

Ecological risk assessment for fisheries: applications in Australia and in the Marine Stewardship Council

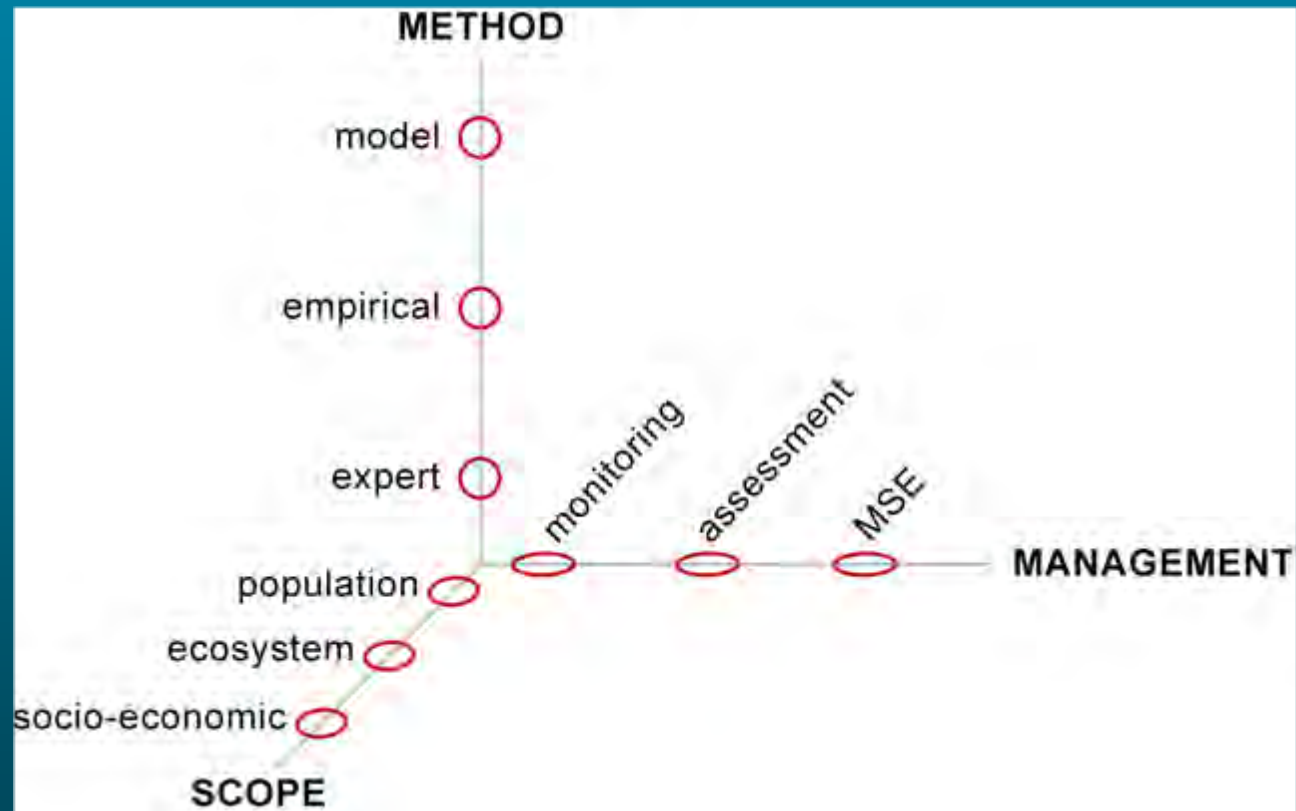
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David Johnson, Keith Sainsbury



Outline

- Background – tools to support EBFM
- ERA and Australian fisheries
- ERAEF – structure and approach
 - SICA
 - PSA
 - SAFE
- Outcomes
- The MSC and its risk based framework
- Concluding comments

Tools to support EBFM



ERA for Australian fisheries

- ERA – ecological risk assessment
- Environmental legislation (1999) required comprehensive assessment of ecological impacts of fishing
- Focus till then mostly on assessment and management of target species
- Both data and methods lacking to assess wider ecological impacts – hence risk based methods
- Developed by CSIRO with major funding and support from the Australian Fisheries Management Authority (AFMA) – 2001-2007

Criteria for ERA design

- Comprehensive
- Scientifically defensible
- Make use of existing data and information
- Precautionary given uncertainty
- Cost effective
- Flexible (apply to all types of fisheries)
- Transparent
- Understandable to stakeholders
- Help inform management response

- No such method exists!

ERAEF

- ERAEF – Ecological risk assessment for effects of fishing
- Key features
 - Hierarchical structure
 - Precautionary approach to uncertainty
 - Applicable to all types of fishery
 - Can deal with variable amounts of data
 - Assess impacts on species, habitats and communities
 - Link to risk management response
 - Assist research prioritisation

ERAEF – hierarchical approach

Levels allow screening & elimination of low risk

- Initial scoping (whole fishery, all issues)
- Level 1 – qualitative risk assessment
- Level 2 – semi-quantitative risk assessment
- Level 3 – full quantitative risk assessment

Proceed to subsequent level depending on

- Estimated risk at current level
- Management response at current level

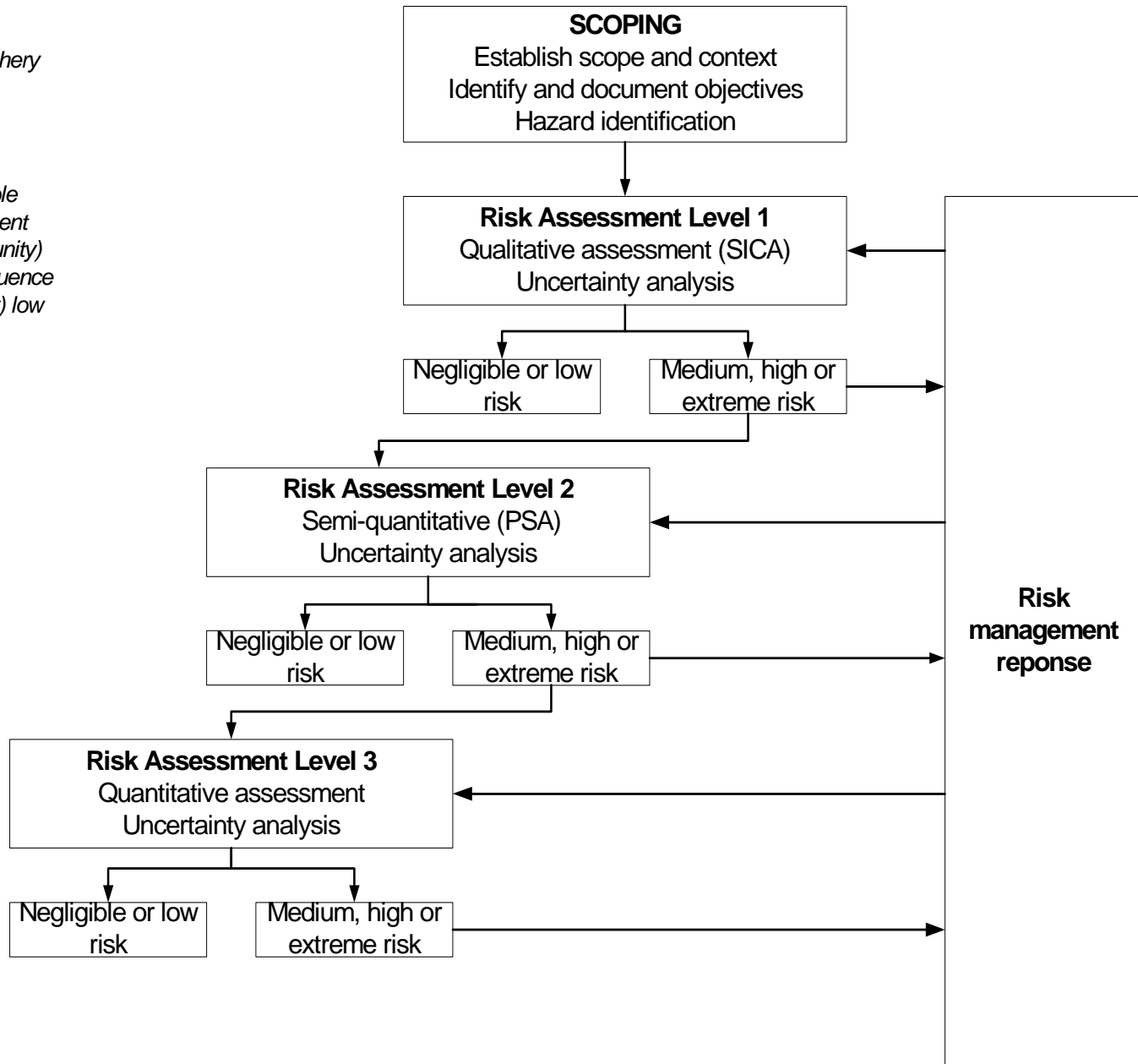
Document rationale and decisions at each level

Analysis: Fishery/subfishery

Analysis: most vulnerable element in each component (species, habitat, community)
Screen out: low consequence activities and (potentially) low risk components

Analysis: full set of elements for each component
Screen out: low risk elements

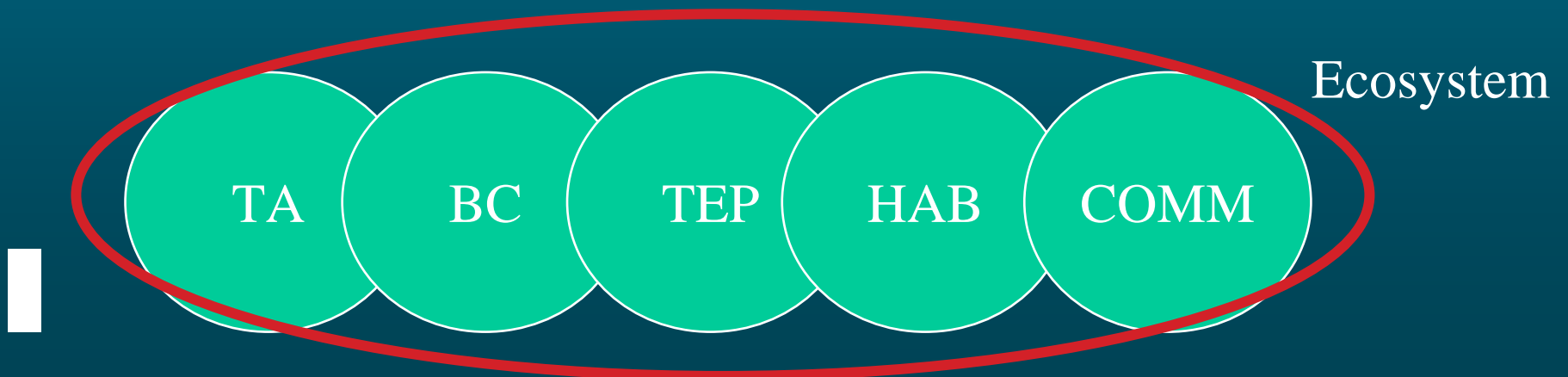
Analysis: selected elements (species, habitat, community); spatial and temporal dynamics



ERAEF – what is assessed

5 ecological components evaluated

- Target species
- Byproduct and Bycatch species
- Threatened, Endangered and Protected species (TEP)
- Habitats
- Communities (including food chains)



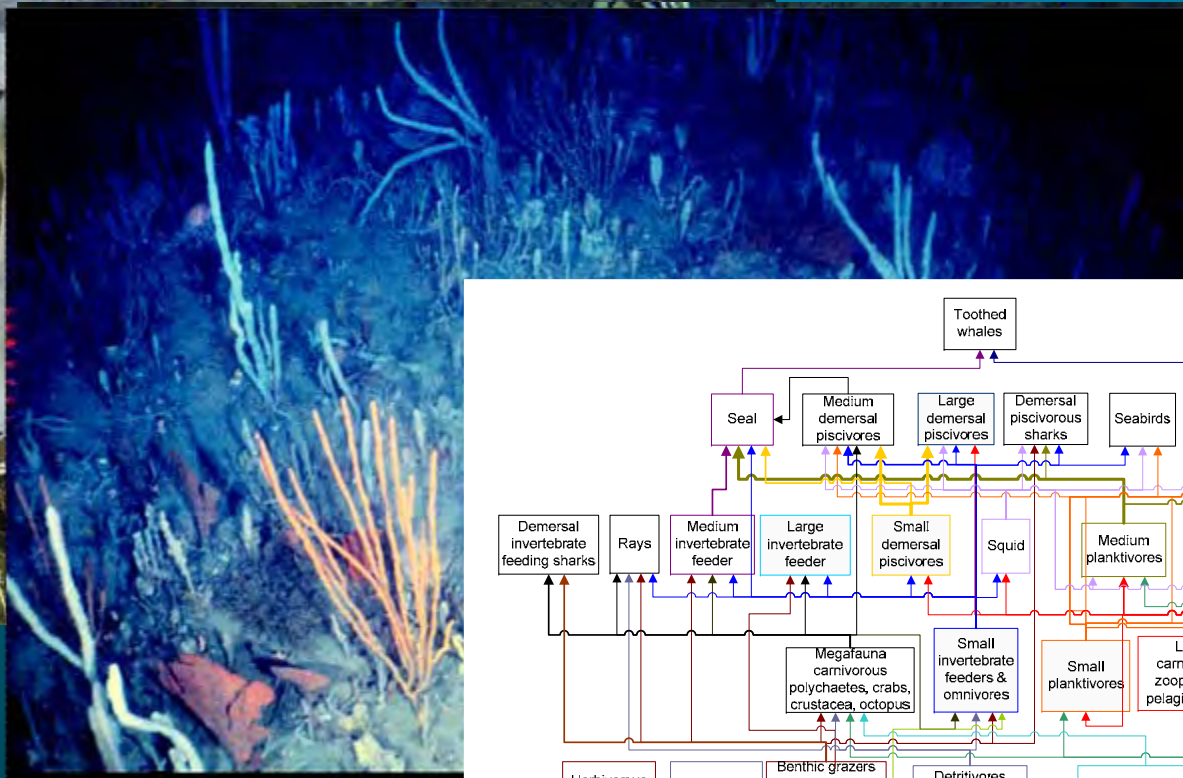
ERAEF: Scoping

- General description of the fishery (sub-fisheries)
- Identification of objectives for each component
- Identification of “units of analysis” for each sub-fishery
 - Lists of species, habitats, and communities
- Hazard identification

Units of analysis

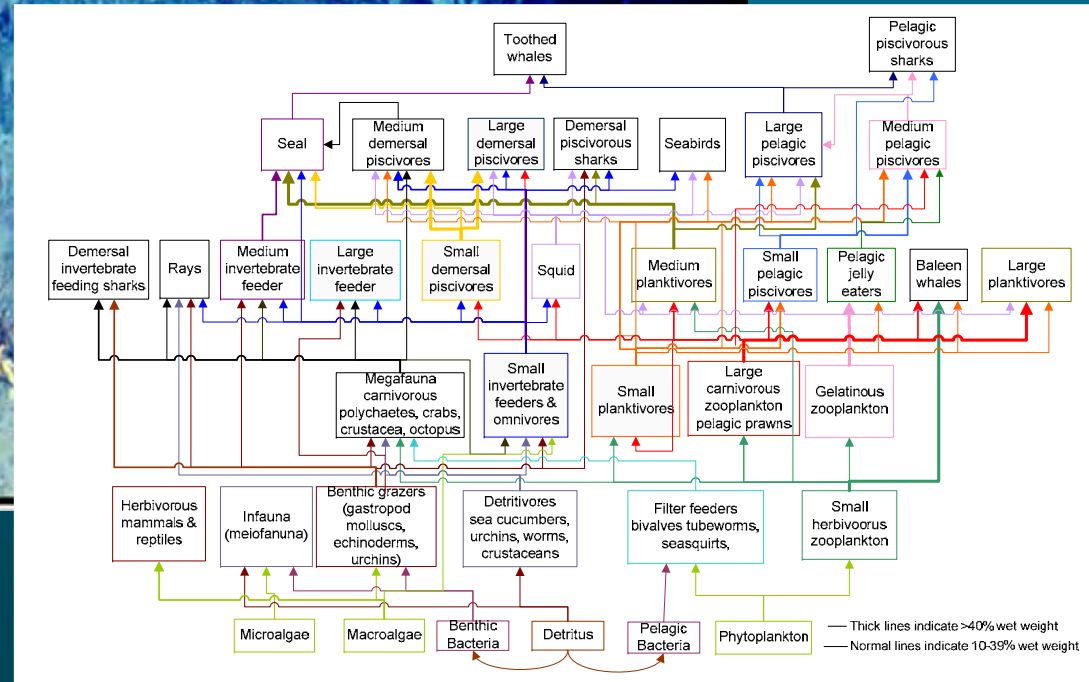


Species



Habitats

Communities



Hazard identification

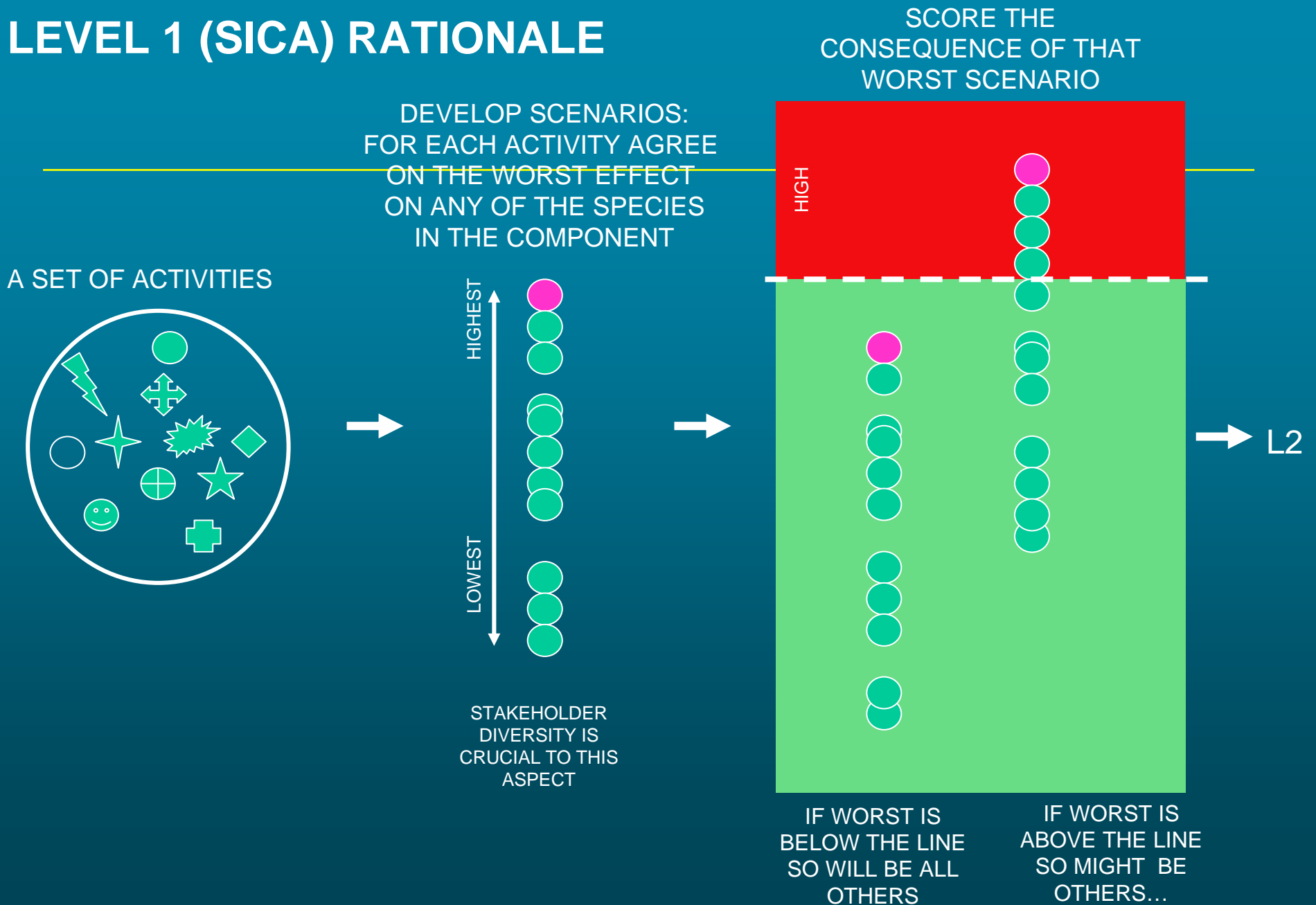
List activities affecting components

- Direct capture or impact
- Discarding
- Translocation
- Disturbance
- Pollution
- Other fisheries
- Other human activities

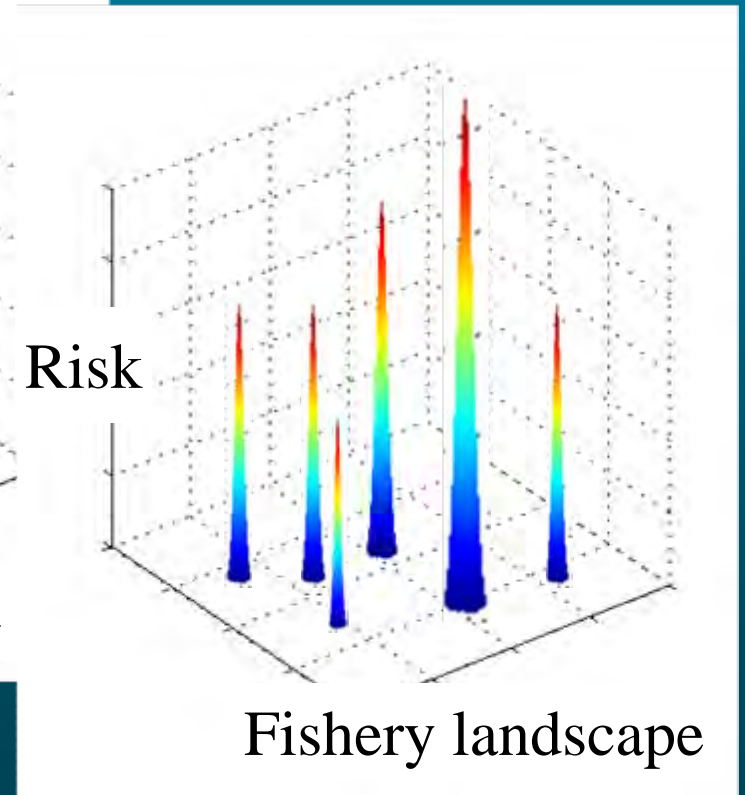
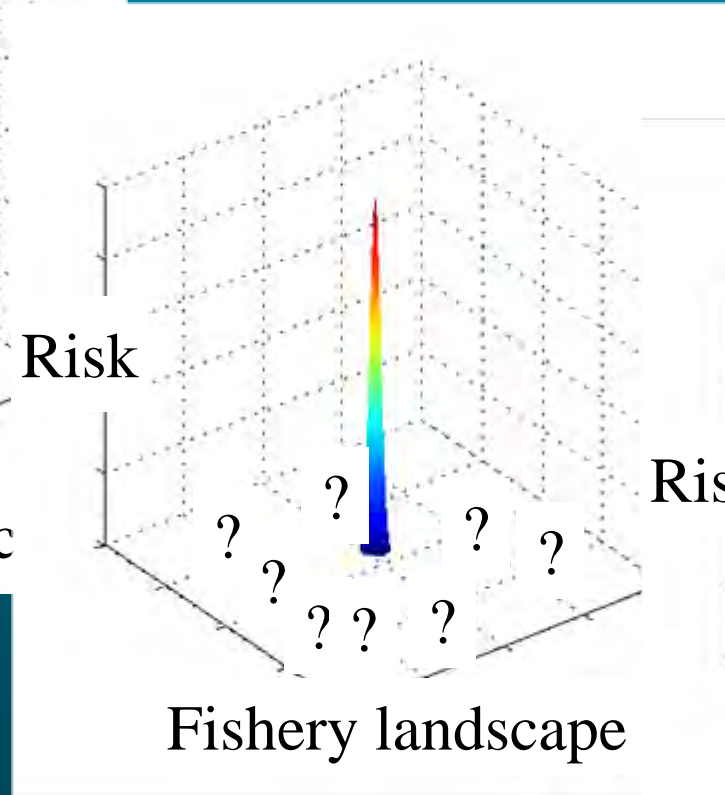
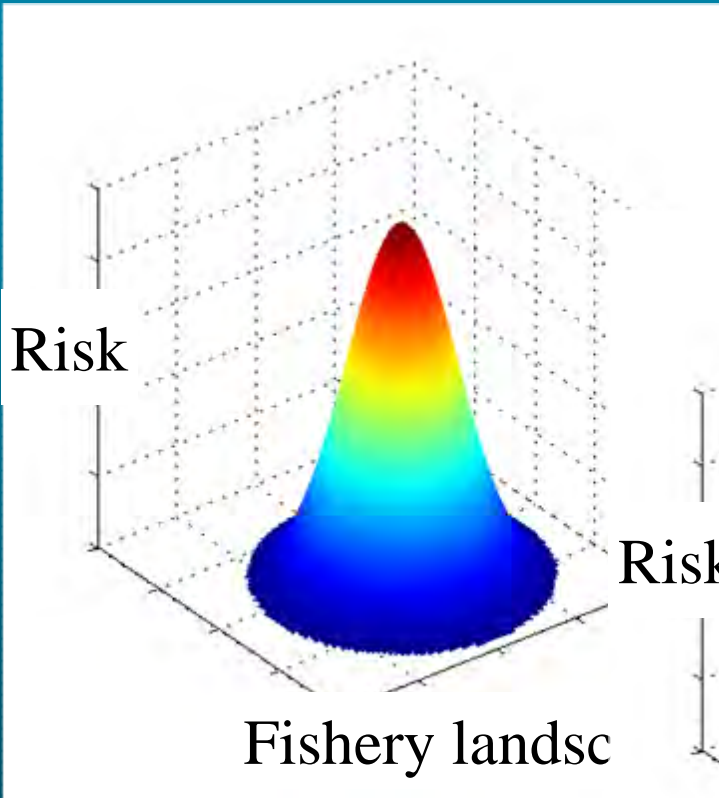
Level 1: SICA

- SICA – scale, intensity, consequence analysis
- Effect of each activity on each component considered
 - E.g. effect of discarding on sea bird behaviour (TEP)
 - Up to 25 activities X 5 components
- Qualitative (expert based) method
- Plausible worst case approach
- Use of look-up tables to guide analysis

LEVEL 1 (SICA) RATIONALE



Risk Landscape - comprehensive



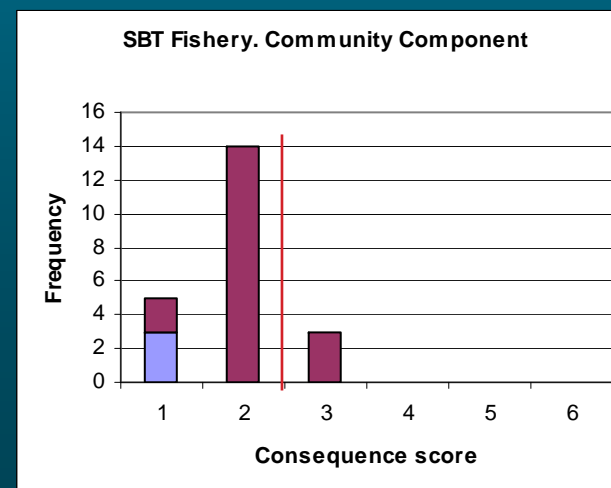
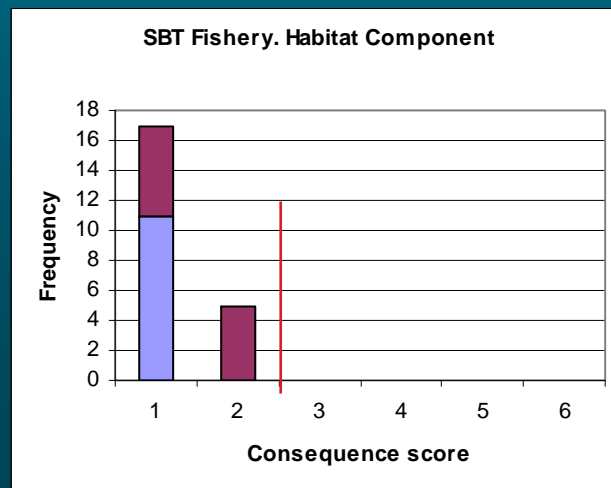
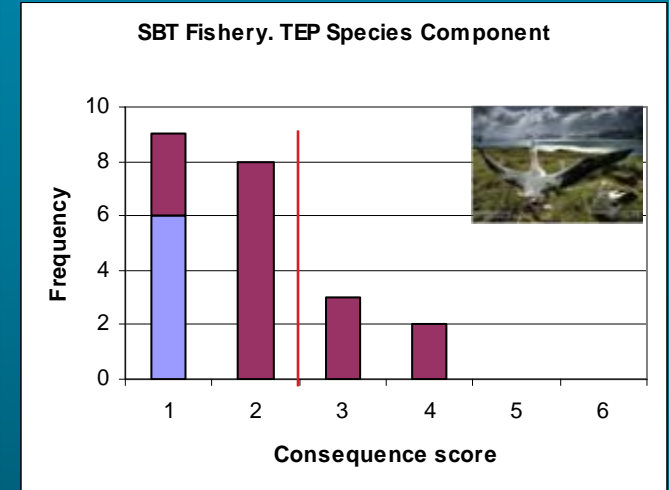
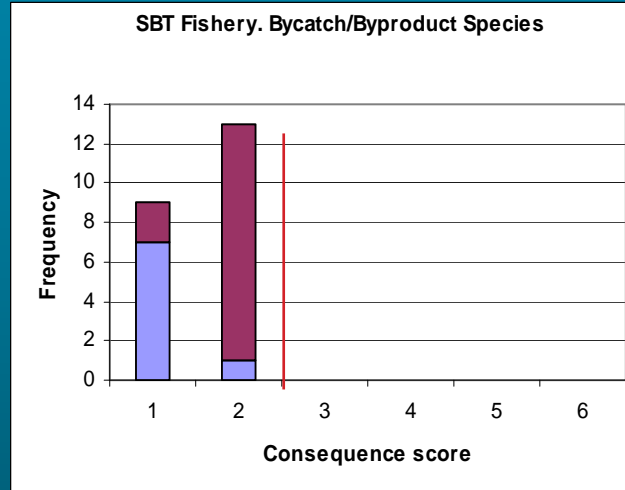
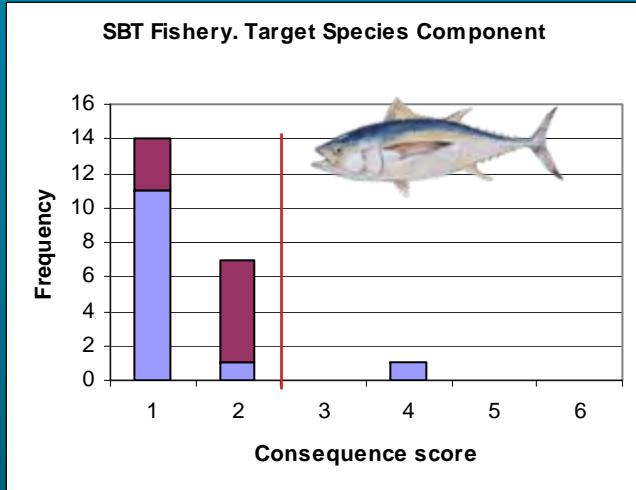
SICA

- Consequence scores rated 1 (negligible) to 6 (intolerable)
- Key to transparency is clear written justification for each score
- Score > 2 (minor) leads to next level analysis (or guided management response)



Key advantage of SICA

- comprehensive approach to risk (wide range of hazards considered)
- Rapid elimination of low risk hazards at relatively low cost

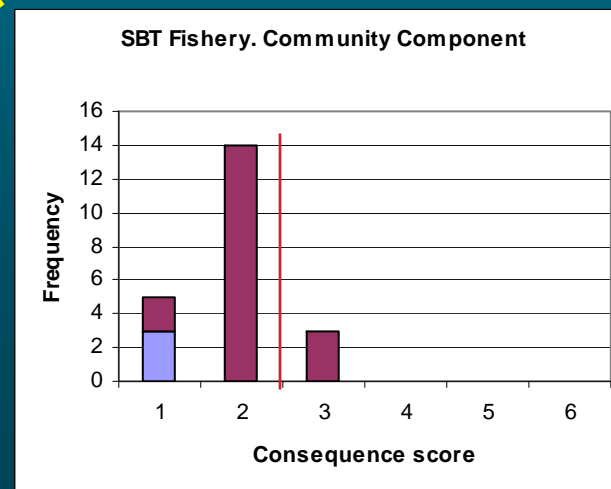
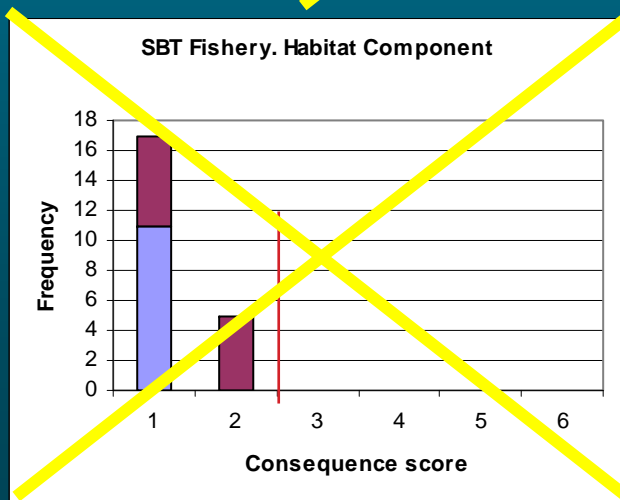
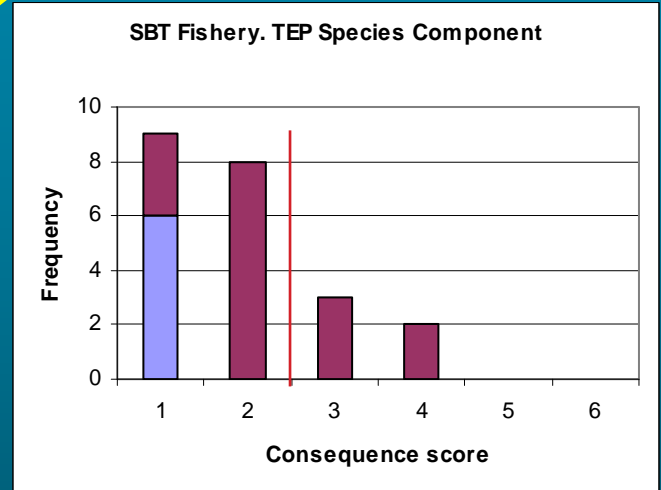
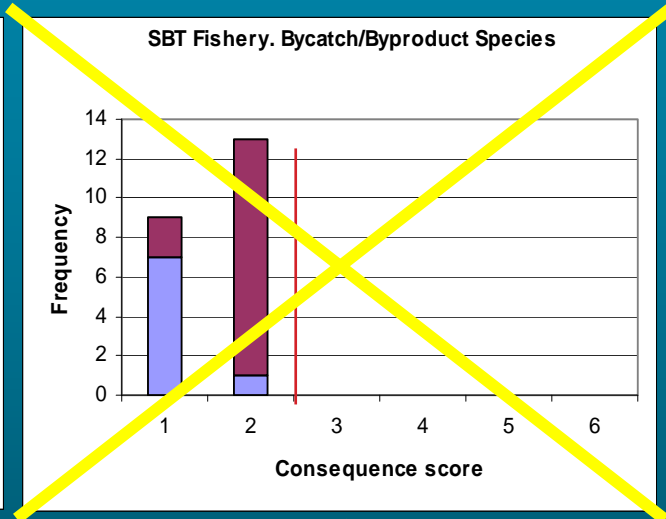
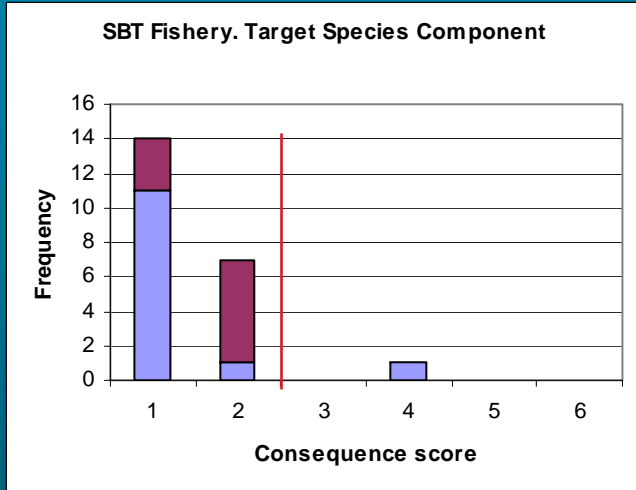
Level 1 – All components





Confidence

- Low 
- High 

Level 1 – All components



Confidence

- Low 
- High 

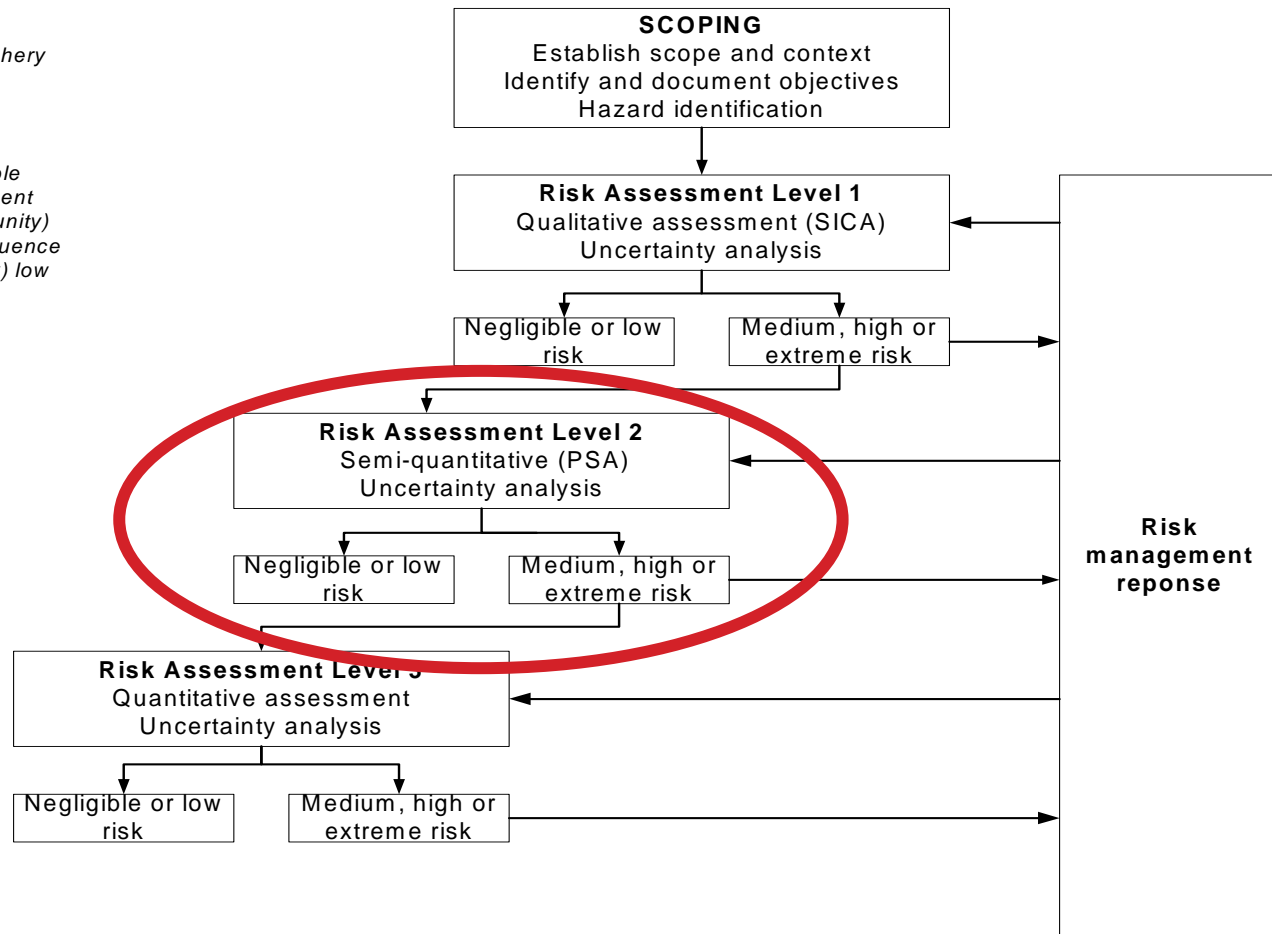
ERAEF Level 2: PSA

Analysis: Fishery/subfishery

Analysis: most vulnerable element in each component (species, habitat, community)
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Analysis: full set of elements for each component
Screen out: low risk elements

Analysis: selected elements (species, habitat, community); spatial and temporal dynamics



PSA

- Consider impacts on all units of analysis within each component assessed
- E.g. over 250 bycatch species in tropical prawn trawl fishery
- Same form of analysis for each unit (but separate method for species, habitat, community)
- “Semi-quantitative” method of analysis
- Reasonable demands on data (not catch or abundance data)
- Measures potential risk rather than actual risk but still useful for prioritizing

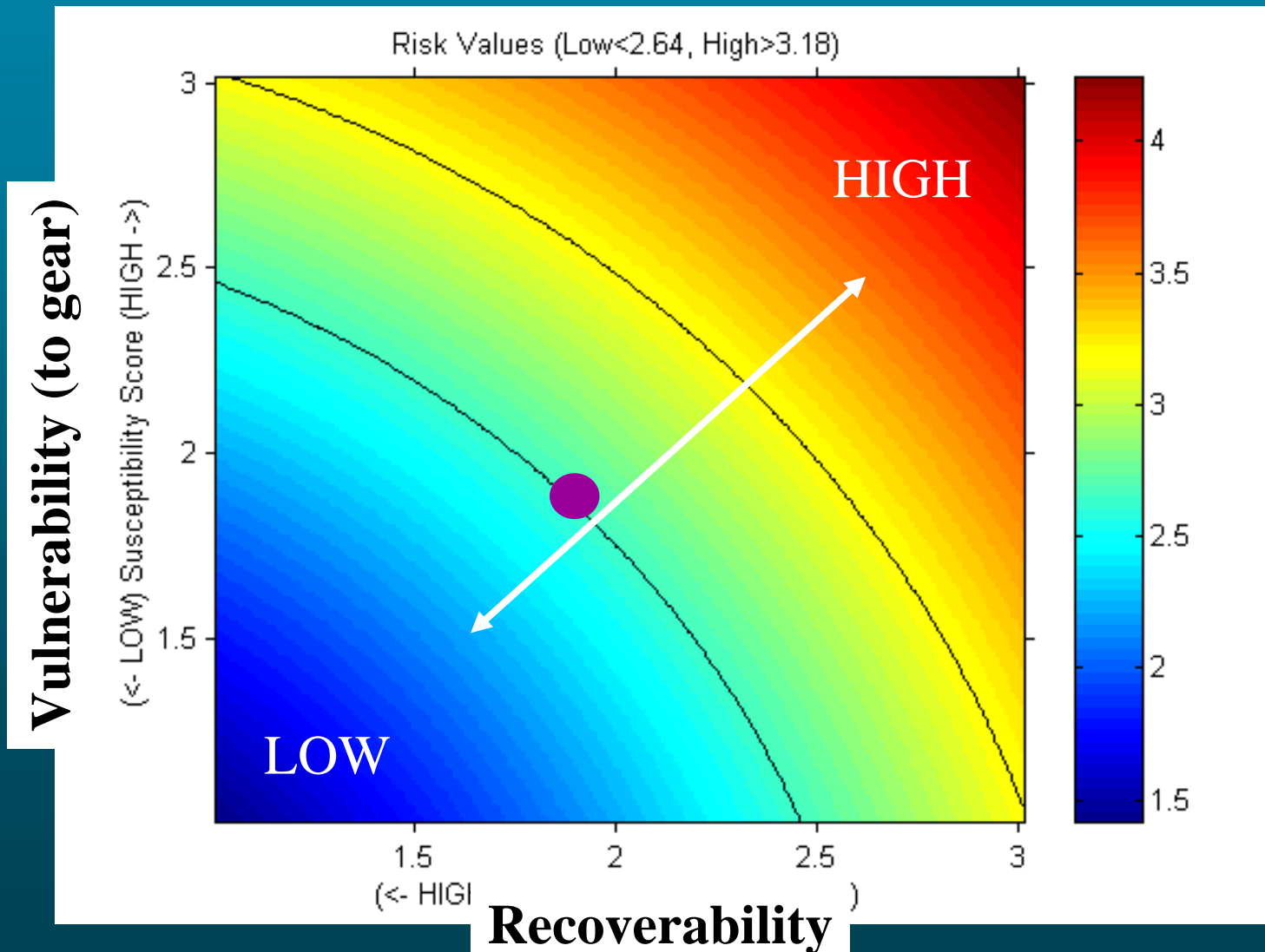
PSA

PSA = Productivity Susceptibility Analysis

Risk to an ecological unit (species, habitat, community) from a given activity will depend on two characteristics of the unit:

- the susceptibility or “exposure” of the unit to the fishing activity (**Susceptibility**) and
- the productivity of the unit which will determine the rate at which the unit can recover after depletion or damage by the fishing activity (**Productivity**)

Productivity Susceptibility Analysis (PSA)



PSA is “semi-quantitative”

$$\frac{dB}{dt} = rB\left(1 - \frac{B}{K}\right) - qEB$$

- Level 3 would solve this equation...e.g. stock assessment
- Cannot do this for all species...time and \$
- PSA estimates the “r” and the “q”
 - Use available attributes related to these terms

(B = units in species, habitat or community component)

PSA: susceptibility is multiplicative

$$\frac{dB}{dt} = rB\left(1 - \frac{B}{K}\right) - qEB$$

- Susceptibility = $q = A \times E \times S \times PM$
 - A = availability
 - E = encounterability
 - S = selectivity
 - PM = post-capture mortality

Attributes for species components

(TA, BP/DI, TEP)

Productivity attributes

- Maximum age
- Age at maturity
- Size at maturity
- Annual fecundity
- Maximum size
- Reproductive strategy
- Trophic level

Susceptibility attributes

- Availability
 - Overlap with fishery
- Encounterability
 - Water column position
 - Habitat overlap
- Selectivity
 - e.g. Size at maturity
- Post-Capture Mortality
 - e.g. Fate/data

Scoring attributes

- Divide each attribute into low, medium, high risk score
- E.g. age at maturity
 - <5 = high productivity = low risk = score 1
 - 5-15 = medium productivity = medium risk = score 2
 - >15 = low productivity = high risk = score 3
- Productivity risk = average risk score across 7 attributes

Susceptibility

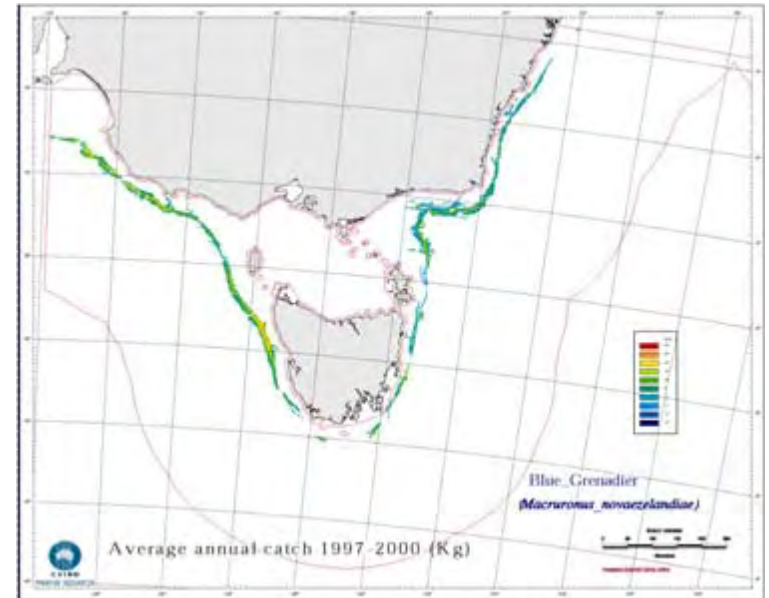
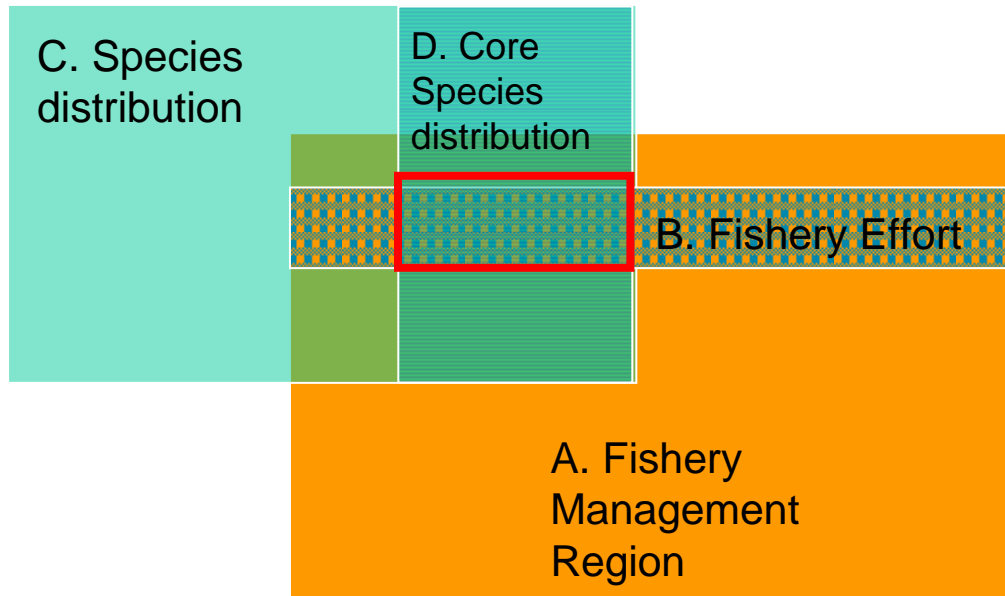
- Availability = spatial overlap of fishery with species
- Encounterability = proportion of available population exposed to the gear
- Selectivity = proportion of animals encountering the gear that are captured
- Post capture mortality = proportion of animals captured that die
- Susceptibility score = product of risk scores $A \times E \times S \times P$

Availability scoring

- Global distribution (endemic = high, SH = med, worldwide = low) (if no distribution maps)
 - Stock likelihood adjustment (table X)

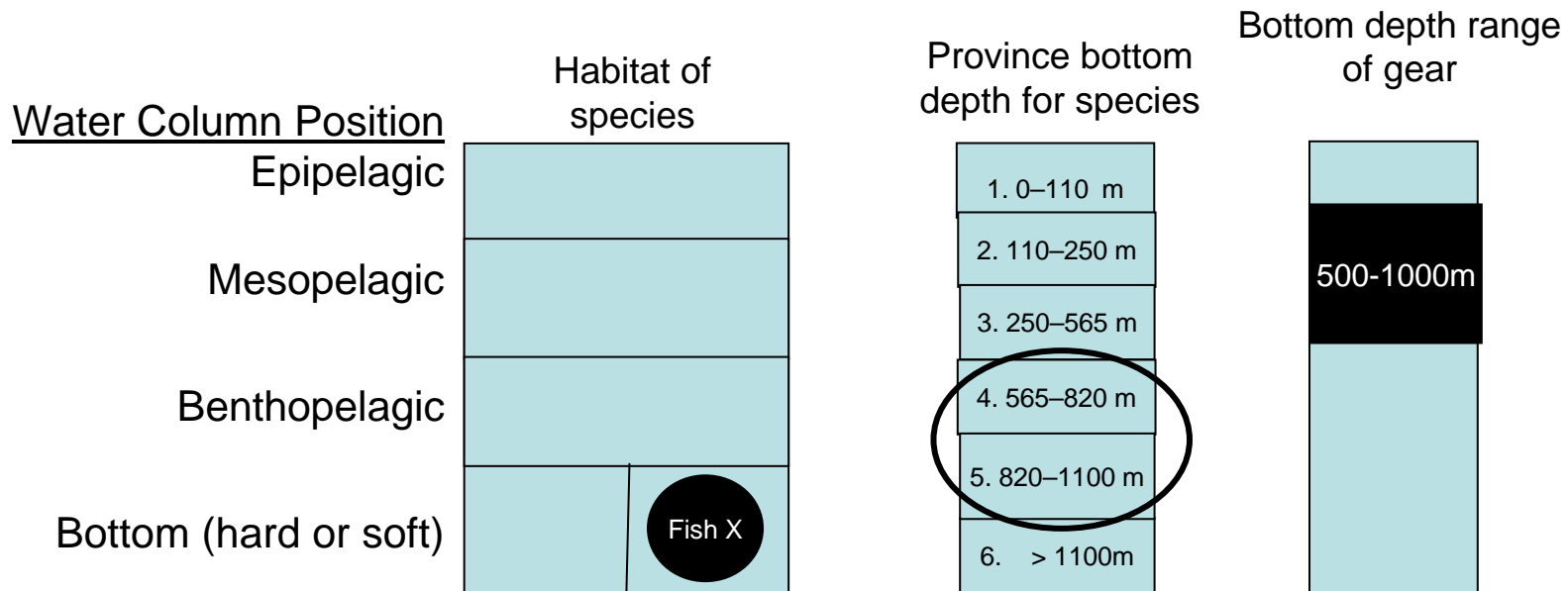
OR

- Score the overlap of core species distribution (D) with core fishing effort (B) (red square)



Encounterability Scoring

1. Score habitat attribute for each unit (species, habitat, community)
2. Generate fishery-specific encounterability score based on gear fishing characteristics
....if data exists and score is M or H, can check to refine overlap....
3. Check bathymetric range of within the species province for overlap with the bottom depth range for the fishery gear type
4. Refine the risk score for encounterability



Scoring Example:

Risk: H

Bottom species living on soft ground
Overlap with demersal gear on soft ground is High

Bathymetry
check →

Risk: L

Depth range for the species is outside the depth range of the fishery: encounterability score is corrected to Low

Selectivity

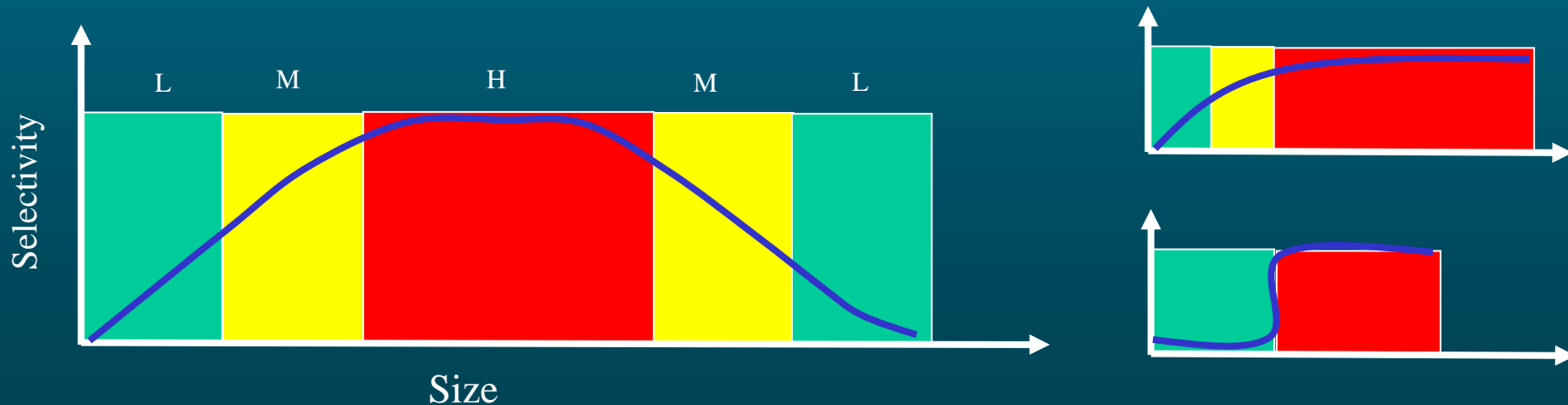
Selectivity is a measure of the proportion of animals encountering the fishing gear that is captured.

Attributes related to selectivity :

Size

(Morphology)

(Swimming capability)



Example of species scoring (1)

	Shortfinned Mako
Productivity	
Average age at maturity	
Average max age	
Fecundity	
Average max size	
Average size at Maturity	
Reproductive strategy	
Trophic level (fishbase)	
Productivity total (additive)	
Susceptibility	
Availability	
Encounterability	
Selectivity	
PCM	
Susceptibility total (multiplicative)	
Overall Risk Value	
Risk Category	

Long-line fishery
Byproduct species

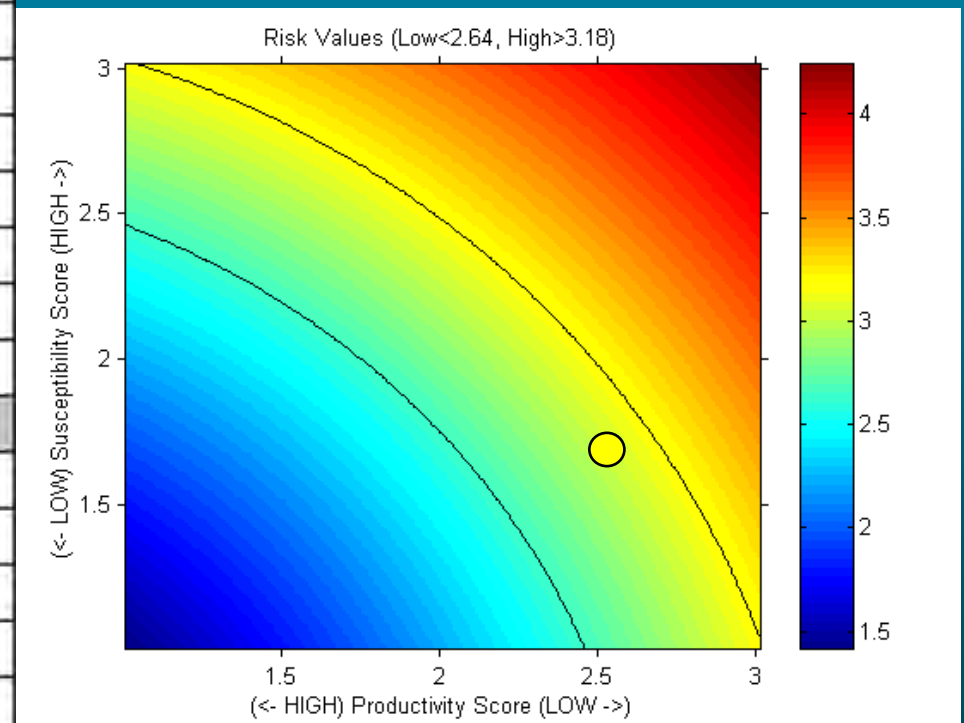


Example of species scoring (1)

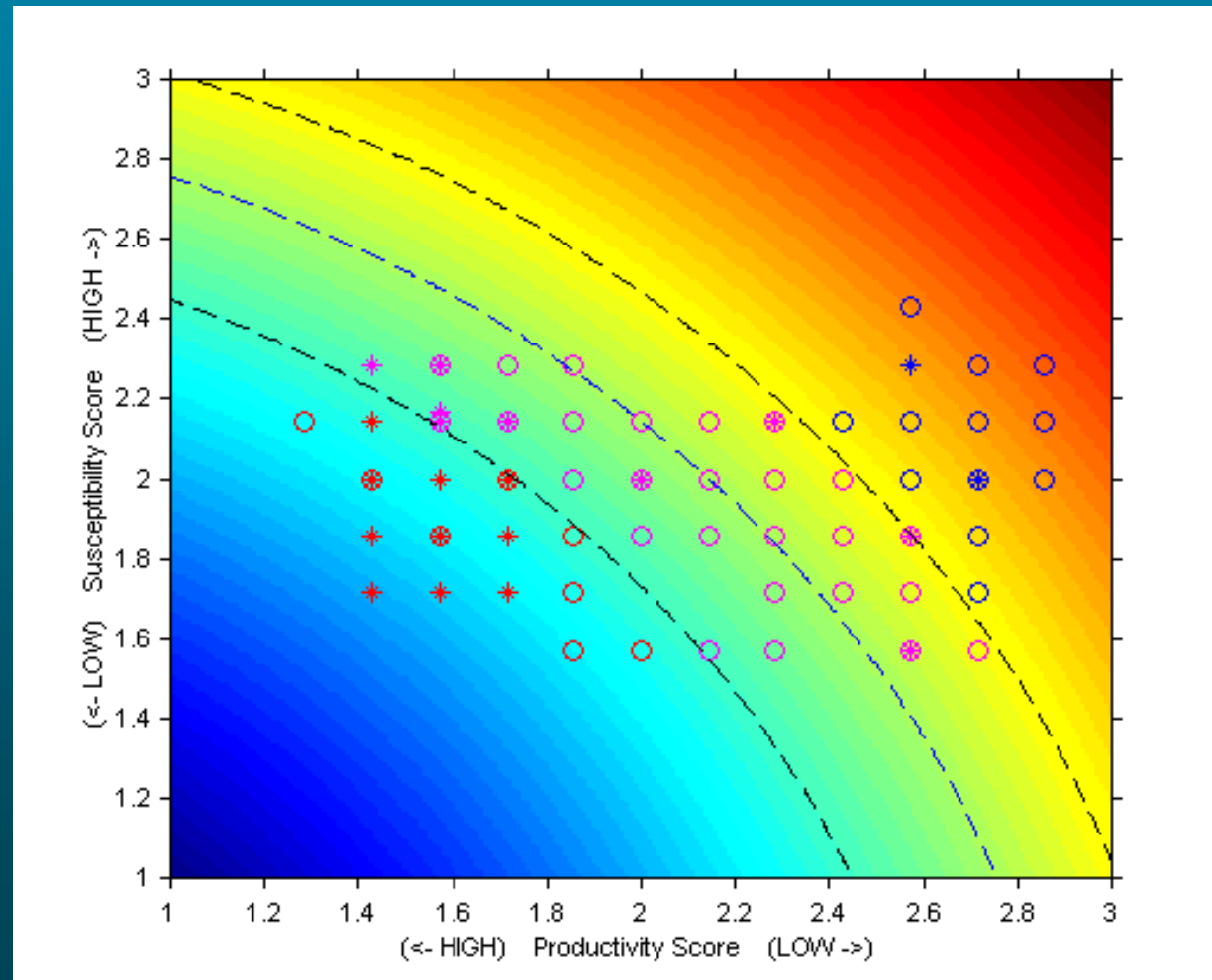
	Shortfinned Mako	Shortfinned Mako
Productivity		
Average age at maturity	6.5	2
Average max age	28	3
Fecundity	2	3
Average max size	400	3
Average size at Maturity	195	2
Reproductive strategy	DS	2
Trophic level (fishbase)	3.78	3
Productivity total (additive)		2.57
Susceptibility		
Availability	0.0288	1
Encounterability	1,2, HB,EP,MP	3
Selectivity	195	3
PCM	3	3
Susceptibility total (multiplicative)		1.67
Overall Risk Value		3.06
Risk Category		Med

Example of species scoring (1)

	Shortfinned Mako
Productivity	
Average age at maturity	2
Average max age	3
Fecundity	3
Average max size	3
Average size at Maturity	2
Reproductive strategy	2
Trophic level (fishbase)	3
Productivity total (additive)	2.57
Susceptibility	
Availability	1
Encounterability	3
Selectivity	3
PCM	3
Susceptibility total (multiplicative)	1.67
Overall Risk Value	3.06
Risk Category	Med



Bycatch and Byproduct species (Danish Seine)



PSA summary (trawl fishery)

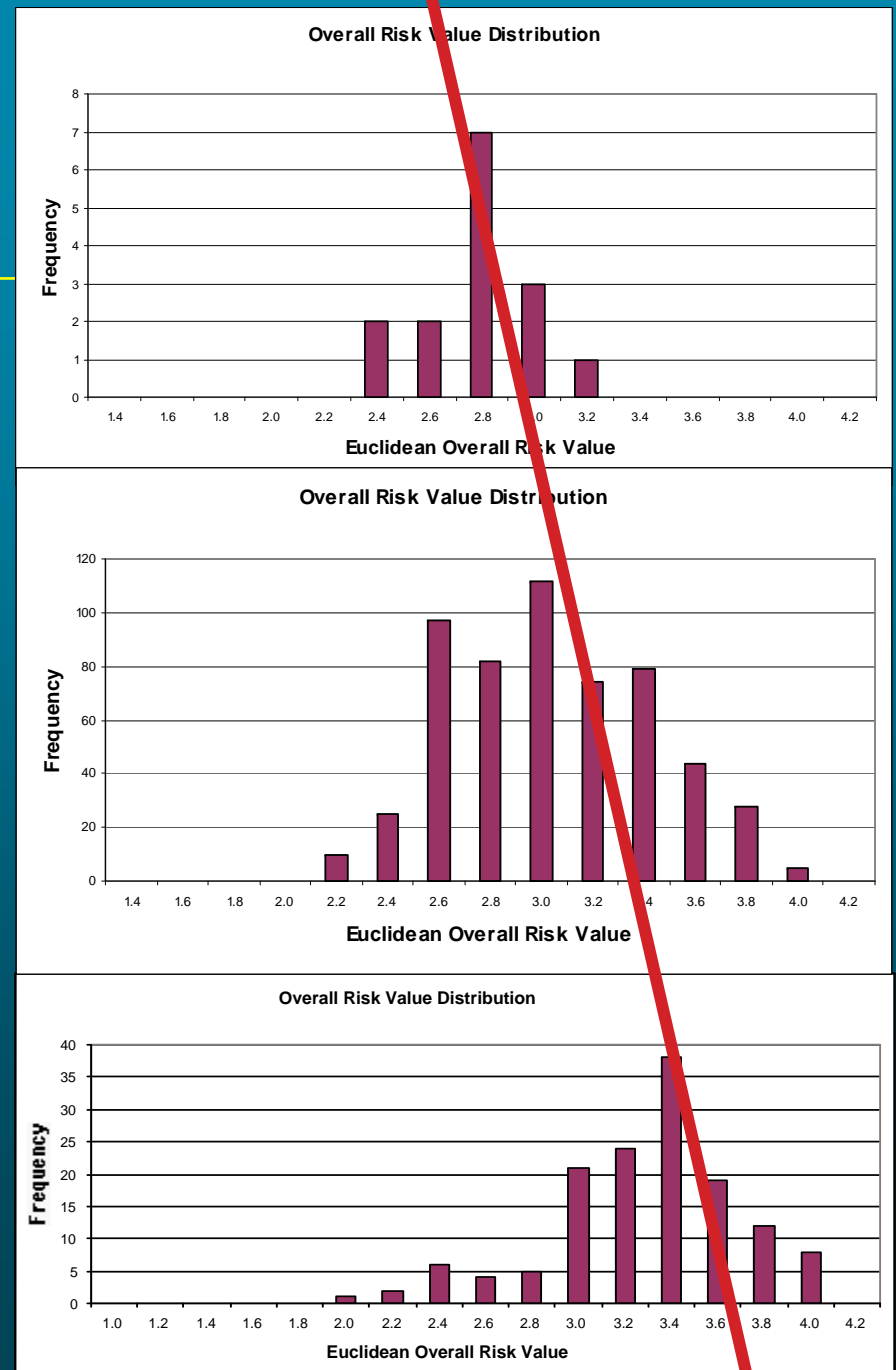
Risk Category	High	Medium	Low	Total
Target species	16	8	4	28
Byproduct species	36	24	20	80
<u>Bycatch species</u>	129	87	82	298
TEP species	3	119	72	194
Total	184	238	178	600

Purse-seine

Example: Species Risk Distributions Across Fisheries

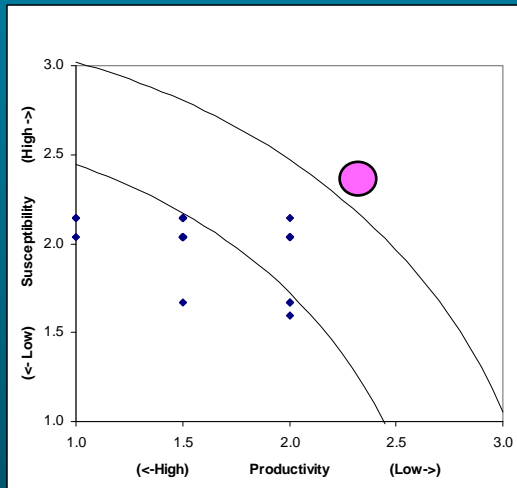
Trawl

Longline



Level 2 Options (categorization will guide this)

Current risk (H)



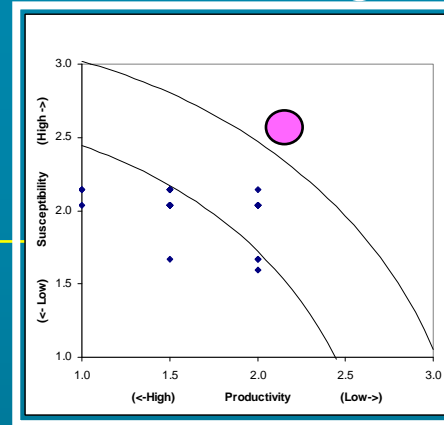
No action

Management
action

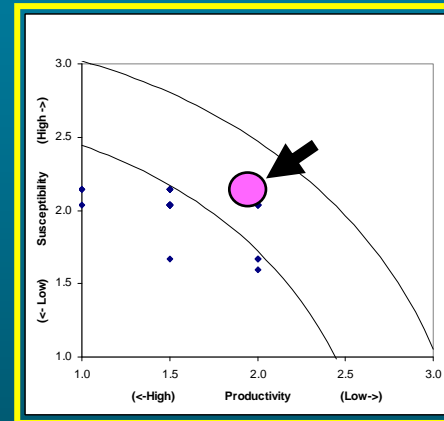
Additional
Analysis
Overrides

Go to next Level

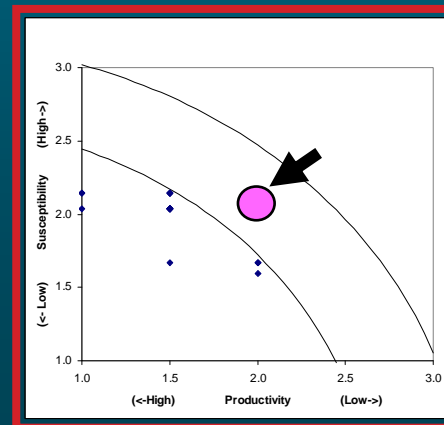
PSA change



No change
Rationale provided
for a “lower risk”
due to expert
consideration of
management



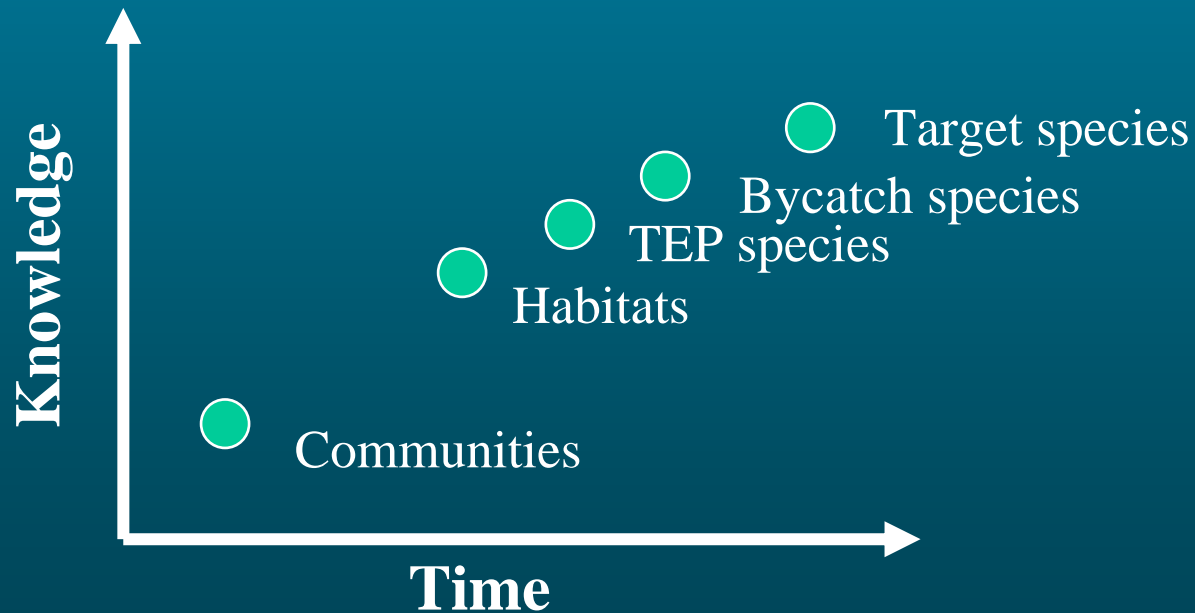
Management
change translates
to A,E,S,PCM and
rescoring reduces
risk score



e.g. additional
data, or assess
with additional
tool, such as PSA
3rd axis, reduces
risk score

Non-species components

- Most experience and theory for species



Defining habitats types and lists for each subfishery

“Habitat” includes both biological and physical elements

Each habitat “type” was defined by a unique combination of S, G and F

Substratum (S)

- Mud (soft)
- Fine sediments (soft)
- Coarse sands (soft)
- Gravel/pebble (hard)
- Cobble/boulder/slab (hard)
- Rock (igneous/metamorphic)
- Rock (sedimentary)
- Biogenic

Geomorphology (G)

- Unrippled/ flat
- Current rippled/ directed scour
- Wave rippled
- Highly irregular
- Debris flow/ rubble banks
- Subcrop
- Low outcrop
- High outcrop

Sessile fauna (F)

- None
- Bioturbators (infauna)
- Mixed low/ encrustors
- Small/ low sponges
- Solitary erect
- Stalked crinoids
- Octocorals
- Mixed epifaunal community
- Large erect sponges



SGF = coarse sand, wave rippled, infauna



= coarse sand, subcrop, large sponges

Each type evaluated against 11 attributes of habitat vulnerability

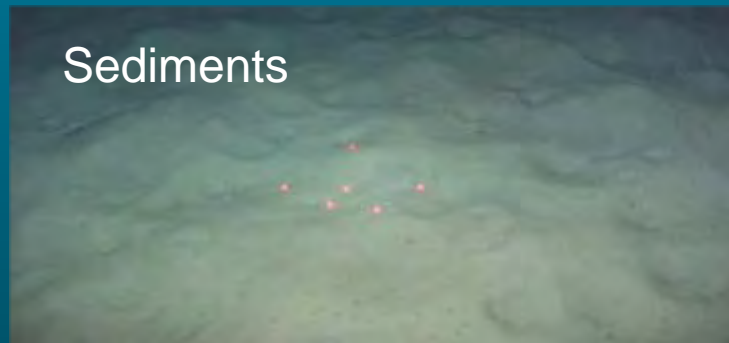
Aspect	Attribute	Concept	Rationale
Availability	General depth range (biome)	Spatial overlap of subfishery with habitat defined at biomic scale	Habitat occurs within the management area
Encounterability	Depth zone and feature type	Habitat encountered at the depth and location at which fishing activity occurs	Fishing takes place where habitat occurs
	Ruggedness (fractal dimension of substratum and seabed slope)	Relief, rugosity, hardness and seabed slope influence accessibility to different sub-fisheries	Rugged substratum is less accessible to mobile gears. Steeply sloping seabed is less accessible to mobile gears
	Level of disturbance	Gear footprint and intensity of encounters	Degree of impact is determined by the frequency and intensity of encounters (inc. size, weight and mobility of individual gears)
Selectivity	Removability/ mortality of fauna/ flora	Removal/ mortality of structure forming epifauna/ flora (inc. bioturbating infauna)	Erect, large, rugose, inflexible, delicate epifauna and flora, and large or delicate and shallow burrowing infauna (at depths impacted by mobile gears) are preferentially removed or damaged.
	Areal extent	How much of each habitat is present	Effective degree of impact greater in rarer habitats: rarer habitats may maintain rarer species.
	Removability of substratum	Certain size classes can be removed	Intermediate sized clasts (~6 cm to 3 m) that form attachment sites for sessile fauna can be permanently removed
	Substratum hardness	Composition of substrata	Harder substratum is intrinsically more resistant
	Seabed slope	Mobility of substrata once dislodged; generally higher levels of structural fauna	Gravity or latent energy transfer assists movement of habitat structures, eg turbidity flows, larger clasts. Greater density of filter feeding animals found where currents move up and down slopes.
Productivity	Regeneration of fauna	Accumulation/ recovery of fauna	Fauna have different intrinsic growth and reproductive rates which are also variable in different conditions of temperature, nutrients, productivity.
	Natural disturbance	Level of natural disturbance affects intrinsic ability to recover	Frequently disturbed communities adapted to recover from disturbance

Example of risk ranking: substratum removability

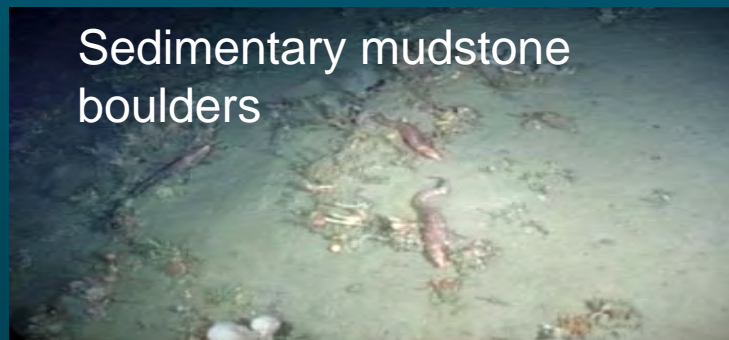
Rationale: Intermediate sized clasts (~6 cm to 3 m) can be permanently removed



Immovable



Transferable



Removable

Risk rank
Bottom trawl Bottom longline

1

1

2

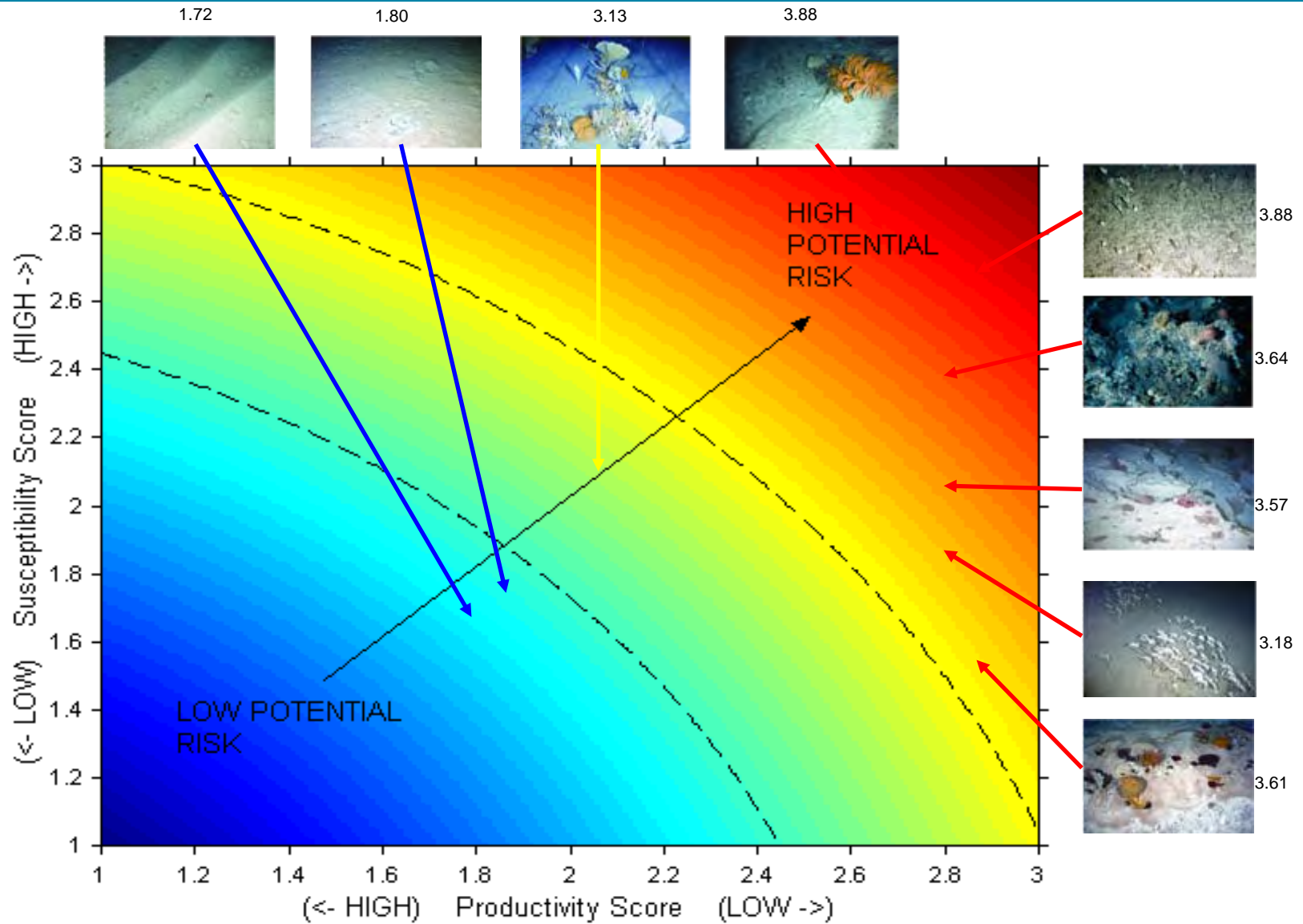
1

3

1

Increasing vulnerability

Habitats: PSA outcome (Otter trawl)



Community component

- PSA for communities still under development
- Qualitative modelling of trophic structure

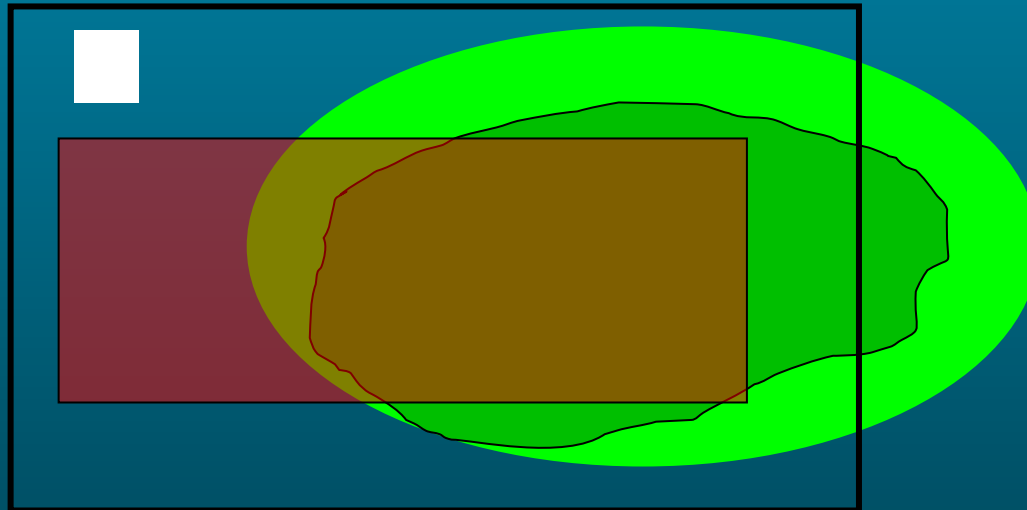
Level 3 – Quantitative

A range of tools exist:

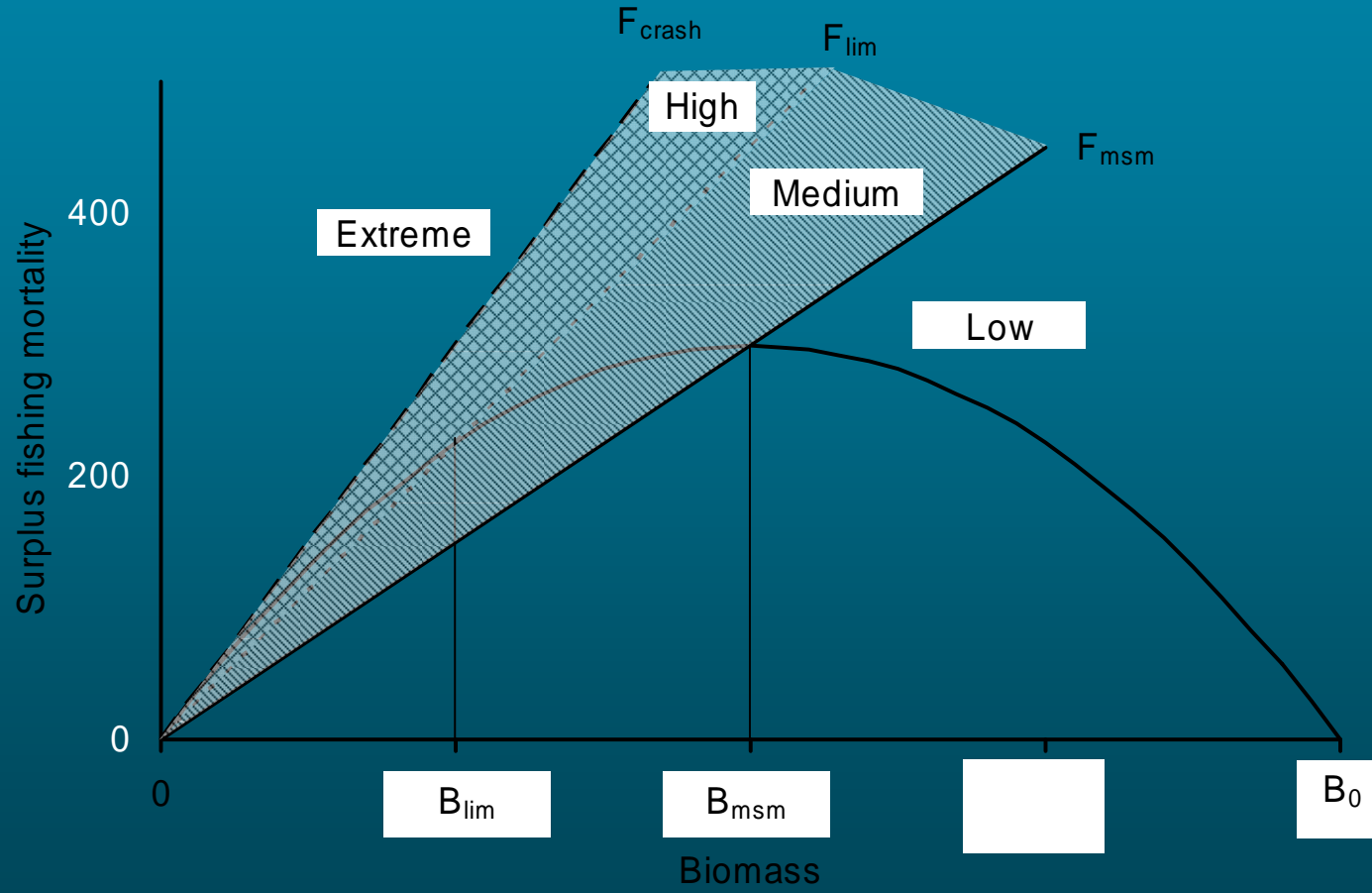
- Stock assessments, PBR for species
- Habitat fragmentation/landscape models
- Eco-family models

- SAFE – quantitative version of PSA for species

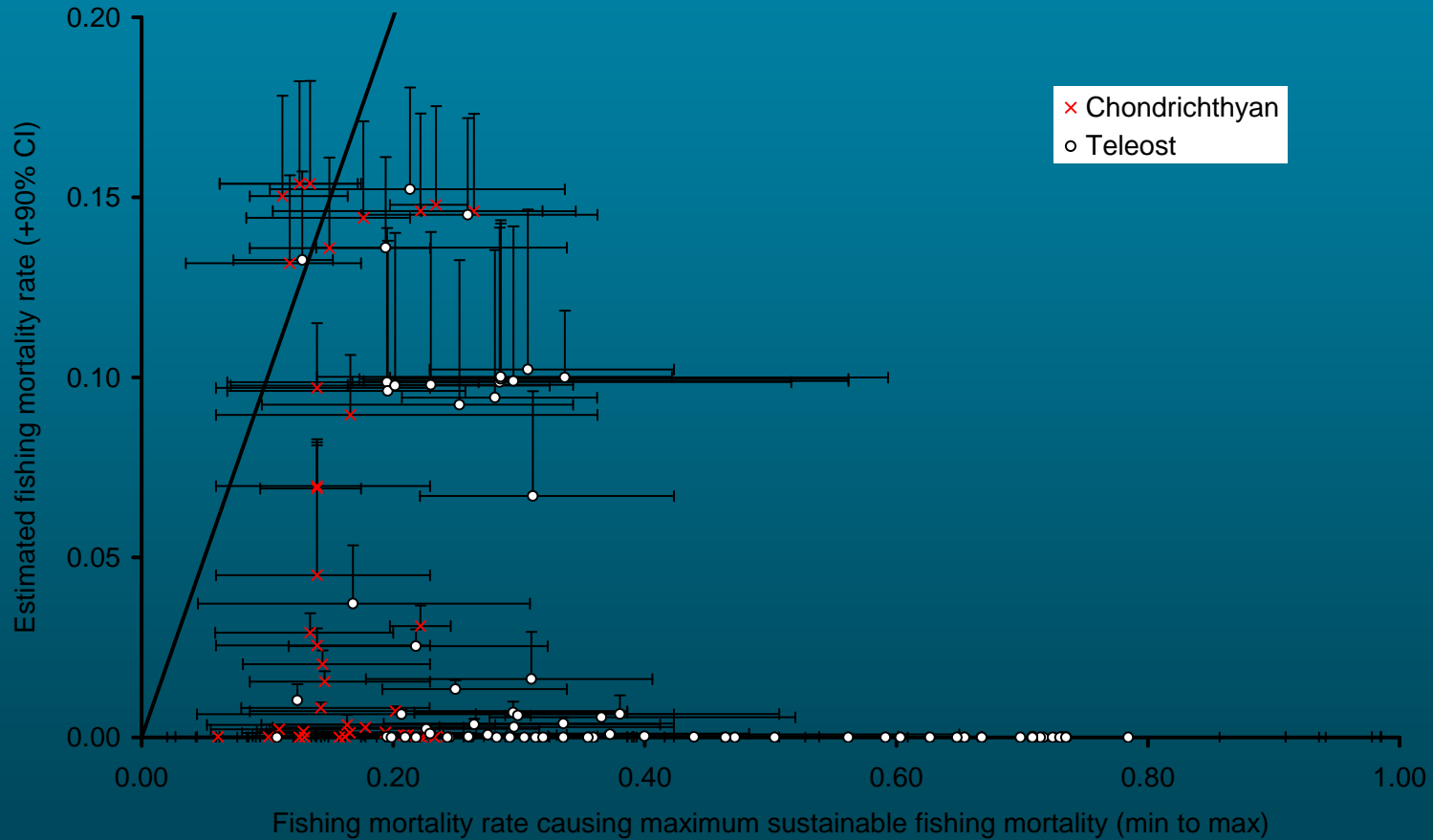
SAFE: Spatial overlap



Determining MSM



SAFE analysis for demersal longline



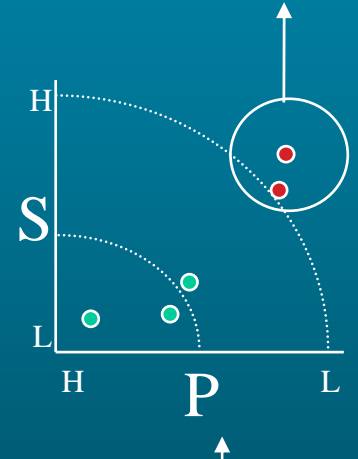
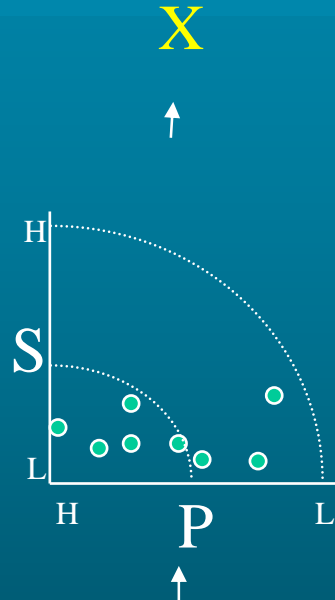
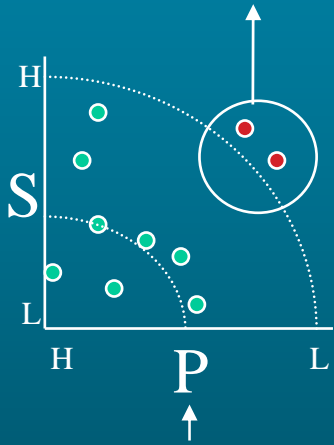
ERAEF OUTLINE

Level 3

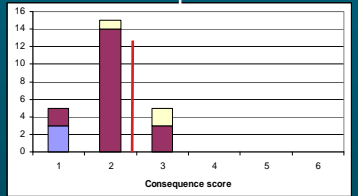
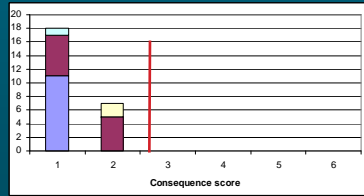
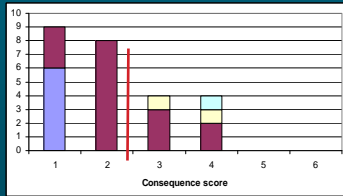
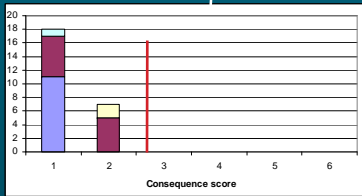
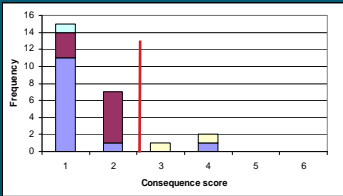
e.g. SAFE

e.g. Ecosim

Level 2



Level 1



Target

Bycatch

TEP

Habitats

Communities

Scoping

Fishing Activities (e.g. Longlining)

X

X

X

Application to Fisheries

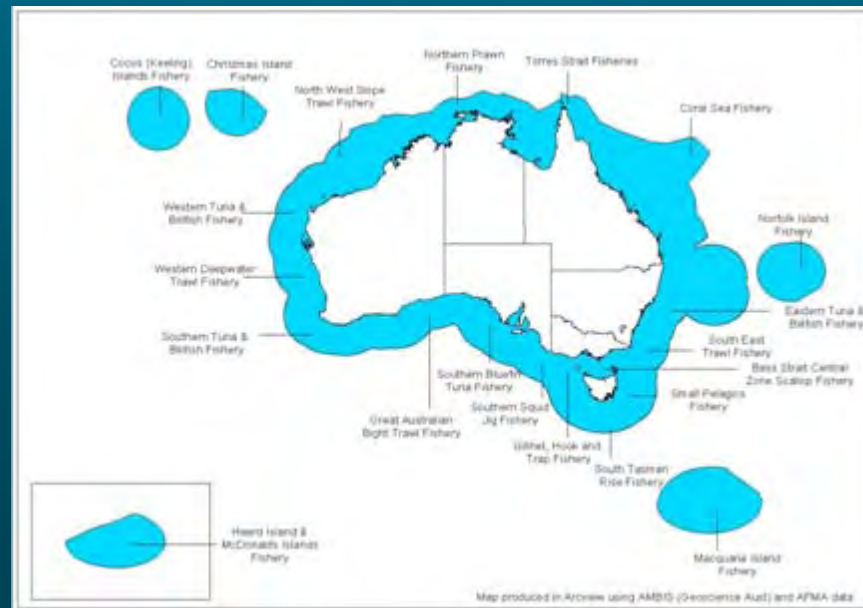
32 fisheries assessed in Australia

- Trawl and demersal
- Pelagic fisheries
- Sub-Antarctic
- Minor – e.g. hand collection

2000 species

200 habitats

50 communities



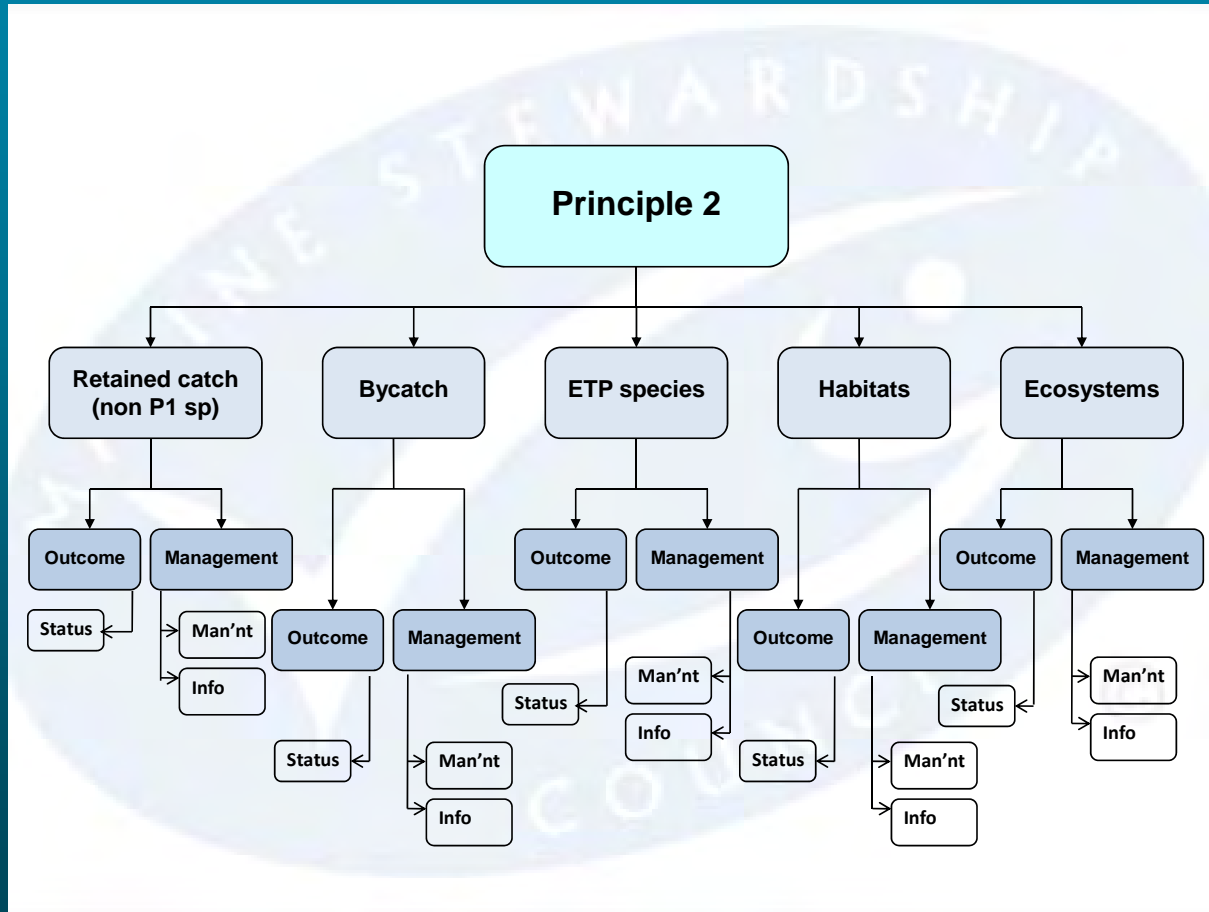
ERA to ERM

- Step through hierarchy to eliminate low risks
- Remaining issues need management attention
- Develop management responses informed by risk analyses
 - E.g. based on PSA analysis
 - Can't alter productivity
 - Can alter susceptibility
 - A: spatial closure
 - E: seasonal closure
 - S: gear modification
 - P: improve on-board handling practice
- AFMA moving to comprehensive ERM strategies for all fisheries

Marine Stewardship Council

- International certification for sustainable fisheries
- Three principles
 - Sustainable stocks
 - Sustainable ecosystems
 - Good governance
- Score fisheries against set of performance indicators
 - 60 minimum for certification
 - 80 pass
 - 100 maximum possible score

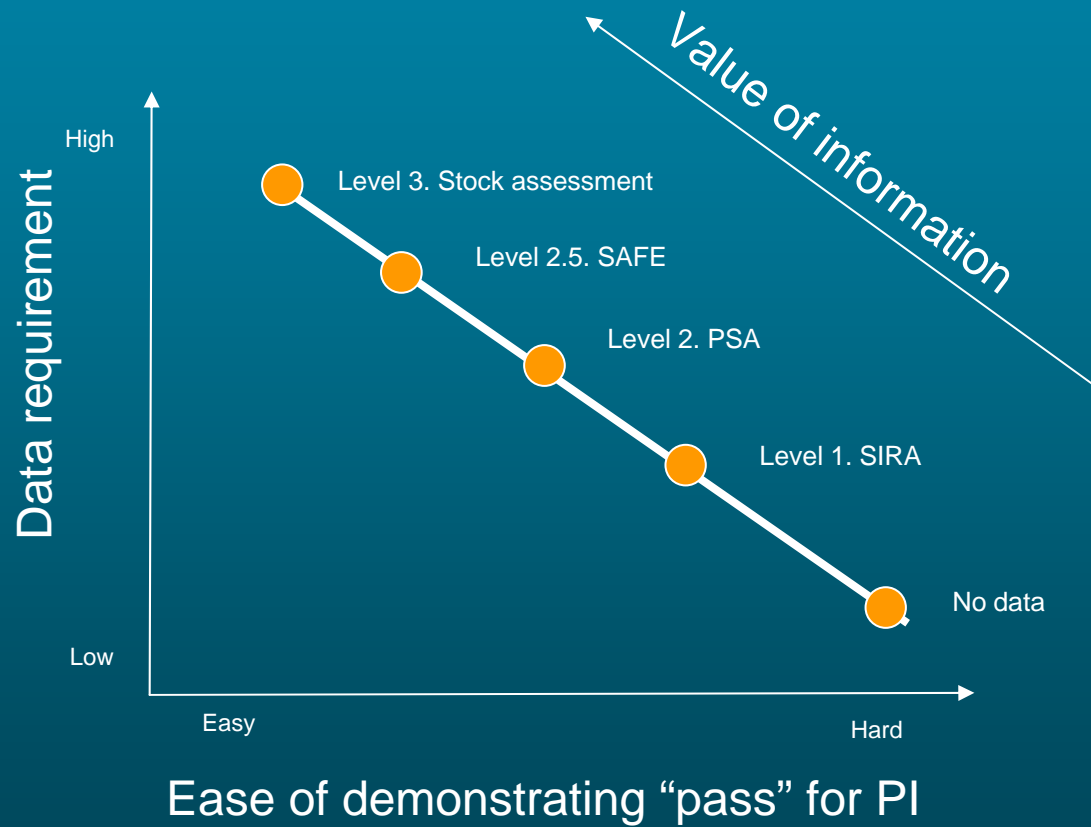
Marine Stewardship Council



Marine Stewardship Council

- RBF (risk based framework) available to score P1 and P2 outcomes indicators (status of species, habitats and ecosystems)
- RBF currently incorporates SICA and PSA methods
- Calibration exercise in 2008 to equate SICA (1-6) and PSA (1-4) scores to MSC PI scores (0-100)
- Don't have to use RBF – available for low information or low value fisheries – but “penalty” for use

Equivalence between “Levels”



Links to management

Data, \$ \longrightarrow

L1

L2

L3

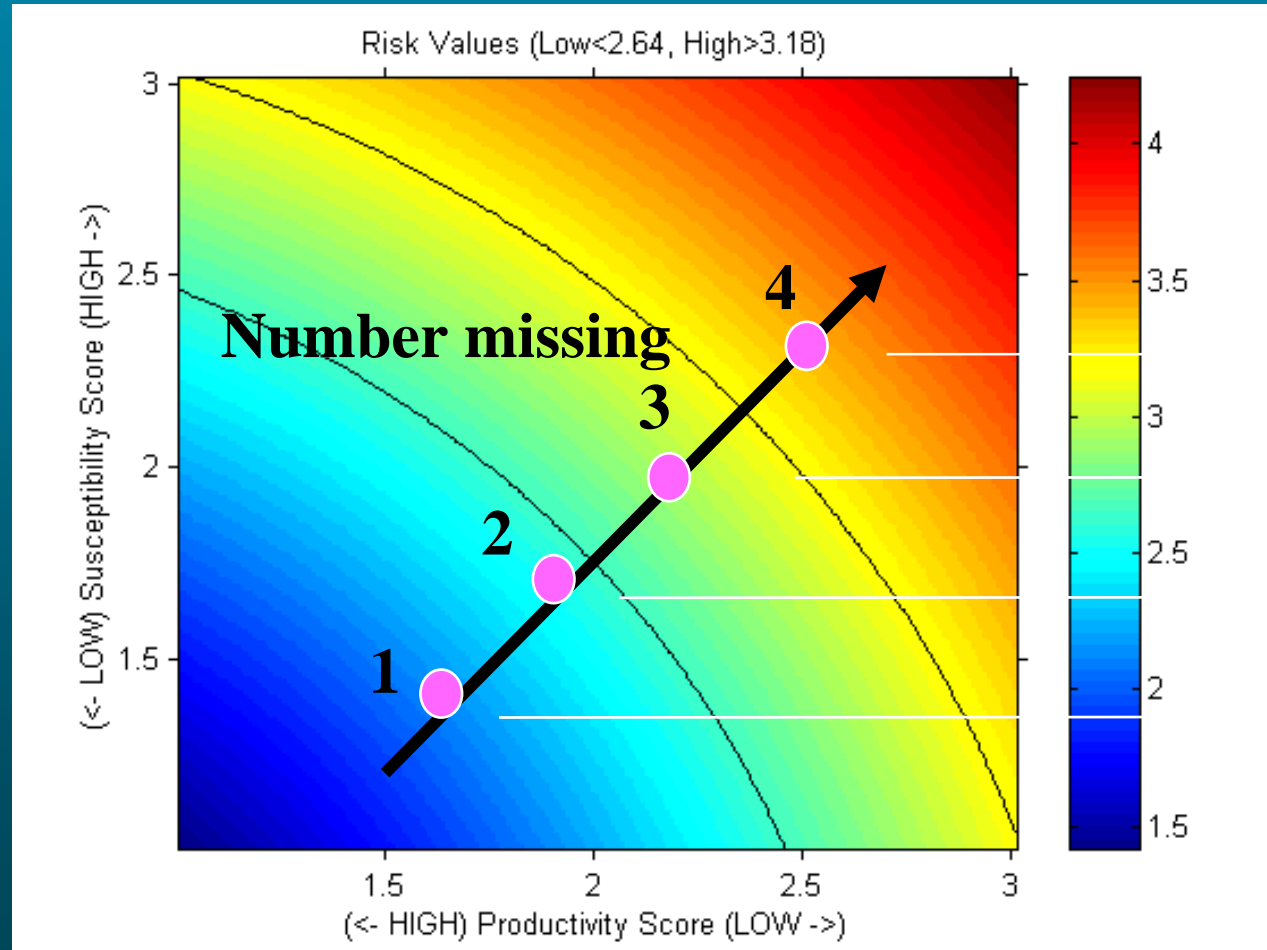


Sustainable

Unsustainable

Effect of missing attributes

Attributes
Missing



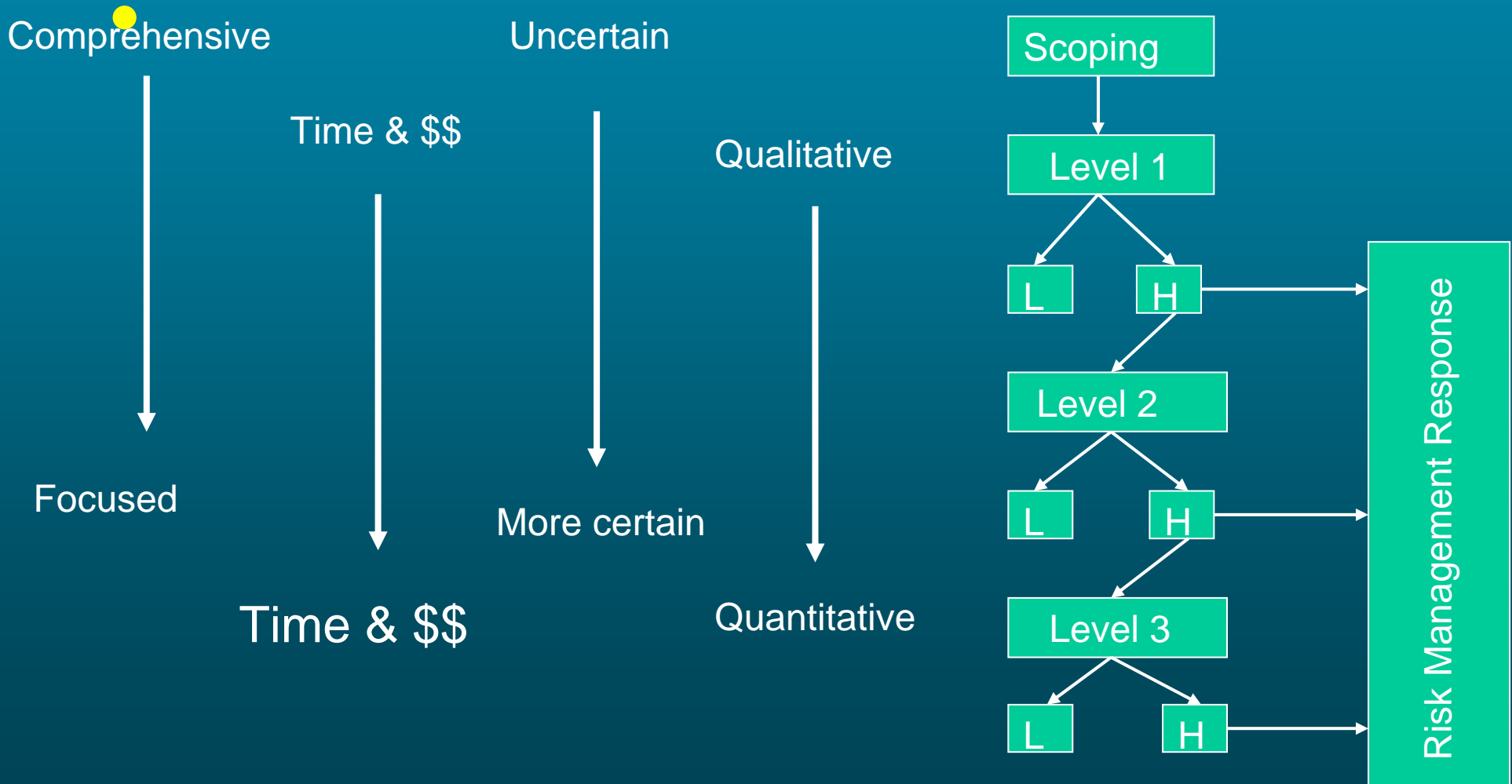
Apply to the indicator

ERA - summary

- Designed for data deficient situations
- Make best use of existing information
 - Don't give up because can't do quantitative analysis
- Inbuilt "precaution" aimed to prevent abuse
 - SICA – plausible worst case scenario
 - PSA – assumes high risk – evidence to lower risk score
- Hierarchical structure
- Toolbox approach →



ERAEF hierarchical structure



Ecological Risk Assessment for the Effects of Fishing (ERAEF)

Principal investigators:
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Tony Smith



Stage 2: Development Team

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Stage 2: Case study authors

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