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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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SCOPING POLICY ANALYSIS FOR AQUATIC GENETIC RESOURCES

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I. INTRODUCTION

The purpose of this scoping policy analysis is to help countries analyze their legal and policy frameworks, and the main drivers of change that policies will need to address with respect to aquatic genetic resources (AqGR). Following an identification of drivers, the analysis provides an overview of the current state of international and national legal and policy frameworks and gaps in those frameworks. Additionally, current approaches to setting policy and frameworks are presented. The scoping policy analysis addresses AqGR in both capture fisheries and aquaculture. The analysis will assist Members develop policy and practices that promote responsible use of AqGR for food and agriculture and will help in the preparation of country reports for the SoWAqGR.

Because AqGR for food and agriculture occur in wild and agro-ecosystems (capture fisheries and aquaculture), the legal and policy framework for AqGR development and management is extremely complex. Therefore, the drivers impacting AqGR are numerous and varied. The scope of 'management' is broad, encompassing both conservation and sustainable use. Aquatic genetic resources need not be the main objective of a policy international instrument in order for the instrument to impact AqGR. Because the vast majority of AqGR still occur in nature, drivers and policies that impact the world's marine, coastal and inland waters will also impact AqGR. The fact that many of these instruments do not address AqGR specifically is a fundamental gap in the policy framework.

II. DRIVERS OF CHANGE IN AQUATIC GENETIC RESOURCES

Six main drivers have been identified that will influence future policies regarding food production (Foresight 2011) and therefore AqGR for food and agriculture:

- Global population increase to 9 billion people by 2050 and increased need for food;
- Increased consumer wealth and GDP with greater demand for fish and fish products;
- The ability to achieve good governance of food production and conservation where public, private and civil society act collectively and holistically in managing resources and production processes;
- Climate change and effectiveness of adaptation and mitigation strategies;
- Competition for resources where demand for global energy and for fresh water could double between now and 2050;
- Changes in values and ethics of consumers that influence food and lifestyle choice, and policy options on issues such as environmental sustainability, animal welfare, fair trade, equity, and biotechnologies.

There are drivers that will impact AqGR both positively and negatively. For the last decade, concern has centered on the following drivers that have adversely impacted or have the potential to adversely impact AqGR:

- Fishing
- Aquaculture;
- Habitat alteration and loss (including hydroelectric development and pollution);
- Introduced species, and
- Climate change.

However, there are positive drivers that will assist in using AqGR for sustainable food production:

- Increased understanding of genetics both at the molecular and population levels;
- Improved conservation strategies for both in situ and ex situ conservation;
- Better fishing and farming technologies that minimize discards and wastes and reduce carbon footprints;
- Improved information technologies and data storage capacity.

The above drivers may have more than one impact, e.g. use of introduced species may have a positive impact in one environment and a negative impact in another. Policy development will need to address both potentialities.

For this analysis, five major factors impacting AqGR are singled out for more detailed examination: fishing, aquaculture, habitat degradation, climate change and introduced species. The drivers are related; pollution and hydro-electric development can be considered as components of habitat degradation; aquaculture is the main reason for the deliberate introduction of non-native species; and introduced species when invasive can degrade habitats.

Fishing

Fish are the only major food source still harvested from wild populations and it is generally agreed that for marine fisheries there is an excess of fishing capacity, i.e. too many boats trying to catch too few fish. The point at which fishing becomes uneconomical is usually above the level required for survival of a species. Therefore the effect on AqGR is mostly at the population level. These relationships are quantitatively captured in the concepts of maximum economic yield (MEY) and maximum sustainable yield (MSY); MEY is usually a harvest level below MSY.

Traditional concepts of fisheries management reflect the view that single species can be managed in isolation from their relation to other species within their ecosystem. If, however, fisheries management policies are to consider not just single species models but entire assemblages of species and their trophic interactions, policy makers will have to consider the following important characteristics of ecosystems (adapted from Murawski 2000):

- Technical interactions between species (bycatch)
- Biological interactions between species (e.g. predation; density dependence; trophic interactions)
- Climate effects
- Geographic range of species and density patterns
- Time scale (seasonal, annual and decadal cycles).

These concepts form a partial basis for an ecosystem approach to fisheries (see below).

Aquaculture and culture-based fisheries

The farming of aquatic organisms can have some general environmental effects on wild AqGR, including spread of pathogens and parasites, pollution of near-site areas, and the reduction of wild populations by fisheries to supply fish meal for carnivorous cultured species.

The direct impact of aquaculture on wild AqGR is through deliberate release of hatchery fish for culture-based fisheries and through inadvertent escapes of farmed fish from aquaculture facilities. In both cases, the genetic character of the hatchery or farmed fish is usually different from the wild stock. When fish that originated in farms breed with wild relatives there is the potential for the natural gene pool to be ‘contaminated’, i.e. diluted and made less fit. It has been shown that when farmed and wild fish interact, it is usually to the detriment of the wild populations (Hindar et al. 1991). Stock enhancement programmes however can produce fish very similar to wild relatives in order to breed successfully with natural populations or for species recovery programmes (see below).

Although direct impacts as above are important, recent appreciation of aquatic ecosystem dynamics indicates that farmed fish have significant indirect genetic effects on wild relatives and other species through predation, competition or introduction of exotic diseases and parasites that weakens or reduces natural populations. Small populations would then be more susceptible to inbreeding depression and environmental perturbations.

Whereas aquaculture strives to farm domesticated strains, there is still a significant amount of seed, i.e. larvae or juveniles, and broodstock, i.e. adults used for production of seed, collected from the wild. When seed or broodstock are collected from the wild rather than produced in a hatchery, there is also potential for local depletion of AqGR.

The technologies used for fish breeding (including hatchery practices and gene banking) have well-known application in conservation biology. A captive breeding program can assist in the recovery of a threatened species or population. Conservation hatcheries, whose goals and methods emphasize genetic compatibility with wild stocks over selective breeding for commercial characters or sheer numbers of fish produced, reflect recent changes in attitudes regarding hatcheries. Such programs aim to increase genetic diversity of wild stocks by increasing their population size while minimizing change to their genetic makeup.

Habitat alteration and loss

Habitat alteration and loss is a large category and can arise from *inter alia* pollution, hydro-electric development, and introduced species. Habitat alteration affects AqGR through a variety of modalities including fragmentation (which can interfere with reproduction or migration, or isolate segments of a population); changing vital attributes such as water temperature, flow, turbidity and chemistry; eliminating structures, refuge and nesting areas; or even re-connecting areas that have long been isolated. Wetlands are drained, and mangrove forests removed, with attendant loss of AqGR. Forestry has a major impact on watershed integrity because it removes ground cover, increases siltation, raises stream temperature and flow rates, and may add chemical pollutants (herbicides). As rivers run to the sea, those impacts on inland AqGR may also find their way to marine and coastal AqGR.

Water development projects, primarily the construction of dams is one of the principle causes of aquatic habitat degradation and loss of AqGR. Dams provide an often impassable barrier to fish migrations as well as change to quantity and quality of water available for fish. Although fish passes have been developed, they are often ineffective at allowing all species to pass at all times of year. Additionally, the creation of reservoirs changes the species composition of the fish community from a river assemblage to a lake assemblage.

Contamination of fresh and marine waters by a range of industrial, municipal, agricultural and pharmaceutical pollutants is widespread and is a form of habitat degradation. While some countries have made progress in reducing water pollution from domestic and industrial sources, threats from excessive nutrient enrichment and other chemicals such as endocrine-disrupters are growing (Dudgeon et al. 2006).

Introduced species

Introduction of non-native species for aquaculture, fisheries, biological control or other reasons can impact AqGR directly, through predation, spread of disease and competition for resources (e.g. mates, food, breeding areas, or habitat). They can directly change the genetic character and fitness of native populations by interbreeding. When introduced species interbreed with local populations it usually reduces fitness of the local population. However, when native populations have been reduced to such a small size that it is unlikely that con-specifics with find and mate effectively, introduced organisms of the same or related species can help rebuild the population to a point where it may be more viable. FAO maintains a Database on Introductions of Aquatic Species (DIAS) that contains information on inter alia international instruments and policies, and reasons for and impacts of international introductions.[1]

How these and other drivers will need to be addressed by national and international policies and legislative frameworks is presented in the following chapters.

[1] DIAS http://www.fao.org/fishery/dias/en

Climate change

Globally, average surface temperature is estimated to increase significantly; regional effects will vary widely (IPCC 2007). Whatever the finer-scale effects in different regions, it is clear that climate change will have many impacts on aquatic systems, including increased water temperature, changes in stream flow, changes in lake size and thermal layering, ocean acidification, a rise in sea levels and consequent loss of estuarine habitat, and a great increase in "extreme events" such as floods and droughts (Sala et al. 2000). Any of these consequences alone will change the distribution and abundance of aquatic life; in combination, their effects on fisheries may be drastic.

Climate change affects the timing and degree of the global water cycle, resulting in major alterations in snowmelt and rainfall. Ocean acidification will impact marine life. Whether a given aquatic species can persist in a changed climate depends to a great extent on its inherent plasticity (ability to withstand a broad range of conditions), its ability to adapt to the new conditions or its ability to move to more suitable climates. These survival strategies are genetically encoded, making AqGR the defining aspect of aquatic life when it's confronted by changes in climate. Plastic, adaptable species may survive, but their geographic ranges are likely to change.

III. THE INTERNATIONAL LEGAL AND POLICY FRAMEWORK

Major instruments and mechanisms that have a mandate for AqGR are listed in Table 3.1. However AqGR are often not explicitly cited in the mandates, and addressing AqGR below the species level in these instruments is extremely are.

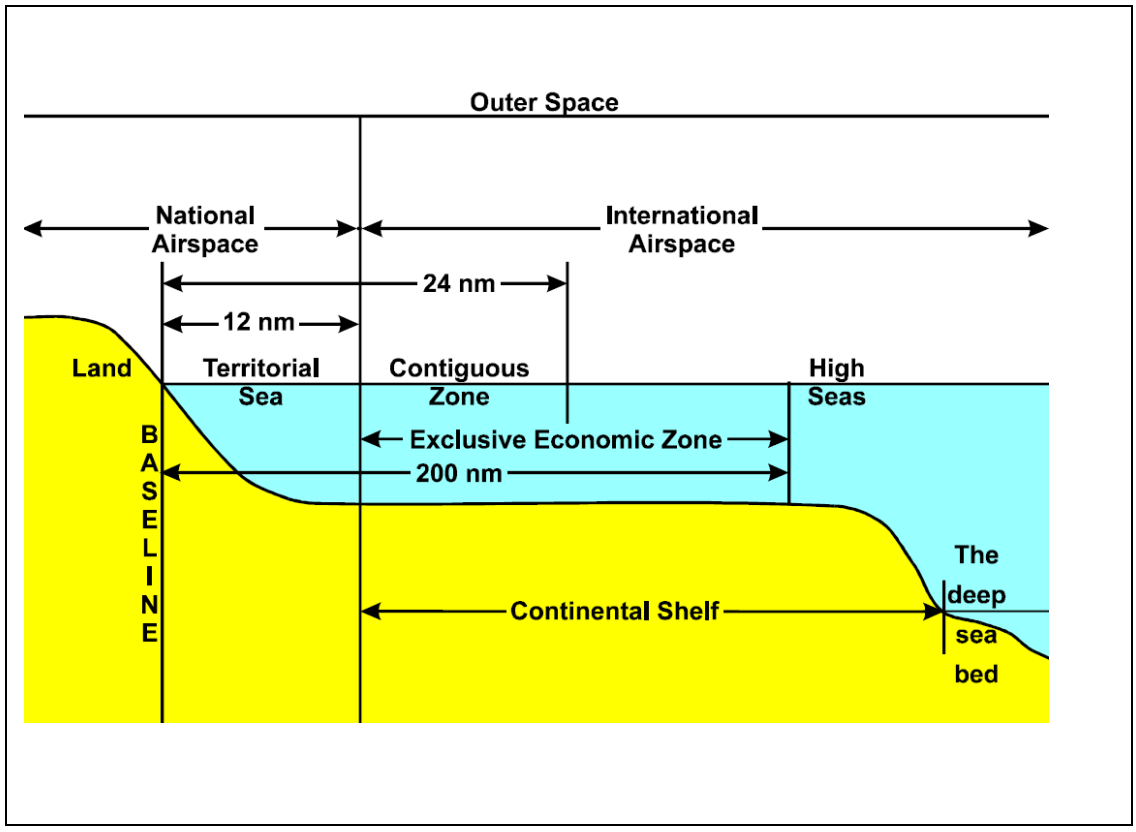
Due to the fact that much AqGR exists in natural water bodies, it is necessary to understand how the world governs water.

As a consequence of a state's sovereignty over its territory as described in the United Nations Convention on the Law of the Sea (UNCLOS), a coastal state has

(a) exclusive access to and full jurisdiction over all resources – both living and non-living – located within its territory; and
(b) full jurisdiction over all activities – both domestic and foreign – occurring within its territory.

Where geographical circumstances allow, states are also entitled to a continental shelf and an exclusive economic zone (EEZ). The EEZ cannot extend further seaward than 200 nm but, in certain circumstances, the continental shelf can (see Figure 3.1 below). Within their EEZs, coastal states have sovereign rights and jurisdiction for certain purposes. The sovereign rights are, among other things, for the purpose of exploring and exploiting, conserving and managing the natural resources that occur in the water column and on the seabed and its subsoil. Moreover, jurisdiction is granted in relation to artificial islands, installations and structures (e.g. for aquaculture), marine scientific research and the protection and preservation of the marine environment (1982 UNCLOS, Art. 56). As regards the continental shelf, coastal states are granted sovereign rights and related jurisdiction for the purpose of exploring it and exploiting its natural resources.

Figure 3.1: Maritime zones



A coastal state's EEZ and continental shelf are not part of the coastal state's territory. Other states have various rights in these maritime zones, including the freedoms of navigation, overflight and the laying of submarine cables and pipelines. The freedoms of fishing and marine scientific research – which exist on the high seas – do not apply to the EEZ and continental shelf. Other states nevertheless have a fishing entitlement in case a coastal state cannot harvest the entire total allowable catch (TAC) and they can also expect to obtain consent to engage in certain types of marine scientific research, provided these do not relate directly to the exploitation of marine living resources (1982 UNCLOS, Arts 58, 62, 87 and 246).

For inland water bodies, there is no single global instrument comparable to UNCLOS. Several international and trans-boundary water bodies have specific treaties and conventions governing the exploitation and conservation of their resources, including AqGR.

General Instruments, Obligations and Principles

The Convention on Biological Diversity (CBD) - Both the 1992 CBD and its 2010 Nagoya Protocol relate to biodiversity and genetic resources in general, rather than focusing on particular sectors (e.g. fisheries and aquaculture), species or issues (e.g. introduction of invasive species). The CBD adopted seven Thematic Programmes and 19 Cross-Cutting Issues, which are integrated into the Thematic Programmes. Two Thematic Programmes – namely 'Inland Waters Biodiversity' and 'Marine and Coastal Biodiversity' are of most relevance to AqGR. The CBD's Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets were endorsed at 'Rio+20', the United Nations Conference on Sustainable Development.[2] The 2000 Cartagena Protocol[3] to CBD seeks to protect

[2] Cf. para. 198 of 'The Future We Want' (UN doc. A/CONF.216/L.1, of 19 June 2012).

[3] Cartagena Protocol on Biosafety to the Convention on Biological Diversity, Montreal, 29 January 2000. In force 11 September 2003; 2226 *United Nations Treaty Series* 208 (257) (2005); <www.biodiv.org>.

biological diversity from the potential risks posed by living modified organisms (LMOs) resulting from modern biotechnology. There are currently no aquatic LMOs available for human consumption, but this could change in the future.

A main objective of the 1992 CBD, is "the fair and equitable sharing of the benefits arising out of the utilization of genetic resources". As a framework convention, the 1992 CBD requires implementation efforts to tailor it to concrete issues and to set priorities. "Use" in this context refers to further development and commercialization and not the simple act of harvesting and selling farmed or wild-caught fish.

United Nations Convention on the Law of the Seas (UNCLOS) - the 1982 UNCLOS, establishes a universally accepted, just and equitable legal order – or 'Constitution' – for the oceans that lessens the risk of international conflict and enhances stability and peace in the international community. It applies to the entire marine environment, all its living and non-living resources and all human activities occurring within it (e.g. marine capture fisheries) as well as those occurring outside but negatively affecting it (e.g. land-based marine pollution). Even though the 1982 UNCLOS does not explicitly mention the terms 'biodiversity' or 'genetic resources', its obligations on the protection and preservation of the marine environment in Part XII are relevant for the management of AqGR.

When UNCLOS was drafted, specific consideration was given to mineral resources in areas beyond national jurisdiction (ABNJ), e.g. the deep seabed. However, the drafters in the early 1980's had no idea that AqGR, and specifically marine genetic resources (MGR), would become a valuable commodity for bio-prospecting. At present, there is no comprehensive and specific mechanism that governs bioprospecting for MGR in ABNJ. Regulation of these activities has been on the agenda of the international community for some years, but no substantive and concrete steps have been taken, especially in terms of developing a regime for sustainable use (FAO 2008). However, the UN General Assembly has invited FAO to contribute within its area of competence to the consideration of conservation and sustainable use of marine biodiversity in ABNJ.[4]

World Trade Organization (WTO) and the World Intellectual Property Organization (WIPO) – deals with international trade law and the international law on patents and intellectual property rights. Relevant instruments are the WTO's 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)[5] and the efforts of the WIPO's Intergovernmental Committee (IGC) on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore, which has been negotiating a global instrument on 'Intellectual property and the protection of genetic resources [their derivatives] and associated traditional knowledge'.[6]

Intellectual property rights have been afforded to some genetically altered aquatic species, e.g. triploid oysters and a transgenic Atlantic salmon. However the transgenic salmon is not available to consumers and the triploid oyster patent was never enforced. High performing strains of fish have been trademarked, such as the Genetically Improved Farmed Tilapia (GIFT) and the AquacAdvantage Salmon. However, when breeders cross trademarked fish with other strains it is often unclear if the

[4] The invitation by the UN General Assembly to FAO to contribute within its area of competence to the consideration of conservation and sustainable use of marine biodiversity in ABNJ is expressed in General Assembly Resolution A/RES/62/215 on Oceans and the Law of the Sea, para. 103 (available at http://www.un.org/Depts/los/general_assembly/general_assembly_resolutions.htm).

[5] Adopted together with the Agreement Establishing the World Trade Organization, Marrakesh, 15 April 1994. In force 1 January 1995, <www.wto.org>.

[6] See the 'Consolidated Document Relating to Intellectual Property and Genetic Resources', of 22 February 2012; available at <www.wipo.int>

trademark still applies. In the case of GIFT, a new designation of 'GIFT Derived Strain' has been applied[7].

International trade is primarily regulated at the species level rather than at the level of AqGR. The World Organization for Animal Health (OIE) is the standard setting body in terms of fish health and disease and can restrict trade of fish based on distribution of parasites and pathogens. Trade in genetically modified plants and animals is restricted in several areas, but currently there are no gm fish available to the consumer.

Instruments on the Conservation of Species and Habitats

Species-specific or habitat-specific instruments often contain obligations that apply across sectors. For example, obligations to conserve coastal habitats such as mangrove forests may constrain aquaculture development, and obligations to conserve sea turtles may require fisheries regulation through gear specifications. Sector-specific measures exist as well, e.g. measures adopted by regional fishery bodies to conserve vulnerable marine ecosystems.

The Convention on International Trade in Endangered Species of Fauna and Flora (CITES) recognizes that the world's diversity of species is valuable and that for endangered species international trade could pose a risk. CITES has three annexes where species may be listed according to their sucseptibility to endangerment from international trade: Annex I, is the most restrictive and for the most endangered species where trade is usually prohibited except under specific condistions; Annex II for species not necessarily now threatened with extinction but may become so unless trade is subject to strict regulation; and Annex III is for species subject to regulation within national jurisdiction for the purpose of preventing or restricting exploitation, and as needing the co-operation of other Parties in the control of trade.

The listing criteria under CITES involves examination of populations and geographic areas to see if they are threatened enough in aggregate to list the entire species. In theory, a population and therefore a genetically distinct stock of aquatic species could be listed. However, recognizing the difficulties in distinguishing populations and stocks, CITES has sought to avoid such listings (known as 'split listings' where components of a species have different status) by adopting the 'look alike' criterion: a look alike species must also be brought under control to ensure protection of the endangered/listed species. Whereas split listing has been done for elephants, i.e. protecting certain populations, its application in aquatic species is scarce. FAO is active in assisting CITES in evaluating and developing listing criteria[8]

The 1971 Ramsar Convention[9] imposes obligations with respect to the conservation and use of designated areas and has established 'Criteria for Identifying Wetlands of International Importance' and 'Guidelines for the application of the Criteria'. The listing of a wetland is justified if "it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity."

[7] Asian Development Bank. 2005. An Impact Analysis of Genetically Improved Farmed Tilapia. http://www.extension.org/mediawiki/files/f/f5/An_Impact_Evaluation_of_the_development_of_Genetically_Imprv.pdf

[8] FAO Expert Advisory Panel for the Assessment of Proposals to Amend Appendices I and II of CITES Concerning Commercially-exploited Aquatic Species, http://www.fao.org/docrep/013/i1899e/i1899e.pdf and ftp://ftp.fao.org/docrep/fao/010/a1143e/a1143e.pdf

[9] Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar, 2 February 1971. In force 21 December 1975, as amended. Consolidated text available at <www.ramsar.org>.

A number of legally binding and non-legally binding regional agreements were adopted to protect certain species in the context of the 1979 Convention on Migratory Species (CMS)[10]. Habitat conservation is pursued by many regional marine environmental protection instruments and bodies, whether part of the United Nations Environment Programme (UNEP)'s Regional Seas Programme or not.[11]

The International Legal and Policy Framework for Specific Drivers impacting Aquatic Genetic Diversity

Fishing

The global instruments on marine capture fisheries have primarily been developed under the auspices of the UNGA and FAO. The only other global instrument is the stand-alone 1946 International Convention for the Regulation of Whaling (ICRW).[12]

The contributions by the UNGA to international fisheries law consist of the 1982 UNCLOS, one of its Implementing Agreements (the 1995 Fish Stocks Agreement), and its Resolutions.

The provisions on marine capture fisheries in the 1982 UNCLOS and the 1995 Fish Stocks Agreement have a so-called 'framework' character. They contain overall objectives and basic rights and obligations for states but not the key substantive standards of actual fisheries regulation such as the Total Allowable Catch (TAC), its allocation, or restrictions to avoid bycatch of non-target species. Actual fisheries regulation is carried out by states individually or collectively, including through Regional Fisheries Bodies (RFBs).

The key objectives of the 1982 UNCLOS are (a) avoidance of overexploitation by means of striving for the maximum sustainable yield (MSY) and setting TACs and (b) optimum utilization, which obliges coastal states that cannot catch the entire TAC themselves to give other states access to the surplus. The 1982 UNCLOS acknowledges or grants rights to coastal states over marine living resources in their maritime zones and to other states on the high seas.

The FAO – guided by its Committee on Fisheries (COFI) – has adopted a wide range of fisheries instruments, both legally binding and non-legally binding. The two legally binding instruments are the 1993 Compliance Agreement[13] and the 2009 Port State Measures Agreement.[14] The 1993 Compliance Agreement addresses the problem of reflagging and the need for flag state responsibility. The 2009 Port State Measures Agreement – not yet in force – establishes global minimum standards for measures taken by port states in order to combat illegal, unreported and unregulated (IUU) fishing.

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[10] Memorandum of Understanding on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range, Abu Dhabi, 31 October 2007. In force same day; www.cms.int; Inter-American Convention for the Protection and Conservation of Sea Turtles; Caracas, 1 December 1996. In force 2 May 2001; <www.iacseaturtle.org>.

[11] Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris, 22 September 1992. In force 25 March 1998, <www.ospar.org>. Annex V, Sintra, 23 September 1998. In force 30 August 2000; amended and updated text available at <www.ospar.org>.

[12] International Convention for the Regulation of Whaling, Washington D.C., 2 December 1946. In force 10 November 1948, 161 *United Nations Treaty Series* 72; <www.iwcoffice.org>.

[13] Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, Rome, 24 November 1993. In force 24 April 2003, 33 *International Legal Materials* 969 (1994); <www.fao.org/legal>.

[14] Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, Rome, 22 November 2009. Not in force; <www.fao.org/Legal>.

Prominent among FAO's non-legally binding instruments is the 1995 Code of Conduct for Responsible Fisheries (CCRF),[15] which complements the 1982 UNCLOS, the 1993 Compliance Agreement and the 1995 Fish Stocks Agreement with more practical guidance on a broad range of fisheries management issues, including aquaculture development (Art. 9). It applies to marine as well as inland fisheries and is addressed to other key players besides states (e.g. fishers (Art. 1.3)). The 1995 CCRF is complemented by International Guidelines, a large number of Technical Guidelines for Responsible Fisheries, and four International Plans of Action (IPOAs), namely on reducing incidental catch of seabirds in longline fisheries (1999), on management of fishing capacity (1999), on management and conservation of sharks (1999) and on IUU fishing (2001).

Global fisheries instruments depend on implementation by states individually and collectively through (sub-)regional and bilateral cooperation. A large number of instruments – and bodies established by them (Tables 3.2 and 3.3) – has been created for that purpose.

Aquaculture and culture-based fisheries

There is currently no legally binding global instrument specifically dedicated to aquaculture. The wide range of generic legally binding obligations that apply include in particular the general obligations and principles of international law examined in section 3.3 above, for instance related to rare or fragile ecosystems, critical habitats, the accidental introduction of new or alien species and EIAs. If aquaculture installations threaten to cause pollution of the marine environment, the provisions of the 1982 UNCLOS on land-based marine pollution (Art. 207) or pollution from seabed activities (Art. 208) apply as well.

FAO's efforts in aquaculture are extensive even if they have not led to legally binding instruments. Article 9 of the 1995 CCRF is devoted to 'Aquaculture development' and canvasses a wide range of issues, including the need for environmental sustainability, Environmental Impact Assessments (EIAs) and avoiding transboundary impacts. It also pays specific attention to genetic diversity. These relatively concise and general provisions are elaborated in considerable detail by means of the Technical Guidelines for Responsible Fisheries devoted to 'Aquaculture Development'. In addition, FAO developed Technical Guidelines on Aquaculture Certification, which were adopted by COFI in 2011[16].

The mandates and work of several of the RFBs also extend to aquaculture (Table 3.2). Apart from the GFCM and NASCO, however, none of these is empowered to impose legally binding obligations on its members. Moreover, the focus in some of these bodies is primarily aimed at promoting aquaculture development and secondarily at environmental sustainability and conservation of biodiversity.

Habitat alteration and loss

Humans and a changing global climate are impacting and will continue to impact aquatic ecosystems and AqGR. Loss of coastal areas to development, land-based pollution and disruption of freshwater flows to coastal areas are human induced changes that adversely impacting marine and coastal areas. Natural processes such as storms and tidal waves also alter coastal habitats. Most significant overall habitat change in inland ecosystems is the construction of dams. In 2000, the WCD proposed a new framework for decision-making based on recognition of rights of and risks to all parties affected by dam construction. Recommendations related to biodiversity impacts suggested that decisions regarding dam approvals should be based on

[15] Code of Conduct for Responsible Fisheries. Adopted by the Twenty-eight Session of the FAO Conference, Rome, 31 October 1995, <www.fao.org/fi>.

[16] See FAO doc. COFI:AQ/V/2010/Inf.7.

- a balanced and comprehensive assessment of all options, giving social and environmental aspects the same significance as technical, economic and financial factors, and ensuring outstanding social and environmental issues are addressed;
- informed participation by all stakeholders in decision-making processes related to large dams;
- provision of entitlements to affected people and downstream communities to improve their livelihoods;
- a basin-wide assessment of the river ecosystem including efforts to avoid significant impacts to threatened and endangered species; and
- provisions for release of environmental flows to help maintain downstream ecosystems.

Policy makers need to ensure that policy responses are informed by local characteristics: economic, community, and ecological.

Introduced species

The CBD calls on contracting parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". The CBD Guiding Principles, adopted by the COP in 2002,[17] set out a "three-stage hierarchical approach" as the basis for all action on invasive alien species (IAS):

- Prevention: prevention of IAS introductions between and within states is generally far more cost-effective and environmentally desirable than measures taken after IAS introduction and establishment;
- Eradication: if an IAS has been introduced, early detection and rapid action are crucial to prevent its establishment: the preferred response is often to eradicate the organisms as soon as possible; and
- Containment: where eradication is not feasible or resources are not available, containment and long-term control measures should be implemented (CBD Guiding Principle 2).

Although well elaborated at the species level, this approach does not consider taxa below the species level, e.g. varieties, strains or stocks.

The International Maritime Organization (IMO)'s instruments are not aimed at the management or conservation of AqGR but rather at the prevention, reduction and control of marine pollution, which would include invasive species. Non-native species accidentally introduced in ballast water or as fouling organisms would be under the mandate of IMO[18].

The International Council for the Exploration of the Sea (ICES) and the European Inland Fisheries Advisory Committee (EIFAC) have developed codes of practice and manuals of procedures that involve environmental and economic risk assessment in order to make good decisions on when a deliberate introduction is justified for aquaculture or fisheries enhancements.[19]

Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) - the primary instrument for discussing and debating issues and advancing long-term cooperative action to combat climate change. The role AqGR are not prominent in the climate change debate. The UNFCCC recognizes the

[17] Decision VI/23 on *Alien Species that threaten ecosystems, habitats and species* (COP VI, The Hague, April 2002) to which are annexed the *Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that threaten Ecosystems, Habitats or Species.*

[18] The International Convention on the Control of Harmful Anti-fouling Systems on Ships, London, 5 October 2001. In force 17 September 2008, IMO Doc. AFS/CONF/26, of 18 October 2001.

[19] The text of these codes on contained in Bartley, D.M. (compiler) 2006. Introduced species in fisheries and aquaculture: information for responsible use and control . [CD-ROM] and links to them may found at http://www.fao.org/fishery/topic/13532/en

important role of forests and other terrestrial and marine ecosystems in tackling climate change. Most efforts to date have focused on climate change mitigation activities. Financing mechanisms for climate change do not recognize soil carbon sequestration, although from the agriculture point of view this provides promising potential for mitigation.[20]

The prospect of significant impacts of climate change on ecosystems and habitats is forcing a shift in conservation science toward development and assessment of future scenarios (Redford & Fleishman 2011). Policies for habitat protection and restoration need to take into account the likelihood that species' geographical distribution will change with climate change.

Selected Approaches for International Policy Development

Several important approaches and methodologies have been developed that form the basis for development of policy and legislative frameworks.

The Precautionary Approach

Principle 15 of the 1992 Rio Declaration described the precautionary approach: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The precautionary approach is binding on states and has been operationalized for fisheries through FAO's Technical Guidelines for Responsible Fisheries 2 (FAO 1996) concerning capture fisheries and species introductions.

The Ecosystem Approach

The ecosystem approach complements the CCRF by considering impacts of an activity on all interdependent target and non-target species, and acquiring the information needed to properly evaluate those impacts. The ecosystem approach typically includes in the decision-making process local communities that may have generations of knowledge of local ecosystems as well an economic incentive to conserve them for future generations.

The ecosystem approach to fisheries (EAF) includes assessing genetic stock structure and impacts of fishing on genetic diversity. EAF helps implement the Code of Conduct for Responsible Fisheries by providing a way "to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems" (FAO 2003).

Integrated resource management planning

Integrated resource management (IRM) planning provides an important tool for an ecosystem based approach by achieving inclusiveness of widely varied and sometimes conflicting interests. Types of IRM planning relevant to AqGR include integrated coastal zone management (ICZM), marine spatial planning (MSP), and integrated watershed management (IWM).

Certification

Certification and eco-labelling are approaches that use market forces to help promote sustainable fisheries and aquaculture. After FAO issued guidelines for fisheries product certification (2001a), the EU introduced labeling requirements requiring all products (except some processed products) to carry labels stating the production method (captured or farmed), catch area of wild species (FAO fishing area), country of production in the case of farmed fish products, Latin name and commercial name.

[20] CGRFA-13/11/Inf. 10.

The EU's General Food Law, which entered into force in 2002, requires all food operators to implement traceability systems that clearly identify the origin and destination of products.

Ownership and benefit-sharing

The number of cultured aquatic species is growing thus posing questions of ownership of the genetic material used to start or improve an aquaculture operation. Similarly, in the ornamental fish trade, harvest of wild animals can be used to start contained breeding populations for future sale, often by companies far removed from the original population with no benefit to the local community. Very often, aquaculture relies upon broodstock from other countries, and that raises questions about who owns the genetic material and whether and how benefits derived by aquaculture should be shared with the country (or community) providing it.

All member countries of the CBD are required to put access and benefit-sharing laws in place, but progress has been slow. Unlike domesticated plants and animals, there is very little traditional knowledge or traditional ownership of aquatic species' AqGR. Most knowledge and development of aquatic varieties and breeds have been developed by well financed companies or institutions and not by traditional fish farmers. AqGR have been developed and improved often in areas far removed from their native habitat (e.g. tilapia, an African fish, has been genetically improved in Asia) (Bartley et al. 2009)

Gaps in the International Legal and Policy Framework

The global and regional instruments discussed in this chapter largely focus on the protection and preservation of the (marine) environment and the conservation of species and habitats: only in a few instances on the conservation and management of AqGR. In general global policies and laws do not address issues below the species level. This is especially true for legislation and policies on introduced 'species'; strains, genetically differentiated stocks, and varieties within a species are usually not addressed. There is an increasing awareness that distinguishing between the species and genetic levels of biodiversity is important for *inter alia* management, traceability, and intellectual property protection, however AqGR at the sub-species level are still not well addressed.

Many of the current approaches to fisheries and aquaculture development and management, e.g. ecosystem and precautionary approaches do not well address AgGR at the genetic level. Reference points, monitoring programmes and acceptable level of risk are not agreed or established for AqGR at the genetic or at the genetic stock levels.

The global legally binding fisheries instruments developed under the aegis of the UNGA and FAO apply in principle only to the marine environment. Global coverage of inland fisheries is only ensured by the non-legally binding 1995 CCRF, its 1997 Technical Guidelines on inland fisheries, its 2008 supplement No. 1 on 'Rehabilitation of inland waters for fisheries' and the 2010 Guidelines for the Ecolabelling of Fish and Fish Products from Inland Capture Fisheries. There are regional river basin authorities and RFBs that include inland fishery issues in their mandate, but many do not implement the mandate and most do not address genetic resource issues. (FAO 2007)

There is no dedicated global instrument - legally binding or non-legally binding - on aquaculture and culture-based fisheries. Global coverage of aquaculture is only ensured by the non-legally binding 1995 CCRF, its 1997 Technical Guidelines and supplements (see specifically supplement 3 – Genetic Resource Management) on aquaculture development and by the 2012 Aquaculture Certification Guidelines.

Table 3.1. List of International Instruments relevant to conservation and sustainable use of AqGR

1945	UN Charter	Charter of the United Nations, San Francisco, 26 June 1945. In force 24 October 1945, 1 *United Nations Treaty Series* xvi; <www.un.org>.
1946	ICRW	International Convention for the Regulation of Whaling, Washington D.C., 2 December 1946. In force 10 November 1948, 161 *United Nations Treaty Series* 72; <www.iwcoffice.org>.
1971	Ramsar Convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar, 2 February 1971. In force 21 December 1975, as amended. Consolidated text available at <www.ramsar.org>.
1972	World Heritage Convention	Convention concerning the Protection of the World Cultural and Natural Heritage, Paris, 16 November 1972. In force 17 December 1975; 11 *International Legal Materials* 1972; <www.unesco.org>.
	London Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, Mexico City, Moscow, Washington D.C., 29 December 1972. In force 30 August 1975, 11 *International Legal Materials* 1294 (1972); as amended, consolidated version available at <www.imo.org>. 1996 Protocol, London, 7 November 1996. In force 24 March 2006, *Law of the Sea Bulletin* No. 34 (1997), p. 71; as amended in 2006, consolidated version at <www.imo.org>.
1973	CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C., 3 March 1973. In force 1 July 1975, 993 *United Nations Treaty Series* 243; <www.cites.org>.
	1973/78 MARPOL	International Convention for the Prevention of Pollution from Ships, London, 2 November 1973, as modified by the 1978 Protocol (London, 1 June 1978) and the 1997 Protocol (London, 26 September 1997) and as regularly amended. Entry into force varies for each Annex. At the time of writing Annexes I-VI were all in force.
	Polar Bear Agreement	Agreement on the Conservation of Polar Bears and Their Habitat, Oslo, 15 November 1973. In force 26 May 1976; text at <pbsg.npolar.no>.
1979	CMS	Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. In force 1 November 1983, 1651 *United Nations Treaty Series* 355; <www.cms.int>.
	CLRTAP	Convention on Long-Range Transboundary Air Pollution, Geneva, 13 November 1979. In force 16 March 1983; <www.unece.org>.
1982	UNCLOS	United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982. In force 16 November 1994, 1833 *United Nations Treaty Series* 396; <www.un.org/Depts/los>.
1985	Vienna Convention	Convention for the Protection of the Ozone Layer, Vienna, 22 March 1985. In force 22 September 1988, 1513 *United Nations Treaty Series* 324 (1988); <www.unep.org/ozone>. Protocol on Substances that Deplete the Ozone Layer, Montreal, 16 September 1987. In force 1 January 1989, as amended. Consolidated

		version available at <www.unep.org/ozone>.
1992	Helsinki Watercourses Convention	Convention on the Protection and Use of Transboundary Watercourses and Lakes, Helsinki, 17 March 1992. In force 6 October 1996; text at <www.unece.org>.
	HELCOM Convention	Convention on the Protection of the Marine Environment of the Baltic Sea Area, Helsinki, 9 April 1992. In force 17 January 2000, as amended; consolidated version at <www.helcom.fi>.
	UNFCCC	United Nations Framework Convention on Climate Change, New York, 9 May 1992. In force 21 March 1994, 1771 *United Nations Treaty Series* 107; <unfccc.int>. Kyoto Protocol, Kyoto, 11 December 1997. In force 16 February 2005, 2303 *United Nations Treaty Series* 214 (2005); <unfccc.int>.
	Rio Declaration	Rio Declaration on Environment and Development, Rio de Janeiro, 13 June 1992. 31 *International Legal Materials* 876 (1992); <www.unep.org>.
	CBD	Convention on Biological Diversity, Nairobi, 22 May 1992. In force 29 December 1993, 1760 *United Nations Treaty Series* 143 (1993); <www.biodiv.org>.
	OSPAR Convention	Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris, 22 September 1992. In force 25 March 1998, <www.ospar.org>. Annex V, Sintra, 23 September 1998. In force 30 August 2000; amended and updated text available at <www.ospar.org>.
1993	Compliance Agreement	Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, Rome, 24 November 1993. In force 24 April 2003, 33 *International Legal Materials* 969 (1994); <www.fao.org/legal>.
1994	TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights. Adopted together with the Agreement Establishing the World Trade Organization, Marrakesh, 15 April 1994. In force 1 January 1995, <www.wto.org>.
	Part XI Deep-Sea Mining Agreement	Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, New York, 28 July 1994. In force 28 July 1996, 1836 *United Nations Treaty Series* 42 (1994); <www.un.org/Depts/los>.
1995	Fish Stocks Agreement	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, New York, 4 August 1995. In force 11 December 2001, 2167 *United Nations Treaty Series* 3; <www.un.org/Depts/los>.
	CCRF	Code of Conduct for Responsible Fisheries. Adopted by the Twenty-eight Session of the FAO Conference, Rome, 31 October 1995, <www.fao.org/fi>.

1996	IACS Convention	Inter-American Convention for the Protection and Conservation of Sea Turtles; Caracas, 1 December 1996. In force 2 May 2001; <www.iacseaturtle.org>.
1997	Watercourses Convention	Convention on the Non-Navigational Uses of International Watercourses, New York, 21 May 1997. Not in force; doc. UNGA Res. 51/229 (1997).
2000	Cartagena Protocol	Cartagena Protocol on Biosafety to the Convention on Biological Diversity, Montreal, 29 January 2000. In force 11 September 2003; 2226 *United Nations Treaty Series* 208 (257) (2005); www.biodiv.org.
2001	POPs Convention	Convention on Persistent Organic Pollutants, Stockholm, 22 May 2001. In force 17 May 2004; text at <chm.pops.int>.
	Anti-Fouling Convention	International Convention on the Control of Harmful Anti-fouling Systems on Ships, London, 5 October 2001. In force 17 September 2008, IMO Doc. AFS/CONF/26, of 18 October 2001.
2004	Ballast Water Management Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments, London, 13 February 2004. Not in force, IMO Doc. BWM/CONF/36, of 16 February 2004.
2007	MOU on Dugongs	Memorandum of Understanding on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range, Abu Dhabi, 31 October 2007. In force same day; <www.cms.int>.
2009	Port State Measures Agreement	Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, Rome, 22 November 2009. Not in force; <www.fao.org/Legal>.
2010	Nagoya Protocol	Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, Nagoya, 29 October 2010. Not in force; Doc. UNEP/CBD/COP/DEC/X/1, of 29 October 2010; <www.biodiv.org>.

Table 3.2 ***Regional fishery bodies (RFBs)***[21]

APFIC	Asia-Pacific Fisheries Commission	LVFO	Lake Victoria Fisheries Organization
BOBP-IGO	Bay of Bengal Programme Inter-Governmental Organization	MRC	Mekong River Commission
CACFish	Central Asian and Caucasus Regional Fisheries and Aquaculture Commission	NAFO	Northwest Atlantic Fisheries Organization
CCAMLR	Commission on the Conservation of Antarctic Marine Living Resources	NAMMCO	North Atlantic Marine Mammal Commission
CCBSP	Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea	NASCO	North Atlantic Salmon Conservation Organization
CCSBT	Commission for the Conservation of Southern Bluefin Tuna	NEAFC	North-East Atlantic Fisheries Commission
CECAF	Fishery Committee for the Eastern Central Atlantic	NPAFC	North Pacific Anadromous Fish Commission
CIFAA	Committee for Inland Fisheries and Aquaculture of Africa	NPFC	North Pacific Fisheries Commission[a]
COMHAFAT	Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean	OLDEPESCA	Latin American Organization for Fisheries Development
COPESCAALC	Commission for Inland Fisheries and Aquaculture of Latin America and the Caribbean	PICES	North Pacific Marine Science Organization
COREP	Regional Fisheries Committee for the Gulf of Guinea	PSC	Pacific Salmon Commission
CRFM	Caribbean Regional Fisheries Mechanism	RECOFI	Regional Commission for Fisheries
EIFAAC	European Inland Fisheries and Aquaculture Advisory Commission	SEAFDEC	Southeast Asian Fisheries Development Center
FCWC	Fishery Committee of the West Central Gulf of Guinea	SEAFO	South East Atlantic Fisheries Organization

[21] Information and links on many RFBs are available at <www.fao.org/fishery/rfb>.

FFA	Forum Fisheries Agency	SIOFA	South Indian Ocean Fisheries Agreement
GFCM	General Fisheries Commission for the Mediterranean	SPC	Secretariat of the Pacific Community
IATTC	Inter-American Tropical Tuna Commission	SPRFMO	South Pacific Regional Fisheries Management Organization (Still to be formally established)
ICCAT	International Commission on the Conservation of Atlantic Tunas	SRFC	Subregional Fisheries Commission
ICES	International Council for the Exploration of the Sea	SWIOFC	Southwest Indian Ocean Fisheries Commission
IOTC	Indian Ocean Tuna Commission	WCPFC	Western and Central Pacific Ocean Fisheries Commission
IPHC	International Pacific Halibut Commission	WECAFC	Western Central Atlantic Fishery Commission

Table 3.3: Schematic overview of global and regional instruments

Drivers		**Global instruments**	**Regional instruments**
General instruments & obligations		• 1992 CBD • 1982 UNCLOS	• Regional seas agreements
Instruments on conservation of species and habitats		• 1992 CBD • 1973 CITES • 1979 CMS • 1971 Ramsar Convention • 1972 World Heritage Convention • 1995 CCRF	• Regional instruments under CMS, e.g. 2007 MOU on Dugongs • 1973 Polar Bear Agreement • Regional seas agreements • EU water framework directive?
Fishing		• 1982 UNCLOS • 1995 Fish Stocks Agreement • 1946 ICRW • UNGA Resolutions • FAO instruments, e.g. 2009 Port State Measures Agreement, 1995 CCRF + IPOAs and Technical Guidelines	• Many RFBs and their constitutive instruments
Aquaculture and culture-based fisheries		• See 'General instruments & obligations' • 1995 CCRF & Technical Guidelines	• Several RFBs and their constitutive instruments
Habitat alteration and loss		• See 'General instruments & obligations' and 'Instruments on conservation of species and habitats' above	
Pollution[22]	Land-based	• UNEP's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities • 1997 Watercourses Convention • 2001 POPs Convention	• Rules adopted by regional bodies, e.g. OSPAR Commission bodies established under UNEP's Regional Seas Programme • 1992 Helsinki Watercourses Convention
	Activities on continental shelf	None	• 1992 OSPAR Convention, Annex III • Arctic Council's Arctic Offshore Oil and Gas Guidelines
	Activities in the Area	• ISA Mining Code	None
	Dumping	• 1972 London Convention, as modified by 1996 Protocol	• E.g. 1992 OSPAR Convention, Annex II
	Vessel-source	• IMO instruments, e.g. 1973/78 MARPOL & 2001 Anti-fouling convention	• Very limited, e.g. HELCOM Convention, Annex IV
	Atmospheric	• 1992 UNFCCC + 1997 Kyoto Protocol • 1985 Vienna Convention + 1987 Montreal Protocol • 1972 London Convention, as modified by 1996 Protocol • 1973/78 MARPOL, Annex VI	• E.g. 1979 Geneva Convention
Introduced species		• See 'General instruments & obligations'	• NASCO Williamsburg Resolution

[22] The relevant provisions of UNCLOS have not been listed.

	• CBD cross-cutting issue • FAO Technical Guidelines	• ICES 2005 Code of Practice • 2004 Ballast Water Management Convention

IV. THE NATIONAL LEGAL AND POLICY FRAMEWORK

This chapter provides a comparative overview of national laws, policies and practices that address main drivers that have an influence, positively or negatively, on the conservation and sustainable use of aquatic genetic resources (AqGR). Table 4.1 provides some examples of national examples discussed.

Towards a Comprehensive Policy Approach for AqGR Management

Food security will depend in large part on the ready availability of fish protein, much of it supplied by aquaculture, now the fastest–growing animal food-producing sector. Aquaculture depends on the conservation of wild stocks for its future sources of supply, and wild populations can be affected by aquaculture and stock enhancement. External threats to aquatic biodiversity (habitat conversion, pollution, climate change, etc.) have direct implications for AqGR that now or in the future may be an important fisheries or aquaculture resource. All of this argues for a comprehensive and coordinated approach to the development and management of AqGR.Implementation of the of the CCRF and CBD's objectives will require countries to develop laws and policies addressing the management of AqGR.

Germany is one of few countries to have attempted such an approach. Its National Technical Programme on the Conservation and Sustainable Use of Aquatic Genetic Resources, introduced in 2010, establishes a common framework applicable to fisheries, aquaculture and conservation, with five main aims, the first of which captures the primary focus of the programme:

> *Preserving the diversity of aquatic genetic resources in the long term in a scientifically substantiated and cost-efficient manner in situ and ex situ, tapping them and making them usable through suitable measures such as evaluation, characterization and documentation and intensifying their use for economic purposes, notably in aquaculture*.

The policy document describing the programme emphasizes the importance not only of coordination and transparency of the activities of the different agencies involved in managing AqGR but also of establishing and strengthening a scientific framework for the study, recording and conservation of genetic diversity.

Aquaculture, which in some countries only made its first appearance in recent decades, is often connected awkwardly with agriculture rather than fisheries in governance structures, with little consideration for conserving a diversity of wild aquatic populations in terms of their potential for domestic or international culture. Few countries have taken steps to define rights of ownership of AqGR in law, or how benefits arising from their use might be shared, even though it is a crucial consideration for any country that engages in aquaculture or provides genetic material to other countries for that or other purposes. Many countries have, at least on paper, embraced the precautionary and ecosystem approaches to biodiversity management, but have not moved towards any systematic approach to the management of AqGR.

General Approaches

Integrated resource management planning

Integrated resource management (IRM) planning provides an important tool for an ecosystem approach by achieving inclusiveness of widely varied and sometimes conflicting interests. Types of IRM planning relevant to AqGR include integrated coastal zone management (ICZM), marine spatial planning (MSP), and integrated watershed management (IWM).

The 1992 Rio Declaration introduced integrated coastal zone management (ICZM) as a dynamic, multidisciplinary and iterative process to promote sustainable development. New Zealand was one of the first countries to initiate ICZM under its 1991 Resource Management Act, which sparked the preparation of a New Zealand Coastal Policy Statement. The Act requires regional authorities to

produce coastal policy plans consistent with the Coastal Policy Statement. Keyuan (2003) recommends the adoption of ICZM in China because the management structure of marine affairs is fragmented among many different government departments. ICZM has more recently been supplemented by marine spatial planning, defined by the Intergovernmental Oceanographic Commission as "a process of analyzing and allocating parts of three-dimensional marine spaces (or ecosystems) to specific uses or objectives, to achieve ecological, economic and social objectives that are usually specified through a political process". National examples include China's Marine Functional Zoning, Australia's marine bioregional plans and Great Barrier Reef Marine Park, Belgium's Master Plan for the North Sea and the UK's Marine and Coastal Access Bill (Intergovernmental Oceanographic Commission 2010). The EU has developed a maritime spatial planning strategy.

Because watersheds are nested across landscapes, IWM plans (the inland waters version of ICZM) may vary considerably in size, ranging from a tiny local landscape to a massive watershed encompassing parts of several countries. The Michigan Department of Natural Resources, USA, replaced the political boundaries previously used for planning with boundaries redrawn along river basin and ecoregion lines, then prepared IWM plans based on local criteria rather than broad standards, resulting in more comprehensive management specific to a watershed or ecoregion (FAO 2001b). A larger example is the EU's 2000 Water Framework Directive (2000/60/EC), which focuses on protection of aquatic ecosystems (including coastal components) and habitats considered unique and valuable.

IWM plans are essential in developing countries where communities depend on fisheries for their livelihoods. The Mekong River Commission,[23] established in 1995, focuses on strategic planning for sustainable development and joint management of shared water resources for its four member countries: Cambodia, Lao PDR, Thailand and Vietnam. In addition, the two upper countries in the Mekong River Basin, China and Myanmar, have the status of dialogue partners. The Lake Tanganyika Authority,[24] established in 2008 by Burundi, Democratic Republic of Congo, Tanzania and Zambia to implement the Convention on the Sustainable Management of Lake Tanganyika, has a more specific focus on the conservation of biological diversity and sustainable use of natural resources of the lake and its basin.

Polices and Legislation Relating to Fishing

Overfishing can have a variety of impacts on genetic diversity. Fisheries management has evolved techniques to limit impacts on fish stocks, including gear restrictions, quotas and area-based restrictions. In order for restrictions to have an impact at the population level, fisheries managers must first have a clear understanding of the genetic makeup of the species in question.

The Ecosystem Approach

The ecosystem approach to fisheries (EAF) includes assessing genetic stock structure and impacts of fishing on genetic diversity. In the USA, the Magnuson-Stevens Fishery Conservation and Management Act[25] captures an important element of an EAF by institutionalizing participatory management through regional Fishery Management Councils, drawn from a broad range of stakeholders. These councils are responsible for preparing fishery management plans within geographic areas big enough to define ecosystems (Sissenwine & Mace 2003). Implementation of the EAF for transboundary ecosystems, for example in the European Union, poses the additional challenge of coordinating different national approaches and integrating economic, ecological and hydrological processes across a variety of spatial scales (Apitz et al. 2006).

Governments implementing the EAF in developing countries may face greater challenges (e.g. less capacity) but also enjoy opportunities (e.g. for sustainable economies for fishing communities). An

[23] http://www.mrcmekong.org/
[24] http://lta.iwlearn.org/
[25] http://www.nmfs.noaa.gov/sfa/magact/

example is the cooperative effort among the fisheries management agencies of Angola, Namibia and South Africa, the Benguela Current Large Marine Ecosystem Programme and FAO to implement an ecosystem approach to fisheries along the southeast Atlantic coast of Africa. This experience revealed the importance of strong scientific support and appropriate indicators for measuring progress, effective engagement of a broad variety of stakeholders, and adequate institutional capacity (FAO 2008b).

EAF in marine fisheries often targets bycatch reduction. Bycatch of unwanted, prohibited or protected species is a problem in most commercial fisheries, most notably in trawl fisheries. Different countries use variations of the quota system to regulate bycatch, e.g.

- New Zealand sets fleet bycatch quotas for sea lion bycatch in the arrow squid trawl fishery and uses catch balancing, or individual transferable quotas, for multi-species trawl fisheries;
- Alaska, U.S.A., uses fleet quotas under a 'vessel incentive program' for prohibited species in the groundfish trawl fishery; and
- Canada uses individual vessel bycatch quotas for prohibited species in the groundfish trawl fishery (Diamond 2004).

A precautionary, ecosystem approach is particularly important for inland fisheries because it can address the impacts of numerous drivers. Inland fisheries management strategies focus almost exclusively on recreation and conservation in industrialized countries and on food security in developing countries, though the emphasis on recreational fisheries and conservation is spreading with globalization.

Several countries have applied the ecosystem approach to large marine ecosystems through laws and policies for the integrated management of ocean ecosystems. These include Australia's 1998 National Oceans Policy, the 2000 USA Oceans Act and Canada's 1996 Oceans Act (Sissenwine & Mace 2003; Juda 2003). The application of the ecosystem approach to marine resource management is likely to accelerate as research reveals feedbacks, ecological effects and economic consequences, and sectors negotiate rules to be established in national law (Murawski 2008).

Community co-management

One way to attempt to mitigate the effects of most drivers of change described earlier is to vest control over aquatic biodiversity in the hands of the communities that have both the motivation to conserve it and, often, some knowledge of different fish stocks and their behavior. As Acheson (2006) points out, all management institutions – whether private property or central government control or local-level management – fail under certain conditions. It pays to follow a risk-averse approach not only in biodiversity management but also in designing governance models for the management of biodiversity.

Innovative examples of community fisheries management include the following:

- Vietnam's IMOLA project,[26] initiated by FAO and jointly funded by the Italian and Vietnamese governments to help the Thua Thien Hue Province promote the livelihoods of local fisherfolk through sustainable management of the Tam Giang-Cau Hai Lagoon, the largest lagoon system in Southeast Asia;

- Cambodia's Tonle Sap Lake project,[27] which helped villagers develop IRMPs that have led to sustainable lake fisheries, replacing a century-old system of commercial fishing concessions plagued by unfair access, corruption and violent disputes, overfishing and illegal fishing;

- Malaysia's Tagal System[28], community-run system for the rehabilitation, protection and conservation of river environments and fisheries resources;

[26] http://www.imolahue.org/
[27] http://www.fao.org/newsroom/en/field/2005/107684/index.html

- Bangladesh's New Fisheries Management Policy, with improved management of inland open-water fisheries through a fisher-led, community-led and women-led arrangement (Kabir et al 2011);

- Fiji's community management, with family group management of traditional fishing territories (Greer and Harvey 2004).

National and state governments that choose to foster local co-management should be careful to avoid a "one size fits all" attitude. Even in the same region, communities may have very different histories and cultural practices that local governance models need to take into account. That is why local consultation is a crucial foundation for community management frameworks that will stand the test of time (Greer and Harvey 2004).

Assessing genetic stock structure

The EAF calls for an assessment of genetic stock structure and impacts of fishing on genetic diversity. Even developed countries face significant challenges conducting adequate research to obtain the data needed to inform fishing management strategies, and countries that do have the resources tend to focus on species of the greatest commercial value, as a result of which the genetic status of a high percentage of major stocks and stock complexes remains uncertain or not determined (Beddington et al. 2007). Germany's National Technical Programme on the Conservation and Sustainable Use of Aquatic Genetic Resources[29] notes with regard to marine AqGR:

> *Very little information is available about the genetic structure of individual species. Either none or only very patchy information is available about most fish species. Merely some heavily exploited species such as cod have recently been examined. It is therefore imperative to close these informational gaps through own research [sic] programmes so that departmental research can provide sound advice in this field.*

Needed actions identified by the programme, to be implemented jointly by the federal government and the Lander, include the following:

> *A concrete need for research exists in the recording of population structures and intra-species genetic variability. The hazards to genetic diversity must be identified early on, especially in the case of heavily exploited species. Alongside potential genetic erosion, genetic changes such as a change in the age and size at spawning maturity as a possible consequence of selective testing should also be considered.*

Canada's most valuable commercial fishery is the Pacific salmon fishery. In 2005 the Department of Fisheries and Oceans (DFO) announced a Wild Salmon Policy[30] to "restore and maintain healthy and diverse salmon populations" by meeting three primary objectives: safeguarding genetic diversity, maintaining habitat and ecosystem integrity, and managing fisheries for sustainable benefits. To fulfill the first of the five strategies in the policy – "standardized monitoring of wild salmon status" – DFO decided to deal not with individual stocks or populations (there are several thousand genetically distinct salmon populations along Canada's west coast) but rather with clusters of populations called "conservation units", characterized as "groups of wild salmon living in an area sufficiently isolated from other groups that, if they are extirpated, that area is unlikely to be recolonized naturally in an acceptable time frame (e.g. a human life time)". The next step, once conservation units had been identified, was to assess the status of each conservation unit – the health of the populations – using indicators such as abundance of fish, changes in abundance and distribution, and habitat use (Irvine 2009).

[28] http://www.fishdept.sabah.gov.my/tagal.asp
[29] http://www.genres.de/fileadmin/SITE_GENRES/downloads/publikationen/national_programme_agr_eng.pdf
[30] http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/wsp-pss/index-eng.htm

Meeting the second and third objectives of the Wild Salmon Policy – maintaining habitat and ecosystem integrity, and managing fisheries for sustainable benefits – presents challenges of a higher magnitude. Implementation of these objectives has been hampered for years by chronic tensions:

- among interest groups including commercial and recreational fishers, indigenous groups, the aquaculture industry, and environmental non-governmental organizations;
- between conservation interests and economic interest regarding fish habitat protection (Canada recently amended its Fisheries Act to significantly reduce habitat protection requirements, citing obstacles to economic development);
- between the federal and provincial government regarding habitat protection responsibilities and strategies;
- between Canada, the United States, and the State of Alaska regarding the terms of the Pacific Salmon Treaty; and
- regarding a decision-making process in which ultimate decision-making authority resides with the fisheries minister (the U.S.A., by contrast, took steps to depoliticize the decision-making process by devolving decision authority to regional councils under the Magnusson-Stevens Act).

Full implementation of the EAF supersedes the single-species management approach that has historically dominated fisheries management. The challenges to implementation are such that, although national policies may emphasize the EAF approach, absence of data and resources means that most ecosystem considerations in fisheries tend to be ad hoc manipulations of the single-species approach (Beddington et al. 2007).

Precautionary approach

Countries have incorporated the precautionary approach into legislation and policy as a component of biodiversity conservation law (Costa Rica, Ecuador, Peru), as a guiding principle of general environmental law (Argentina, Mozambique, Cameroon, South Africa) or through court-ordered inclusion in the interpretation of national law (Pakistan, India). Australia required recognition of the precautionary approach at both the national and state levels through its 1992 Inter-Governmental Agreement on the Environment and subsequently embedded the precautionary approach in both Commonwealth fisheries legislation and the 1999 Environment Protection and Biodiversity Conservation Act (Sant 2005). One of the most important and most challenging components of the precautionary approach to fisheries is the concept of target and limit reference points.

The precautionary approach to fisheries suggests the importance of establishing target and limit reference points to ensure avoidance of stock collapse resulting from overexploitation, in which target reference points typically indicate the biomass needed to produce maximum sustainable yield and limit reference points indicate the stock biomass below which recruitment becomes substantially reduced. In the USA, National Standards under the 1976 Fishery Conservation and Management Act (Magnuson-Stevens Act) incorporated the precautionary approach, describing three steps to be followed in specifying optimum yield: set target reference points such as optimum yield safely below reference points such as maximum sustainable yield (MSY), harvest stocks at sizes below the level that produces MSY at lower levels than stocks at sizes above that level, and, as uncertainty about stock status or productive capacity increases, set catch levels more cautiously (Gabriel & Mace 1999). As in the case of DFO's Wild Salmon Policy described above, success in the application of target and limit reference points can be and often is jeopardized by tensions between economic and biological objectives (Beddington et al. 2007). In addition, managers who have the benefit of adequate information about stock status but not about the quantification of threats to those stocks may find it difficult to apply reference points effectively (Grafton et al. 2007). Caddy & Mahon (1995) emphasize the importance of advance agreement among stakeholders regarding the limiting conditions

corresponding to the reference points used and the actions to be triggered by non-compliance with reference points.

User rights

Innovative user rights can provide a useful tool for achieving reference points and avoiding overexploitation of common pool stocks. Rights-based management approaches – including community development quotas (CDQs) or other group fishing rights, territorial use rights in fishing (TURFs), cooperatives, and individual fishing rights or individual transferable quotas (ITQs) – cause fishers to work to prevent or at least reduce overcapacity.

Historically, communities dependent on local fisheries could not afford the consequences of bad management and have long used variations of TURFs as a component of customary marine management. Traditional community-based management practices for artisanal and small-scale fisheries are today experiencing a revival as governments more fully appreciate their effectiveness in ensuring sustainable use. For example, the Secretariat of the Pacific Community,[31] serving 22 Pacific island countries and territories, is promoting the revival of traditional marine tenure and resource allocation mechanisms throughout its region. Chile's co-management policy, which grants to coastal artisanal fisher organizations exclusive TURFs known as Management and Exploitation Areas for Benthic Resources (MEABRs), has been found to enhance diversity and abundance of reef fish species inside the MEABRs, indicating they could represent an important ancillary network to complement biodiversity objectives of fully protected MPAs (Gelcich et al. 2008). Efforts at the national level to manage user rights for industrial fisheries have focused primarily on entitlements in the form of ITQs or as a subset of a limited number of licences to fish. This strategy has been introduced with some success in countries such as Australia, Canada, Iceland, New Zealand and the USA (FAO 2002) though evidence for positive benefits is mixed (Beddington et al. 2007).

Fisheries certification and traceability schemes

The simple creation of rights-based incentives may not be enough to address ecosystem problems because fishers have little incentive to minimize bycatch or habitat damage that does not affect their target species (Beddington et al. 2007). Certification schemes such as the Marine Stewardship Council (MSC) programme typically require the assessment process to consider compliance with national laws, and to that extent national governments can define the minimum requirements for certification. Aware of the certification's growing influence on consumer buying patterns, governments have been eager to facilitate certification in their seafood industries. The Dutch parliament voted to amend the 2009 and 2010 budgets to make €1.5 million available for certification, while a French parliamentary report recommended that all French fisheries be assessed by an independent, third-party standard programme. In Mozambique, the Ministry of Fisheries has taken an active role to facilitate MSC certification of the shallow-water and deep-water shrimp fisheries. In 2007 the government of Japan initiated an ecolabelling programme of its own (Marine Eco-Label Japan) in cooperation with the Japanese Fisheries Association.

Marine protected areas (MPAs)

MPAs have the potential to complement fisheries management regimes by protecting AqGR of endangered species and populations at risk. Recognizing the fact that MPAs may take many different forms, FAO's guidelines define them broadly as including any marine geographical area that is afforded greater protection than the surrounding waters for biodiversity conservation or fisheries management purposes (FAO 2011e). A convergence of interests about the design of MPAs has come about as fisheries managers emphasize healthy ecosystems as a requirement for sustainable fisheries while conservation groups have become increasingly aware of the importance of taking human needs and interests into account (FAO 2012c).

The CBD target of protecting 10 percent of the oceans by 2020 remains elusive, with little more than 1

[31] http://www.spc.int/

percent protected to date in spite of the recent creation of very large MPAs by the USA, Australia, the United Kingdom and the Pacific nation of Kiribati (Cressey 2011). China in recent years has embarked on an ambitious program of expanding the number and size of its MPAs and strengthening their management (Keyuan 2003). While MPAs are a novel idea in many countries, they have a long history in indigenous communities such as those in the Pacific Island countries of Palau, Vanuatu, the Cook Islands and Tonga, where customary management practices include seasonal bans on harvesting and temporary closed (no-take) areas in accordance with traditional beliefs (Vierros et al. 2010).

What works for MPAs in developed countries may not be appropriate in developing nations. Ban et al. (2011), considering MPA opportunities for coral reef nations, found that most studies on MPA design and planning were from North America, Europe and Australia and did not sufficiently take into account the tight coupling of social and ecological systems in developing countries. The importance of local community benefits from and meaningful participation in the management of an MPA was illustrated in a study of a failing Caribbean coral reef MPA in Colombia. Here, absence of income opportunities for local people, combined with weak communication among stakeholders and with government authorities, contributed to overexploitation of marine resources in the MPA and difficulty adapting to restrictive conservation rules (Camargo et al. 2009).

The use of inland or freshwater protected areas (FPA) is also a management strategy however use of the terminology is not as widespread nor as high profile as MPAs. The Aichi Targets[32] of 17 % of 'inland water' are 'conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes' is extremely vague and ambitious, and will certainly present problems in national implementation.

Polices and Legislation Aquaculture and Culture-based Fisheries

As aquaculture's contribution to food security becomes ever more vital, the global industry faces three particular challenges: secure access to land and water to provide a stable operations base; availability of the diversity and quality of genetic material needed to optimize opportunities for expansion and stability; and avoidance of negative impacts on wild fish populations and other ecological values.

A global aquaculture review by Costa-Pierce (2008) found good progress towards an ecosystem approach for salmon in Canada, some progress in the United Kingdom and Norway but little in Chile, and little or no progress in cage culture developments in China and Southeast Asia. It emphasized the need for a tighter coupling of science, policy and management. An ecosystem approach to aquaculture should be guided by three main principles: it should account for and not threaten the sustained delivery of ecosystem services, ensure that aquaculture improves human well-being and equity for all relevant stakeholders, and be developed in the context of and integrated to other relevant sectors, policies and goals (Soto et al. 2008).

Seed production

National governments that have relied in the past on central hatcheries for the provision of seed are now finding that they need to nurture public-private partnerships and decentralized networks of small- to medium-scale hatcheries. This includes developing and implementing mechanisms (e.g. development and promotion of best management practices, seed certification, domestication, broodstock banks) that will ensure a stable supply of quality seed to farmers. For example, government institutions in India (the Indian Council of Agricultural Research and the Aquaculture Authority of India) are working to promote codes of practice for hatcheries and to develop certification systems, and Thailand's Department of Fisheries is promoting that country's Code of Conduct and Good Aquaculture Practices for hatcheries. Government extension institutions could develop and disseminate best management practices for everyone involved in the seed production and supply chain, with comprehensive stakeholder consultation. Finally, research institutions could

[32] http://www.cbd.int/sp/targets/

identify researchable issues on fish seed quality and initiate appropriate research programmes (Mohan 2007).

An FAO workshop emphasized the value of developing and expanding private-public partnerships and recommended that national governments promote public and private selective breeding as the core of genetic improvement programs of species for which sustainable aquaculture industries have developed. Other recommendations relevant to national governance included assistance in the development of national broodstock certification programs, development of policies and laws governing the production and supply of quality fish seed, and assistance for developing guidelines for standardized protocols for optimizing seed quality and hatchery certification at the national level (FAO 2007). For example, the Thai government support of backyard shrimp hatcheries providing seed stock to the industry has been pivotal in ensuring the sustainability of these small-scale operations and the quality of their seed supply.

Public-private partnerships may also advance the management of *ex situ* collections of aquatic animal germplasm and whole organisms in gene banks, which are currently maintained by a variety of national, state and indigenous governments, private companies, academics and NGOs (FAO 2008d).

Genetic alteration

Genetic alteration can occur in a variety of ways, e.g. as a result of deliberate application of genetic technologies such as hybridization, gene transfer or selective breeding, or as an unintended impact on native fish after stocking water bodies with hatchery-produced fish. One of the few jurisdictions that specifically address the latter risk is the Canadian province of New Brunswick, whose Fish Stocking Policy prohibits stocking "where stocked fish could harm other species at a population level".[33] Germany's National Technical Programme on the Conservation and Sustainable Use of Aquatic Genetic Resources notes that, because of the poor state of knowledge of the genetic differentiation of stocks, stocking with material of unclear origin should not take place.

The application of genetic technologies in aquaculture in both developing and developed countries can produce many benefits. However, capitalizing on this resource requires levels of information and capacity that may not be currently available, especially in developing countries. Existing national data collections have major gaps with respect to aquatic genetic variation below the species level, while small, local databases that do include knowledge on intra-specific variation, fish stocking histories or breeds and varieties are scattered, not easily accessed and limited in scope. Information is also needed on available technologies. To exacerbate the problem, many countries lack the capacity needed to collect information on genetic diversity, to apply genetic techniques and to conduct appropriate risk analysis. Consequently, national and regional efforts will be needed to develop that capacity given available resources and priorities (FAO 2012b).

Given public controversies about the breeding of transgenic fish, regulatory debates have led to tension among policy-makers but little decisive action. The State of California passed a bill making it illegal to spawn, cultivate or incubate transgenic fish in Pacific waters under state jurisdiction. After the GloFish, a zebra fish with a coral gene that produces a red fluorescing protein, slipped through the federal regulatory gap when all three federal agencies stated it did not fall under their purview, California banned sales of GloFish under state laws governing transgenic fish (Lombardo & Bostrom, 2008). A 15-year effort by AquaBounty Farms to obtain USA Food and Drug Administration approval for their transgenic "AquAdvantage" salmon, making it the first genetically modified animal allowed into the country's food supply, remained stalled as of late 2012.

Certification

Consumer demand for fish products certified to be from sustainable fisheries has produced pressure for certified aquaculture products. In 2011, FAO's Committee on Fisheries approved publication of technical guidelines on aquaculture certification, setting minimum standards (FAO 2011c). The

[33] http://www2.gnb.ca/content/dam/gnb/Departments/nr-rn/pdf/en/Publications/FWB0192006.pdf

guidelines call on national governments to support capacity-building of fish producers for developing and complying with aquaculture certification systems.

Prominent aquaculture certification programmes include the Aquaculture Certification Council, GlobalGAP, the World Wildlife Fund's Aquaculture Stewardship Council, and Friends of the Sea. In addition, there are more than 20 certifying bodies for organic aquaculture products, including Naturland (based in Germany), Bio Suisse (Switzerland) and the Soil Association (England). In many of the schemes, the use of certain genetic technologies prohibits certification and most schemes have no special consideration for AqGR below the species level.

Ownership and benefit-sharing

All member countries of the CBD are required to put access and benefit-sharing laws in place, but progress has been slow. Although more than 50 countries have reported to the CBD secretariat that they have access and benefit sharing measures in place, some are little more than vague policy statements or address only a fragment of the issue (Greer & Harvey 2004). The following are some notable examples of components of national laws to date:

- Andean Community Decision 391 makes a clear distinction between genetic and biological resources, providing that while biological resources containing genetic components can be subject to private or collective property rights, genetic resources belong solely to the state.
- Brazil's Provisional Measure requires that the origin of genetic material and associated traditional knowledge be identified when applying for intellectual property rights but doesn't make clear whether states under its federal system have the right to regulate access to genetic resources within their borders; a series of draft bills on ABS have yet to be finalized.
- Canada has passed no laws or regulations regarding ABS, and although existing laws and policies have direct or indirect implications, there are no specific provisions about ownership of genetic resources.
- Costa Rica's biodiversity law provides that sovereignty over the genetic components of biodiversity rests with the state but recognizes separate rights over biological resources and requires prior informed consent by regional councils of Conservation Areas, farm owners or indigenous farmers for access in their territories, with agreement on benefits to be stipulated.
- Ethiopia distinguishes between ownership of genetic resources by the state and ownership of community knowledge vested in the concerned local community; its ABS law recognizes the right of local communities to regulate access to their community knowledge and to share in benefits arising from the use of their genetic resources and community knowledge.
- South Africa's Biodiversity Act provides a framework for regulation of access and benefit sharing, recognizes private ownership of genetic resources, and requires benefit-sharing arrangements for access to indigenous biological resources and for holders of knowledge (CBD secretariat 2007).

Polices and Legislation Relating to Habitat Alteration and Loss (including hydroelectric development and pollution)

Any factor impacting aquatic ecosystems will have the potential to impact AqGR at a variety of levels. Therefore the number of national policies and legislative frameworks relevant is extensive. Some general examples are given here, recognizing that they often do not apply specifically to AqGR at the genetic level.

Wetlands

Wetlands are crucial to the health of inland fisheries and freshwater biodiversity, yet more than half the world's wetlands have disappeared during the past century. The decline in freshwater wetlands and species can only be arrested with conservation and sustainable management at a large scale, often based on river basins (Pittock et al. 2006). In partial fulfilment of their Ramsar Convention

obligations, several countries (e.g. New Zealand, Australia, Philippines, China, Canada) have developed Wetland Action Plans (Ramsar Convention Secretariat 2007) to protect wetlands from conversion to other uses and from pollution, water diversion projects and other human-caused impacts.

Pollution

National governments constantly struggle to find effective and cost-effective solutions to chronic point source and increasingly prevalent non point source pollution of waters. As in the case of other drivers, the traditional "command-and-control" approach has had limited effect. In the USA, for example, water pollution is criminalized not only by the federal government but also by every state, yet pollution laws at both levels are widely disobeyed and universally under-enforced (Franz 2011). In many developing countries, the success of the command-and-control approach is hampered by lack of political will to allocate scarce resources to environmental protection and enforce environmental regulations. Some are now experimenting with alternative pollution control strategies that seek to leverage "informal" nonregulatory pressures for environmental quality, including those applied by communities, capital markets and consumers (Blackman 2010).

IWM and ICZM can provide an effective means of addressing the effects of nonpoint source pollution in watersheds. In the USA, the Chesapeake Bay Program – a partnership of federal, state and local governments – is a notable example of a cooperative approach to sustainable management of a large watershed. Chesapeake Bay is North America's largest and most biologically diverse estuary, in a 64,000-square mile watershed. The Chesapeake Bay Program has a particular emphasis on pollution control and restoration of aquatic habitat damaged by centuries of pollution (Wolflin 2008).

Strategies that have proven successful for pollution control in urban watersheds in developed countries may need to be adapted to local needs and capabilities in developing countries. NGOs have a played a central role in Costa Rica in the organization of multi-stakeholder Voluntary Environmental Agreements in which public or private parties commit to improve the environmental conditions in a watershed (Miranda et al. 2007). Phuong (2007) suggests that developing countries like Vietnam could gradually create new nonprofit organizations, mobilize existing social organizations (e.g., youth union, women's associations) to play similar roles, engage a university to organize the type of community watershed restoration projects organized by a university in Ho Chi Minh, and enhance community awareness of water pollution issues.

Water Diversion Projects and Hydroelectric Dams

The World Commission on Dams (WCD) was funded by the World Bank and IUCN with a mandate to review the development effectiveness of dams and develop standards and guidelines for future dams.

Several governments – including Germany, Nepal, South Africa, Sweden and Vietnam – are trying to integrate WCD recommendations into national policies.[34] An ecosystem approach that includes integrated watershed management planning offers one logical avenue for implementing the WCD recommendations.

Policy makers need to ensure that policy responses are informed by local economic, community, and ecological characteristics. Unfortunately, management of impounded river basins in many developing countries still follows models developed in North America, relying on strategies recommended by or adapted from foreign experts, paying little attention to local realities. Blind application of imported principles inevitably results in policy failures such as Brazil's law requiring fish-passage facilities, which failed to take into account local species requirements, leading in one instance to the construction of a fish ladder in a river lacking migratory species (Miranda 2001).

Polices and Legislation Relating to Introduction of non-native species

[34] http://www.internationalrivers.org/campaigns/the-world-commission-on-dams

Policies and legislation for non-native species need to address both deliberate, e.g. for fisheries, aquaculture and biological control, and accidental introductions, i.e. species introduced through ballast water or as fouling organisms. Only a small number of (primarily developed) countries routinely undertake remediation and controlling actions on introduced non-native fish. New Zealand is one of few countries to have enacted specific laws aimed at the comprehensive prevention and management of non-indigenous species: the 1993 Biosecurity Act, which seeks to manage unintentional introductions and sets standards for creating pre-border quarantine systems and post-border incursion response, and the 1996 Hazardous Substances and New Organisms Act, which focuses on intentional introductions of new species and genotypes and is enforced by the Environmental Risk Management Authority. Australia's approach is also comprehensive but operates under its federal system, with states having responsibility for managing introductions in their territorial seas, while national marine biosecurity operates under the 1906 Quarantine Act, with control and eradication covered by the 1984 Biological Control Act (Hewitt & Campbell 2007).

Polices and Legislation Relating to Climate Change

Approximately 50 least developing countries have developed National Adaptation Programme of Action to Combat Climate Change (NAPA) to address "urgent and immediate needs to adapt to climate change"[35]. Low-lying Bangladesh, already vulnerable to sea level rise associated with climate change, needs to address climate change now. In 2008 the national government implemented an integrated climate change strategy and action plan, setting aside a local fund of US $100 million for adaptation and mitigation under the aegis of the Ministry of Environment and Forests. As part of its climate change mitigation initiative, the government partnered with the Global Environment Facility and United Nations Development Programme to implement the Community-based Adaptation to Climate Change through Coastal Afforestation programme. Its purpose is to reduce the vulnerability of coastal communities to the impacts of climate change by planting forests, creating a natural barrier of primarily mangrove plantations, together with dykes and embankments. The project offers subsidies to vulnerable communities and attempts to diversify economic training to include forestry, fishing and farming, in addition to integrating aquaculture and food production within reforested and afforested plantations (Rawlani & Sovacool 2011).

Gaps in the National Legal and Policy Framework

The gaps at national level reflect those discussed above at the international level, with the addition of lack of awareness and local capacity to adapt international instruments to local conditions. The management of AqGR above the species level has benefited in recent years from international commitments to the precautionary approach and ecosystem approach, but efforts to implement these at the national level, and at levels below the species, frequently suffer from lack of capacity, inadequate scientific understanding, absence of political will, and lack of public awareness of the vital role AqGR could play in global food security. Another major problem is that responsibilities for management of AqGR are typically spread among a variety of government departments or levels of government that may not communicate effectively with one another.

A national strategy for the conservation and sustainable use of AqGR (as in Germany) can facilitate effective management by coordinating the focus of diverse government agencies, encouraging the development and sharing of scientific information, and raising public awareness about the social and economic value of AqGR and the importance of focusing conservation initiatives not only on aquatic biodiversity generally but also on the component of biodiversity that is genetic diversity.

The political will to manage for sustainability may be lacking due to the perceived economic implications for economically important sectors such as hydro-electric, agriculture, forestry and

1. [35] UNFCCC Database of NAPAs, http://unfccc.int/cooperation_support/least_developed_countries_portal/submitted_napas/items/4585.php

fisheries (Andresen et al. 2005). In 2012, for example, the government of Canada appeared to take a step back from the ecosystem approach by repealing a Fisheries Act prohibition of damage to fish habitat and replacing it with a provision requiring protection only of fish considered important for commercial, recreational or indigenous uses; overzealous protection of fish habitat was considered potentially damaging to agricultural and other economic interests.

Table 4.1: National policy approaches to conservation and use of aquatic genetic resources: a comparative overview.

Driver/ Issue	Policy Response	Country Examples	International Guidance / Standards
General Approaches (addressing multiple drivers)	Precautionary approach	– Biodiversity conservation laws (Costa, Rica, Ecuador, Peru) – General environmental laws (Argentina, Mozambique, Cameroon, South Africa, Australia, USA) – Fisheries: USA 1976 Magnuson-Stevens Fishery Conservation and Management Act; Australia risk assessment processes	1995 FAO Code of Conduct for Responsible Fisheries 2005-2012 FAO World Inventory of Fisheries. Precautionary approach to fisheries management.
	Ecosystem approach	– Fisheries: Benguela Current Large Marine Ecosystem Programme (Angola, Namibia, South Africa); EAF-Nansen Project (Norway supporting several African initiatives); USA 1976 Magnuson-Stevens Act – Oceans management: Australia 1998 National Oceans Policy; USA 2000 Oceans Act; Canada 1996 Oceans Act	FAO. 2003. Fisheries management 2. The ecosystem approach to fisheries. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2; FAO. 2012. EAF-Net. About the EAF Toolbox. In: FAO Fisheries and Aquaculture Department [www.fao.org/fishery/eaf-net/ topic/166272/en
	Integrated resource management planning	New Zealand 1991 Resource Management Act	
	Integrated coastal zone management		
	Marine spatial planning	China, Australia, Belgium, Norway, UK, EU marine spatial planning initiatives	
	Integrated watershed management planning	EU Water Framework Directive, Danube River Protection Commission (14 countries); Mekong River Commission (Cambodia, Lao PDR, Thailand, Vietnam); Lake Tanganyika Authority (Burundi, DR Congo, Tanzania, Zambia)	

	Community co-management	Vietnam IMOLA project; Cambodia Tonle Sap project; Malaysia Tagal System; Bangladesh new Fisheries Management Policy; Fiji family group management	
Fishing			
Overfishing	User rights	Pacific Community (22 Pacific island communities and territories) traditional marine tenure system Chile territorial use rights to fish (TURFs) individual transferable quotas (ITQs): Iceland, Australia, Canada, New Zealand, USA	
	Bycatch quotas	Fleet quotas (New Zealand, USA); vessel quotas (Canada)	
	Fisheries Certification	Mozambique fisheries ministry facilitation of MSC certification for shrimp fisheries Marine Eco-Label Japan (government certification)	FAO Marine Guidelines, 2005/2009; Inland Guidelines, 2011
	Traceability programmes	EU 2002 General Food Law traceability requirements Sweden's proposed RFID system to trace fish from capture to purchase	
	Marine protected areas	China policy to expand number and size of and improve management of marine nature reserves traditional seasonal bans(Palau, Vanuatu, Cook Islands, Tonga) MPA networks (Indonesia, Malaysia, Philippines, Timor-Leste, Papua-New Guinea, Solomon Islands) EU 2010 CDS to stem the flow of IUU-	FAO. 2011. Fisheries management. 4. Marine protected areas and fisheries. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 4.

		caught fish into the European market	
IUU fishing	Catch documentation scheme (CDS)	New Zealand 1991 Resource Management Act; Scottish Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Waters; German integrated coastal zone management	1995 FAO Code of Conduct for Responsible Fisheries, Article 9; 2008 FAO Aquaculture development: Genetic resource management; 2012 FAO Genetic resources and technologies in aquaculture development.
Aquaculture and Culture-based Fisheries	Aquaculture approval procedure	Environmental codes of practice and best management practices (USA, Chile, New Zealand, Ireland, Canada); Chinese promotion of rice-fish culture	2011 FAO. Technical guidelines on aquaculture certification
Siting, use of land and water	Operational requirements	Chile Integrated Management System (Salmon Chile); Scottish Salmon Producers' Organisation Code of Good Practice; Label Rouge (France); Thai Shrimp GAP; USA Food and Drug Administration certification pilot program for imported shrimp.	
Operational impacts	Aquaculture certification	Thailand promotion of Code of Conduct and Good Aquaculture Practices for hatcheries, and support for flexible small-scale hatcheries; Indian development of certification systems for hatcheries; public-private partnerships; *ex situ* gene banks	2007 FAO Assessment of freshwater fish seed resources for sustainable aquaculture
Quality seed supply	Promotion of reliable sources	California, USA, restriction under Sustainable Oceans Act of use of fishmeal as an aquaculture food supply; development of plant-based alternatives	2011 FAO Aquaculture Development: use of wild fish as feed in aquaculture
Feed supply (fishmeal and fish oil)	Regulation of use of wild fish as feed	Andean Community Decision 391; Brazil Provisional Measure; Costa Rica biodiversity law; Ethiopia ABS law; South Africa Biodiversity Act	CBD Bonn Guidelines; Nagoya Protocol

Access and benefit-sharing	ABS laws/policies	Control programmes: England, Wales, Australia; Kenya Lake Naivasha Management Plan Legislated quarantines / incursion responses: New Zealand 1993 Biosecurity Act, 1996 Hazardous Substances and New Organisms Act; Australia 1984 Biological Control Act	CBD 2002 COP VI : Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species
Genetic alteration	Controls mitigating impacts on wild fish	– Integration into national policies: Germany, Nepal, South Africa, Sweden, Vietnam – Maine, USA, complementary energy policy, rivers policy	UN Framework Convention on Climate Change. National Adaptation Programmes of Action.
Habitat alteration and loss	Wetland protection		
Water diversion / dams	World Commission on Dams framework proposal: assess risks, recognize rights	– Bangladesh Community-based Adaptation through Coastal Afforestation programme – National Mission for a Green India	
Introduced species		England and Wales 2009 Aquatic Animal Health Regulations	
Introduction of non-native species	Suppression / containment	New Brunswick, Canada, fish stocking policy California law prohibiting transgenic fish	2006 Ramsar Convention. A conceptual framework for the wise use of wetlands.
Movement of live fish	Control of pathogen introductions	Wetland Action Plans (New Zealand, Australia, Philippines, China, Canada) Wetland mitigation banking (USA)	FAO 2001 Dams, fish and fisheries: opportunities, challenges and conflict resolution.
Climate change	National action programmes		

V. CONCLUDING SECTION

The scoping policy analysis identified important drivers that will need to be addressed in international and national policies and legislative frameworks. Some of these drivers are being addressed currently at the species level and in some environments; however, there are very few policies or frameworks that address the drivers at levels of AqGR below the species level.

With the uncertainties of climate change and resulting change in environments and species' distributions, and the certainty of needing to provide about 9 billion people with food from fisheries and aquaculture by 2050, policies will need to be developed, implemented and enforced which directly address AgGR at levels below the species. The advances in genetic technologies, understanding of the role of genetics in breeding programmes and population ecology, and increased awareness of the importance of genetics in food production will assist in providing sound science on which to base these policies and frameworks.

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