Brief Communication

Species prioritization for marine fish stock assessments in India

A. Gopalakrishnan,*Shoba Joe Kizhakudan, J. Jayasankar, U. Ganga, M. Muktha, Eldho Varghese, Geetha Sasikumar, Gyanranjan Dash, Rajan kumar, C. Anulekhmi, Santosh Bhendekar and Sandhya Sukumaran
ICAR- Central Marine Fisheries Research Institute, Kochi - 682 018, Kerala

*E-mail: shoba.joe@icar.gov.in

Stock assessments of fish stocks are critical for framing effective management measures of fishery resources to ensure sustainability. While species-wise national assessments have been done in the past, India has not had a prioritized list of species/resources to be assessed regularly to provide an index of the health of the country's fishery resources. In a first of its kind for the country, a marine fish stock status (MFSS) report was published recently (CMFRI, 2023). The MFSS report indicated the sustainability status of 70 important species, encompassing 135 stocks (region-based management units) spread across 5 different coastal regions of India, viz., north-east (NE), north-west (NW), south-east (SE), south-west (SW) and Lakshadweep islands, under the prevalent fisheries management regime of the country. The assessments of the 49 finfish and 21 shellfish species were carried out using globally accepted methodologies and sustainability indicators. The study indicated that 91% of the stocks evaluated were healthy and optimally exploited, whereas the remaining 9% were found to be overfished. The report also highlighted concerns on select species and actions needed to sustain the marine fisheries sector.

The wide acceptance of MFSS 2022 among researchers, policy-makers and stakeholders across the country emphasized the need for regular stock status assessments of a greater number of resources. Increasingly, marine fishing nations of the world are moving towards regular stock assessments' reporting and India also needs to move in the same direction. However, the tropical marine fisheries of India are supported by ~1000 species of finfish and shellfish, in varying levels of contribution, all of which cannot be assessed regularly. Given the vast diversity of marine fish species in the Indian EEZ, prioritizing the species/resource groups for assessment is a complex and strategic task. Recognising this challenge, it is imperative that the country has a priority list of marine fish species for potential management interventions, allowing more effective use of scientific and financial resources. In this context, prioritising the list of species solely based on commercial importance in terms of the quantity landed and unit price of the resources (Varghese *et al*, 2021) may not be adequate. A transparent and objective framework for this prioritization process utilises six key criteria (Table 1), with each species potentially meeting multiple criteria.

Marine fish landings data from across the coastal states of the country over the past 7 decades, and inputs from researchers at ICAR-CMFRI could identify 196 species/groups for regular stock assessments (Table 2). Each of the 196 prioritized species/resources satisfies one or more of these criteria. Of the 196 species/resources thus identified, 155 are finfishes and 41 are shellfishes. Among finfishes, 143 are teleosts while 12 are elasmobranchs. Among shellfishes, 29 are crustaceans and

Table 1. Criteria employed for prioritizing species for stock assessment

1	Data availability	DA	Part of regular fishery monitoring by ICAR-CMFRI
2	Commercial importance	CI	Significant volume of the species is recorded in the total marine fish landings and holds market demand/value
3	Conservation Significance	CS	Protected under law or assessed to be of conservation concern
4	Cultural Significance	CuS	Holds regional/local association with livelihood/culture/diet/ cuisine
5	Ecological importance	EI	Forage fish/plays an important role in the trophic network
6	Life-history traits	LH	Diversity of LH traits among species that determines the vulnerability or resilience of a species/group to fishing pressure

Table 2. List of prioritized species for stock assessment based on various criteria

S No.	Species/group	BoB-NE	BoB-SE	AS-NW	AS-SW	AS-L'dweep	Criterion for prioritization
1	*Ablennes hians*		■	■	■		DA, CI
2	*Acetes* spp.			■	■		DA, EI
3	*Acropoma* spp.			■			DA, EI
4	*Aetobatus* spp.		■				DA, CS. EI. LH
5	*Alepes* spp.				■		DA, CI
6	*Aluterus monoceros*		■		■		DA
7	*Ambassis* spp.				■		DA, EI
8	*Amblygaster clupeoides(Sardinella clupeoides)*		■				DA
9	*Amblygaster sirm (Sardinella sirm)*		■				DA
10	*Amphioctopus neglectus*				■		DA
11	*Anodontostoma chacunda*	■			■		DA
12	*Ariomma (Psenes) indicum(Psenes indicus)*		■				DA, EI, CI
13	*Aristeus alcocki*				■		DA, EI
14	*Arothron (Tetradon)* spp.		■				DA
15	*Auxis rochei*		■		■		DA, CI
16	*Auxis thazard*	■	■	■	■		DA, CI
17	*Bregmaceros mcclellandi*			■			DA, EI
18	*Brevitrygon imbricata*			■			DA, EI, LH
19	*Carangoides* spp.				■		DA, CI
20	*Caranx heberi (C. sem)*		■				DA, CI
21	*Caranx ignobilis*		■				DA, CI
22	*Caranx sexfasciatus*		■				DA, CI
23	*Caranx* spp.		■	■	■		DA, CI
24	*Carcharhinus* spp.	■	■		■		CS, EI, LH
25	*Charybdis feriatus (C. feriata/cruciata)*	■	■	■	■		DA, CI
26	*Charybdis natator*		■				DA, CI
27	*Charybdis* spp.			■			DA, EI
28	*Chirocentrus dorab*		■	■			DA, CI
29	*Chirocentrus* spp.		■	■			DA, CI
30	*Cistopus indicus*			■	■		DA, CI
31	*Coilia dussumieri*	■		■			DA, CI, EI
32	*Coryphaena hippurus*		■	■	■		DA, CI
33	*Cynoglossus macrolepidotus (C. arel)*	■	■				DA, CI
34	*Cynoglossus macrostomus*				■		DA, CI
35	*Cynoglossus* spp.		■	■	■		DA, CI
36	*Dasyatis* spp.		■				DA, CS. EI. LH
37	*Decapterus russelli (D. dayi)*		■		■		DA, EI
38	*Decapterus* spp.		■	■	■		DA, EI
39	*Dussumieria acuta*		■		■		DA

S No.	Species/group	BoB-NE	BoB-SE	AS-NW	AS-SW	AS-L'dweep	Criterion for prioritization
40	*Epinephelus diacanthus*			■	■		DA, CI, LH
41	*Epinephelus* spp.	■	■		■		CS
42	*Escualosa (Kowala) thoracata (K. coval)*	■	■		■		DA, CI
43	*Euthynnus affinis*	■	■	■	■		DA
44	*Exhippolysmata ensirostris*			■			DA, EI
45	*Gazza minuta*		■				DA, CI, EI
46	*Gerres* spp.		■				CI
47	*Grammoplites suppositus*				■		DA
48	Guitarfishes	■	■	■	■		CS, EI, LH
49	*Harpadon nehereus*	■		■			DA, CI, EI
50	*Heterocarpus chani*				■		DA, EI
51	*Heterocarpus woodmasonii*				■		DA, EI
52	*Hilsa kelee*		■				DA
53	*Himantura* spp.		■				DA, CS. EI. LH
54	*Ilisha elongata*		■				DA, CI
55	*Ilisha megaloptera*	■		■			DA
56	*Istiompax indica (Makaira indica)*			■	■		DA, CI, LH
57	*Istiophorus platypterus*			■	■	■	DA, CI, LH
58	*Johnius carutta*	■	■				DA, CI
59	*Johnius* spp.	■	■	■	■		DA, CI
60	*Karalla dussumieri (Leiognathus dussumieri)*		■				DA, CI, EI
61	*Kathala axillaris*		■				DA, CI
62	*Katsuwonus pelamis*		■	■	■	■	DA, CI
63	*Lactarius lactarius*		■	■	■		DA
64	*Lagocephalus inermis*				■		DA
65	*Leiognathus* spp.		■				DA, CI, EI
66	*Lepturacanthus savala*	■					DA, CI
67	*Lethrinus* spp.		■				DA, CI, EI
68	*Lutjanus spp*	■	■		■		CI, CS
69	*Makaira nigricans*			■	■		DA, CI, LH
70	*Megalaspis cordyla*	■	■	■	■		DA, CI
71	*Mene maculata*		■		■		DA, EI
72	*Metapenaeopsis andamanensis*				■		DA, CI
73	*Metapenaeopsis* spp.		■				DA, CI
74	*Metapenaeus affinis*		■	■			DA, CI
75	*Metapenaeus brevicornis*		■	■			DA, CI
76	*Metapenaeus dobsoni*		■		■		DA, CI
77	*Metapenaeus monoceros*		■	■	■		DA, CI
78	Mobulids	■	■	■	■		CS, EI, LH
79	*Mugil cephalus*	■	■				DA, CI

S No.	Species/group	BoB-NE	BoB-SE	AS-NW	AS-SW	AS-L'dweep	Criterion for prioritization
80	*Muraenesox bagio*			■	■		DA, CI
81	*Muraenesox* spp.	■	■				DA, CI
82	*Nematopalaemon tenuipes*			■			DA, EI
83	*Nemipterus bipunctatus (N. delagoae)*		■				DA, CI
84	*Nemipterus japonicus*		■	■	■		DA, CI
85	*Nemipterus randalli*		■	■	■		DA, CI
86	*Neotrygon* spp.		■				DA, CS. EI. LH
87	*Nibea maculata*		■				DA, CI
88	*Octopus* spp.		■				DA, CI
89	*Odonus niger*				■		EI
90	*Opisthopterus tardoore*	■	■		■		DA
91	Other bull's eye				■		DA, CI
92	Other Carangids		■				DA, CI
93	Other catfishes	■	■	■	■		CS, CI, LH
94	Other Clupeoids		■				DA
95	Other croakers	■	■	■	■		DA, CI
96	Other eels	■	■	■	■		DA, CI
97	Other flatheads				■		DA
98	Other goatfishes		■		■		DA
99	Other lizardfishes	■	■		■		DA, CI
100	Other rays	■	■	■	■		DA, CI, CS. EI. LH
101	Other ribbonfishes		■	■	■		DA, CI
102	Other sharks	■	■				CI, CS, CuS, EI, LH
103	Other Silverbellies		■				DA, CI, EI
104	Other snappers				■		DA, CI, CS
105	Other threadfin breams		■	■	■		DA, CI
106	*Otolithes cuvieri*			■	■		DA, CI
107	*Otolithes ruber*	■	■	■	■		DA, CI
108	*Otolithoides biauritus*			■			DA, CI, CS, LH
109	*Pampus candidus (P. argenteus)*			■	■		DA, CI, CS
110	*Pampus chinensis*	■	■				DA, CI
111	*Pampus griseus (argenteus)*	■	■				DA, CI
112	*Panulirus polyphagus*			■			DA, CI, CS, LH
113	*Parapenaeopsis hardwickii*	■					DA, CI
114	*Parapenaeopsis sculptilis*			■			DA, CI
115	*Parapenaeopsis stylifera*	■	■	■	■		DA, CI
116	*Parastromateus (Formio) niger(F. niger)*		■	■	■		DA, CI
117	*Pellona ditchela*		■	■	■		DA
118	*Penaeus indicus*	■	■		■		DA, CI
119	*Penaeus japonicus*		■				DA, CI

S No.	Species/group	BoB-NE	BoB-SE	AS-NW	AS-SW	AS-L'dweep	Criterion for prioritization
120	*Penaeus merguiensis*			■			DA, CI
121	*Penaeus monodon*	■	■	■			DA, CI
122	*Penaeus semisulcatus*		■	■			DA, CI
123	*Photopectoralis bindus (Leiognathus bindus)*		■				DA, CI, EI
124	Pig-face breams		■	■	■		DA, CI, CS
125	*Platycephalus indicus*		■		■		DA
126	*Plectorhinchus (Gaterin)* spp.		■				DA, CI
127	*Plicofollis dussumieri (A. dussumieri)*	■					DA, CI, CS
128	*Plicofollis layardi*	■		■	■		CS, CI, LH
129	*Polynemus* spp.	■	■	■			CI, CS, LH
130	*Pomadasys kaakan (P. hasta)*	■	■				DA, CI
131	*Pomadasys* spp.		■				DA, CI
132	*Portunus pelagicus*	■	■		■		DA, CI
133	*Portunus sanguinolentus*	■	■	■	■		DA, CI
134	*Priacanthus hamrur*			■	■		DA, CI
135	*Protonibea diacanthus*			■			DA, CI, CS, LH
136	*Psammoperca waigiensis*		■				DA
137	*Psettodes erumei*		■				DA, CI
138	*Rachycentron canadum*		■	■	■		DA, CI
139	*Rastrelliger kanagurta*	■	■	■	■		DA, CI
140	*Rhizoprionodon oligolinx*			■			DA, CS. EI. LH
141	*Sarda orientalis*				■		DA, CI
142	*Sardinella albella*		■				DA, CI
143	*Sardinella fimbriata*	■			■		DA, CI
144	*Sardinella gibbosa*		■		■		DA, CI
145	*Sardinella longiceps*	■	■		■		DA, CI
146	*Sardinella* spp.		■	■			DA, EI
147	*Saurida tumbil*		■	■	■		DA, CI
148	*Saurida undosquamis*		■	■	■		DA, CI
149	*Scarus (Callyodon)* spp.		■				DA
150	*Scoliodon laticaudus*	■	■	■	■		DA, CS, EI, LH
151	*Scolopsis* spp.		■				DA
152	*Scomberoides commersonnianus*	■					DA, CI
153	*Scomberoides* spp.		■	■	■		DA, CI
154	*Scomberomorus commerson*	■	■	■	■		DA, CI
155	*Scomberomorus guttatus*	■	■	■	■		DA, CI
156	*Secutor insidiator*	■	■				DA, CI, EI
157	*Selar crumenophthalmus*	■	■		■		DA, CI
158	*Selaroides leptolepis*		■				DA
159	*Sepia aculeata*	■	■				EI

S No.	Species/group	BoB-NE	BoB-SE	AS-NW	AS-SW	AS-L'dweep	Criterion for prioritization
160	*Sepia elliptica*			■	■		DA, CI
161	*Sepia pharaonis*	■	■	■	■		DA, CI
162	*Sepiella inermis*	■	■	■	■		DA, CI
163	*Sepioteuthis lessoniana*		■				DA
164	Sicklefishes, scats & spadefishes		■				DA, EI
165	*Siganus canaliculatus (S. oramin)*		■				DA, CI, EI
166	*Siganus* spp.		■				DA, CI, EI
167	*Sillago sihama*		■				CI, EI
168	*Sillago* spp.	■	■				CI, EI
169	Silverbellies				■		DA, CI, EI
170	*Solenocera crassicornis*	■	■	■			DA, CI
171	*Sphyraena barracuda*		■		■		DA, CI
172	*Sphyraena jello*		■	■			DA, CI
173	*Sphyraena obtusata*			■			DA
174	*Sphyraena* spp.		■	■	■		DA
175	*Stolephorus commersonnii*		■		■		DA, CI
176	*Stolephorus indicus*		■				DA, CI
177	*Stolephorus* spp.		■		■		DA, CI
178	Stomatopods		■	■	■		DA, EI
179	*Strongylura* spp.		■				DA, CI
180	*Tenualosa ilisha (Hilsa ilisha)*	■		■			DA, CI
181	*Terapon jarbua*	■	■				DA
182	*Terapon* spp.		■				DA
183	*Thenus unimaculatus*			■	■		DA, CI, CS, LH
184	*Thryssa mystax*	■					DA
185	*Thryssa* spp.		■	■	■		DA, EI
186	*Thunnus albacares*		■	■	■	■	DA, CI, LH
187	*Thunnus tonggol*			■	■		DA, CI
188	*Trichiurus lepturus*	■	■	■	■		DA, CI
189	*Turbinella(Xancus) pyrum(X. pyrum)*		■				CS
190	*Upeneus moluccensis*			■			DA
191	*Upeneus sulphureus*		■				DA
192	*Upeneus taeniopterus*		■				DA
193	*Uroteuthis(Photololigo) duvaucelii*	■	■	■	■		DA, CI
194	*Uroteuthis(Photololigo) edulis*		■		■		CI
195	*Uroteuthis(Photololigo) singhalensis*				■		CI
196	*Xiphias gladius*		■	■	■		DA, CI, LH
		N=59	N=139	N=88	N=103	N=3	

Data availability- DA; Commercial importance- CI; Conservation significance- CS; Cultural significance – CuS; Ecological importance- EI; Life-history traits–LH

12 are molluscs. Assessments will be done for 198 stocks in the western Bay of Bengal along the east coast of India (139 on the SE coast, and 59 on the NE coast) for 194 stocks in the eastern Arabian Sea along the west coast of India (103 on the SW coast, 88 on the NW coast, and 3 in Lakshadweep waters).

With species prioritization based on six criteria, and many of the species satisfying two or more criteria, reflected predominantly by a combination of factors 1, 2 and 6 as indicated in Table 1, it is very likely that sufficient information will be available to decide whether a species qualifies for regular stock status assessment. Based on the granularity and taxa-level specificity of the data available spatial and/or ecosystem-centric assessment of bona fide final units can be devised. As is evident from the MFSS 2022 exercise, LH-based data can be an efficient tool to define the various critical values of established models utilizing abundance and rates of removal of fish from the designated final unit. These critical values could range from deciding the initial values of sub- and super- parametric computations envisaged in dynamic modelling routines to evolve a framework that could be a sequential or simultaneous compartmentalization of even multi-final unit assessment. In a nutshell, mutually compatible and maximally informative amalgamation of catch-effort and biology-based, species-wise data would be subjected to the planned assessment routines.

Typical of tropical marine fisheries, India also has a highly dynamic marine fisheries sector. There is a complex interweaving of multiple craft-gear combinations landing multiple species (either targeted or by-catch), from multiple locales and involving diverse fishermen communities, each with its own distinctive fishing traditions and cultural norms. Hence uniform management regimes for these fisheries are not easy to develop or implement and require high level of stakeholders' engagement, research and governance support besides a strong policy framework. Stock status assessments provide the primary, scientific and robust inputs to support such management frameworks. The process of stock status assessments is itself quite complex, requiring large data sets and appropriate models to perform the assessments based on the quality and quantum of data available. NOAA Fisheries reports the use of a variety of models which fit into one of six general categories based upon their data availability–Data-limited, Index-based, Aggregate biomass dynamics, Virtual population dynamics, Statistical catch-at-length, and Statistical catch-at-age (NOAA, 2023). While the MFSS 2022 report projected the results of assessments done using length-based virtual population analysis (VPA) for finfishes and a combination of VPA and spawning potential ratio (SPR) for shellfishes, future assessments will include a combination of suitable methods.

Scientific management of fishery resources is of paramount importance for ensuring the sustainability of the fishery and perpetuating the biological resources. Stock assessment is the preliminary step for devising science-based management plans, and identifying stock structure or stock boundaries is a precursor to stock assessment. Different stocks or subpopulations may possess differential characteristics concerning genetic, physiological and behavioural traits and for a population under intense fishing pressure, management measures like catch limit, seasonal restrictions on fishery and gear types can be devised based on this information. Stock assessment and management based on information regarding stock structure is important to preserve intra-specific diversity, thus ensuring resilience to environmental perturbations like climate change. Stock structure or subpopulation structure can be delineated using advanced genetic and genomic tools. Extensive research has been undertaken by ICAR-CMFRI to identify the genetic stock structure of 24 marine species of commercial and conservation importance. Significant heterogeneity has been detected between India's east and west coasts, indicating the role of oceanographic and environmental barriers limiting migration and larval dispersal. It is imperative to generate genetic stock structure information regarding all the assessed stocks for accurate management of fishery resources.

Ultimately, the aim of fish stock assessments is to facilitate sustainable fisheries and ensure that the livelihoods of the stakeholders are secure. Under the Sustainable Development Goals (SDG -14, Life Under Water) of the United Nations with FAO as the custodian, Target 14.4.1 aims at "implementing science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce Maximum Sustainable Yield (MSY) as determined by their biological characteristics" (FAO, 2020). Hence execution of this massive exercise on marine capture fisheries is expected to yield long-term benefits for the country as it marches forward towards a *Viksit Bharat* goal.

References

CMFRI, 2023. Marine Fish Stock Status in India 2022. CMFRI Booklet Series No 32/2023 (Reprint 2023), ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India, 26p.

FAO. 2020. Factsheets on the 21 SDG indicators under FAO custodianship. A highlight of the main indicators with the greatest gaps in country reporting. Rome. https://doi.org/10.4060/ca8958en

NOAA. 2023. Fish Stock Assessment Report. National Oceanic and Atmospheric Administration, US Department of Commerce.

https://www.fisheries.noaa.gov/national/population-assessments/fish-stock-assessment-report

Varghese, E. *et al.*, 2021. *Mar. Fish. Infor. Serv., T & E Ser.*, 250: 7 - 17