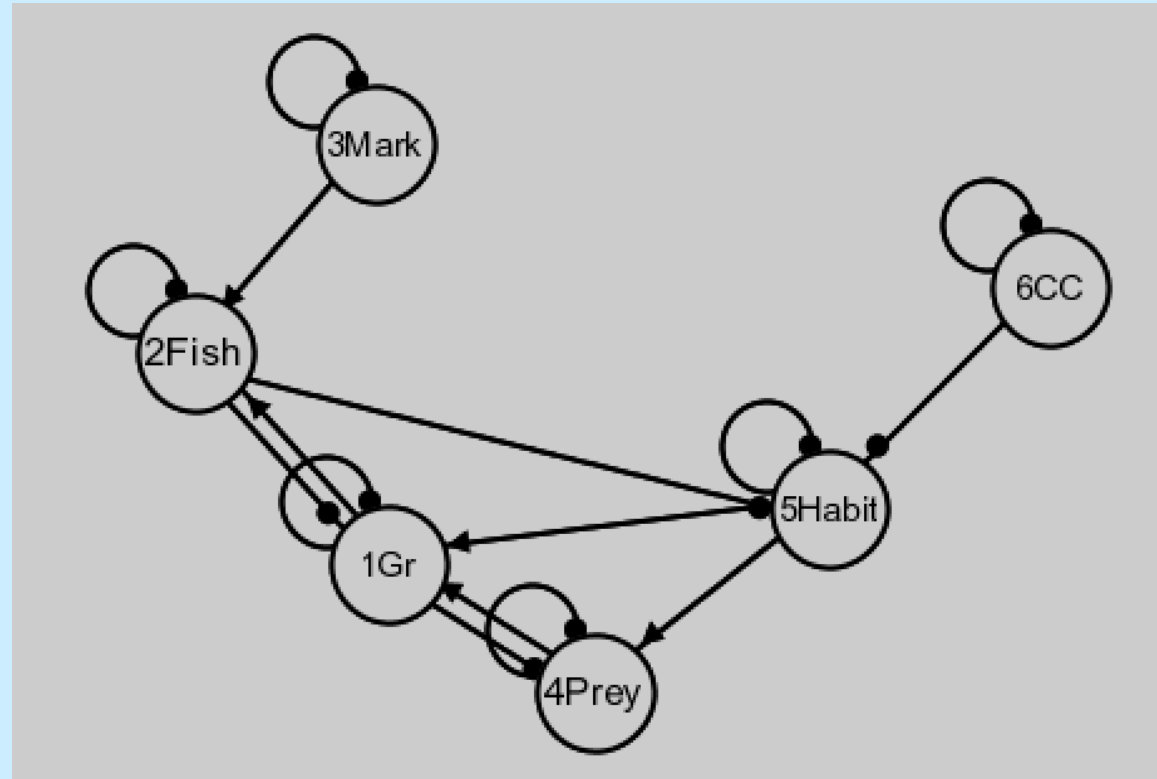
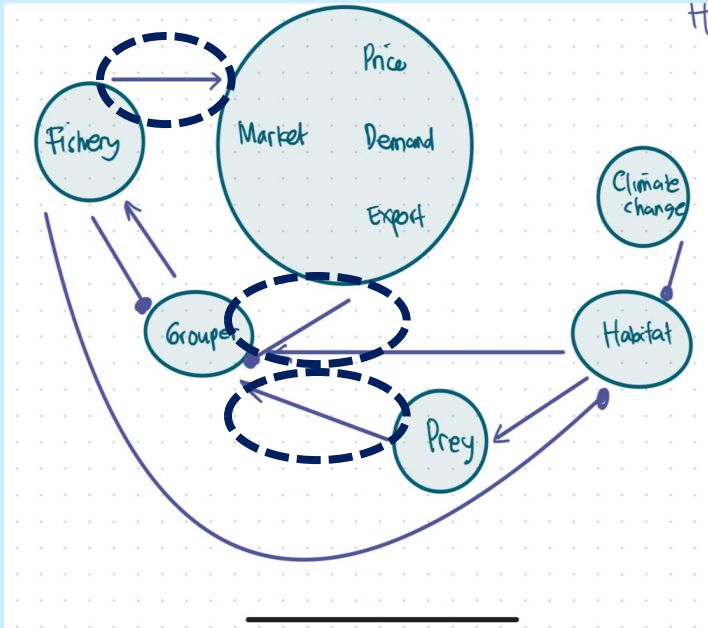
Heidi, Siska, Ika, Ikeu, Neri, ADS, Tasrif, Irfan

6 Nodes

- **Fishery:** (-) affect on grouper & habitat
- **Habitat:** (+) affect on grouper stock, and grouper prey
- **Grouper stock:**
(-) affect by fishery,
(+) affect by prey & habitat
- **Market:** (+) affected fishery
- **Prey:** (+) affect on grouper stock
- **Climate change:** (-) affected on habitat



Signed digraph – Powerplay app

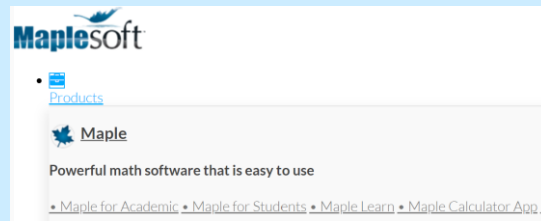


6 nodes

1: 1Gr, 2: 2Fish, 3: 3Mark, 4: 4Prey, 5: 5Habit, 6: 6CC

Interactions

$[-1,-1,0,1,1,0],[1,-1,1,0,0,0],[0,0,-1,0,0,0],[-1,0,0,-1,1,0],[0,-1,0,0,-1,-1],[0,0,0,0,0,-1]$



Community matrix [A]

Community matrix [A] and stability - Maple

"Community Matrix (°A)"

$$A := \begin{bmatrix} -1 & -1 & 0 & 1 & 1 & 0 \\ 1 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ -1 & 0 & 0 & -1 & 1 & 0 \\ 0 & -1 & 0 & 0 & -1 & -1 \\ 0 & 0 & 0 & 0 & 0 & -1 \end{bmatrix}$$

"Criterion i"

$\text{poly_coef_F0_to_Fn} = [-1, -4, -7, -6, -2]$

$\text{positive_feedback} = [0 \ 0 \ 0 \ 0 \ 0]$

$\text{negative_feedback} = [-1 \ -4 \ -7 \ -6 \ -2]$

$\text{absolute_feedback} = [1 \ 4 \ 7 \ 6 \ 2]$

$wFn = [-1. \ -1. \ -1. \ -1. \ -1.]$

"Criterion ii"

$wD_3 = 0.42$

$\text{ratio_to_model_C} = 4.7$

"Class I Model"

	Gr	Fish	Mark.	Prey	Hab.	CC
Grouper	-1	-1	0	1	1	0
Fishery	1	-1	1	0	0	0
Markets	0	0	-1	0	0	0
Prey	-1	0	0	-1	1	0
Habitats	0	-1	0	0	-1	-1
Climate ch.	0	0	0	0	0	-1

Prediction/Adjoint matrix [-A], weights and certainty

"adjoint (-A)"

$$\begin{bmatrix} 1 & -3 & -3 & 1 & 2 & -2 \\ 1 & 2 & 2 & 1 & 2 & -2 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ -2 & 1 & 1 & 3 & 1 & -1 \\ -1 & -2 & -2 & -1 & 3 & -3 \\ 0 & 0 & 0 & 0 & 0 & 5 \end{bmatrix}$$

"absolute feedback (T)"

$$\begin{bmatrix} 1 & 3 & 3 & 1 & 2 & 2 \\ 1 & 2 & 2 & 1 & 2 & 2 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 2 & 3 & 3 & 3 & 3 & 3 \\ 1 & 2 & 2 & 1 & 3 & 3 \\ 0 & 0 & 0 & 0 & 0 & 5 \end{bmatrix}$$

"weighted predictions (W)"

$$\begin{bmatrix} 1. & 1. & 1. & 1. & 1. & 1. \\ 1. & 1. & 1. & 1. & 1. & 1. \\ 1.0 & 1.0 & 1. & 1.0 & 1.0 & 1.0 \\ 1. & 0.33 & 0.33 & 1. & 0.33 & 0.33 \\ 1. & 1. & 1. & 1. & 1. & 1. \\ 1.0 & 1.0 & 1.0 & 1.0 & 1.0 & 1. \end{bmatrix}$$

	Gr	Fish	Mark.	Prey	Hab.	CC
Grouper	-1	-1	-1	1	1	-1
Fishery	1	1	1	1	1	-1
Markets	0	0	1	0	0	0
Prey	-1	1?	1?	1	1?	-1?
Habitats	-1	-1	-1	-1	1	-1
Climate ch.	0	0	0	0	0	-1

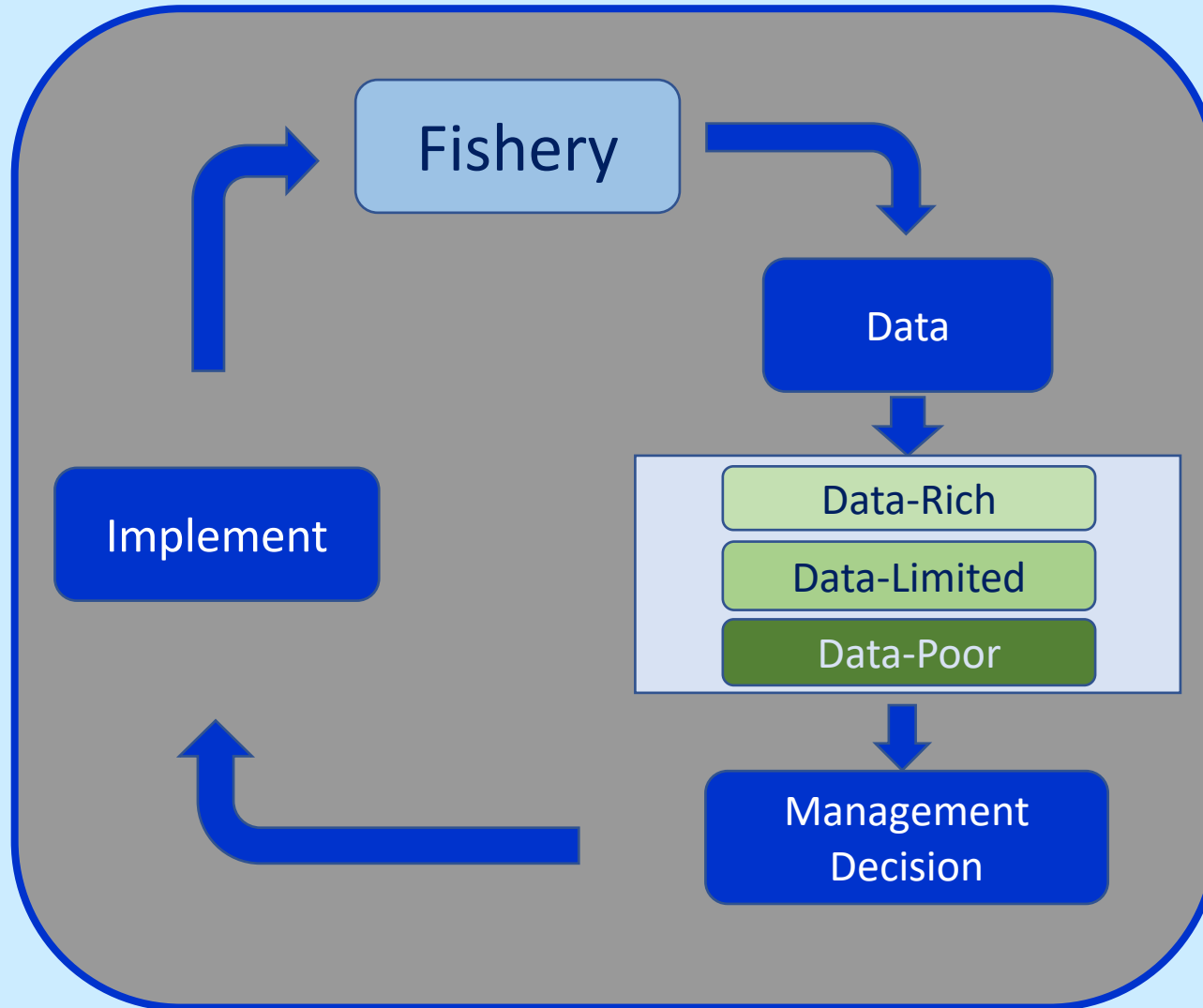
Ecosystem understanding for sustainable Grouper and Snapper fisheries of Teluk Saleh



- Focus on building a quantitative ecosystem model – Ecopath w Ecosim (EwE - Rekam team with Hector Lozano)
- Completing interviews with fishers and key informants – perspectives of the state of the fishery, management, importance to livelihoods
- Refining the Ecopath w Ecosystem model in technical and stakeholder workshops
- Develop other conceptual and qualitative models

Fisheries Management System

(design by
Dr Adrian Hordyk)



Objectives

Ecological



Economic



Social



Trans-disciplinary approach

- People, culture & fisheries
- Biology and ecology
- Data, statistics & models
- Communication

Collaboration, partnerships, knowledge sharing

Government, Universities, NGOs, fishers, fishing industry, fishing communities

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Developing ecosystem understanding for Ecosystem-Based Fisheries Management



AFS Webinar 2: 24 September 2024

Thank you

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all participants

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