Convention on the Conservation of Migratory Species of Wild Animals

CMS

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Reports of the Taxonomic Sub-Groups: Fish

Introduction

Migration

Migration is a key component to the life-history of a great many fish species (Secor 2015; Lucas and Baras 2008; Morais and Daverat 2016). It is difficult to estimate what proportion of fish species migrate but it is likely to be substantial (ca 50%). UN Convention on the Law of the Sea Annex 1 highlights important marine migratory species including tuna and their allies, pomfret, marlin (9 species), marlin, sailfish, swordfish and ocean-going sharks (multiple species). Other important commercial migratory species include salmonids and eels. Fish migrate in the oceans, lakes and rivers and often times between these habitats (Alo et al 2020). In this way, migration is responsible for connecting habitats as well as the movement of nutrients between them and therefore plays an important role in ecosystem function. Fish migrations tend to be predictable in time and space and as such human populations exploit them. The fact that migrants occupy multiple locations at different times also makes them more vulnerable to anthropogenic impacts (Lennox et al 2019). Overfishing or habitat disturbance at breeding grounds, for instance, might have a catastrophic impact on species resilience. In many instances, migrations are instigated dependent on specific environmental cues such as light, temperature or water flow which may be disrupted by human activities. Building dams, for example, not only physically block fish passage in rivers, but also alter flow and temperature regimes. Although we have a growing knowledge of fish migrations there is still much we don't know and this plays a critical role in our capacity to protect migrating fish species.

Migration in fishes is often a collective movement of individuals and it is clear that a proper understanding of fish migration necessarily involves insight into collective behaviour, social interactions, social learning and culture (Dodson 1988, Petitgas et al 2006, Secor 2015, Brown 2022). One apparent outcome of this realisation is that migration patterns may rapidly change and may or may not be linked to shifts in the environment. Thus, migration is likely subject to complexity owing to the interplay between inherited, learned and cultural sources of information (Laland et al 2011). There is growing awareness that migration patterns of many species may be maintained via cultural processes and this has profound implications for fisheries and conservation management (see Brown 2023 for a review and references therein).

Threats

Migrating fish are under threat from a number of processes, not least of which is competition for their habitat with humans. Water is a key resource for humans and our populations are almost universally centred on rivers, lakes, embayments or coastal areas. Humans use water for industry, farming, drinking, transport, energy production and so on, all of which have direct consequences for migrating fishes. On top of that, human waste also ends up in the aquatic environment, be it chemicals, plastic or pharmaceuticals. We rely heavily on fishes for food and overfishing is recognised as a key threatening process. Barriers to migration such as dams and weirs have long been recognised as threats to migrating fishes. Climate change and associated processes (ocean acidification, warming waters, deoxygenation, shifts in rainfall) all pose existential threats to fishes. Moreover, it is expected that animals will shift their distributions in response to climate change, but the capacity to respond varies tremendously between species, thereby setting up mismatches in aquatic ecology. There is already evidence that climate change has changed the distribution of cartilaginous and teleost fishes (Hammerschlag et al 2022; Sanford et al 2019). Less obvious threats include artificial light and noise pollution both of which are gaining increased attention. Only about one third of all known fishes have been assessed by the IUCN Red List but 25% of assessed freshwater species are at risk of extinction.

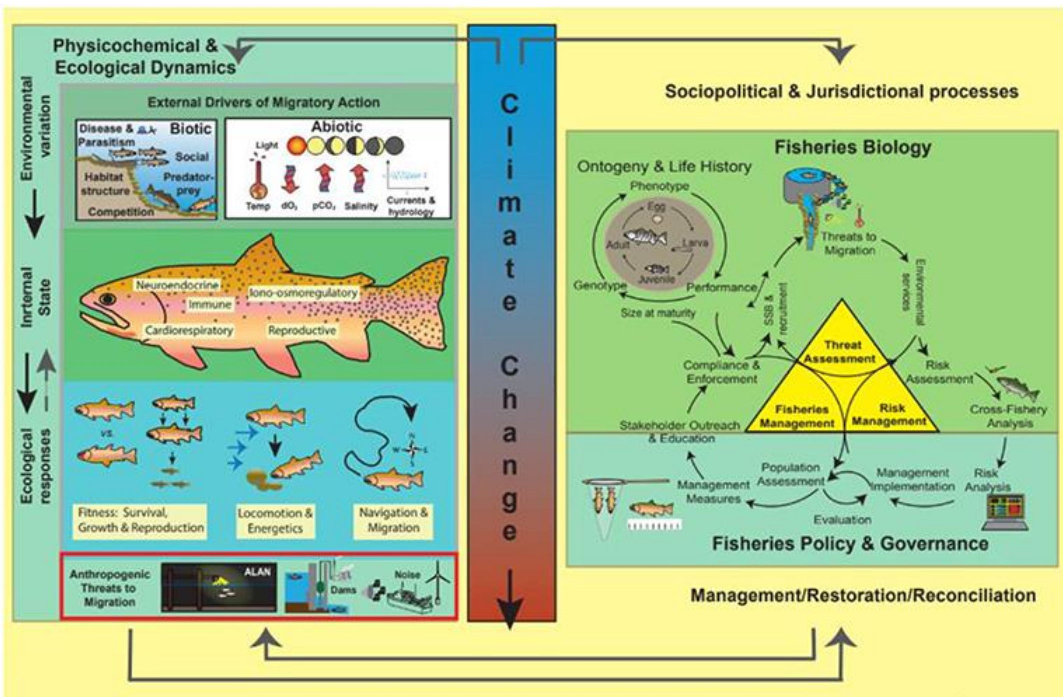

Fig. 1 From Lennox et al 2019: understanding and management of fish migration

Sharks, rays and freshwater fishes are widely recognised as been exceptionally prone to extinction. The IUCN red list suggests that 37% of all sharks and rays that have been assessed (1226 species) are vulnerable to extinction. The primary threat is overfishing but shark control programs also threaten many species (Dulvey et al 2014).

Social learning and culture

We know a lot about social learning and culture in fishes (including elasmobranchs). There are multiple reviews on the topic (Brown and Laland 2003, 2006, 2011, Brown 2023). We know that social learning plays important roles in movement/migration, mate choice, foraging, anti-predator behaviour and so on. All key fitness traits.

We should bear in mind that these data are generally from a limited number of species perhaps half a dozen sharks and rays and 20 or so teleost fish. It may be possible to generalize by stating that social learning is probably universally important to all fishes and some of their behaviour is likely cultural – particularly migration (Warner 1988; Brown 2023). The reality is there are more species of fish than all other vertebrates combined and we know next to nothing about most of them.

It is likely that many commercially important species, salmonids, tunas, clupeids (herrings, sardines etc) also have strong cultural components to their movements, and migrations (Ferno et al 2011) and that fishing operations has resulted in the loss of cultural information in these populations where largest/oldest fish are removed by the fishery (Wilson & Giske 2023). There have been suggestions that the collapse of some of these fisheries, particularly in the North Sea is partially due to cultural collapse of migratory pathways between spawning, feeding and overwintering grounds (see MacCall et al 2019, Chambers 2021, Ferno et al 2011, Brown 2023 and refs therein). Moreover, if a stock collapses and the ratio of juvenile to experienced individuals becomes too high, the social transmission chain can be interrupted and cultural information lost from the system. Simulations show how overexploitation can push populations towards tipping points, precipitating collapse. Subsequent recovery is dependent on stochastic events that reintroduce groups of adults, likely contributing to the slow recovery of cod and herring populations despite years of protection (Rogers et al 2018).

Social learning protocols have also been increasingly used to prepare hatchery fishes for life in the wild, both for fisheries enhancement and conservation biology (so called life-skills training; Brown and Laland 2001; Brown and Day 2002). So there are practical outcomes of recognising social learning and culture in fishes in the context of conservation and fisheries management.

Limitations

Appendix 1 and 2 lists very few fish species and the first observation here is that this is a gross underestimate of the threatened migratory fish (tuna, eels, cyprinids, clupeids and salmoniids are obvious examples of missing taxa) far more work needs to be done adding species to this list. It may be that there are impediments to placing commercially important species on the list. Having said that, most of the species listed in the appendices we simply know nothing about. Social learning has never been studied in any of the sharks and rays listed. Our work on the social behaviour of reef manta rays suggests that cleaning stations may act as places of information exchange (information hubs - where are the good food patches) but that is just an educated guess (Perryman et al 2019; 2021). Similarly whale shark social behaviour seems to be reasonably sophisticated but there have been very few formal studies of their social interactions. They do show up in aggregations from time to time but it is not clear why (Rowat 2007). Most speculate that they are drawn towards food patches the location of which is dependent on currents and water temperature, rather than for social reasons. Examination of the social behaviour of multiple species of sharks using network analysis have repeatedly revealed sophisticated social behaviour, including preferred companions (Jacoby et al 2012; Pini-Fitzsimmons et al2022). Interestingly, though, white sharks seem to be more solitary and analysis of their social interactions off the coast of South Africa suggests they were not different from random (Findlay et al 2016) whereas a later study at a seal colony in Australia found non-random associations (Schlids et al 2019). Although white sharks do migrate under certain conditions, nothing is known about the role of social learning in this species. Similarly oceanic whitetip sharks are considered solitary apex predators but they do form aggregations which are dominated by mature females in the Bahamas each year from April to June. These are likely breeding aggregations, but very little is known about their social lives (Gallagher et al 2014). We are gradually increasingly our knowledge about the social behaviour, migration and intelligence of sharks and rays but much remains unknown (Speed et al 2010, Jacoby et al 2012, Brown & Schluessel 2022).

As for the listed fishes in the appendices, 19 species of sturgeon are listed; no one has ever studied social learning in sturgeon that we are aware of. However, there is some suggestion that sturgeon migration might have cultural elements to it given that there appear to be multiple sub-groups that vary in their migratory behaviour and they seem to have preferred social partners (Kessel et al 2017, Lilly et al 2020). Further, there has also been attempts to use conspecific alarm cues to teach hatchery-reared lake sturgeon to recognise predators with some success (life-skills training: Sloychuk et al 2016). Scientists are gradually piecing together the migration route of the European eel which looks to be a mixed migration strategy. Some eels depart Europe in Autumn, converge on the Azores and arrive in the Sargasso Sea in time for that spawning season in mid-February, whereas other are more leisurely and arrive for the following spawning season (Righton et al 2016). It is currently believed that the silver eels rely on olfactory cues imprinted on or learned during the leptocephalus phase. There is no suggestion that there is a cultural component to eel migrations. One early paper examining agonistic interaction in European eels suggested that individuals can learn their position in hierarchies perhaps based on body size of opponents (Knights 1987) which might indicate that the social behaviour of eels is complex. Knights (1996) conducted foraging studies and suggests that social facilitation might be important for young eels to try novel foods by enhancing readiness to feed. Lastly, the giant Mekong catfish is one of the largest fish in the world and migrates from resident habitat (possibly deep holes) to spawning areas within the Mekong River but very little is known about its movements or reproduction (Hogan 2004).

Recommendations and Priorities

It is probably reasonable to assume that most species of teleosts and elasmobranchs have reasonably complex social lives and can learn via social learning. Many fishes also migrate at various points of their life-history, and evidence suggests that migration can be influenced or shaped by cultural knowledge. There is speculation that anthropogenic impacts such as overfishing causes population crashes not just because too many animals are removed from the population, but because fishing targets older, wiser individuals who are likely the guardians of cultural knowledge.

There are clearly conflicts of interest involved in protecting migratory fish species because they are highly valued commodity. This likely explains why so few are listed in the Appendices. Moreover, even for the species that are listed, we have very little direct knowledge about the social mechanisms driving movement and migration. There is a clear knowledge gap in this context that urgently needs to be addressed.

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Full taxonomic list of bird species listed in CMS Appendix I & II:

Appendix I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS)

Appendix I
An asterisk (*) placed against the name of a species indicates that the species, or a separate population of that species, or a higher taxon which includes that species is included in Appendix II.

Pisces

Elasmobranchii
ORECTOLOBIFORMES
Rhincodontidae
Rhincodon typus* (Whale shark)
LAMNIFORMES
Lamnidae
Carcharodon carcharias * (White shark)
Cetorhinidae
Cetorhinus maximus * (Basking shark)
CARCHARHINIFORMES
Carcharhinidae
Carcharhinus longimanus (Oceanic whitetip shark)
SQUATINIFORMES
Squatinidae
Squatina squatina* (Angel shark)
RHINOPRISTIFORMES
Rhinobatidae
Rhinobatos rhinobatos *(Mediterranean population) (Guitarfish)
Pristidae
Anoxypristis cuspidata * (Narrow sawfish)
Pristis clavata * (Dwarf sawfish)
Pristis pectinata * (Smalltooth sawfish)
Pristis zijsron * (Longcomb sawfish)
Pristis pristis* (Narrowtooth sawfish)
MYLIOBATIFORMES
Mobulidae
Manta alfredi * (Reef manta)
Manta birostris* (Oceanic manta)
Mobula mobular* (Devil ray)
Mobula japanica* (Spinetail devil ray)
Mobula thurstoni * (Smoothtail devil ray)
Mobula tarapacana * (Chiliean devil ray)
Mobula eregoodootenkee * (Pygmy devil ray)
Mobula kuhlii * (Shortfin devil ray)
Mobula hypostoma * (Lesser devil ray)
Mobula rochebrunei * (Guinean devil ray)
Mobula munkiana* (Munk’s devil ray)

Actinopterygii
ACIPENSERIFORMES
Acipenseridae
Acipenser sturio * (Atlantic sturgeon)
SILURIFORMES
Schilbeidae
Pangasianodon gigas (Mekong giant catfish)

Appendix II
An asterisk (*) placed against the name of a species or higher taxon indicates that the species, or a separate population of that species, or one or more species includedin that higher taxon is included in Appendix I.

Pisces

Elasmobranchii

ORECTOLOBIFORMES
- Rhincodontidae
  - Rhincodon typus* (Whale shark)

LAMNIFORMES
- Lamnidae
  - Carcharodon carcharias * (White shark)
  - Isurus oxyrinchus (Shortfin mako shark)
  - Isurus paucus (Longfin mako shark)
  - Lamna nasus (Porbeagle shark)
- Cetorhinidae
  - Cetorhinus maximus * (Basking shark)
- Alopiidae
  - Alopias pelagicus (Pelagic thresher shark)
  - Alopias superciliosus (Bigeye thresher shark)
  - Alopias vulpinus (Common thresher)

CARCHARHINIFORMES
- Triakidae
  - Galeorhinus galeus (School shark)
- Carcharhinidae
  - Carcharhinus falciformis (Eastern school shark)
  - Carcharhinus obscurus (Dusky shark)
  - Prionace glauca (Blue shark)
- Sphyrnidae
  - Sphyrna lewini (Scalloped hammerhead shark)
  - Sphyrna mokarran (Great hammerhead shark)
  - Sphyrna zygaena (Smooth hammerhead shark)

SQUALIFORMES
- Squalidae
  - Squalus acanthias (Northern Hemisphere populations)(Spiny dogfish)

SQUATINIFORMES
- Squatinidae
  - Squatina squatina* (Angel shark)

RHINOPRISTIFORMES
- Rhinobatidae
  - Rhinobatos rhinobatos* (Guitarfish)
- Rhinidae
  - Rhynchobatus australiae (White-spotted guitarfish)
- Pristidae
  - Anoxypristis cuspidata * (Narrow sawfish)
  - Pristis clavata * (Dwarf sawfish)
  - Pristis pectinata * (Smalltooth sawfish)
  - Pristis zijsron * (Longcomb sawfish)
  - Pristis pristis* (Narrowtooth sawfish)

MYLIOBATIFORMES
Mobulidae
Manta alfredi * (Reef manta)
Manta birostris* (Oceanic manta)
Mobula mobular* (Devil ray)
Mobula japanica* (Spinetail devil ray)
Mobula thurstoni * (Smoothtail devil ray)
Mobula tarapacana * (Chiliean devil ray)
Mobula eregoodootenkee * (Pygmy devil ray)
Mobula kuhlii * (Shortfin devil ray)
Mobula hypostoma * (Lesser devil ray)
Mobula rochebrunei * (Guinean devil ray)
Mobula munkiana* (Munk’s devil ray)
Actinopterygii
ACIPENSERIFORMES
Acipenseridae
Huso huso (Beluga sturgeon)
Huso dauricus (River Beluga)
Acipenser baerii baicalensis (Siberian sturgeon)
Acipenser fulvescens (Lake sturgeon)
Acipenser gueldenstaedtii (Russian sturgeon)
Acipenser medirostris (Green sturgeon)
Acipenser mikadoi (Sakhalin sturgeon)
Acipenser naccarii (Adriatic sturgeon)
Acipenser nudiventris (Ship sturgeon)
Acipenser persicus (Persian sturgeon)
Acipenser ruthenus (Danube population) (Sterlet)
Acipenser schrenckii (Japanese sturgeon)
Acipenser sinensis (Chinese sturgeon)
Acipenser stellatus (Starry sturgeon)
Acipenser sturio *(Atlantic sturgeon)
Pseudoscaphirhynchus kaufmanni (False shovelnose sturgeon)
Pseudoscaphirhynchus hermanni (Little shovelnose sturgeon
Pseudoscaphirhynchus fedtschenkoi (Syr Darya sturgeon)
Psephurus gladius (Chinese paddlefish)
ANGUILLIFORMES
Anguillidae
Anguilla Anguilla (European eel)

Highly Migratory Species

(As listed in Annex 1 of the United Nations Convention on the Law of the Sea (UNCLOS)[1])

1. Albacore tuna: *Thunnus alalunga*.
2. Bluefin tuna: *Thunnus thynnus*.
3. Bigeye tuna: *Thunnus obesus*.
4. Skipjack tuna: *Katsuwonus pelamis*.
5. Yellowfin tuna: *Thunnus albacares.*
6. Blackfin tuna: *Thunnus atlanticus*.
7. Little tuna: *Euthynnus alletteratus*; *Euthynnus affinis*.
8. Southern bluefin tuna: *Thunnus maccoyii*.
9. Frigate mackerel: *Auxis thazard*; *Auxis rochei*.
10. Pomfrets: Family *Bramidae*.
11. Marlins: *Tetrapturus angustirostris*; *Tetrapturus belone*; *Tetrapturus pfluegeri*; *Tetrapturus albidus*; *Tetrapturus audax*; *Tetrapturus georgei*; *Makaira mazara*; *Makaira indica*; *Makaira nigricans*.
12. Sail-fishes: *Istiophorus platypterus*; *Istiophorus albicans*.
13. Swordfish: *Xiphias gladius*.
14. Sauries: *Scomberesox saurus*; *Cololabis saira*; *Cololabis adocetus*; *Scomberesox saurus scombroides*.
15. Oceanic sharks: *Hexanchus griseus*; *Cetorhinus maximus*; Family *Alopiidae*; *Rhincodon typus*; Family *Carcharhinidae*; Family *Sphyrnidae*; Family *Isurida*.

[1] https://www.un.org/depts/los/convention_agreements/texts/unclos/annex1.htm