



Global Cooperation among Diverse Organizations to Reduce Illegal Fishing in the Southern Ocean

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Abstract: *Illegal, unreported, and unregulated (IUU) fishing is prevalent globally and has detrimental effects on commercial fish stocks and nontarget species. Effective monitoring and enforcement aimed at reducing the level of IUU fishing in extensive, remote ocean fisheries requires international collaboration. Changes in trade and vessel activities further complicate enforcement. We used a web-based survey of governmental and non-governmental organizations engaged in reducing IUU fishing in the Southern Ocean to collect information on interorganizational collaborations. We used social-network analyses to examine the nature of collaborations among the identified 117 organizations engaged in reducing IUU fishing. International collaboration improved the ability to control and manage harvest of commercially important toothfish (*Dissostichus* spp.) stocks and reduced bycatch of albatrosses (*Diomedidae*) and petrels (*Procellariidae*) in longlines of IUU fishing vessels. The diverse group of surveyed organizations cooperated frequently, thereby making a wide range of resources available for improved detection of suspected IUU vessels and trade flows, cooperation aimed at prosecuting suspected offenders or developing new policy measures. Our results suggest the importance of a central agency for coordination and for maintaining commonly agreed-upon protocols for communication that facilitates collaboration. Despite their differences, the surveyed organizations have developed common perceptions about key problems associated with IUU fishing. This has likely contributed to a sustained willingness to invest in collaborations. Our results show that successful international environmental governance can be accomplished through interorganizational collaborations. Such cooperation requires trust, continuous funding, and incentives for actors to participate.*

Keywords: CCAMLR, global environmental governance, IUU fishing, organizational networks, toothfish

Cooperación Global entre Organizaciones Diversas para Reducir la Pesca Ilegal en el Océano del Sur

Resumen: *La pesca ilegal, no reportada y no regulada (INN) es prevalente globalmente y tiene efectos negativos sobre las reservas de peces comerciales y especies acompañantes. El monitoreo efectivo y la aplicación de leyes enfocadas a reducir el nivel de INN en pesquerías oceánicas remotas y extensivas requiere de colaboración internacional. Los cambios en el comercio y actividades de embarcaciones complican aun más la aplicación de leyes. Utilizamos un muestreo basado en la red sobre organizaciones gubernamentales y no gubernamentales involucradas en reducir la pesca INN en el Océano del Sur para recabar información sobre colaboración entre organizaciones. Utilizamos análisis de redes sociales para examinar la naturaleza de las colaboraciones entre las 117 organizaciones involucradas en cooperación. La colaboración internacional mejoró la habilidad para controlar y manejar la captura de reservas de *Dissostichus* spp. de importancia comercial y redujo la captura incidental de albatros (*Diomedidae*) y petreles (*Procellariidae*) por embarcaciones de pesca INN. El grupo diverso de organizaciones muestreadas cooperaba frecuentemente, por lo tanto hicieron disponible un amplio rango de recursos para una mejor detección de embarcaciones y flujos comerciales de INN. Esta cooperación tenía por objetivo procesar a presuntos ofensores o desarrollar nuevas*

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medidas políticas. Nuestros resultados sugieren la importancia de una agencia central para coordinar y mantener los protocolos acordados en común y para comunicación que facilita la colaboración. No obstante sus diferencias, las organizaciones muestreadas han desarrollado percepciones comunes sobre los problemas clave asociados con la pesca INN. Probablemente esto ha contribuido a la disponibilidad sostenida para invertir en colaboraciones. Nuestros resultados muestran como se puede lograr una gobernanza ambiental internacional exitosa por medio de colaboración entre organizaciones. Tal cooperación requiere de confianza, financiamiento continuo e incentivos para la participación de actores.

Palabras Clave: CCAMLR, *Dissostichus* spp., Gobernanza Ambiental Global, pesca INN, redes organizacionales

Introduction

Social networks, which facilitate collaboration and compliance with regulations (Borgatti & Foster 2003; Scholz & Wang 2006; Santos et al. 2008), have been identified as important for local collaborative management of natural resources (Folke et al. 2005; Ernstson et al. 2008; Bodin & Crona 2009). However, social, economic, and political factors that affect resource management at the international level are substantially different from those that exert effects at the local level (Biermann & Patberg 2008; Walker et al. 2009). To date, there have been few studies on the role of social networks at the international level (but see Peterson 1992; Broadbent 2010). Regulation of global fisheries is one of the greatest governance challenges for the international community (Pauly et al. 2002). Illegal, unreported, and unregulated (IUU) fishing (Sumaila et al. 2006) is prevalent worldwide (Agnew et al. 2009) and has been identified as one of the greatest threats to marine ecosystems by the UN General Assembly (UNGA 2011). Estimates of total IUU catches globally range from 11 to 26 million tons annually, and IUU catch monetary values range from US\$10 to \$23.5 billion (Agnew et al. 2009). Developing countries are particularly vulnerable to IUU fishing due to their limited governance capacity (Agnew et al. 2009).

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) provides an international forum for collaboration among states that manage natural resources in the Southern Ocean. IUU fishing presents a major challenge because these fisheries have substantial environmental and economic effects in the Southern Ocean. IUU catches of Patagonian toothfish (*Dissostichus eleginoides*) and Antarctic toothfish (*Dissostichus mawsoni*) in the Southern Ocean have raised serious concern and resulted in substantial actions by CCAMLR (Agnew 2000; Miller et al. 2010; Österblom & Sumaila 2011). Although relatively small from a global perspective, IUU catches of Patagonian toothfish were around 35,000 t at their peak in 1997, which was 4 times the licensed quota allowed by CCAMLR, and had a value of over US\$150 million (COLTO 2003; SC-CAMLR 2009). These IUU catches of Patagonian toothfish had a direct negative effect on the fishing industries licensed

by CCAMLR operating in the same area as IUU operations (COLTO 2003). IUU vessels primarily caught toothfish with deep-sea longlines with baited hooks, which also attract seabirds. In 1997 the scientific committee of CCAMLR concluded that IUU fishing was “causing the likely collapse of the populations of several species of albatross (*Diomedidae*) and of white-chinned petrels (*Procellaria aequinoctialis*), as well as the potential collapse of the *Dissostichus* stocks” (SC-CAMLR 1997). These concerns were reiterated in 2002 (SC-CAMLR 2002). Furthermore, addressing IUU fishing is often politically complicated because some CCAMLR member states have been identified as port or flag states of IUU fishing vessels or have been identified as having their citizens involved as IUU vessel owners, operators, or crew on IUU vessels (COLTO 2003; Österblom et al. 2010; Österblom & Sumaila 2011).

The most valuable fishing grounds within the Southern Ocean are around sub-Antarctic islands, where some member states exercise national jurisdiction within the area covered under CCAMLR agreements (Fig. 1) (Miller et al. 2010; Österblom & Sumaila 2011). Several of these countries participate in the licensed toothfish fishery and have national monitoring and enforcement programs. For instance, Australia, France, United Kingdom, and New Zealand use ship-based, aerial and satellite surveillance to perform extensive searches of the Southern Ocean for IUU fishing (ANAO 2008; Österblom & Sumaila 2011). The ability to detect IUU vessels is complicated by the vastness, remoteness, and dangerous conditions of the Southern Ocean. Hence, collaborative monitoring, control, and surveillance (MCS) operations increase the collective ability to detect IUU fishing activities. Enforcement (pursuit and boarding of suspected vessels), primarily involving Australia, France, United Kingdom, and South Africa, has benefited from international collaboration (Molenaar 2004; Österblom & Sumaila 2011). Vessels reported to have engaged in IUU fishing are added, if members of CCAMLR collectively agree to the addition, to the official IUU vessel list (<http://www.ccamlr.org/pu/e/sc/fish-monit/iuuvess.htm>), which is maintained by the CCAMLR secretariat. Listing of vessels, provides a sanctioning mechanism that affects the value of the vessel (Agnew 2000; Miller et al. 2010).

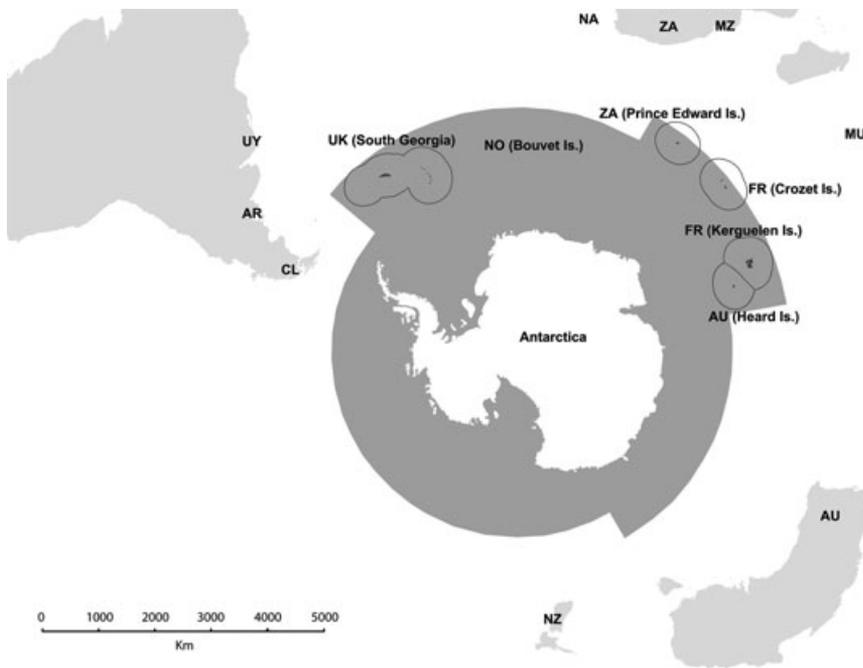


Figure 1. The area in the Southern Ocean managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) (gray). The area includes a United Kingdom (U.K.) South Georgia maritime zone and exclusive economic zones around South African (ZA) Prince Edward Island, French (FR) Crozet and Kerguelen Islands, and Australian (AU) Heard Island. Norway (NO) has not declared an exclusive economic zone around Bouvet Island. Geographical boundaries derived from Sea Around U.S. Project (www.seaaroundus.org) (AR, Argentina; CL, Chile; NA, Namibia; NZ, New Zealand; MZ, Mozambique; MU, Mauritius; UY, Uruguay).

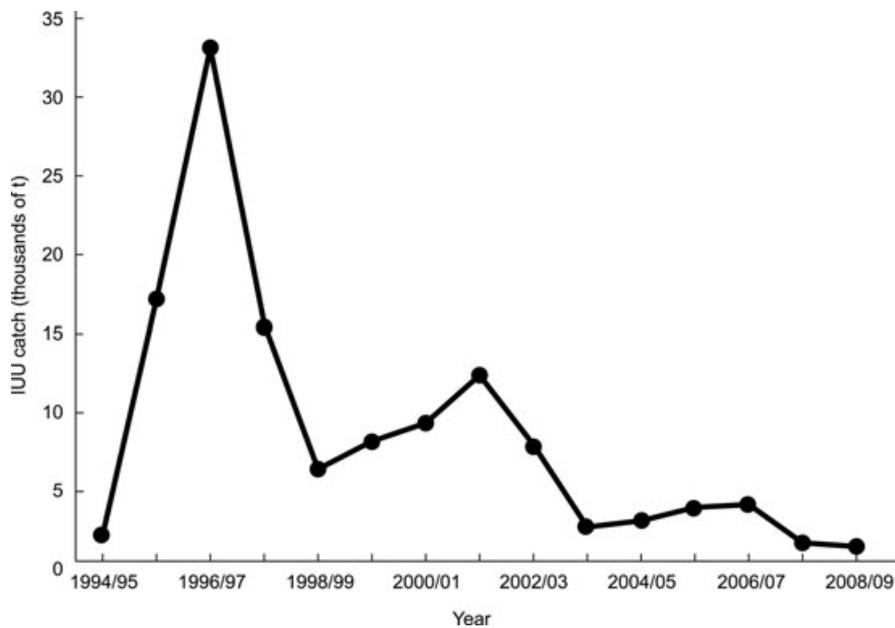
Although IUU products from toothfish are caught in the Southern Ocean, they are landed throughout the world and traded on a global market. To trace trade flows from vessels to markets, CCAMLR developed a catch-documentation scheme (Agnew 2000), which is implemented by CCAMLR members and administered and supported by the CCAMLR secretariat (CCAMLR 2012). This instrument for determining the legitimacy of catches (Agnew 2000; Miller et al. 2010) is used in combination with the IUU list as a mechanism for excluding IUU catches from the ports and markets of CCAMLR members. Nonstate actors can provide complementary sources of information related to toothfish markets (Lack & Sant 2001; Österblom et al. 2010; Österblom & Sumaila 2011). Enforcing rules (e.g., seizing and inspecting shipments or investigating and prosecuting suspected offenders) in complex national or international court cases requires substantial international cooperation. The catch-documentation scheme resulted in a novel capacity for CCAMLR that facilitated information flow and cooperation (Österblom & Sumaila 2011).

The commission includes nonstate actors, representatives of the licensed fishing industry, and environmental nongovernmental organizations (NGOs), which are active in either national delegations to the commission or are official observers to the commission. On one hand, intergovernmental decision-making processes requiring consensus (e.g., in CCAMLR) can delay the establishment of effective policy tools (Agnew 2000; Österblom & Sumaila 2011). Independent nonstate actors, on the other hand, can speed up the policy process because they do not have to consider diplomatic aspects of politically sensitive issues (e.g., IUU fishing). Nonstate actors with observer status to CCAMLR have presented controversial

reports to the commission. Although such reports contained politically sensitive information, they were perceived as useful by the commission because they contained important new information related to IUU fishing, thereby stimulating policy debate (Österblom & Sumaila 2011). A precursor to the official IUU list was developed by NGOs (Österblom & Sumaila 2011). The catch-documentation scheme was also, in part, stimulated by NGO lobbying (Agnew 2000).

Formal and informal compliance mechanisms, aimed at reducing IUU fishing in the Southern Ocean, have been developed through CCAMLR that involve substantial collaboration among state and nonstate organizations (Miller et al. 2010; Österblom & Sumaila 2011). After these mechanisms were put in place, there was an approximately 90% or greater decrease in IUU catches (Fig. 2), whereas licensed catches generally remained stable (Österblom & Sumaila 2011). It is likely that the reduction in IUU catches was not the result of a declining market for the fish, but rather of the collaborative effort to enforce fishing regulations.

We investigated the structure and function of an international network of collaborating organizations aimed at reducing IUU fishing in the area managed by the commission. This network primarily consists of state and nonstate actors associated with the commission. However, not all members and observers in CCAMLR are actively involved in efforts to reduce IUU fishing, and some of the identified collaborating organizations are not members of CCAMLR. We used data from our previous studies of the changing nature of IUU fishing and the development of compliance mechanisms in CCAMLR (Österblom et al. 2010; Österblom et al. 2011; Österblom & Sumaila 2011) in combination with results of a web-based survey



*Figure 2. Estimated weight of toothfish (*Dissostichus* spp.) caught by illegal, unreported, and unregulated (IUU) fishing in the Southern Ocean between 1995 and 2009 (SC-CAMLR 2002, 2009). Estimates derived from vessel sightings and reports of undocumented landings by national compliance programs, the licensed fishing industry, or other sources and calculated by fishing season (e.g., 1996/1997) each austral summer.*

we conducted that was designed to capture patterns of cooperation and the incentives and perceptions of organizations involved in cooperation. We explored whether the structure and function of this organizational network is associated with reduction of IUU fishing.

Methods

We used social network analysis to map, describe, and analyze the organizational network of organizations associated with reducing IUU fishing in the Southern Ocean. Social network analysis originated in the social sciences, but is also used in other scientific disciplines, such as physics and biology (Freeman 2004; Bodin & Prell 2011). In this approach one first defines the actors of interest (nodes) and then collects data on specific types of relations (e.g., friendship) among them (links) (Wasserman & Faust 1994). The resulting social network is then typically analyzed with the objective of inferring relations between patterns of social links and substantive outcomes in terms of behavioral characteristics of either the entire set of actors or individual actors (i.e., community or individual outcomes, respectively).

To gather data on relations among organizations in the network we studied, we asked the identified organizations (see below) to participate in a web-based survey (Supporting Information). We used the data from the survey to assess actor heterogeneity (i.e., how many organizations of each type) and the overall frequency of cooperation within and between organizations of different types (Supporting Information). These relations are likely to affect the community of organizations' joint ability to access different types of resources (Bodin & Crona 2009).

We analyzed both qualitatively and quantitatively, how individual organizations are positioned in the networks. In particular, we were interested in identifying organizations that occupy positions in the networks that are favorable in terms of providing opportunities for organizations to collaborate (Provan & Kenis 2007; Bodin & Crona 2009). Here, degree centrality is a key concept. Degree centrality is the number of links (or the sum of the strength of all links) any given organization has with other organizations and is typically assumed to be a measure of the organization's influence, prestige, and power (Wasserman & Faust 1994).

To facilitate the analyses, we reduced the complexity of the organizational network by aggregating all organizations into a subset of metaorganizations of varying sizes (Supporting Information). This also helped us compensate for missing data (i.e., from organizations that did not respond). We aggregated the organizations on the basis of their country of origin and type. We used a spring-embedding technique (e.g., Borgatti et al. 2002) to plot the networks of the metaorganization in a social network diagram. With this technique, a node that is well connected (high degree centrality) and connected to other nodes in a uniform manner is positioned in the middle of the diagram. Nodes that are less connected or are connected only to a subset of nodes that are less integrated in the larger network tend to be in the periphery of the diagram. Hence, nodes positioned closer to the center of the figure can be qualitatively assessed as being more embedded in the network.

Identification of Organizations

We used several methods to identify organizations that had been operationally involved in reducing IUU fishing (Supporting Information). We used multiple-entry

snowball sampling (starting with government agencies, NGOs, and fishing-industry organizations) to identify organizations perceived as critical for reducing IUU fishing in the Southern Ocean and to identify other organizations that had a role that was minor, but perceived to be important. We conducted over 40 in-depth qualitative interviews (Österblom & Sumaila 2011) to refine our understanding of the different organizations cooperating to reduce IUU fishing in the Southern Ocean. We conducted these interviews in person or over the telephone with senior staff from international organizations, government agencies, the licensed fishing industry, NGOs, and other organizations with experience in the area managed by CCAMLR (Österblom & Sumaila 2011). This procedure gave us confidence that we had included in our web-based survey virtually all organizations involved in reducing IUU fishing in the Southern Ocean (Fig. 2). Protocols from CCAMLR meetings conducted over the last 10 years contained records of participating individuals, and that information together with our snowball sampling and in-depth interviews gave us information on which individuals we should target in the organizations. For the web-based survey, we preferentially targeted people who were leaders of and participated as experts in national delegations, senior managers in the fishing industry, and experienced individuals from the NGO community. We asked them to answer the survey question in their capacity as organizational representatives.

We characterized government agencies and ministries as state actors and environmental NGOs and fishing-industry organizations as 2 different types of nonstate actors. We characterized organizations that did not fit into these groups as either international governance organizations (e.g., the Food and Agriculture Organization of the United Nations) or other (e.g., consulting firms). The web-based survey was designed to identify 3 different types of cooperation (described below), perceptions of IUU fishing prevalent within the organizations, willingness to and resources for addressing IUU fishing, and the role of the organizations in reducing IUU fishing. We discussed the list of survey respondents and the draft survey questions with policy makers and researchers who had a great deal of experience with IUU fishing in the area managed by CCAMLR. We obtained informed consent from all of the individuals responding to the survey.

Gathering Data on Collaborations

To assess the joint ability of the identified organizations to address IUU fishing, we focused on 3 challenges: detecting and apprehending IUU vessels, tracing trade flows of fish products, and developing efficient policies aimed at reducing IUU fishing. IUU fishing in the Southern Ocean is conducted over vast areas far from human settlement. Species caught and catch areas change over time in response to policies designed to reduce such fish-

ing (Österblom et al. 2010; Österblom & Sumaila 2011), which makes it difficult to detect and apprehend IUU vessels. We, therefore, asked respondents to select all other organizations on the list of the identified organizations they collaborated with to detect and communicate information about IUU vessels (MCS at sea).

Toothfish species are traded globally and consumed primarily in the United States, Japan, and Europe (Lack & Sant 2001). We asked respondents to identify the other organizations with which they collaborate to conduct investigations of toothfish products suspected to have been the result of IUU fishing (i.e., tracking trade flow).

Development of efficient policies for reducing IUU fishing is challenging because these policies have to be revised as IUU operators change where and how they catch, land, or transport fish products. Hence, we asked respondents to identify the other organizations they collaborate with in developing policies to reduce IUU fishing.

We asked respondents to indicate their relations with organizations on a list we provided them (i.e., name recognition). This method typically reveals more relations than asking the respondents to recall their relations with others (Marsden 1990). For all 3 types of collaboration, we asked whether communication among organizations is current and regular (≥ 3 times/year), current and occasional (< 3 times/year), previous (no longer operational), or nonexistent. We numerically weighted these different frequencies of collaboration as 3, 2, 1, and 0.

Perceived Importance, Incentives, and Critical Resources

We asked survey respondents to rank the activity and usefulness of each organization in reducing IUU fishing as high, medium, or low. We converted these to scores of 3, 2, or 0 respectively. Respondents could also indicate whether the organizations had been highly active and useful in the past, but currently is neither (score = 1). To capture different organizational incentives for addressing IUU fishing, we asked respondents to characterize statements regarding IUU fishing as I fully agree, I mostly agree, I agree to some extent, and I disagree (scored as 3, 2, 1, and 0 respectively). We also asked respondents to qualify the importance of 10 different resources for reducing IUU fishing for toothfishes as critical, important, useful, or not important (scored as 3, 2, 1, and 0 respectively).

Results

Cooperating Actors

We identified 119 organizations that cooperated to reduce IUU fishing in the area managed by CCAMLR. We excluded 2 of these organizations because respondents stated they had not been involved in addressing IUU fishing, so the final number of organizations

we examined was 117. The organizations included 60 government agencies and ministries (51.3%), 29 fishing organizations (24.8%), 18 NGOs (15.4%), 6 international governance organizations (5.1%), and 4 other organizations (3.4%). The organizations were from 6 continents.

Forty-two (36%) of the 117 organizations responded to the survey (22 government agencies, 5 fishing organizations, 3 international governance organizations, 8 NGOs, and the 4 other organizations). The respondents had on average been employed by their organizations for 12 years. Grouping the respondents into metaorganizations (Supporting Information) changed the effective response rate to 58–69%, depending on the type of cooperation (Supporting Information).

The CCAMLR secretariat occupied a central position for all 3 types of cooperation (Supporting Information). Directorate-General for Maritime Affairs and Fisheries of the European Commission, South Africa, France, and the United Kingdom, among others, were also centrally located in the identified networks (Figs. 3a-c & Supporting Information). Both state and nonstate actors collaborated frequently (Figs. 3a-c).

Monitoring, Control, and Surveillance at Sea

The organizational network around MCS at sea spanned multiple types of actors operating across the Southern Ocean (Fig. 3a). Australia engaged a number of national organizations (Supporting Information) and together with France, the United Kingdom, and New Zealand occupied central positions in this network (Fig. 3a & Supporting Information). The licensed fishing industry, which can report on observations of suspected vessels and CapFish, a private company deploying observers on licensed fishing vessels, were also centrally positioned (Fig. 3a & Supporting Information).

Illicit Trade Flows

The organizational network that traces IUU trade flows (Fig. 3b) largely resembled the MCS network (Fig. 3a). The central position of the licensed fishing industry, the Coalition of Legal Toothfish Operators (Fig. 3b), improved the collective ability to trace IUU trade flows (Österblom & Sumaila 2011). NGOs in the Antarctic and Southern Ocean Coalition (ASOC) have published reports on trade flows, and the ASOC occupied a fairly central position (Fig. 3b). An important difference compared with the MCS network is that the European Commission (Directorate-General for Maritime Affairs and Fisheries of the European Commission), which played a key role in the development of the catch-documentation scheme (Agnew 2000), occupied a much more central position in this network (Supporting Information).

Policy Development

In the network for policy development, the Antarctic Southern Ocean Coalition (ASOC) occupied a more central position (Fig. 3c & Supporting Information) relative to their positions in the 2 other networks (Fig. 3a-b). Directorate-General for Maritime Affairs and Fisheries of the European Commission (DG MARE) occupied a central position, as did the Food and Agriculture Organization (FAO) of the United Nations, which is a much more peripheral organization in the 2 other networks (Fig. 3a-b & Supporting Information). The FAO has held a key role in the development of global policies aimed at reducing IUU fishing, but it is not involved in management of the area managed by CCAMLR.

Collaboration among Different Types of Organizations

In general, organizations tended to collaborate more with other organizations of the same type (Table 1). The identified links among government organizations, among NGOs, and among industry organizations were significantly stronger than expected by chance for all 3 types of cooperation ($p < 0.01$ in all cases), except for the MCS cooperation among NGOs (Table 1). In contrast, cooperation among international governance organizations was only significantly stronger than expected by chance with regard to trade ($p < 0.01$). Governmental organizations were significantly and strongly connected to international governance organizations (the ratio of observed versus expected number of relations ranged from 2.17 to 2.40, all with $p < 0.01$). International governance organizations were significantly connected to governmental organizations (ratio range between 1.22 and 3.14, where the former relates to policy and the latter to trade, all with $p < 0.05$). Governmental agencies were, in contrast, less connected to NGOs. The levels of collaboration between governmental agencies and NGOs, and vice versa, ranged from 0.42 to 0.99 (all ratios except 0.99 with $p < 0.01$). Collaborations reported by the fishing industry with NGOs were fairly strong for policy development (ratio 1.36, $p < 0.05$) and weaker for monitoring and trade cooperation (0.63 and 1.12, $p < 0.05$ and $p < 0.05$, respectively). All relations reported by NGOs with the fishing industry were, in contrast, significantly weak (0.1–0.41, all with $p < 0.01$).

Perception of Organizations, Problems, and Critical Resources

The CCAMLR secretariat was identified as the most important actor for reducing IUU fishing (Table 2). The Coalition of Legal Toothfish Operators, together with 2 Australian government agencies (Australian Fisheries Management Authority and Australian Antarctic Division), were among the top 4 most important organizations and were followed directly by the Antarctic Southern Ocean

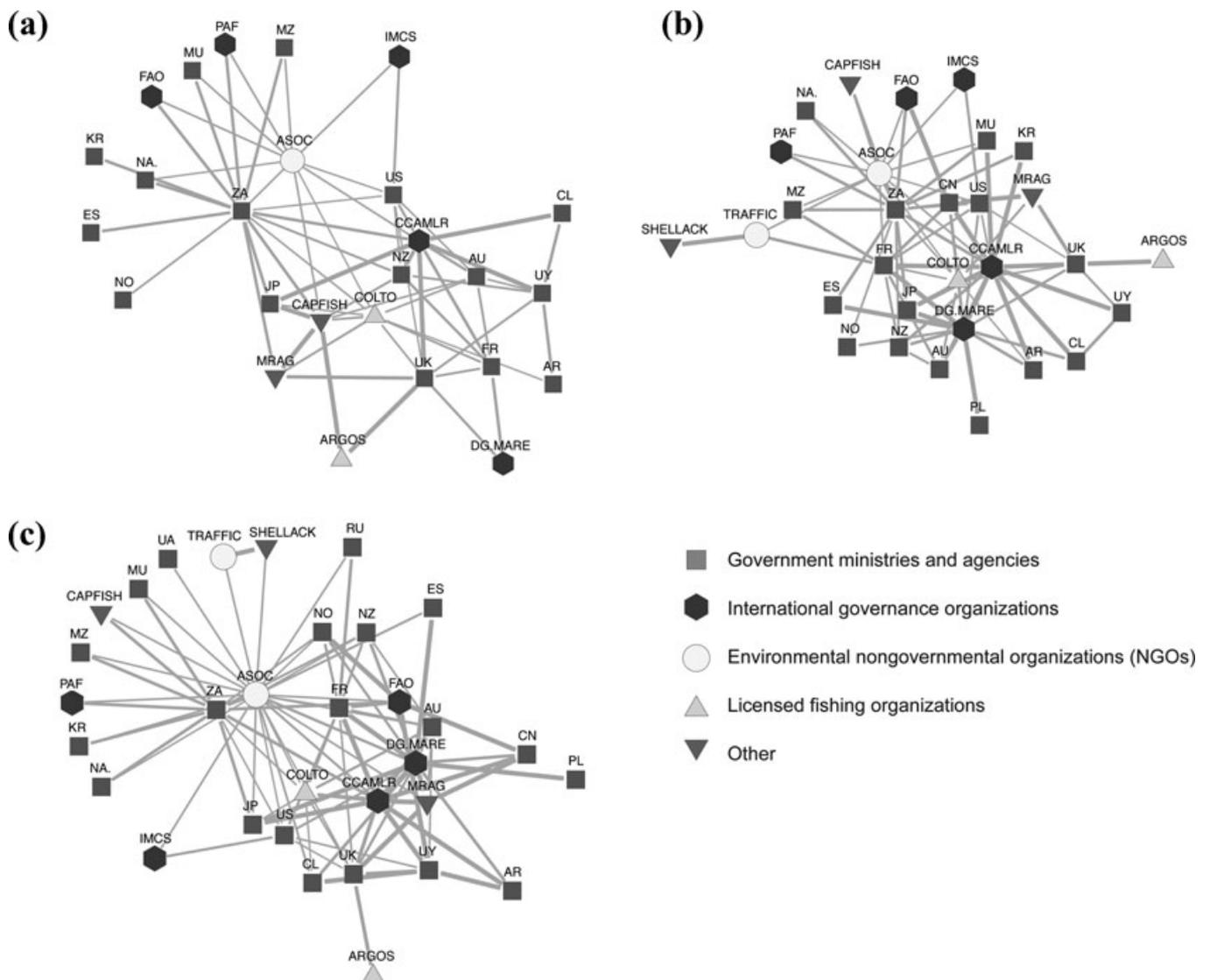


Figure 3. Networks of collaborations between metaorganizations (i.e., aggregates of similar organizations [Supporting Information]) engaged in cooperation aimed at reducing illegal, unreported, and unregulated (IUU) fishing in the Southern Ocean. Thickness of lines corresponds to the strength of collaboration (thickest links, maximum possible strength, meaning all individual organizations in each metaorganization are strongly connected to each other [Supporting Information]). Positions of organizations are determined through a spring-embedding technique and thus correspond to their level of embeddedness (see Methods) in the networks for (a) monitoring, control, and surveillance of IUU fishing, (b) tracing IUU trade flows, and (c) developing policy to reduce IUU fishing (AR, Argentina; CN, China; PL, Poland; UY, Uruguay; AU, Australia; NZ, New Zealand; ES, Spain; NO, Norway; JP, Japan; FR, France; UK, United Kingdom; CL, Chile; US, United States; ZA, South Africa; UA, Ukraine; MZ, Mozambique; KR, Korea; MU, Mauritius; NA, Namibia; FAO, United Nation Food and Agriculture Organization; IMCS, International Monitoring Control and Surveillance Network; DG Mare, Directorate General for Marine Affairs and Fisheries; Traffic, TRAFFIC; CapFish; Shellack, Shellack Pty Ltd; Argos, Argos Froyanes Ltd; COLTO, Coalition of Legal Toothfish Operators; CCAMLR, Commission for the Conservation of Antarctic Marine Living Resources Secretariat; ASOC, Antarctic Southern Ocean Coalition).

Coalition and the New Zealand Ministry of Fisheries (Table 2).

The perceptions of IUU fishing typically differed among governments, the licensed fishing industry, and NGOs and were influenced by national and international

obligations, the protection of state sovereignty, commercial use of sustainable fish stocks, and the conservation of seabirds (Table 3). There was however consistent agreement with the statement “IUU fishing undermines our international obligations,” and general agreement with

Table 1. Level of collaboration between and among different types of organizations involved in cooperation aimed at reducing illegal, unreported, and unregulated fishing in the Southern Ocean.*

Type of cooperation and organization	Government (GOV)	Licensed fishing industry (IND)	International governance organizations (IGO)	Nongovernmental organization (NGO)	Other organizations
Monitoring, control, surveillance					
GOV	1.40 ⁺⁺	1.01	2.30 ⁺⁺	0.59 ⁻	0.69
IND	1.10	2.50 ⁺⁺	1.23	0.63 ⁻	0.76
IGO	1.75 ⁺⁺	0.14 ⁻	1.15	0.41 ⁻	0.86
NGO	0.42 ⁻	0.10 ⁻	1.41	1.05	0.72
other	0.48	1.08	0.36 ⁻	0.00 ⁻	1.08
Tracing IUU trade flows					
GOV	1.20 ⁺⁺	0.65 ⁻	2.40 ⁺⁺	0.53 ⁻	0.69 ⁻
IND	1.18 ⁺	2.52 ⁺⁺	1.23	1.12	1.65
IGO	3.14 ⁺⁺	1.99 ⁺⁺	2.50 ⁺⁺	0.99	1.87
NGO	0.44 ⁻	0.14 ⁻	1.56 ⁺	1.72 ⁺⁺	0.73
other	0.17 ⁻	0.08 ⁻	0.13 ⁻	0.39 ⁻	0.00 ⁻
Policy development					
GOV	1.11 ⁺⁺	0.52 ⁻	2.17 ⁺⁺	0.66 ⁻	0.66 ⁻
IND	0.98	2.00 ⁺⁺	1.30	1.36 ⁺	1.57
IGO	1.22 ⁺	0.08 ⁻	1.45	0.47 ⁻	0.48
NGO	0.99	0.41 ⁻	2.48 ⁺⁺	3.26 ⁺⁺	1.29
other	0.56 ⁻	0.44 ⁻	1.11	0.37 ⁻	0.40 ⁻

*The numbers refer to the ratio of observed to expected number of relations assuming all relations were distributed randomly (i.e., null hypothesis, see Supporting Information). If the ratio of collaboration deviates significantly (in either direction) from unity ($p < 0.05$ or $p < 0.01$), the value is marked with plus or minus signs, respectively.

regards to the statement “This fishing represents a form of organized crime” (Table 3).

The IUU list and the catch-documentation scheme provide for a commonly agreed-upon protocol for interaction and information exchange, which seems to further facilitate interorganizational collaboration. According to a senior representative who has a decade of experience in

leading a national delegation to CCAMLR, “The existence of the CDS [catch-documentation scheme] provides a platform which lowers the barrier to [international] cooperation, because it provides a common platform for dialogue.” The catch-documentation scheme and the IUU list serve the interests of all organizations and were collectively identified as being critically important. In the

Table 2. The 20 organizations perceived by respondents as the most important for addressing illegal, unreported, and unregulated fishing in the Southern Ocean.

Organization	Total score*
Commission for the Conservation of Antarctic Marine Living Resources Secretariat	102
Coalition Of Legal Toothfish Operators (COLTO)	65
Australian Fisheries Management Authority (AFMA)	64
Australian Antarctic Division (AAD)	55
Antarctic Southern Ocean Coalition (ASOC)	50
New Zealand Ministry of Fisheries	50
Directorate-General for Maritime Affairs and Fisheries of the European Commission	49
U.S. National Oceanic and Atmospheric Administration (NOAA)	47
Australian Department of Agriculture, Fisheries and Forestry (DAFF)	43
United Kingdom Foreign and Commonwealth Office	42
TRAFFIC	41
New Zealand Ministry of Foreign Affairs and Trade	41
Marine Resources Assessment Group (MRAG)	40
Australian Customs Service	40
Australian Department of Foreign Affairs and Trade	40
Government of South Georgia and South Sandwich Islands	40
French Navy	39
French Southern and Antarctic Lands	38
U.S. Department of State	37
UN FAO Food and Agriculture Organization	37

*The responding organizations scored each organization’s level of importance (high, 3; medium, 2, or low, 0) in terms of how active and useful they are in addressing illegal, unreported, and unregulated fishing for toothfish. Values correspond to the sum of scores for each organization.

Table 3. Perceptions of responding organizations of their level of agreement with a number of problem statements related to illegal, unreported, and unregulated (IUU) fishing in the Southern Ocean.

Problem statement	Level of agreement*			
	3	2	1	0
This fishing leads to the collapse of toothfish stocks.	20	14	8	1
This fishing leads to the collapse of seabird populations.	8	14	17	3
This fishing leads to the collapse of the legal industry.	12	15	11	5
This fishing threatens the sovereign right of my country.	12	7	11	11
IUU fishing undermines our international obligations.	27	12	0	1
This fishing represents a form of organized crime.	31	8	3	1

*Level of agreement with the problem statements: 3, fully agree with the statement; 2, mostly agree with the statement; 1, somewhat agree with the statement; 0, do not agree with the statement. Numbers in columns are number of responding organizations that reported agreement with the statement at the level indicated in the column heading.

survey, 31 and 21, respectively, of 45 organizations rated the catch-documentation scheme and the IUU list as being critical for the successful reduction of IUU fishing, and 13 and 20 organizations, respectively, rated these tools as important. No organizations rated them as unimportant.

Discussion

The global reach of the identified networks matches the global scale and scope of IUU activities in the Southern Ocean (Österblom et al. 2010). Sixteen of the 20 organizations identified as most important for reducing IUU fishing responded to the survey, which suggests we adequately captured the characteristics of the network structure that were most important. The actor-defined assessment of organizations that are important for reducing IUU fishing includes state and nonstate actors and strengthens our conclusion that all types of organizations are engaged in addressing IUU fishing and are perceived as important for a reduction of IUU catches (successful collaboration). The rare occurrences of zero or near zero levels of collaboration among organizations emphasizes that all types of organization are collaborating (Table 1). The response rate of fishing-industry organizations was low compared with the response rate from other organizations; thus, the assessments of the strength of collaboration reported by the industry with other types of organizations should be treated with caution.

Our results suggest it is possible to engage diverse organizations in international environmental governance. The 117 organizations that collaborate to reduce IUU fishing operate in different sectors; have different man-

dates, incentives, and capacities; and can therefore provide access to network organizations' complementary infrastructure, expertise, and information that can improve the ability to detect IUU vessels or trade flows, communicate politically sensitive issues, and stimulate compliance with regulations through formal and informal sanctions (Österblom & Sumaila 2011). The CCAMLR secretariat (Figs. 3a-c) seems to have been instrumental in reducing IUU fishing in the Southern Ocean, but would not have been effective had other actors been unable to perceive clear benefits from collaboration. Organizations are cooperating both at the national and international level (Fig. 3) and have a wide range of perceptions of IUU fishing (Table 3). In spite of the different perceptions, all actors perceive clear synergies from working together to reduce IUU fishing (Österblom & Sumaila 2011).

To make productive use of existing and diverse competences, organizations need to be actively engaged in collaboration. This requires the development of trust and a common objective (Rhodes 2007) between types of organizations that may not typically cooperate. Our results show that although there were some different perceptions of what kind of problems are associated with IUU fishing, there were also striking similarities. Perceptions of the level of threat IUU fishing poses to the sovereignty of states differed substantially, but there was a consensus that IUU fishing undermines international obligations, leads to the collapse of toothfish stocks, and represents a form of organized crime (Table 3). Agreements on these issues have likely facilitated collaboration among the diverse organizations.

The central position of the CCAMLR Secretariat in the network diagrams was consistent across all 3 types of cooperation, and the secretariat played a key role in coordinating communication and collaboration and in providing information and advice (i.e. resembled a bridging organization [Cash et al. 2003]). The secretariat hosts the annual meetings of the commission and provides data and information to facilitate the development of new measures for, for example, improved information sharing or sanctioning mechanisms and policies to ensure compliance. The secretariat also invites the participation of new countries that have been identified as being important for the successful reduction of IUU fishing (Agnew 2000) and can thus actively stimulate an evolution of the network. However, Australia, the European Commission, France, New Zealand, and the United Kingdom were also centrally located in all 3 networks, as was the Coalition of Legal Toothfish Operators and the Antarctic Southern Ocean Coalition. In addition, South Africa acted as a link to several otherwise unconnected countries for all 3 collaboration networks. Some of its neighbors have also been used as ports for offloading IUU catches (Österblom et al. 2010). Because most of the centrally positioned organizations were also represented among the organizations identified as being most

important for addressing IUU fishing (Table 2), it seems clear that the interorganizational collaborations largely rely on a core of well-connected, centrally positioned, willing, and able organizations with strong incentives to address IUU fishing.

Our results show that addressing international environmental challenges do not necessarily depend on the construction of new governance organizations. Instead, successful governance responses can build on existing organizational networks. However, this does not mean international environmental governance does not require substantial funding. Several of the identified key countries have invested heavily in human, financial, and technical capacities for MCS, trade investigations, and policy development. Australia, for example, has invested US\$270 million for armed enforcement at sea within and beyond their national sub-Antarctic territories (ANAO 2008) and has allocated substantial resources for joint enforcement actions and a cooperative agreement with France (Moleenaar 2004; Gullett & Schofield 2007). The relatively small and concentrated licensed fishing industry had strong incentives to invest US\$2 million over a short period to investigate and mitigate IUU fishing because sustained high levels of IUU fishing would otherwise have decreased their catch and lowered their catch quotas (SC-CAMLR 2002; COLTO 2003). The ASOC is a global NGO network with a diverse funding base (ASOC 2012). In a regional context, South Africa also has a substantial capacity to address IUU fishing (Hauck & Kroese 2006).

The development of agreed-upon mechanisms for communication was collectively rated as being of critical importance for addressing IUU fishing. These mechanisms facilitate information exchange and collaboration. The current development of catch-documentation schemes in several fisheries (Miller et al. 2010) and the implementation of global port state measures (Flothmann et al. 2010), including a global IUU list and unique vessel identifier (UVI) schemes, could become important in curtailing IUU fishing.

If exchange of information is facilitated by agreed-upon protocols for collaboration and the allocation of other resources required to address IUU fishing are effectively coordinated, investments in novel technology and human capacity need not necessarily cost hundreds of millions of dollars. This is illustrated by purpose-built mobile telephone applications, used together with waterproof cameras, that have enabled Liberian fishers to voluntarily report on suspect fishing activities (IMCS 2011). Such reporting capacities, which enable complex problem solving through “crowdsourcing” (Khatib et al. 2011), can be effectively mobilized, but depend on the creation of adequate incentives and the building of cooperation and trust.

Although conclusions from a single case study should be drawn with caution, lessons from this organizational network could potentially be applicable to a range of

other environmental governance challenges. Whether or not the identified organizations will be able to maintain their current financial, technical, and human capacity is unknown. The historical dynamics of noncompliance in the area managed by CCAMLR illustrates its adaptive capacity and the necessity for continuous coevolution of the identified networks and the resources they use to address novel challenges within and beyond the Southern Ocean.

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Supporting Information

The survey (Appendix S1), the 117 organizations engaged in addressing IUU fishing, grouped in metaorganizations (Appendix S2), detailed methods (Appendix S3), information on degree centrality for cooperation around monitoring, control, and surveillance at sea (Appendix S4), investigations into and tracings of trade flows (Appendix S5), and degree centrality for developing policies (Appendix S6) are available as part of the on-line article. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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