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Stopping overexploitation of living resources on the high seas

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A B S T R A C T

This paper reviews the provisions and efforts to implement the 1946 International Convention for the Regulation of Whaling (ICRW) and the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). It illustrates progress and continuing challenges to stopping the overexploitation of living resources in high seas areas beyond national jurisdictions. Progress includes recognition that living organisms interact with each other and the environment in complex ways and that single-species management to attain maximum sustainable yield (MSY) fails to account for these interactions. Continuing challenges include data limitations that allow differing views concerning the adequacy and interpretation of the available data, and decision-making that allows a minority of the decision-makers to block adoption of regulatory measures that the majority believe necessary to meet the intent and provisions of the regulatory agreements. The provisions and continuing challenges to meeting the objectives of these two conventions should be considered in the formulation of future international high seas regulatory agreements such as the regime to govern fisheries in the central Artic Ocean as envisioned in the 16 year ban on commercial fishing there agreed in October 2018 by Canada, Denmark (for Greenland), Iceland, Russia, Norway, the United States, the European Union, Japan, China, and South Korea.

1. Introduction

Ocean areas outside national jurisdictions constitute a global commons where both living and non-living resources can be exploited with no limits unless legally binding and enforceable agreements are in place to provide regulation, and the countries with relevant involvement are parties to the agreements. Before and since the end of World War II, multiple international agreements have been instituted to regulate fisheries and other activities in these areas [1]. In the following sections the provisions and continuing efforts to implement the 1946 International Convention for the Regulation of Whaling and the 1980 Convention on the Conservation of Antarctic Marine Living Resources are compared to illustrate the advances that have been made and the continuing challenges to stopping the overexploitation of marine living resources in areas beyond national jurisdictions. Both the advances and continuing challenges should be considered in the formulation of future agreements to regulate fisheries and other activities in areas beyond national jurisdictions.

2. The International Convention on the Regulation of Whaling (ICRW)

Efforts to regulate pelagic whaling began in the 1920s [2,3]. The current era began with the signing in December 1946 and entry into force in November 1948 of the ICRW. The stated objective of the Convention is to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry. The Convention established the International Whaling Commission (IWC) and a Schedule containing agreed regulatory measures. It provides that the Schedule can be amended by a 3/4^{ths} majority vote of the IWC members. It also provides that members who object to amendments within 90 days of their adoption are not bound by them. It did not provide for limiting the number of factory ships or catcher boats that could be employed in the industry, or allocating agreed catch quotas among the whaling nation members or their whaling fleets.

2.1. The evolution of the IWC's regulatory process

The IWC met for the first time in September 1949. The Blue Whale Unit (BWU), which had been established previously to control production of whale oil following the record catches in the Antarctic in 1930–31, was used from its start-up until 1972 as the basis for establishing catch limits [4,5]. The BWU was the amount of oil obtained from an average blue whale (*Balaenoptera musculus*), and the estimated equivalent from two fin whales (*B. physalus*), two and a half humpback whales (*Megaptera novaeangliae*) and six sei whales (*B. borealis*). Market prices were high following World War II and pressure from the whaling industry led to higher and higher catch limits being set. The catch limit for 1959–60, for example, was set at 17,600 BWUs, meaning that as many as 17,600 blue whales, 35,200 fin whales, 44,000 humpback whales, 105,600 sei whales, or some combination of the four could be taken [3].

The whaling fleets raced to get the largest share possible of the authorized catches, principally in the Antarctic. Most fleets were primarily interested in oil and preferentially searched for and took the larger blue, fin and humpback whales. Consequently, Antarctic stocks

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of blue and humpback whales that had been overexploited before WW II were further depleted and overexploitation of fin and sei whales soon followed [5–8].

Recognizing its failure to prevent overexploitation, the IWC in 1961 appointed a three-person group of fishery biometricians, later expanded to four, to conduct an assessment of the status of the exploited Antarctic whale stocks and to recommend measures to restore and maintain them at sustainable take levels. In their reports [9,10], the group provided analyses indicating the precarious status of the Antarctic blue and humpback whale stocks, and recommended a moratorium on taking from those stocks. The group also noted the need for more reliable information on the demography and dynamics of all exploited stocks, and recommended adoption of the fishery management concept of maximum sustainable yield (MSY) to replace the BWU and establish catch levels for individual stocks. In partial response to the recommendations, the IWC established moratoria in 1963 and 1964, respectively, on the taking of humpback and blue whales in the Antarctic. However, the necessary 3/4th majority of members could not agree on establishing catch limits for individual stocks.

Because of the IWC's continuing failure to prevent the overexploitation of stocks of large whales, the participants in the 1972 United Nations' Stockholm Conference on the Human Environment called for a ten year moratorium on all commercial whaling. Although some IWC members agreed that a moratorium was merited, the necessary 3/4th majority did not. However, in 1974 the IWC adopted what was called the *New Management Procedure* whereby catch limits were to be established for individual stocks based on their status relative to their estimated MSY levels, thought then to be 60% of their pre-exploitation sizes.

Each exploited or potentially exploited stock was to be assigned to one of three groups based on their estimated existing sizes relative to their estimated MSY sizes: (1) *Sustained Management Stocks* whose estimated existing sizes were between 10% below and 20% above their estimated MSY levels; (2) *Initial Management Stocks* whose estimated existing sizes were more than 20% above their estimated MSY levels; and (3) *Protected Stocks* whose estimated sizes were 20% or more below their estimated MSY levels. No takes from *Protected Stocks* were to be allowed to enable them to recover as fast as possible to their estimated MSY levels. Catch levels for *Sustained* and *Initial Management Stocks* were to be set respectively to maintain them at and to bring them to their estimated MSY levels [8,11].

It was thought that the new procedure would prevent further overexploitation and enable recovery of depleted stocks [12]. However, the procedure did not work as expected. The principal reasons for the failure were (1) the MSY levels for whale populations likely were higher than the assumed 60% of their pre-exploitation sizes; (2) the available life history, demographic and productivity data were insufficient to indisputably determine the current, pre-exploitation, and MSY levels of the various stocks, which in turn led to disagreements concerning the adequacy and interpretation of the available data; (3) the disagreements forced the IWC members to seek compromise “middle-ground” assessments of existing and MSY stock sizes and productivity levels to achieve the 3/4th majority necessary to establish catch limits; and (4) from the late 1950s to the early 1970s, the former Soviet Union substantially under reported its whaling fleets’ annual catches, and both allowed and did not report catches of protected right (*Eubalaena* spp.), blue and humpback whales [13–16].

Also, by the mid-1970s awareness was growing that living organisms interact with each other and their physical environment in complex ways and that single species MSY management fails to account for possible adverse effects on other species and their associated food webs [17]. Additionally, a number of the IWC's member countries had stopped whaling and there had been an influx of new members with little or no interest in commercial whaling. Consequently, in 1982 the necessary 3/4th majority of the IWC members agreed on a commercial whaling moratorium, pending completion of a comprehensive assessment of the status of the exploited stocks and development of a more effective regulatory regime. The moratorium entered into force in 1986.

The IWC's Scientific Committee subsequently completed the required status-of-stocks assessments and recommended a *Revised Management Procedure* (RMP). With minor revisions, the recommended RMP was adopted by the Commission in 1995 [8]. However, it has not been possible to reach agreement on an observer and inspection system to ensure compliance with the take levels that would be authorized by the RMP. Also, some IWC members are now opposed to resumption of commercial whaling. Consequently, it has not been possible for the necessary 3/4th majority of the IWC members to agree on resumption of commercial whaling and the moratorium remains in effect.

Three IWC members have continued to authorize their nationals to conduct limited whaling in accordance with provisions of the ICRW. Norway, which objected to the moratorium following its adoption, is not bound by it and authorizes its nationals to take small numbers of minke whales (*B. acutorostrata*) in the North Atlantic for commercial purposes. Iceland, which withdrew from and later rejoined the IWC, filed a reservation to the moratorium when it rejoined and authorizes its nationals to take small numbers of minke and fin whales in the North Atlantic for commercial purposes. Japan, which initially filed an objection to the moratorium but subsequently withdrew it, has issued permits pursuant to Article VIII of the ICRW authorizing its nationals to take specified numbers of minke whales and other species in the Antarctic and North Pacific for purposes of scientific research. Japan also authorizes its nationals to sell the meat and other products from those whales in Japanese markets.

Much of what is known about the current abundance and trends of minke and other whales in the Southern Ocean has been provided by sighting surveys carried out by Japan and others as part of the IWC's International Decade of Southern Ocean Cetacean Research [18–21]. However, the killing of whales authorized by Japan for research purposes has generated considerable controversy because much of the resulting data could be obtained using non-lethal means [22–26]. Consequently, in 2013 Australia challenged Japan in the International Court of Justice (ICJ) arguing that Japan's authorization of lethal taking served no legitimate scientific purpose. The court found that the permits being issued by Japan were not for purposes of scientific research as authorized by Article VIII of the ICRW [27]. Although it was expected that Japan would stop issuing permits for research whaling, it has continued doing so in accordance with a revised scientific whaling program established in 2015 [28,29]. From 8 December 2017 to 28 February 2018, Japanese whalers took 333 minke whales in the Antarctic, including 181 females, 95% of which were pregnant [30].

In December 2018, Japan announced that it was withdrawing from the IWC, would authorize resumption of commercial whaling in its coastal exclusive economic zone, and would no longer issue permits to its nationals to take whales in the Antarctic for research purposes.

2.2. Regulation of subsistence whaling by indigenous (aboriginal) peoples

Both live and dead whales and other marine mammals have been hunted for food, oil and other useful products for thousands of years by indigenous peoples living in and near marine coastal areas. Historically, the number of live whales killed was limited by the needs of the small and dispersed indigenous whaling communities and the ability of the whalers to venture far from shore and to successfully approach and kill whales using paddled wooden or hide-covered boats and hand-thrown harpoons with stone or bone tips. It therefor was unlikely that such subsistence whaling had significant effects on the size or productivity of the affected species or populations. Consequently, the 1946 ICRW continued in its Schedule of regulations a provision of its predecessor, the 1931 Geneva Convention for the Regulation of Whaling, that prohibited the taking of all protected right whales, including bowhead whales (*Balaena mysticetus*), that had been severely depleted by

commercial whaling, except when the meat and products from such whales would be used exclusively for local consumption by aborigines [31].

The constraints on aboriginal subsistence whaling were subsequently reduced by use of modern technologies (e.g., larger boats with motors, rifle fired harpoons with exploding heads) that allowed the whalers to travel farther and faster to find whales, to approach and kill them more effectively, and to take more whales. In 1977, the IWC terminated the Schedule exemption for aboriginal subsistence whaling following concerns expressed by the Scientific Committee that increasing takes of bowhead whales by Alaska Eskimo whalers were increasing the risk of extinction of the severely depleted Western Arctic bowhead population [32]. Subsequently the IWC adopted and inserted in the Schedule paragraph 13 establishing principles for setting catch limits for aboriginal subsistence whaling and listing the catch limits agreed to meet aboriginal subsistence needs while minimizing the extinction risk of populations depleted by commercial whaling. Paraphrased, the principles listed in paragraph 13(a) (1–5) direct that:

1. Aboriginal subsistence catches shall be permitted from stocks at or above their MSY level so long as total removals do not exceed 90% of MSY;
2. For stocks below their MSY level, but above a certain minimum level, aboriginal subsistence catches shall be permitted so long as they are set to allow the stocks to increase to their MSY level;
3. Catches and the status of stocks subject to subsistence whaling shall be kept under review by the Scientific Committee;
4. Striking calves or whales accompanying calves is prohibited; and
5. All aboriginal whaling shall be conducted under national legislation that accords with the above listed principles.

Agreed catch limits for subsistence whaling in the United States, Russia, Greenland, and Bequia are listed in paragraph 13(b) (1–4) of the Schedule. For additional information on catch limits see Ref. [33].

The subsistence whalers and their national governments are responsible for documenting subsistence and traditional cultural requirements and providing to the IWC's Scientific Committee the information needed to determine catch levels that both meet those requirements and do not cause the affected whale stocks to be reduced or maintained below their MSY levels (for an example of information provided in such submissions, see Ref. [34]). The Scientific Committee has developed and uses catch limit algorithms to determine and advise the Commission of catch levels that meet the paragraph 13(a) principles, taking into consideration uncertainties concerning the reliability of the submitted documentation and other available information.

There are differing views within the IWC concerning what constitutes aboriginal subsistence whaling and the requirement that the resulting products be used locally exclusively for non-commercial purposes [35]. There appears to be no doubt, however, that the regulation of subsistence whaling is meeting the aforementioned principles set forth in paragraph 13 (a) of the Schedule.

2.3. Expansion of the IWC's cetacean conservation efforts

In recent years it has become increasingly evident that whales play important functional roles in marine ecosystems [36–40]. There also has been growing awareness that commercial whaling is not the only threat to whales [41–43] and that the profits from commercial whale watching may be as great or even exceed those from whales killed for commercial purposes [44–46]. Therefore, the IWC and its Scientific Committee have begun in recent years to expand their whale conservation efforts to include consideration of the threats to whales and marine ecosystems posed by such things as climate change, anthropogenic noise and other environmental pollutants, ship strikes, entanglement in fishing gear, diseases, and fisheries competing with whales for the same prey species [47]. Further, there have been substantial improvements in research methods and partnerships. In 2009, for example, 12 IWC members formed the Southern Ocean Research Partnership (IWC-SORP) to cooperatively gather demographic, life history, movement and behavioural data on Southern Ocean whales using a variety of innovative non-lethal means [48–50].

2.4. Uncertainty concerning the future of the ICRW

It is not apparent what will happen following Japan's withdrawal from the IWC. One possibility would be for the necessary 3/4th of IWC members to agree on resumption of commercial whaling in accordance with the *Revised Management Procedure* with or without special conditions (for example, that the moratorium will automatically be reinstated after a specified number of years if there is not indisputable evidence that the authorized take levels are sustainable, not being exceeded, and not having adverse ecosystem effects), and Japan rejoining the Commission. Other possibilities could include *inter alia* failure of the necessary 3/4th majority to agree to resumption of commercial whaling, indefinite continuation of the moratorium on commercial whaling, one or more additional IWC members withdrawing from the ICRW and allowing their nationals to resume commercial whaling in accordance with national regulations, and those countries with a continuing interest in commercial whaling establishing a separate international body with restricted membership to regulate whaling.

3. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)

The CAMLR Convention was one of the first manifestations of the *New Principles for the Conservation of Wild Living Resources* [17], which state on pages 14 and 15 that:

The privilege of utilizing a resource carries with it the obligation to adhere to the following four general principles:

1. The ecosystem should be maintained in a desirable state such that
   a. Consumptive and non-consumptive values could [can] be maximized [optimized] on a continuing basis,
   b. Present and future options are ensured, and
   c. Risk of irreversible change or long-term adverse effects as a result of use is minimized;
2. Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect;
3. Measures to conserve a wild living resource should be formulated and applied so as to avoid wasteful use of other resources; and
4. Survey or monitoring, analysis, and assessment should precede planned use and accompany actual use of wild living resources. The results should be made available promptly for critical public review.

The establishment of CCAMLR was rooted in the whaling problem. That is, the depletion of Antarctic stocks of krill-eating whales had led in the 1960s to the *Krill Surplus Hypothesis* that there were hundreds of thousands of tons of Antarctic krill (*Euphausia superba*), previously eaten by baleen whales in the Southern Ocean, that could be taken for human uses [51–53]. At the same time, many fishery resources in more accessible areas had been overfished, and many coastal states were stopping foreign vessels from fishing within 200 nautical miles of their coasts in accordance with provisions of the United Nations' Law of the Sea Convention (UNCLOS) then being finalized. In response, in the late 1960s and the 1970s the former Soviet Union subsidized fisheries for both krill and finfish in the Southern Ocean and Japan began exploratory fishing for krill [54,55].

In addition to being the principal prey of several baleen whale species, Antarctic krill is the principal prey of crabeater seals (*Lobodon carcinophagus*) and several species of penguins, flying birds, fish and squid. Some of these in turn are the principal prey of higher trophic level species such as leopard seals (*Hydruga leptonyx*), killer whales

(*Orcinus orca*), and sperm whales (*Physeter macrocephalus*) [56,57]. Therefore, if not regulated effectively, the krill fishery could adversely affect these species as well as prevent or impede recovery of the depleted stocks of krill-dependent whales.

3.1. The formulation of CCAMLR

The Antarctic Treaty Consultative Parties (ATCPs) recognized that unregulated krill fishing could have adverse effects on both the krill resource and ecologically associated species and populations. In 1975 they requested (ATCM Recommendation VIII-10) that the Scientific Committee on Antarctic Research (SCAR) provided them an assessment of the available knowledge, on-going research, and critical uncertainties concerning the role of Antarctic krill in the Antarctic marine ecosystem. SCAR's response was provided to the ATCPs in 1977 [58]. At the ATCM later in 1977, the ATCPs adopted Recommendation IX-2, which, among other things, called for the establishment, as a matter of priority, of a definitive regime for the conservation (wise or rational use) of Antarctic marine living resources.

Australia subsequently offered to host a Special Consultative Meeting (SCM) to elaborate the regime. The offer was accepted and the first session of the SCM was held in Canberra, 27 February – 17 March 1978. A second session was held in Buenos Aires, 17–28 July 1978, and following several rounds of informal discussions, the concluding session was held in Canberra, 7–20 May 1980, at which the CAMLR Convention was signed. The Convention entered into force in April 1982 following ratification by eight (half plus one) of the 15 original signatories.

Also, in response to the recommendations in Ref. [58], several ATCPs provided funding and ship support for a research program titled *Biological Investigations of Marine Antarctic Systems and Stocks* (BIOMASS), the history, organization and accomplishments of which are described in Ref. [59]. Among other accomplishments, broad-scale acoustic surveys conducted in 1980/81 provided information on the distribution and abundance of Antarctic krill in the Scotia Sea and off the West Coast of the Antarctic Peninsula, a data set that subsequently was used by the CAMLR Scientific Committee as the baseline for assessing the status and allowable take of Antarctic krill.

3.2. Similarities and differences between the ICRW and CCAMLR

The CAMLR Convention is similar to and differs from the ICRW in a number of ways. One similarity is that it established and indicates the functions of a regulatory body (the Commission for the Conservation of Antarctic Marine Resources) and a scientific advisory body (the Scientific Committee for the Conservation of Antarctic Marine Living Resources). The most significant difference is that the CAMLR Convention is intended to be a marine ecosystem conservation agreement, not a MSY fishery management agreement. This distinction is made clear in the Preamble and in Articles I and II of the Convention.

The first paragraph of the Preamble references the Contracting Parties' recognition of the importance of safeguarding the environment and protecting the integrity of the seas surrounding Antarctica. Article I defines Antarctic marine living resources as all living organisms and their interactions with each other and the physical environment in the area south of the Antarctic Convergence (now referred to as the Antarctic Polar Front). Article II(1) states that "[t]he objective of this Convention is the conservation of Antarctic marine living resources" – that is, the conservation of all living organisms and their interactions with each other and the physical environment in the marine ecosystem (s) south of the Polar Front.

To make it clear that the Convention was not intended to exclude appropriately precautionary or rational use of living resources in the Convention Area, Article II(2) states that "[f]or the purposes of this Convention, the term 'conservation' includes rationale use." Article II (3) then provides principles of conservation for deciding what constitutes rational use. It states that –"[a]ny harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation;

(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;
(b) maintenance of the ecological relationships between the harvested, dependent and related populations of Antarctic marine living resources and restoration of depleted populations to levels defined in subparagraph (a) above; and
(c) prevention of changes or minimization of the risk of changes which are not potentially reversible over two or three decades [an approximation of a human generation], taking into account the state of knowledge of the direct and indirect impact of harvesting, the effect of introduction of alien species, the effects of associated activities on the marine ecosystem and the effects of environmental change, with the aim of making possible the sustained conservation [not yield] of Antarctic marine living resources [and therefore maintaining the fullest possible range of management options for future generations]".

Another significant difference from the ICRW is that the CAMLR Convention provided in Article XXIV for the establishment of an observation and inspection system to ensure compliance with conservation measures adopted by the Commission. The system that has since been developed, and is regularly reviewed and updated, includes (1) licensing and inspection obligations of the contracting parties with regard to their flag vessels fishing in the Convention Area (see for example CCAMLR Conservation Measure (CM) 10-02 (2015)); (2) requirements for placement of non-flag state scientific observers on vessels fishing in the Convention Area (the CCAMLR Scheme of International Scientific Observers (SISO)); (3) an automated satellite-linked Vessel Monitoring System (VMS) to track the real-time movements of contracting party vessels fishing in the Convention Area (see for example CM 10-04 (2015)); (4) a catch documentation system to detect illegal, unreported and unregulated (IUU) catches of toothfish (*Dissostichus spp.*) by requiring documented tracking of legal catches from the fishing vessels to markets (see for example CM 10-05 (2016)); and (5) establishment of a Standing Committee on Implementation and Compliance.

A significant difference is that, while the ICRW requires 3/4th of the IWC members to agree to changes in the regulatory Schedule, the CAMLR Convention requires the consensus of all the Commission members to agree or revise conservation measures. Like the ICRW, CCAMLR provides that conservation measures will not be binding on members that notify the Commission within 90 days that they are unable to accept them. However, there are no indications in the Commission's meeting reports that this "opt-out" provision has ever been used, possibly because consensus decision-making enables a single Commission member to block adoption of conservation measures to which they object. Like the ICRW, the CAMLR Convention does not provide for limiting the number of vessels that can fish in the Convention Area or allocating authorized catch levels among the member countries or their fishing fleets.

Article VI of the CAMLR Convention states that "[n]othing in this Convention shall derogate from the rights and obligations of Contracting Parties under the International Convention for the Regulation of Whaling and the Convention for the Conservation of Antarctic Seals." The parties to those conventions are responsible respectively for regulating commercial whaling and regulating possible future commercial sealing in the CCAMLR Area. The CAMLR Commission is responsible for ensuring that fishing and associated activities in the Convention Area do not cause any species or population of Antarctic marine living resources, including whales and seals, to be

reduced or maintained below the level specified in Article II(3) (b). Although it is not clear from publicly available documents precisely what is being done, it is evident from their meeting reports that the IWC, the CAMLR Commission, and their respective scientific committees recognize that they must work cooperatively to meet their related responsibilities.

3.3. On-going efforts to meet CCAMLR's ecosystem conservation objective

Actions and the rationale for actions taken by the CAMLR Scientific Committee from the mid-1980s to the early 2000s to provide scientifically justifiable advice to the Commission on measures needed to meet the Convention's ecosystem conservation objective are reviewed in Refs. [55,60]. Among other things, they indicate that –

- There were no precedents for (a) the Convention's ecosystem conservation objective or its principles for deciding what constitutes rational use of living resources in the Convention Area, or (b) means for meeting the ecosystem conservation objective and complying with the Article II(3) conservation principles;
- The available data on ecosystem structure and dynamics were insufficient to reliably determine the numerical and functional relationships between target, dependent and related species and populations;
- Consensus decision-making makes it difficult to get agreement on needed conservation measures when there are uncertainties and possible different interpretations of the available data;
- In 1985, an ecosystem monitoring program was initiated to detect the possible effects of the krill fishery on representative colonies of pupping and nesting krill-dependent seals and birds in areas off the west coast of the Antarctic Peninsula and South Georgia Island where most of the fishery was occurring;
- One of the regulatory objectives is to assure that fisheries develop no faster than the acquisition of data needed for effective regulation; and
- In the 1990s, decision rules (described later) were developed to provide practical means for dealing with uncertainty.

It is clear from these reviews that there has been significant progress in efforts to meet the Convention's ecosystem conservation objective and apply the Article II(3) conservation principles. As noted below however, there now are conflicting interpretations of Articles I and II of the Convention. Also as noted below, it is questionable whether (1) new finfish fisheries are not being allowed to develop faster than the acquisition of data needed for effective regulation, and (2) the data, models and decision rules being used by the Scientific Committee to provide advice to the Commission on allowable take levels for toothfish (*Dissosticus* spp.) are actually precautionary with respect to the Article II (3) conservation principles.

3.4. Conflicting interpretations of CCAMLR Articles I and II

As pointed out in Refs. [61,62], when the Convention was concluded in 1980 there were no indications of dissent by any of the 15 original signatories that (1) the singular objective of the Convention was the maintenance of the integrity (structure and dynamics) of the Southern Ocean ecosystem as defined in its Article I, (2) Article II(2), indicating that, "[f]or the purposes of this Convention the term 'conservation' includes rational use," was meant to make it clear that the term conservation was not to be interpreted as a prohibition on the rational use of marine living resources in the Convention Area, and (3) rational use was to be determined using the principles of conservation provided in paragraph 3 of Article II. However, since then, 10 more countries have accede to the Convention and beginning in the 1990s, Article II(2) appears to have been interpreted to mean that ecosystem conservation and rational use of marine living resources should be given separate and equal consideration.

This alternative interpretation is reflected in the section of the CCAMLR website (ccamlr.org) titled "Fisheries," in parts of [55,60], and in a number of conservation measures regarding marine protected areas (MPAs). That is, the section of the CCAMLR website titled *Fisheries* states that - "… fisheries in the Convention Area are managed using the ecosystem-based and precautionary approach, and management objectives which balance conservation and rational use of living resources …. "

Similarly [55], states (pp. 2335–2336) that Article II(3) provides, among other things, for "balancing conservation with the needs for rational use." CM 91-04 (2011) establishing the general framework for the establishment of MPAs in the Convention Area and CM 91-05 (2016) establishing the Ross Sea Region MPA likewise include objectives providing for balancing conservation and rational use of marine living resources.

The two CMs also contain provisions that arguably are inconsistent with the Article I ecosystem conservation objective of the Convention. That is, they provide for protecting representative examples of marine ecosystems rather than the maintenance of the integrity of the Southern Ocean marine ecosystem[s] as a whole. In this regard, it should be noted, as pointe out in Ref. [61], that establishing MPAs would do nothing to maintain the biodiversity and ecological processes in the Convention Area unless there was reason to believe that the Article 1 ecosystem conservation objective of the Convention was not being met. As indicated in the following sections concerning fishery management, there are reasons to question whether the ecosystem conservation objective of the Convention is being met. Also, while at least some of the questions no doubt could be answered by the establishment and implementation of appropriately focused MPAs, it is at best questionable, as indicated in Refs. [63–66], whether effort to date to establish and implement MPAs in the Convention Area will do much to assure that the ecosystem conservation objective of the Convention is being met.

In retrospect, the differing interpretations and the consequences of the differing interpretations of Articles I and II of the Convention could have been avoided, with no change in their intent, if the convention had been titled the "Convention for the Rational Use of Antarctic Marine Living Resources" rather than the "Convention on the Conservation of Antarctic Marine Living Resources" and thus eliminating the need to include Article II(2) indicating that the term "conservation" was not meant to prohibit rational use of marine living resources in the Convention Area.

3.5. The Antarctic krill fishery

The development of the Antarctic krill fishery and efforts to ensure that it develops no faster than the acquisition of information needed to ensure that it complies with the Article II(3) conservation principles are reviewed progressively in Refs. [55,67,68]. Among other things they indicate that:

- Although some exploratory fishing has occurred and is occurring elsewhere, to date the fishery has occurred almost exclusively off the west coast of the Antarctic Peninsula and in the Scotia Sea (Statistical Subareas 48.1–48.4), believed to encompass the primary spawning area and distributional range of *Euphausia superba;*
- A CCAMLR Ecosystem Monitoring Program (CEMP) [69]was established in 1985 to detect the possible effects of the krill fishery on representative pupping and nesting colonies of krill-dependent seals and birds adjacent to the areas being fished;
- Subsequent actions have included establishment of:
  (1) a Working Group on Ecosystem Monitoring and Management (WG-EMM) to assess and provided advice to the Scientific Committee and Commission on measures needed to meet the ecosystem conservation objective of the Convention; [there should be a subparagraph break here so that (2) occurs between

1 and 2] (2) a precautionary 630,000 metric ton (mt) catch limit (cap) on the total allowable catch in Statistical Subareas 48.1–48.4 pending development of more reliable information on the distribution, abundance and productivity of the krill resource and its role in food web dynamics;
(3) area-specific allocation of parts of the authorized catch quotas to limit the likelihood of adversely affecting krill abundance in the offshore foraging areas of pupping and nesting colonies of krill-dependent seals and birds;
(4) a decision rule described later to provide practical means for determining precautionary catch limits;
(5) a scientific observer program to ensure collection of reliable information on fishing methods, locations, and catches; and
(6) on-going efforts to (a) use fishing vessels to augment distribution and abundance data obtained from synoptic acoustic surveys conducted in 1980 and 2000 [59,77], and (b) develop a feed-back system to minimize the risk of adversely affecting the food web of which Antarctic krill is a keystone species (for details see the annual meeting reports of the CAMLR Commission, Scientific Committee, and their subsidiary working groups);

The referenced review papers also indicate that -

- Since the mid-1980s the total krill catch has averaged about 210,000 mt per year, less than 1% of the 665 million mt biomass estimate before initiation of the fishery;
- The fishery did not grow as fast as expected when CCAMLR was concluded in 1980, due to the cost of fishing in the Southern Ocean and the failure of expected development of markets for products for human consumption. However, in recent years market demand by the global fish farming, fish meal, and pharmaceutical industries has been increasing. See also [70–72];
- On-going increases in air and water temperatures due to climate change are causing decreases in seasonal sea ice important to the survival of the larval and juvenile stages of Antarctic krill and enabling fishing to occur further south and during the winter where it previously had been blocked by sea ice. See also [73–76];
- The results of the aforementioned acoustic surveys carried out in 1980 - 81 as part of the BIOMASS research program before the CCAMLR entered into force [59] and in 2000 [77] have provided the principal fishery-independent baseline information concerning the distribution and abundance of Antarctic krill; and
- Although contentious, the lack of more regular systematic collection of fishery-independent distribution and abundance data has led to the supposition that climate change has caused a 38%–80% decline in the distribution and abundance of krill in the southwest Atlantic (See also [78] which indicates that, although the CAMLR Commission and Scientific Committee recognize that the effects of climate change may necessitate changes in the management of the krill and other fisheries, they have not yet determined or initiated the research and monitoring that will be required to make those determinations in a timely manner)..

The Scientific Committee was aware when the CEMP was developed that baleen whales and crabeater seals were major krill predators likely to be impacted if the krill fishery was not regulated effectively. However, because of their pelagic and pack ice habitats, and absence of remote assessment technologies, it would have been prohibitively costly at that time to include them in the CEMP. However, as shown by Refs. [79,80] and the IWC's SORP described earlier [48], the technologies now exist to asses and monitor the movements, feeding behaviour and body condition of krill-dependent whales using satellite-linked radio tags, recoverable data loggers and video cameras, drones, photogrammetry, and passive acoustic monitoring. The IWC and CAMLR Commission have related responsibilities in this regard and, while not certain, presumably are working cooperatively to support monitoring of krill-dependent whales whose recovery and maintenance near their maximum net productivity levels (MNPLs) could be impacted by increasing krill catches.

Also, satellite imagery has shown promise for assessing and monitoring the distributions and abundance of Weddell seals (*Leptonychotes weddellii*) and penguins in remote areas of the Antarctic [81–83]. This capability could provide a cost-effective means for assessing the effects of the krill fishery on the distribution and abundance of crabeater seals and penguins in remote areas.

3.6. Finfish fisheries

Before the CCAMLR was established, several finfish species in the Southern Ocean had already been overfished. The status of those stocks were assessed by the Scientific Committee in the early 1980s, found to be severely depleted, and led the Commission to adopt conservation measures to prevent further overharvesting and enable the stocks to recover [55]. However, more than 30 years later, at least two of the stocks have not recovered sufficiently to allow resumption of the fisheries [84,85].

After CCAMLR entered into force, increased demand for Patagonian toothfish (*D. eleginoides*), sold as Chilean sea bass in up-scale markets and restaurants in a number of countries, led to expansion of fishing for that species further south, principally around the low latitude islands of South Georgia, Heard, Crozet and Kerguelen, where the sovereignty of several nations over 200 mile exclusive fishing zones extending into the CCAMLR Area are recognized. Management of fisheries in those areas therefore is done cooperatively with the respective sovereign nations in accordance with CCAMLR Article XI. In the mid-1990s, a fishery for Antarctic toothfish (*D. mawsonii*), also sold as Chilean sea bass, was initiated in the Ross Sea. As pointed out later, it has been questioned whether management of that fishery is appropriately precautionary with respect to the Article II(3) principles for deciding what constitutes rational use.

3.7. The decision rules for krill and finfish

The section on the CCAMLR website titled *Setting catch limits* describe the decision rules developed and used by the Scientific Committee with simulation models to provide advice to the Commission on allowable take levels for krill and finfish. The central tenet of the decision rule regarding Antarctic krill is that limiting the authorized take level to no more than 25% of its estimated pre-exploitation biomass will enable 75% escapement which will allow the suite of krill-dependent whales, seals, birds and fish to be restored to and/or be maintained at or near their MNPLs as called for in CCAMLR Article II(3) (b). The central tenant of the decision rule regarding finfish is that, unlike krill, there is no reason to believe that there are any dependent or ecologically associated species or populations that could be affected adversely by those fisheries and that they therefore can be managed for MSY by establishing constant catch levels that will cause the spawning biomass of the targeted species and populations to be reduced to 50% of their pre-exploitation levels over 35 years.

For neither krill nor finfish were their pre-exploitation distributions, abundance and productivity known or determined before the fisheries began. Further, the 75% escapement level for krill was chosen arbitrarily [55] and therefore may or may not allow sufficient escapement to enable restoration and/or maintenance of the suite of krill-dependent predators at or near their MNPLs as called for by CCAMLR Article II(3) (b). Likewise, there is no indication whether the 50% MSY level for finfish was chosen arbitrarily, based on an assumption that the MSY for all finfish occurs at 50% or less of their pre-exploitation levels, or based on assessments of the likelihood that, if the fisheries are terminated for any reason, the species and populations being fished would recover to their pre-exploitation levels in 20–30 years as called for in CCAMLR Article II(3) (c).

On a related matter, there is no indication in the meeting reports of the Commission or Scientific Committee that the Committee has advised the Commission of the uncertainties and assumptions inherent in the decision rules and in the data and models that it uses to provide advice on allowable take levels believed to be appropriately precautionary with respect to the Article II(3) conservation principles. Likewise, there are no indications in the meeting reports that the Commission has been advised of the data limitations, the possible consequences if the assumptions are not valid, or the research and monitoring that would be required to resolve the data limitations and validate the assumptions. If this is in fact the case, the Committee in effect is making the allowable take determinations and the Commission cannot be held accountable if its authorizations of allowable takes fail to comply with the Article II(3) conservation principles and allow the targeted fishery resources to be depleted with corresponding adverse ecosystem effects.

Also, contrary to the assumption that no predator, prey, or ecologically associated species could be affected by finfish fisheries, there is growing evidence indicating that at least several marine mammal species could be affected by and be affecting the Patagonian and Antarctic toothfish fisheries [86–88]. Also, for reasons that are not evident, the CEMP has not been expanded to include assessment and monitoring of these and other species and populations possibly being affected by the fishery.

3.8. Transparency concerning claimed precautionary management

Much of the data, analyses and supporting documentation used by the Scientific Committee and its working groups to provide advice to the Commission on allowable catch levels are not available to the public or outside scientists for independent assessment. Some of the data, such as precisely where, when, what and how individual boat captains deploy fishing gear, may have proprietary economic values and appropriately are not made public except in summary form. However, data, analyses, and conclusions contained in papers submitted to the Committee, Commission, and their subsidiary working groups for consideration in their decision making processes also are considered proprietary. They cannot be obtained by the public and outside scientists except by requesting them from the originating countries, organizations, or individuals who can refuse to provide them or place conditions on their use.

Because of the lack of transparency, it has been questioned whether the management of at least the Antarctic toothfish fishery in the Ross Sea region is actually precautionary with respect to the Article II(3) conservation principles. At its 2013 meeting, the Scientific Committee's Working Group on Fish Stock Assessment (WG-FSA) received for consideration a prepublication draft of a paper (WG-FSA-13/PO2) titled *How precautionary is the policy governing the Ross Sea Antarctic toothfish* (*Dissostichus mawsoni*) *fishery*. The paper, subsequently published in *Antarctic Science* [89], questioned whether the data and assumptions inherent in the model(s) being used to advise the Commission of allowable take levels for the Ross Sea fishery were actually precautionary as claimed.

Some members of the WG-FSA thought the criticisms were unjustified and advised the full Committee that they were preparing a response pointing out misconceptions and inconsistencies in WG-FSA-13/PO2. Paragraphs 3.56–3.75 in the Committee's 2013 meeting report note the working group's response to WG-FSA-13/PO2, indicate that there is a lack of transparency to outside scientists concerning the data, models, and procedures being used to formulate its advice to the Commission on allowable take levels, and advised the Commission that it would be desirable to arrange for periodic independent and in-depth reviews of the status-of-stocks-determinations for all harvested species and populations, beginning with the Antarctic toothfish population in the Ross Sea region.

The Commission subsequently endorsed the Committee's advice that a process be established to obtain independent reviews of its status-of-stocks determinations (CCAMLR-XXXII-paragraph 5.14). There was no indication in either meeting report why the Committee advised the Commission, and the Commission agreed, that it would be desirable to arrange for independent reviews of the Committee's status-of-stocks determinations, rather than its rational for believing that its advice on allowable catch level was precautionary with respect to the Article II(3) conservation principles.

The response by ten members of the WG-FSA to Ref. [89] was published in *Antarctic Science* in 2015 [90]. A rebuttal to parts of that paper, as well as an elaboration of what the authors considered constitutes justifiable precautionary fishery management, was published in 2016 in *Fish and* Fisheries [91]. For reasons not indicated in the Commission's or Scientific Committee's meeting reports, nothing was done in 2014, 2015, or 2016 to establish a process for obtaining independent reviews of the Committee's status-of-stocks determinations. In 2017, the Committee endorsed a recommendation from the WG-FSA to establish an expert panel of outside scientists to conduct an independent review of its integrated toothfish stock assessment methods. Among other things, the terms of reference (TOR) for the review, provided in Annex 9 of the Committee's 2017 meeting report, stated that – "The primary objective for the expert panel is to provide advice to the Scientific Committee and its working groups on the adequacy of the modelling approaches and methods used in CCAMLR's integrated toothfish stock assessments relative to Inter-national best practices."

As noted earlier, the Article II (3) conservation principles for deciding what constitutes rational use are unique to CCAMLR. There was no indication in either the WG-FSA's or the Committee's report why the objective of the review was to assess the modelling approaches and practices with respect to international best practices rather than the Article II (3) conservation principles. Although not clear, the failure of the TOR to call for the panel to assess whether the Committee's advice to the Commission is in fact precautionary with respect to the Article II (3) conservation principles could have been indicative of the previously noted conflicting interpretations of Article II(2) of the Convention. It also could have been that, given consensus decision-making, one or more Committee or Commission members questioned the need for transparency and would agree to outside reviews only if they were limited to assessing the WG-FSA's modelling approach and methods relative to best practices in other fishery management organizations whose objectives are sustainable fisheries not ecosystem conservation.

The expert panel review was held 18–22 June 2018 at the University of East Anglia in the United Kingdom. A Summary Report of the Panel's findings (SC-CAMLR-XXXVII/02 Rev.1) was provided to the Scientific Committee for consideration in advance of its 2018 meeting. The report contains multiple, well-reasoned suggestions and recommendation, which if accepted and implemented by the WG-FSA, will provide more reliable assessments of the status of the toothfish stocks. It also indicates that ecosystem considerations were outside the terms of reference for the review and advised that "[t]he CCAMLR may wish to consider an external review whose goal is to consider this question specifically."

3.9. Uncertainty concerning the future of CCAMLR

It is not apparent what would happen if the Committee's advice and the Commission's management of fisheries in the Convention Area fail to prevent the overexploitation and adverse ecosystem effects of fisheries in the Convention Area. Possibilities could include, *inter alia*: (1) the Commission, with advice from the Scientific Committee, (a) establishing moratoria on the taking of species and populations determined to be depleted with respect to the Article II(3) conservation principles, or (b) trying to restore depleted species or populations without adversely affecting the fisheries as happened with the IWC's efforts to sustain the whaling industry; and (2) one or more CCAMLR members with claims to sovereignty in the Antarctic withdrawing from both the Antarctic Treaty and the CAMLR Convention and then

asserting and attempting to enforce 200 nautical mile exclusive fishing zones adjacent to their claimed areas as provided for by the U.N. Convention on the Law of the Sea.

4. Summary and conclusions

There have been significant advances in commercial whaling and fishery management philosophies and methods since the ICRW was established in 1946, many of them reflected in CCAMLR. With regard to the ICRW, for example, there have been progressive improvements in management procedures and recognition of threats to cetacean conservation beyond commercial whaling. Examples regarding CCAMLR are its recognition that the single-species MSY management concept is flawed, establishment of an ecosystem conservation objective and principles for deciding what constitutes rational use of living resources, and provisions for the establishment of an effective observation and inspection system. There also have been significant advances in research methods and partnerships as exemplified by the IWC's Southern Ocean Research Partnership and the CAMLR Ecosystem Monitoring Program. However there remain common challenges that have prevented the IWC from stopping the overexploitation of whales and that could be impairing the CAMLR Commission's efforts to meet the Convention's ecosystem conservation objective.

The principal challenges appear to be (1) the ICRW prohibits the IWC from expanding or amending the regulatory Schedule unless 3/4th of the members accept the changes; (2) the CCAMLR requires the consensus of all members to institute regulatory measures; (3) available data concerning the life histories and demographics of the target and ecologically related species and populations have been and remain insufficient to indisputably determine and agree measures necessary to meet the intent and provisions of the respective conventions; (4) because of the data limitations, management decisions necessarily are based largely on simulation modelling of catch/effort data with little or no fishery-independent data; (5) their respective scientific committees do not routinely advise the commissions of (a) the uncertainties and assumptions inherent in their management advice, (b) the possible consequences if the uncertainties are not resolved and the assumptions are not validated, and (c) the research and monitoring that would be required to resolve the uncertainties and validate the assumptions; and (6) there is no requirement and little incentive for either the member countries or their whaling and fishing industries to provide the funding and ship support necessary to conduct the research and monitoring required to resolve the uncertainties and validate the assumptions inherent in the management decisions.

Meeting the intent and provisions of both the ICRW and CCAMLR would be more effective if: (1) the burden-of-proof could be shifted so that a minority or a single member of the respective decision-making bodies could not block adoption of regulatory measures deemed necessary by the other members; (2) procedures were instituted to actually ensure that whaling and fisheries develop no faster than the acquisition of data needed for effective regulation; (3) there was a requirement that the uncertainties and assumptions inherent in management advice be clearly documented and reflected in management decisions; and (4) there were requirements or meaningful incentives for the member countries and/or their whaling/fishing industries to provide the funding and ship support to conduct the research and monitoring necessary to resolve the uncertainties and validate the assumptions inherent in the management decisions.

Correcting the burden of proof problem would require amending the conventions to prohibit or limit commercial whaling and fishing until the majority of members agree that there are sufficient safeguards in place to prevent overexploitation and adverse ecosystem effects. Although both conventions provide that signatories may propose amendments, it seems likely that a proposed amendment to shift the burden of proof would generate alternative proposals and that none would obtain the consensus necessary to be agreed. However, there is nothing in the conventions that would prohibit the IWC and the CAMLR Commission from correcting the other problems – for example, (1) establish procedures that actually assure that commercial whaling and fisheries develop no faster than the acquisition of data needed for effective regulation; (2) require that their scientific advisory bodies routinely advise them of the uncertainties and assumptions inherent in their management advice and the possible consequences if the uncertainties are not resolved and the assumptions are not validated; and (3) establish economically meaningful incentives for their whaling/fishing industries to provide the ship support and funding necessary to resolve the uncertainties and validate the assumptions.

The scientific advisory bodies also could help to assure that the decision-making bodies are aware of and accountable for the consequences of their management decision by using multiple models and input parameters to forecast the results of differing management strategies and then provide advice to the commissions on a range of possible allowable catch levels with the degree of risk of unacceptable adverse effects assigned to each possibility.

These challenges and means to avoid them should be considered in the formulation and implementation of future ecosystem and fishery management agreements. For example, in October 2018, nine countries and the European Union agreed to ban commercial fishing in the central Artic Ocean for at least 16 years to provide time to obtain the biological and ecological information necessary to establish an effective, science-based regulatory regime. However, the agreement does not specify the needed information or indicate how it is expected to be obtained. If they have not already done so, the signatories of the agreement should be aware of, and take steps to avoid, the kinds of challenges encountered because of the formulation, decision-making provisions, and absence of sufficient data to effectively implement the ICRW and CCAMLR.

Declarations of conflicts of interest

None.

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Appendix A. Supplementary data

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