Global Index of Fishing Intensity (FI)

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NOAA Fisheries

Ways these measures can be used

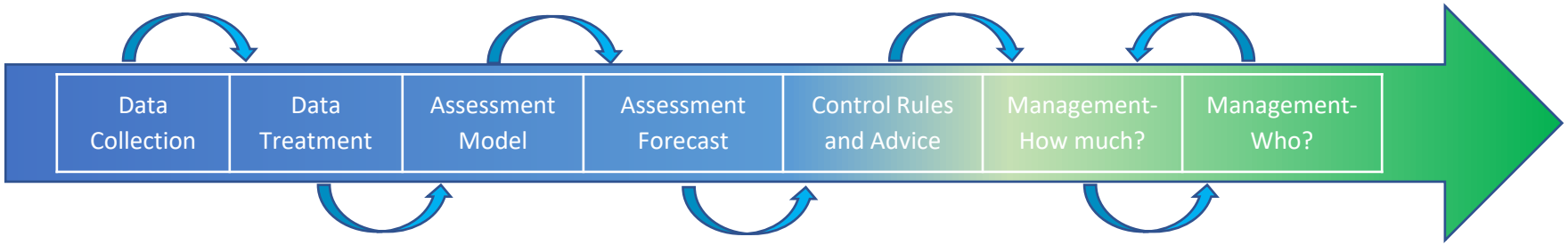
Directly to

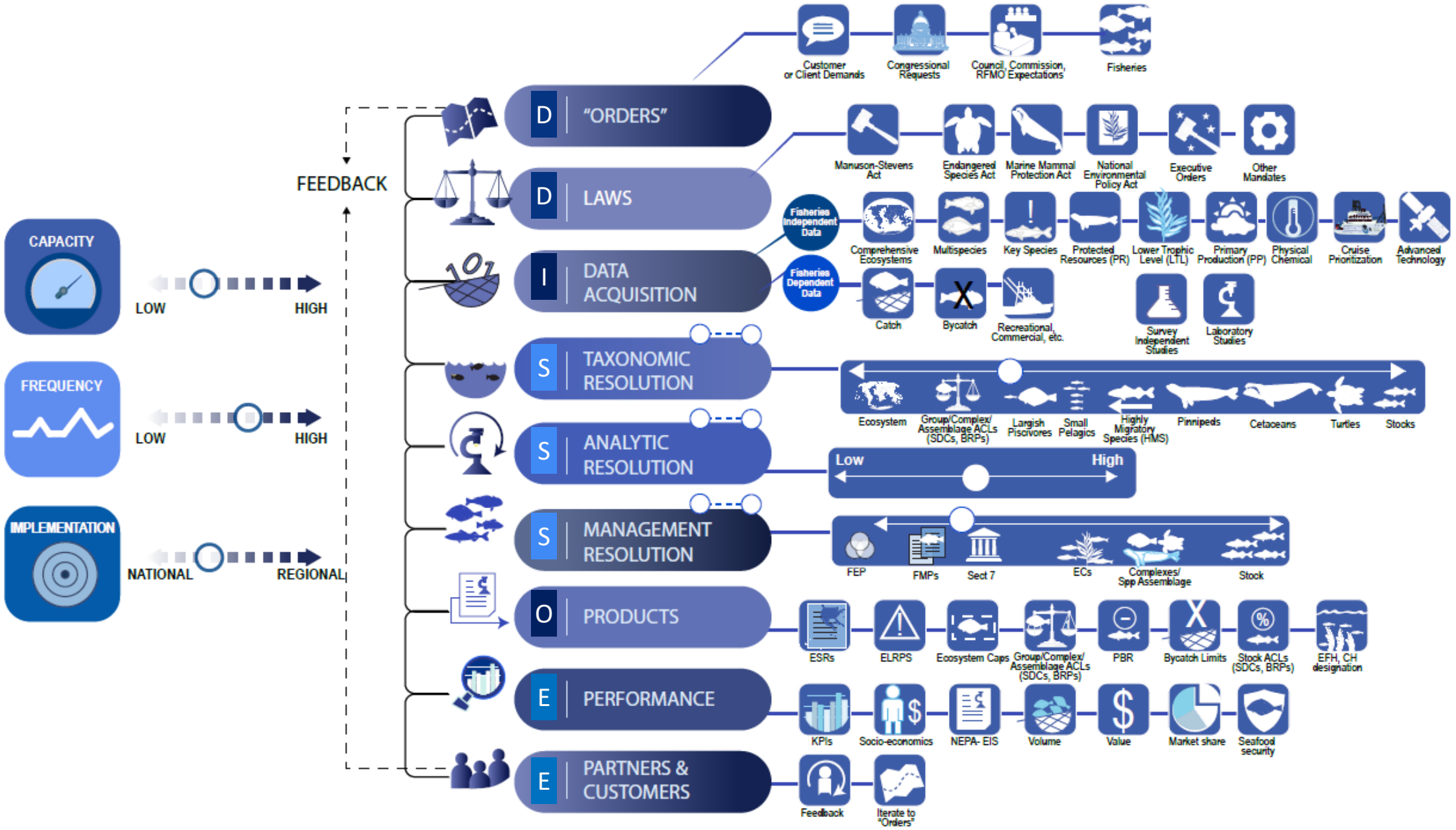
- set OFLs, ACLs, ACTs, SDCs,etc. of the ecosystem, guilds, etc.
- measure EOF
  - serve as comparable “Kobe” plots to delineate EOF when multiple are combined
- inform allocation, effort decisions
- evaluate (overall) fishery performance
- clarify expectations of what Fisheries Removals could be

Indirectly to

- provide context
- provide an ensemble “reality check”
- provide trade space within which systematic degradation is avoided
  - provide backstopping to all fisheries removals
- evaluate the best socio-economic options
- provide insights into system dynamics
- provide early warning signals of system-wide events

Should be viewed as part of a process (or work flow) which combines a set of (different) analytical methods

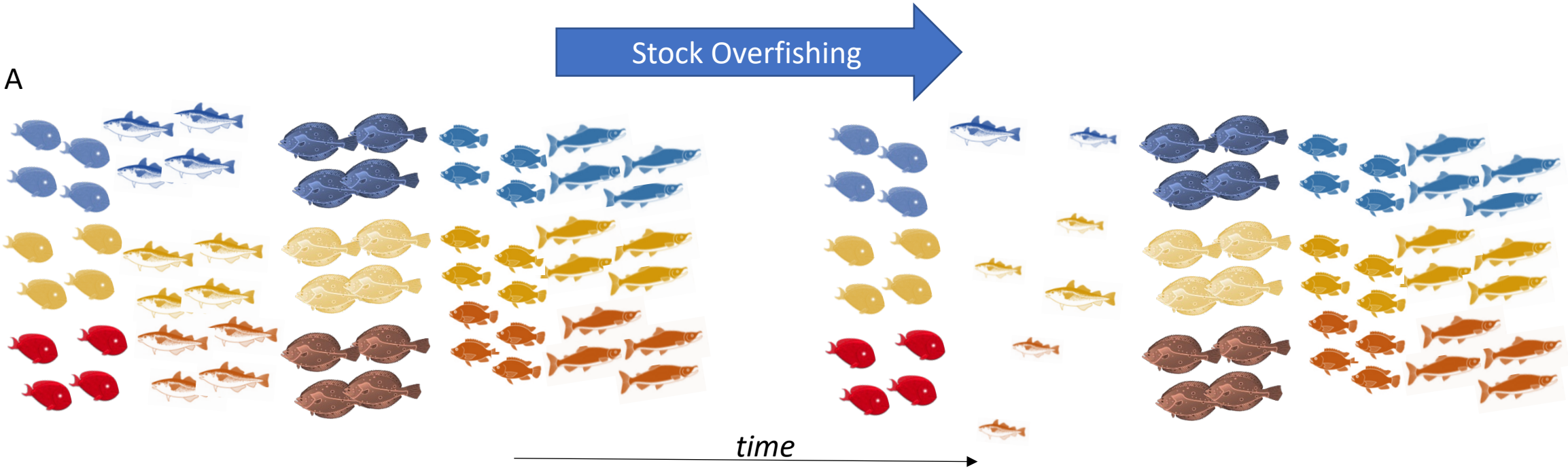



CAPACITY
LOW
HIGH
FREQUENCY
LOW
HIGH
IMPLEMENTATION
NATIONAL
REGIONAL
FEEDBACK
D "ORDERS"
Customer or Client Demands
Congressional Requests
Council, Commission, RFMO Expectations
Fisheries
D LAWS
Magnuson-Stevens Act
Endangered Species Act
Marine Mammal Protection Act
National Environmental Policy Act
Executive Orders
Other Mandates
I DATA ACQUISITION
Fisheries Independent Data
Comprehensive Ecosystems
Multispecies
Key Species
Protected Resources (PR)
Lower Trophic Level (LTL)
Primary Production (PP)
Physical Chemical
Cruise Prioritization
Advanced Technology
Fisheries Dependent Data
Catch
Bycatch
Recreational, Commercial, etc.
Survey Independent Studies
Laboratory Studies
S TAXONOMIC RESOLUTION
Ecosystem
Group/Complex/ Assemblage ACLs (SDCs, BRPs)
Largish Piscivores
Small Pelagics
Highly Migratory Species (HMS)
Pinnipeds
Cetaceans
Turtles
Stocks
S ANALYTIC RESOLUTION
Low
High
S MANAGEMENT RESOLUTION
FEP
FMPs
Sect 7
ECs
Complexes/ Spp Assemblage
Stock
O PRODUCTS
ESRs
ELRPS
Ecosystem Caps
Group/Complex/ Assemblage ACLs (SDCs, BRPs)
PBR
Bycatch Limits
Stock ACLs (SDCs, BRPs)
EFH, CH designation
E PERFORMANCE
KPIs
Socio-economics
NEPA- EIS
Volume
Value
Market share
Seafood security
E PARTNERS & CUSTOMERS
Feedback
Iterate to "Orders"

Summary Up Front

- Method description: global index of fishing intensity (FI)
- Data inputs (especially critical data and their viability now and in the future): Catch (landings), fishing effort, PP, TL of all species
- Analysis/data output summary: 4 indicators, the latter a composite index fish pressure
- How this method can inform management: Potential Indicator of EOF
- Caveats for this method: depends on coarse global datasets, robustness uncertain, granularity unclear at more local scales below national levels, may not tie directly to actionable steps, good diagnostic
- Previous applications of this method: global consideration, Ye & Link 2023
- Any graphs or diagrams to show for this method: see more info

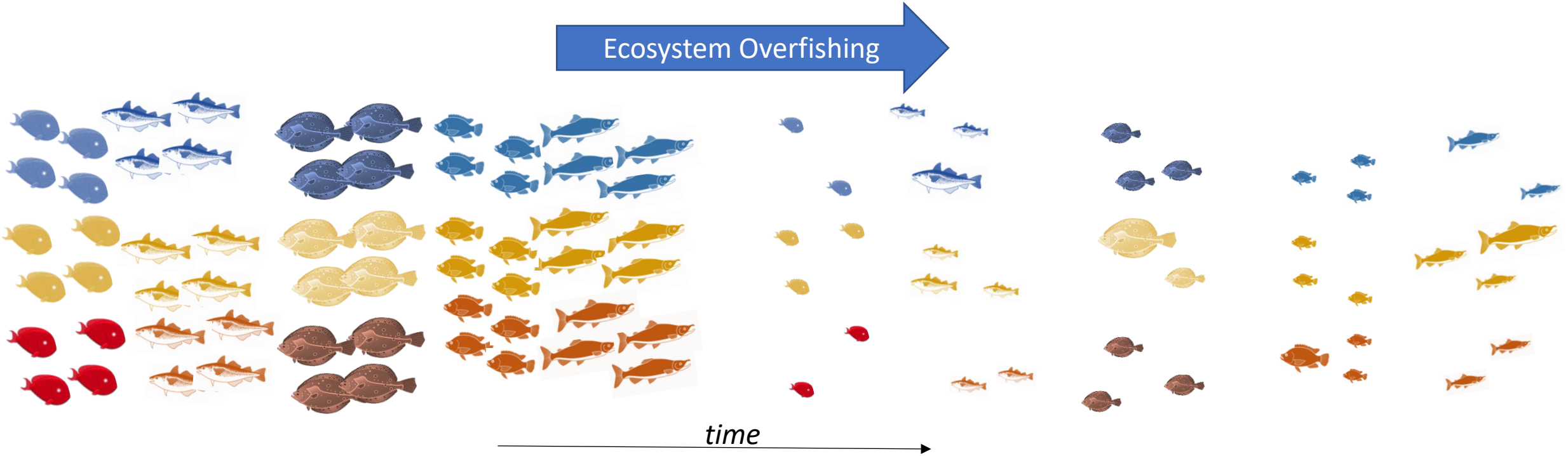
A



C↓, E↑, CPUE ↓, repeat…

(Graham's Law of Overfishing)

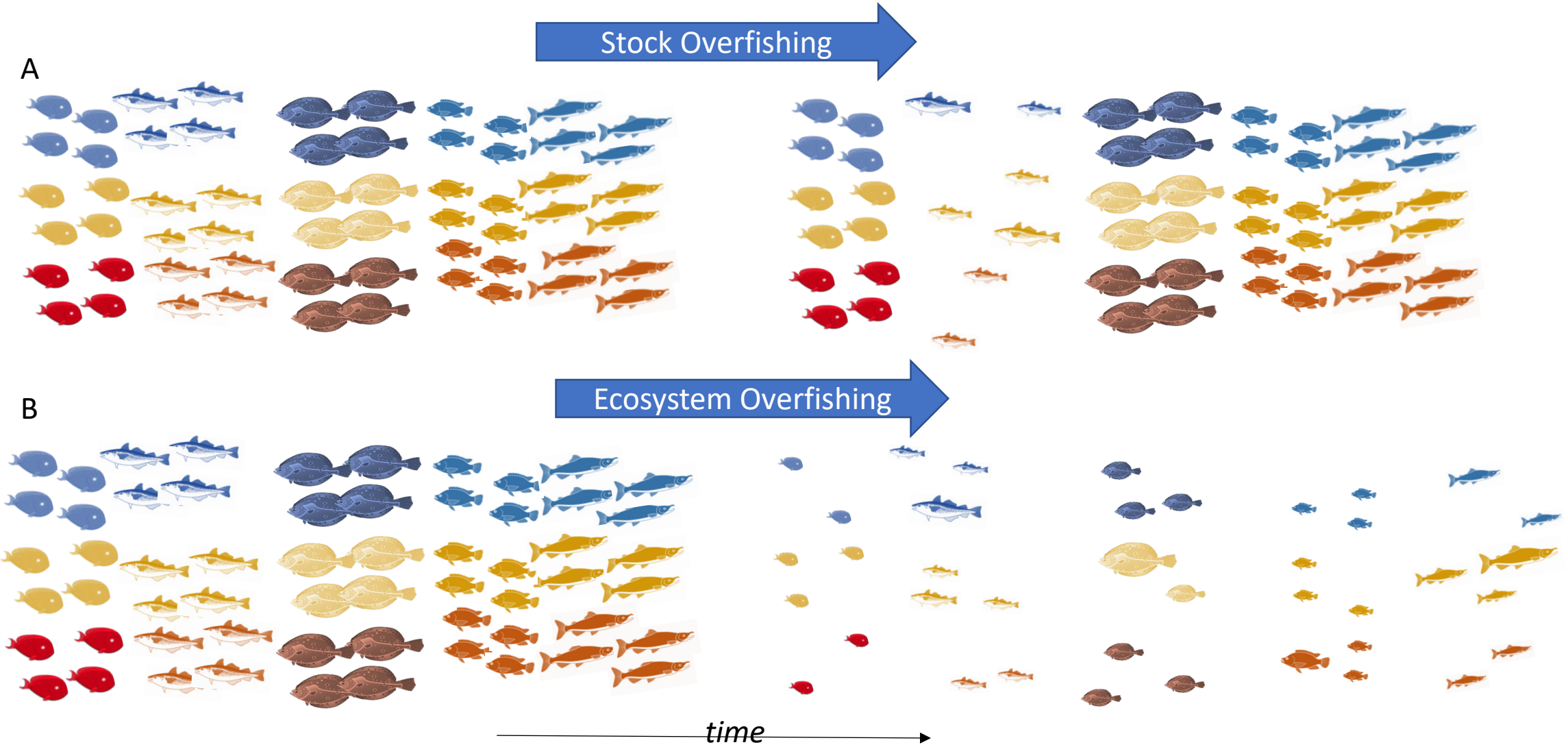
$$F_{\rightarrow max} \xrightarrow{yields} \downarrow \begin{cases} N, B, Y, B/B_{MSY} \\ r, size_{mat}, age_{mat}, \\ wt_a, len, g \end{cases} , \uparrow \begin{cases} E \\ Area_{fished} \\ F/F_{MSY} \end{cases}$$



$C_1\downarrow$, $E_1\uparrow$, … $CPUE_1\rightarrow min$; → $E_2\uparrow$, $C_2\uparrow$, $CPUE_2\uparrow$, $C_2\downarrow$, $E_2\downarrow$, … $CPUE_2\rightarrow min$; →
(Law of Sequential Depletion)

$$F_{system\ \rightarrow max} \xrightarrow{yields} \downarrow \begin{cases} \sum N, \sum B, \sum Y, B_{apex} \\ \bar{l}, cumB_{infl}, cumP \\ L_{index}, TST, A, R, TL_{\mu} \end{cases} , \uparrow \begin{cases} E, \beta \\ Area_{fished} \\ F_{system}\ / F_{System\ MSY} \end{cases}$$

Bringing it Back to Management



The global index of fishing intensity (FI)

- Combines 3 main indicators to assess status of fisheries ecosystem
- Is designed for relatively data ltd situations around the world
- Unclear how much more FAO is going to push it

Input indicators

input intensity (I^a) is the amount of fishing effort (*F*; kilowatt-days per year) expended per area of ecosystem (*A*; square kilometre) *i* during year *t*:

- $I_{it}^{a} = F_{it}/A_i$

Where total catches (*C*) to total net primary productivity (*P*) (Fogarty ratio), then the output intensity (I^b) of ecosystem *i* at year *t*:

- $I_{it}^{b} = C_{it}/P_i$

Changes in the mean trophic level (*L*) of fish species caught relative to mean trophic level in 1970 is a proxy indicator of fishing impacts (I^c) on ecosystem *i* at year *t* in this paper

- $I_{it}^{c} = 1 - L_{it}/L_{i1970}$

Combining them…

weighted geometric means are used for I^a and I^b and weighted arithmetic means for I^c, as shown bellow:

- $SI_t^j = \prod_{i=1}^{n} {I_{it}^j}^{W_i} = \exp\left(\frac{\sum_{i=1}^{n} W_i ln\left(I_{it}^j\right)}{\sum_{i=1}^{n} W_i}\right)$ for *j=a* and *j=b*

and

- $SI_t^j = \frac{\sum_{i=1}^{n} W_i I_{it}^j}{\sum_{i=1}^{n} W_i}$ for *j=c*

where

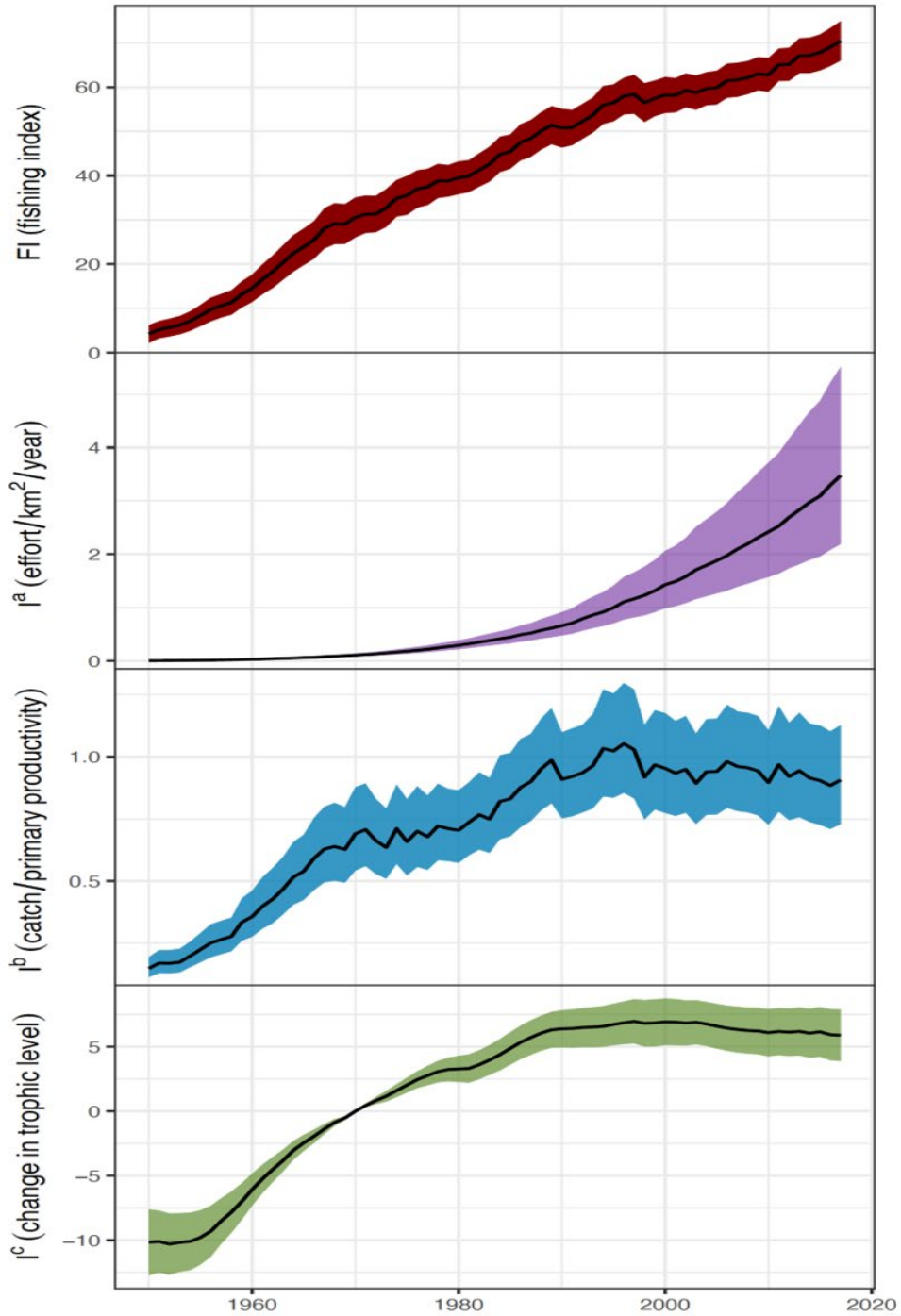
- $W_i = \frac{\bar{C}_i}{\sum_i \bar{C}_i}$

and where $\bar{C}_i$ is the annual average of fish landings over the study period, indicating the size of fisheries in ecosystem *i*.

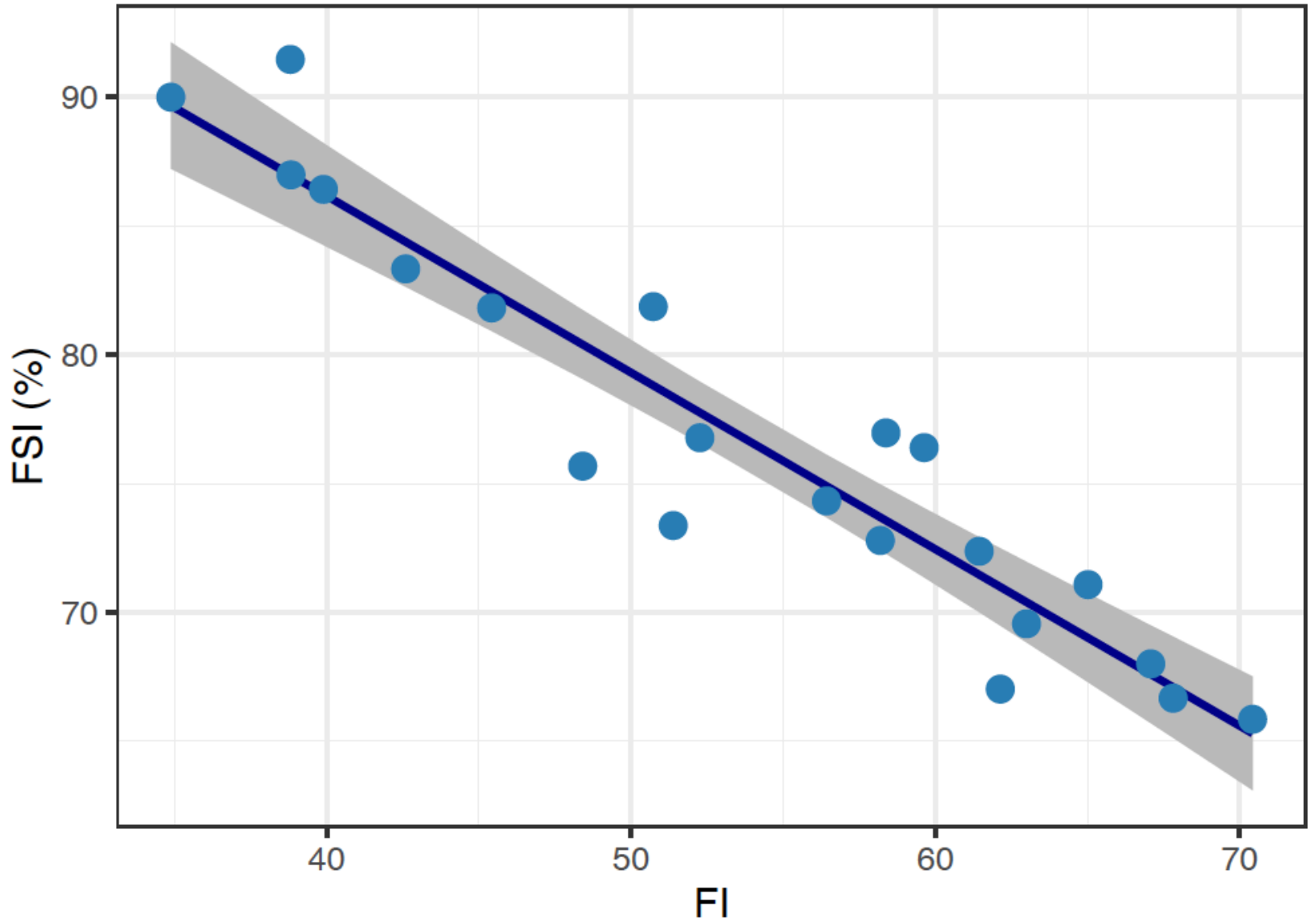
Results in FI

After normalization, we derived a composite fishing index (*FI*) using their geometric mean

- $FI_t = \left(\prod_{j=a}^{c} SI_t^j\right)^{1/3}$



Ye and Link 2023 *Sci Rep*


90
80
70
FSI (%)
40
50
60
70
FI

Management implications

- This serves as a Potential Indicator of EOF
- Can be used as an ELRP
- Provides broader context

Management Applications

- Global consideration, Ye & Link 2023
- These can be calculated, and are available, for major LME-level zones as well. Doable, but maybe less robust, at smaller, regional scales
- This is compared to the fisheries sustainability index (FSI), which shows that this is a good match that captures the dynamics of all the stocks in a region.

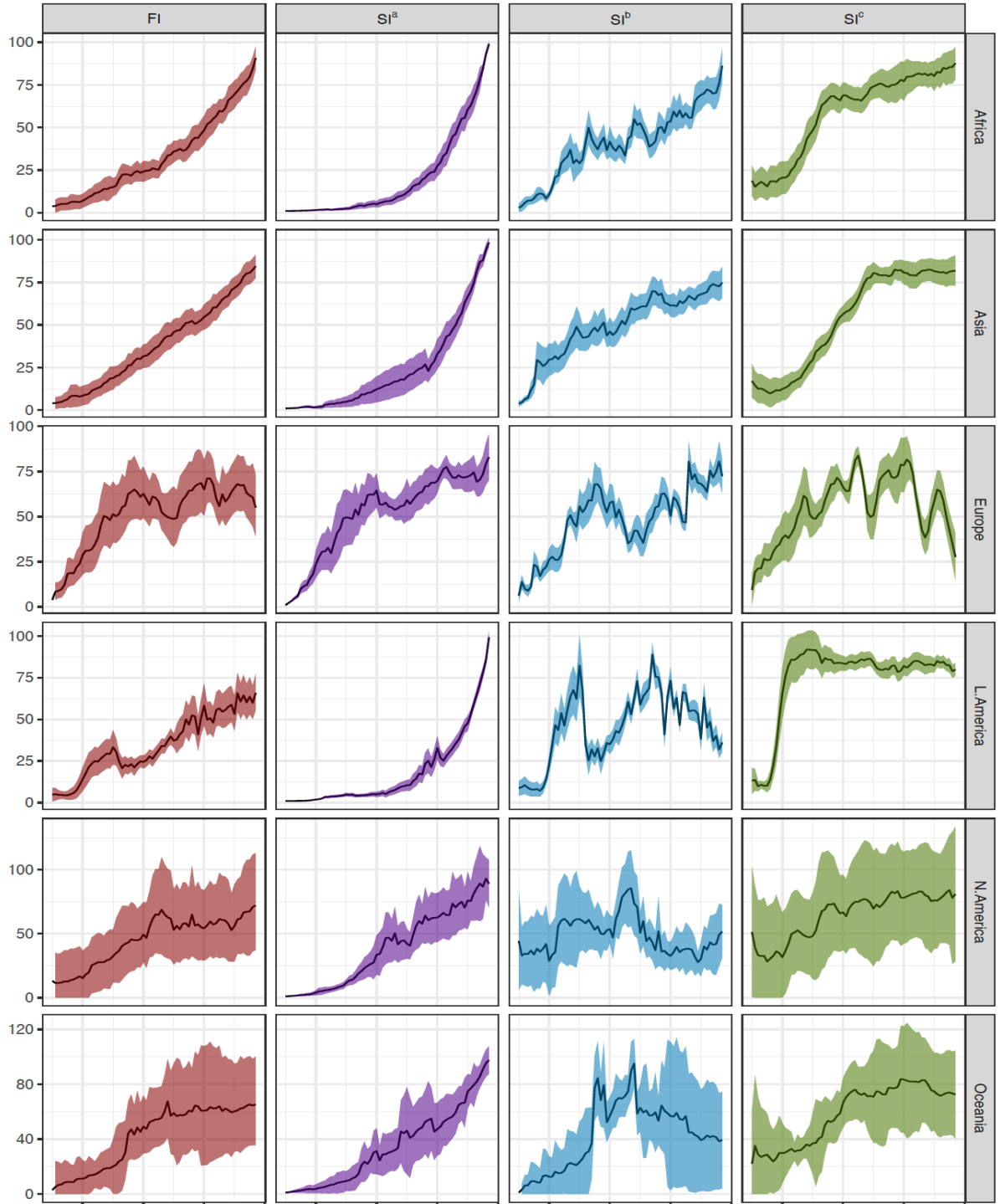
Responses specific to SEDAR 103 and CFMC

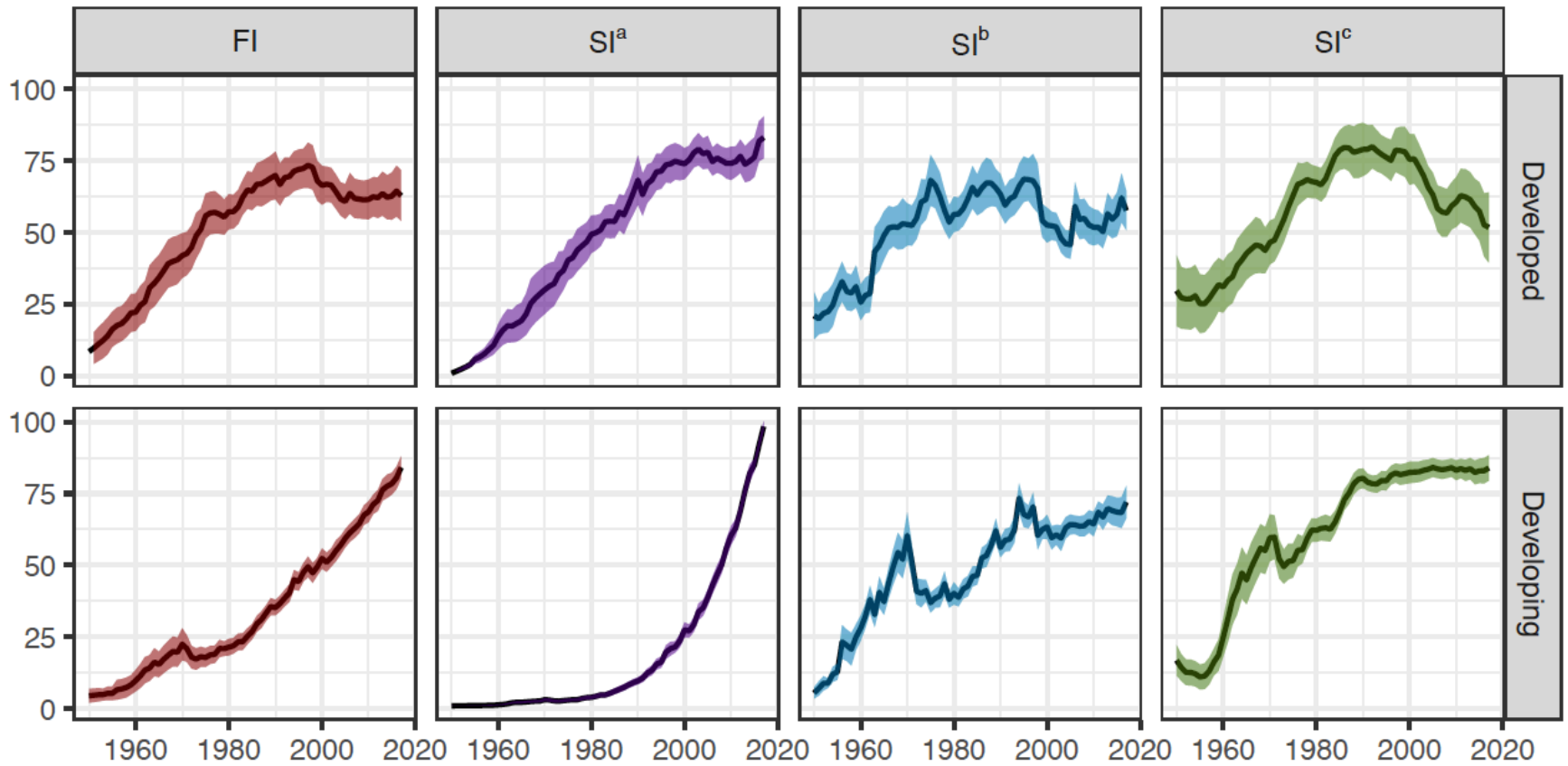
- Are the required data currently available for some number of Caribbean species based on the data reviews provided in the Data Webinars? Probably not
- What species or species groups can the method currently be performed on? All
- Does the time step (e.g., day, week, year) required for the method align with currently available data? Typically annual, but can be flexible
- Can the method inform management now? Yes, but indirectly

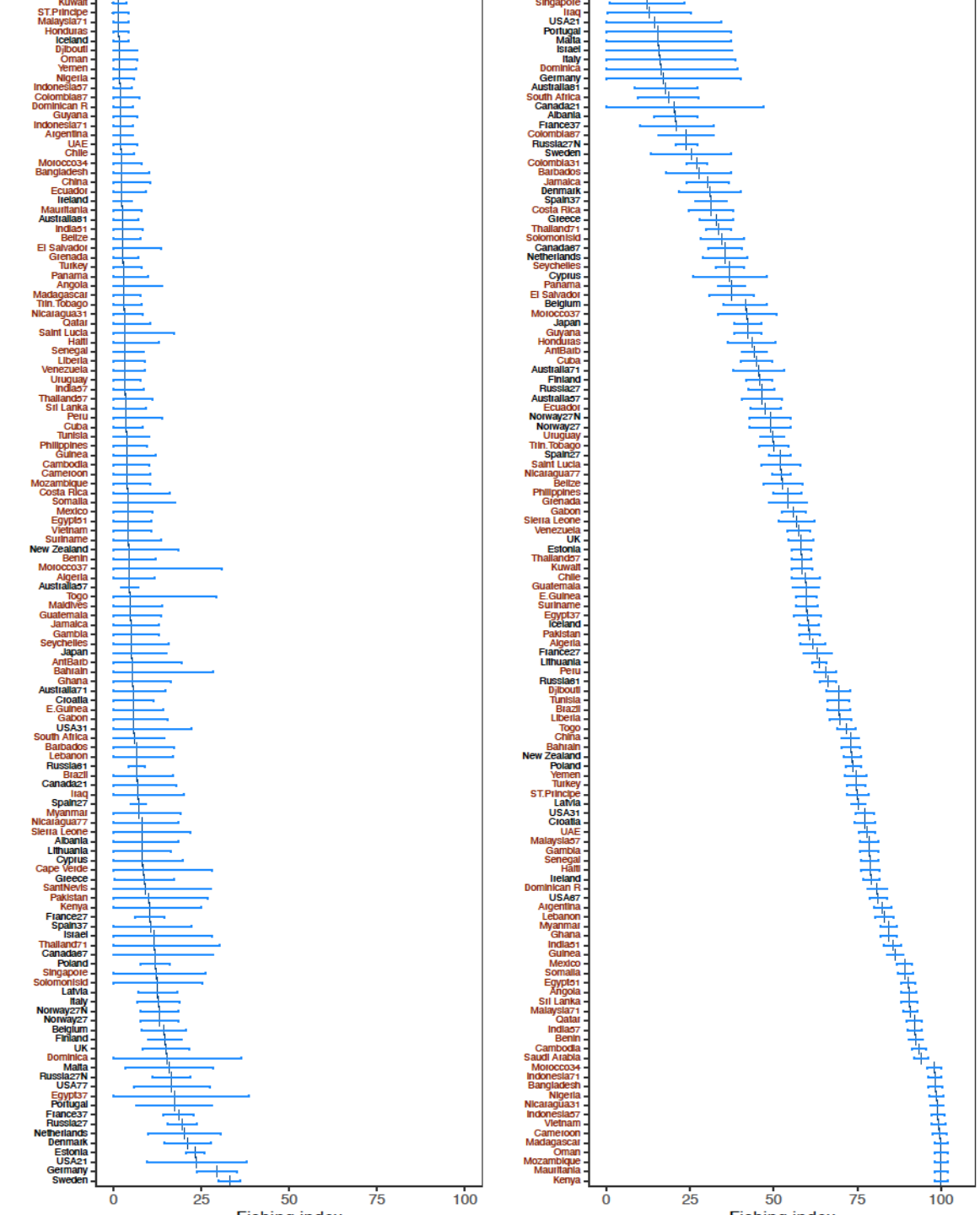
Recommended Approach to use all this information and address major considerations

1. Evaluate Ecosystem Caps for each Island
   - Use 1-2 main methods, complement with an ensemble for reality check
2. Estimate ACLs for guilds/aggregate groups
   - Use 1-2 main methods of modeling
3. Estimate ACLS/etc. for top 3-4 individual taxa
   - Use appropriate data ltd Stock Assessment methods
   - Use appropriate prioritization protocols
4. Evaluate economic performance
   - Some form of efficiency frontier
5. Translate to clear mgt decisions
   - Likely to focus on effort (input) controls

Extra Slides


FI
SI[a]
SI[b]
SI[c]
Africa
Asia
Europe
L.America
N.America
Oceania
100
75
50
25
0
120
80
40


FI
SI[a]
SI[b]
SI[c]
Developed
Developing
100
75
50
25
0
1960
1980
2000
2020


Kuwait
ST.Principe
Malaysia71
Honduras
Iceland
Djibouti
Oman
Yemen
Nigeria
Indonesia57
Colombia87
Dominican R
Guyana
Indonesia71
Argentina
UAE
Chile
Morocco34
Bangladesh
China
Ecuador
Ireland
Mauritania
Australia81
India51
Belize
El Salvador
Grenada
Turkey
Panama
Angola
Madagascar
Trin.Tobago
Nicaragua31
Qatar
Saint Lucia
Haiti
Senegal
Liberia
Venezuela
Uruguay
India57
Thailand57
Sri Lanka
Peru
Cuba
Tunisia
Philippines
Guinea
Cambodia
Cameroon
Mozambique
Costa Rica
Somalia
Mexico
Egypt51
Vietnam
Suriname
New Zealand
Benin
Morocco37
Algeria
Australia57
Togo
Maldives
Guatemala
Jamaica
Gambia
Seychelles
Japan
AntBarb
Bahrain
Ghana
Australia71
Croatia
E.Guinea
Gabon
USA31
South Africa
Barbados
Lebanon
Russia81
Brazil
Canada21
Iraq
Spain27
Myanmar
Nicaragua77
Sierra Leone
Albania
Lithuania
Cyprus
Cape Verde
Greece
SantNevis
Pakistan
Kenya
France27
Spain37
Israel
Thailand71
Canada87
Poland
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Solomonisld
Latvia
Italy
Norway27N
Norway27
Belgium
Finland
UK
Dominica
Malta
Russia27N
USA77
Egypt37
Portugal
France37
Russia27
Netherlands
Denmark
Estonia
USA21
Germany
Sweden
0
25
50
75
100
Fishing index
Singapore
Iraq
USA21
Portugal
Malta
Israel
Italy
Dominica
Germany
Australia81
South Africa
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Albania
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Nigeria
Nicaragua31
Indonesia57
Vietnam
Cameroon
Madagascar
Oman
Mozambique
Mauritania
Kenya
0
25
50
75
100
Fishing index