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Do subsidies drive Southern Ocean fishery operations? A comprehensive analysis of Southern Ocean fishery subsidies and the economics of distant water fleets

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Across the high seas, distant water fisheries have benefited from government subsidies. Public funds directed toward supporting the fishery sector have enabled these fisheries to extend their range and duration at sea, threatening fish populations and the health of ocean ecosystems. Fuel subsidies have been identified as the primary form of subsidy, often allowing fishing vessels to continue operations despite declining revenues. While significant attention has been directed toward understanding fishery subsidies on a global scale, the magnitude of fishery subsidies specific to the Southern Ocean remained largely unknown. The Southern Ocean accounts for 10% of the global oceans, and its two main fisheries, for Antarctic krill and toothfishes, are managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Through primary data collection in the form of interviews, our study provides a comprehensive analysis of the complex operations that underpin Southern Ocean fisheries. Our research drew upon 29 expert interviews with industry representatives, government officials, and researchers from 13 CCAMLR Member States engaged in fishing activities in the Southern Ocean. The most commonly identified subsidies in our interviews included: fuel subsidies; tax breaks; discounted loans; research, development, and innovation grants; infrastructure support; and import subsidies. However, our results show that, based on research interviews, few Southern Ocean fishing companies heavily depend on government subsidies, with subsidy allocation varying greatly by State. For the majority of CCAMLR Member States, Southern Ocean fishery subsidies are largely insufficient to induce significant changes in fishery operations. Instead, private fishery organizations continually adjust their economic strategies and operational dynamics to increase profitability and lower expenses, often foregoing government subsidies by relocating their operations (e.g., home ports) to foreign States closer to the Southern Ocean. This research suggests that distant water fisheries subsidies are complex and nuanced, needing further investigation at the regional, Nation State, and company level scale.

KEYWORDS

fishery subsidies, CCAMLR, Southern Ocean, high seas, marine governance

Introduction

Fishery subsidies have garnered significant global attention as key funding mechanisms for distant water fisheries (DWF) (Sala et al., 2018; Schuhbauer et al., 2017, 2020; Skerritt and Sumaila, 2021a). Reports indicate that some DWF receive subsidies amounting to up to 40% of their catch value, suggesting that without such financial support, these fleets might not be profitable (Skerritt and Sumaila, 2021a). In areas beyond national jurisdiction (ABNJ) (i.e., the high seas), ocean areas that lie beyond the 200 nautical mile jurisdictional limit of Nation States, it is estimated that 54% of fishing grounds would be unprofitable without subsidies (Sala et al., 2018). This is underscored by the World Trade Organization's (WTO) 12th Ministerial Conference (MC12) Agreement, which aims to prohibit harmful fishery subsidies, which are typically categorized as capacity enhancing, beneficial, or ambiguous based on their impacts on fish stocks (Andreoli et al., 2023; Skerritt and Sumaila, 2021b; Sumaila et al., 2010a). Capacity enhancing subsidies are often regarded as those that encourage excessive fishing by reducing fishing costs, thus artificially increasing profits, thereby leading to resource overexploitation. Ambiguous subsidies can either contribute to sustainable management or to the overexploitation of resources, depending on how they are implemented (Sumaila et al., 2019). Beneficial subsidies are considered investments that promote the sustainable management of fishery resources, such as those supporting the establishment and maintenance of protected areas (Andreoli et al., 2023). Capacity-enhancing subsidies represent the largest subsidy category, with an estimated total of over US 22 billion in 2018 (Sumaila et al., 2019). Within this category, fuel subsidies constitute the largest subsidy type, accounting for 22% of global subsidies (Sumaila et al., 2019).

DWF, which operate in the Exclusive Economic Zones (EEZs) of foreign States or in ABNJ are largely dominated by a small number of fishing States (Sala et al., 2018). This is particularly evident in the Southern Ocean, the waters surrounding Antarctica, which represents 10% of the global ocean and hosts some of the most remote and inaccessible fisheries worldwide. Unlike most fisheries operating in ABNJ, which are managed by regional fishery management organizations (RFMOs), the Southern Ocean fisheries are managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR carries out the provisions of the Convention on the Conservation of Marine Living Resources (CAMLR Convention), through implementing Conservation Measures for its 26 Member States along with the European Union (CCAMLR, 1980). Its Convention effectively mandates an ecosystem-based precautionary approach for the conservation of Antarctic marine living resources (Chavez-Molina et al., 2023; Constable et al., 2000). Under CCAMLR's rules, Member States must notify their intention to fish in the Convention Area. In the most recent season (2023), 13 Member States notified to fish. Antarctic Krill (*Euphausia superba*, hereafter krill) and Patagonian and Antarctic toothfish (*Dissostichus eleginoides* and *D. mawsoni*, respectively; hereafter toothfish) are the two main fisheries in the Southern Ocean, with the value of these fisheries estimated at 370 million USD per year (Stoeckl et al., 2024). The Convention Area roughly encompasses waters south of the Polar Front. While most of these waters are considered ABNJ, some of the northern parts of the Convention Area include subantarctic islands, some of which have uncontested sovereignty (CAMLR Convention 1980, Chairman's Statement). These include the Prince Edward and Marion Islands, Crozet Island, Kerguelen Island, and Heard Island and McDonald Islands which have EEZs surrounding them.

Within the scope of marine conservation and fisheries management, significant attention has been given to studying the broad ranging impacts of subsidies for DWF. Studies have shown that direct transfers of funds to private fisheries can enable them to operate beyond economically sustainable limits (Schuhbauer et al., 2020; Skerritt et al., 2023; Skerritt and Sumaila, 2021a). Subsidies can enable fisheries to extend their range and duration at sea. For instance, fuel subsidies frequently allow fishing vessels to continue operations despite declining revenues, or in some cases even at a net loss that is offset by the subsidy (Skerritt and Sumaila, 2021a). This raises a fundamental question: can DWF remain viable without government subsidies? This is particularly important for the Southern Ocean, which is characterized by its remoteness and inaccessibility (Murphy et al., 2021), making it an ideal case study.

Several global subsidy studies have been published (e.g., Sumaila et al., 2019; Villasante et al., 2022; Skerritt et al., 2023), and some suggest that many DWF are highly subsidized (Sala et al., 2018; Sumaila et al., 2010a,b, 2016, 2019). However, there is very little information about Southern Ocean specific fisheries subsidies with the exception of a recent study on the economics of the krill industry which provided insight into the varying levels of government subsidies among CCAMLR Member States (Cappell et al., 2022).

Given the evidence suggesting that the profitability of most DWF hinges significantly on substantial government subsidies (Sakai et al., 2019; Sala et al., 2018; Skerritt and Sumaila, 2021a), it is reasonable to infer that Southern Ocean fisheries greatly depend on such support. This is further emphasized by Cappell et al. (2022), which indicates that private fishing companies in several CCAMLR Member States benefit from direct subsidies, including fuel subsidies, for their krill fishery operations.

Recent assessments of Southern Ocean ecosystems have underscored the global implications associated with Southern Ocean fisheries (Cavanagh et al., 2021; Grant et al., 2021; Murphy et al., 2021; Pertierra et al., 2021). Krill and toothfish fisheries may impact the overall capacity of the Southern Ocean to provide globally significant ecosystem services (Cavanagh et al., 2021; Meredith et al., 2019; Brooks et al., 2022, 2018; Grilly et al., 2015; Santa Cruz et al., 2018). Regulating services, including primary production, climate change regulation, and support for regional and global biodiversity connectivity, are particularly vulnerable to the threats posed by overfishing and escalating human activities (Cavanagh et al., 2021; Wauchope et al., 2019; Bindoff et al., 2022; Rayfuse, 2018). If subsidies are contributing to promoting fishing effort in the Southern Ocean, with implications for ecosystems and biodiversity, a State-specific analysis of government subsidies is warranted.

In this paper, we aim to decipher the current state of Southern Ocean fishery subsidies and the role these subsidies play in the fishing activities of CCAMLR Member States. This research specifically seeks to identify the extent to which each

of the 13 Member States included in this study are subsidizing their Southern Ocean fleet, including the sources and types of subsidies distributed. Through primary data collection in the form of interviews, we provide an in-depth analysis of the complex operations that underpin Southern Ocean fisheries. Our investigation focused on interviewing industry representatives, government officials, and other experts to gain insight into the intricate operations and economic factors that characterize Southern Ocean fisheries. This was further combined with secondary data sources including company financial documents, government reports, Global Fishing Watch data, and CCAMLR catch data to deepen our understanding of fishery operations and subsidy allocation. Our findings and implications demonstrate that Southern Ocean fishery subsidies are complex and diverse, varying significantly between Member States and individual companies. Our results suggest that States have unique and distinct relationships with subsidies, influenced by both the type of subsidy and the fishery location. This implies that DWF subsidies may be more nuanced than previous studies suggested.

Methods

Definition

Documenting fishery subsidies requires defining what subsidies are, and there is no single accepted definition. For the purposes of this study, we define fishery subsidies to include all direct and indirect transfer of funds from government and public bodies to private fishery organizations operating in the Southern Ocean (see Table 2 for each subsidy type defined in our study).

Historically, the term "subsidy" has been subject to ongoing debate regarding its definition (Rickard, 2018). The WTO, the leading international body governing trade rules between nations, defines subsidies as "financial contributions made by a government or any public body that confer a benefit and are generally considered to be trade-distorting" (WTO, 2023, p. 1, 2022a; 2022b; Lennan and Switzer, 2023). However, the WTO definition includes specific clauses on "specificity" (ASCM, 1996), which often exclude subsidies related to pre- and post-harvesting activities, such as transportation, processing, packaging, and distribution of catch (Irschlinger and Tipping, 2023). Additionally, subsidies that are not "industry specific" but benefit multiple industries (e.g., fisheries and agriculture alike) are often not accounted for under the WTO's legal definition of fishery subsidies. While the WTO definition serves as a foundation, it is essential to recognize that it originated as a political compromise shaped by extensive diplomatic negotiations among the 164 current WTO Member States (WTO, 2023). In our research, we aim to broaden the scope beyond the confines of this legal definition by including subsidies related to pre- and post-harvesting activities, as well as non-industry-specific subsidies.

Semi-structured interviews

To gather primary data on fishery subsidies, we conducted semi-structured interviews with industry representatives, government officials, and expert researchers from the 13 Member States that fished in the Southern Ocean during the 2023 season. In States with available research on fishery subsidies, we also interviewed expert researchers knowledgeable about both their own State's fishery subsidies and those specific to the Southern Ocean.

Our investigation focused on the 2023 CCAMLR fishing season, which started on December 1st, 2022 and ended on November 30, 2023. During this season, under CCAMLR's list of authorized vessels, a total of 13 Member States notified to fish, representing 23 fishing companies (Table 1). Additionally, five companies based in Réunion Island registered to fish in the Crozet and Kerguelen Islands (French subantarctic EEZ) within the CCAMLR Area for the 2023 season. Altogether, this included 28 companies (Table 1).

Information on licenses and authorizations were collected from CCAMLR's "List of Authorized Vessels" for the 2023 season (CCAMLR, 2023). These States include: Australia, Chile, China, France, Japan, the Republic of Korea, New Zealand, Norway, South Africa, Spain, Ukraine, the United Kingdom, and Uruguay. Among these States, some have exclusively targeted toothfish,

TABLE 1 List of Member States, licensed fishing companies, and licesned number of fishing vessels for the 2023 CCAMLR fishing season.

Member States	Authorized fishing companies	Number of licensed fishing vessels
Australia	Australian Longline Fishing Pty Ltd, Austral Fisheries Pty Ltd	4
Chile	Pesca Chile S.A.	2
China	Liaoning Pelagic Fisheries Co., Ltd, Rongcheng East China Fisheries Co., LTD, Zhongyu Global Seafood Corp (ZGSC), Jiangsu Sunline Deep Sea Fishery Co., Ltd	4
France	Pêche Avenir S.A., COMATA, Cap Bourbon, Samper S.A., Armements Réunionnais, Reunion Pêche Australe	9
Japan	Taiyo A & F Co. Ltd	1
Republic of Korea	TNS Industries Inc., Hongjin Corporation, Jeongil Corporation, Dongwon Industries Co. Ltd.,	10
New Zealand	Talleys Limited, Sanford Limited	3
Norway	Aker Biomarine	3
South Africa	Pesquera Azul S.A.	1
Spain	Pesquerias Georgia SL	1
Ukraine	LLC Fishing Company Neptuno, Taurus Logistics Group LP, Marissco Fishing Limited	5
United Kingdom	Argos Froyanes Ltd	3
Uruguay	Pesquera Azul S.A.	1

Data extracted from CCAMLR's list of authorized vessels (https://www.ccamlr.org/en/compliance/licensed-vessels).

TABLE 2 Definitions of subsidy types investigated in this study.

Subsidy type	Definition
Fuel subsidy	Financial assistance to fisheries for the cost of fuel. Fuel subsidies can take various forms, including fuel tax concessions, fixed prices, tax exemptions on consumption, sales tax reductions, and restitution payments (Rickard, 2018).
Tax breaks	Tax breaks reduce companies' tax burdens allowing businesses to keep a larger portion of their revenue (Rickard, 2018). They are made possible by legislative enactments typically in the form of credits or deductions tailored to specific industries or individual behaviors.
Royalties	Direct payments received by industry for the use of government property or rights, based on an agreed rate per unit extracted, produced, manufactured, or on a fixed share of the income or profit resulting from the use of the property (USDT, 2024).
Catch share programs	Fishery management strategy often enacted by governments that allocate a portion of the total allowable fishery catch to individuals, cooperatives, communities, or industry (NOAA, 2024).
Discounted loans	A loan sold at a lower price in which the borrower gets an amount that is already reduced by the interest and other charges (Cambridge, 2024). Discounted loans are a form of subsidy often prevalent in Nation States with banks that are State owned, and State funded. This allows private companies to apply for low interest loans, long term loans, and financial guarantees.
Research, development, and innovation (RDI) grants	Grants intended to stimulate scientific and technological innovation to particular sectors. RDIs are often regarded as beneficial subsidies, promoting fisheries resource conservation, management and sustainability (Andreoli et al., 2023).
Infrastructure support	Direct transfer of funds for the development of infrastructure in the fishery sector, such as for fishing vessels, equipment, technology, ports, and processing facilities (Sumaila et al., 2019).
Import subsidies	Payments made by governments or public institutions to industry for imported goods. In the fishery sector, import subsidies are often used as financial incentives for the import of catch at municipal or federally managed ports (Mallory et al., 2021).
Export subsidies	Policies that provide financial encouragement from governments to beneficiaries for the export of goods, often to achieve desired export objectives (UNCTAD, 2024).

such as Australia, France, New Zealand, South Africa, and the United Kingdom. Others, such as China and Norway, have focused on fishing for krill in recent years. Additionally, States like Chile, the Republic of Korea, Japan, and Ukraine have fishing companies that historically targeted both toothfish and krill.

We sought to interview industry representatives from each company and government officials from each Member State fishing in CCAMLR's waters. For each licensed vessel, we first determined the flag State and the company to which the vessel belonged. Subsequently, we conducted a web search for the 23 fishing companies operating in the Southern Ocean, identifying industry representatives from each company. For French Southern Ocean fishing companies specifically, we conducted a separate investigation as these vessels were not part of CCAMLR's list of authorized vessels. This included researching French fishing companies active in the Southern Ocean. For government representatives, we adopted two approaches. First, we visited the Ministry of Fisheries websites for each State and identified government representatives with authority and expertise in DWF operations and subsidies. Second, we consulted the CCAMLR 2023 annual meeting report list of participants, identifying government officials in fishery relevant positions. Lastly, we also targeted key informants who had completed research on fisheries subsidies either in the Southern Ocean or in a specific Member State. These expert researchers were contacted via email upon reviewing their publications and research on fishery subsidies. This also included reaching out to representatives of the Coalition of Legal Toothfish Operators (COLTO) and the Association of Responsible Krill Harvesting Companies (ARK), both of which serve as industry groups for Southern Ocean fisheries. Approval for interviews was obtained through the University of Colorado Boulder's Institutional Review Board.

We developed three sets of interview questions, each tailored to the specific group identified above. Although we inquired about specific aspects such as subsidies, fishery operations, and catch data, our interviews adhered to a semi-structured format. This approach provided both the interviewee and interviewer with the flexibility to explore certain topics in greater depth or introduce additional questions as necessary. Research shows that semi-structured interviews work best when dealing with high-level government officials and elite members of an industry (Bernard, 2006). Interview questions consisted of two sections. The first section focused on fishery operations, encompassing topics such as catch numbers, vessel movement, costs, crews, gear, and export markets. This section aimed to obtain quantitative data on fishery operations. The second section delved into subsidy data, covering various types of subsidies, including fuel subsidies, tax breaks, royalties, catch share programs, discounted loans, research development and innovation grants, infrastructure support, import subsidies, and export subsidies (Table 2). Each interviewee was asked to elaborate on the presence or absence of these subsidies in their context. Through this process, a total of six subsidy types were identified as the most frequently mentioned by the interviewees. This section predominantly focused on qualitative data, as subsidies are frequently indirect, and there is a lack of a universally agreed upon method for calculating vessel specific subsidies.

Our correspondence began with industry representatives, followed by government officials, and concluded with expert researchers. This sequential approach allowed us to prioritize collecting primary data from the Southern Ocean fishing industry before engaging in discussions about subsidy data and economic operations with government officials. Each interviewee was contacted three times before being considered unreachable, resulting in no responses from 20 industry representatives, 22 government officials, and six researchers. Within industry representatives, we interviewed those representing a diverse range of fisheries which varied in vessel numbers, size, catch, and operational scale. For France, the Republic of Korea, and Ukraine,

we interviewed the companies with the largest vessel fleets involved in their States' Southern Ocean operations. In other Member States, such as Chile, Norway, and Spain, we interviewed their sole Southern Ocean fishing company.

The majority of interviews were conducted using the Zoom platform and were recorded with permission from the interviewees. A limited number were conducted in person or on the phone. Each interview session lasted ~1 h. The Zoom AI assistant was utilized for qualitative transcription and note-taking purposes. Interviews were analyzed manually, through categorizing information according to subsidies for each specific State and each company. Data from interviews was further categorized into subsidy types and sources as well as influence on fishery operations for each Member State.

Other sources of information

While interview data was the focal point of our investigation, our results also drew on other available information, including government reports and secondary sources. For States where we were unable to conduct interviews with fishery representatives or government officials, we relied on information and data provided by expert researchers. This included scientific reports from institutes and organizations conducting subsidy research, government reports, scientific literature, and company financial documents.

Our investigation also relied on CCAMLR's statistical bulletin of catch data. This data was used to quantify the total catch in tonnes per State, species, and Division and Subarea locations. We did this for the 2022 season as the 2023 data has not been published yet at the time of analysis. Coupled with our subsidy analysis, this allowed us to highlight the States with the highest catch, the regions most heavily targeted by the fishing industry, and the distribution of krill and toothfish catch by Member States.

We further mapped home ports and fishing grounds of each fishing company interviewed. For each industry representative interviewed, we gathered information on their fishing operations, including their home ports, catch landing locations, refueling sites, maintenance service locations, and whether their vessels operate in any regions outside the Southern Ocean. This data enabled us to manually map the trajectory of 26 individual Southern Ocean fishing vessels, from their port of origin to where they land their catch. This approach enabled us to present an overview of the current state of Southern Ocean fishing operations, highlighting the distribution patterns of various fishing companies, their selection of home ports, and the role subsidies play in their fishing operations. For those Member States and companies we were unable to interview, we used data from Global Fishing Watch to track the movements of their fishing vessels.

Results and discussion

Below, we begin by outlining our interview results for Southern Ocean fishery subsidies, which are contextualized in Figure 1. This figure presents an initial overview of the presence and absence of Southern Ocean fishery subsidies by type, as well as the number of interviews conducted with each group. We then examine two integral components of Southern Ocean fishery operations: fishery catch and vessel movement. Following this, we discuss our State-specific subsidy findings, derived from interviews with fishery representatives, government officials, and expert researchers. Finally, we highlight knowledge gaps and apply the lessons learned from Southern Ocean fishery subsidies to the broader context of subsidies for DWF.

Interviews

In our study, we had a total of 29 interviewees from 13 Member States, including 11 industry representatives, nine government officials, and nine expert researchers (Figure 1). Industry representatives included CEOs, general managers, and policy managers. Government officials included high level diplomats, national directors of fishery operations, and several ministries of fishery representatives. Researchers interviewed specialized in fishery subsidies, some focusing on their own States' jurisdiction and others on subsidies specific to the Southern Ocean. At least one group was interviewed for each State, and both industry and government officials were interviewed for Australia, Chile, France, New Zealand, South Africa, Spain, and Ukraine (Figure 1).

The extent of subsidies received by Southern Ocean fisheries varied greatly among CCAMLR Member States. While two Member States were identified as providing significant subsidies to their Southern Ocean operations, most fisheries receiving government support suggested that the amount received was insufficient to significantly alter operations or greatly affect profitability. While we emphasize the qualitative aspects of our results, quantitative data provided by some interviewees suggest subsidies range from zero to millions of USD per year across different fleets. Figure 1 shows the presence and absence of subsidies for each category among the 13 Member States that fished in the 2023 CCAMLR fishing season. Notably, government subsidies directed to private fishery organizations was highest for Chinese and Norwegian Southern Ocean fisheries.

Southern ocean fishery operations

During the 2022 season 13 CCAMLR Member States were authorized to fish. Of these, 10 States engaged in toothfish fishing operating 37 vessels, including eight French vessels operating within their subantarctic EEZs (Lefebvre and Maghin, 2019). Five States targeted krill, operating 13 vessels. France, Australia, and the United Kingdom reported the highest toothfish catches by tonnage, with Norway significantly surpassing other States in krill catch (Figure 2). While the eight French vessels were not listed under CCAMLR list of authorized vessels (CCAMLR, 2023), their catch was reported in CCAMLR's statistical bulletin (CCAMLR, 2022). Collectively, a total of 50 vessels were authorized to fish in the CCAMLR Convention Area, resulting in a combined catch of 15,031 tonnes of toothfish and 415,509 tonnes of krill (Figure 2).

FIGURE 1
Presence or absence of subsidies by category (fuel subsidies, tax breaks, discounted loans, research development and innovation grants, infrastructure support, and import subsidies) for each of the 13 CCAMLR Member States which had representatives interviewed in our study. Green boxes indicate the presence of subsidies, while gray boxes indicate their absence. Additionally, green check marks show the number of interviews conducted with industry, government, and research representatives, whereas gray dashes indicate the absence of interviewees for those groups.

There are large differences in catch among CCAMLR Member States particularly for the toothfish industry. States with subantarctic island territories, such as Australia and France, have exclusive access and fishing rights to large areas of the Southern Ocean. This is also true for South Africa, which has exclusive access to the Prince Edward and Marion Islands (Subarea 58.7), however these fisheries have been less profitable in recent years. As interviewee 019 stated, South Africa's Southern Ocean fisheries catch has declined because "one boat broke down, and the other was decommissioned due to illegal fishing." Fisheries operating in these EEZs often land substantially more catch than those in the rest of the CCAMLR Convention Area and have less competition for marine resources. Australia has exclusive access to the Heard Island and McDonald Islands EEZ (CCAMLR Division 58.5.2) and its four vessels caught 2,944 tonnes of toothfish in the 2022 season. France has eight fishing vessels in the Crozet and Kerguelen Islands (CCAMLR Subarea 58.6 and Division 58.5.1, respectively) and in the 2022 season registered a total catch of 5,936 tonnes of toothfish. That same season, the United Kingdom was the only State that fished for toothfish in the waters around South Georgia and South Sandwich Islands (CCAMLR Subareas 48.3 and 48.4 respectively), and caught a total of 2,235 tonnes. These three States (United Kingdom, France, and Australia) dominate the Southern Ocean toothfish industry (Figure 2). Subantarctic EEZs play a critical role in the profitability of toothfish fisheries. They enable private industries operating within them to capitalize on reduced competition with foreign States.

Vessel movement

Data on home ports and vessel movements were collected through interviews with industry representatives from Australia, Chile, France, the Republic of Korea, New Zealand, Norway, South Africa, Spain, Ukraine, and the United Kingdom (Figure 3). These interviews involved representatives from 11 companies, accounting for 26 fishing vessels, of which 22 targeted toothfish and four targeted krill. Data on each vessel's movement was collected by asking interviewees to detail the home ports and target fishing grounds for each of their Southern Ocean vessels. While not every State is included in this figure (e.g., China and Japan), or every fishing company (it represents only 11 out of 23), it provides a picture of where some States' fisheries are operating from and what fishing grounds they are targeting. This in turn, reveals the operational distribution of some Southern Ocean fisheries, and underscores how decisions by private fishery organizations to operate from abroad could influence the extent of government subsidies they receive.

Our vessel movement data shows that fishing companies are mostly operating outside of ports of their flag State, ultimately moving their home ports to Nation States closer to the Southern

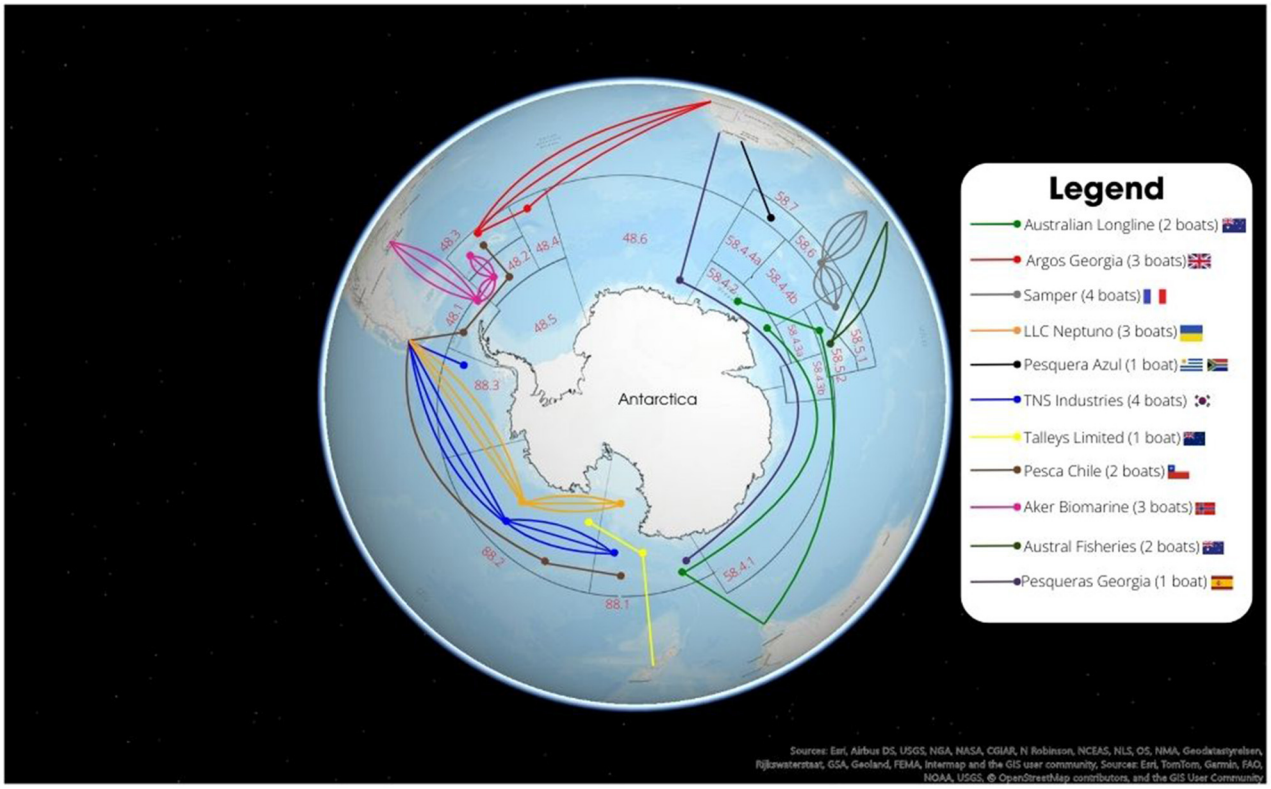

FIGURE 2
Movements of 26 fishing vessels from their home ports to their targeted fishing grounds during the 2023 CCAMLR fishing season. CCAMLR Area is represented by the gray lines with Divisions and Subareas labeled in red. Fishing vessels are operated by 11 different companies from 10 CCAMLR Member States. Each line represents one fishing vessel, commencing at the port of origin with the circles at the end of each line indicating general areas of fishing activity within CCAMLR Divisions and Subareas, rather than precise locations. Movement data was obtained through interviews with fishery representatives from each company included in this figure to confirm the operational routes from their home ports to their target fishing grounds. *Pesquera Azul (black line) is a Uruguayan fishing vessel that was granted permission by the South African government to fish in Subarea 58.7, a subantarctic EEZ.

Ocean. Only the fisheries whose flag States are relatively close in proximity to the Southern Ocean (e.g., Australia, Chile, New Zealand, South Africa, and Uruguay) operate from their national territory. For Australia, however, one of its two Southern Ocean fishing companies, Austral Fisheries, operates its home port from Mauritius (Figure 3). This is due to cost efficiencies compared to Australian ports and the advantage of quicker access to fishing grounds. Interviewee 003 noted that the "cost of repairs, maintenance, and port space" were also determining factors for Austral Fisheries not to operate from Australia. Unlike Austral Fisheries, Australian Longline Fisheries, a competing company, operates from Hobart, Tasmania (Figure 2) and can access government support programs, such as the Tasmanian Freight Equalization Scheme, that don't apply for the former.

The remaining fishery companies included in Figure 3 have all shifted their operations to foreign States. Interviewee 008 from Samper, a toothfish fishery from France, stated that their company operates from Reunion Island, a French island territory east of Madagascar which is much closer to the Southern Ocean than France. Interviewee 013 from TNS industries, a Korean toothfish fishing company, mentioned that it had moved its four toothfish vessels to Punta Arenas, Chile. Interviewee 026 noted that Aker Biomarine, a krill fishing company from Norway, recently signed an agreement with Uruguay to have their home port in Montevideo. Pesqueras Georgia from Spain is a joint venture between Spain and the Falkland Islands, and interviewee 020 indicated that its toothfish vessel normally operates from Cape Town, South Africa. Interviewee 023 from LLC Fishing Company Neptuno, a Ukrainian toothfish company, confirmed that they also operate from Punta Arenas, Chile, and its Southern Ocean fishery represents Ukraine's sole DWF operation. Further, interviewee 024 from Argos Froyanes LTD, the United Kingdom's only Southern Ocean fishing company, explained that they had recently changed their home port from New Zealand to Namibia. Unlike many of its European counterparts, it chose not to operate from the South American continent likely due to political tensions between the United Kingdom and Argentina over the Falkland Islands.

Tracking and home port data elucidate the differences between Southern Ocean fisheries and other DWF. While research shows that a great portion of DWF operate from their flag States' territorial boundaries, complete fishing in ABNJ for several months, and then return to their home ports to land their catch (Chen et al., 2008; Stäbler et al., 2022; Yu and Wang, 2021), Southern Ocean fishing companies mostly operate from foreign ports and frequently change ports to improve profitability. DWF that operate from their States' home ports are bound to their States' regulations

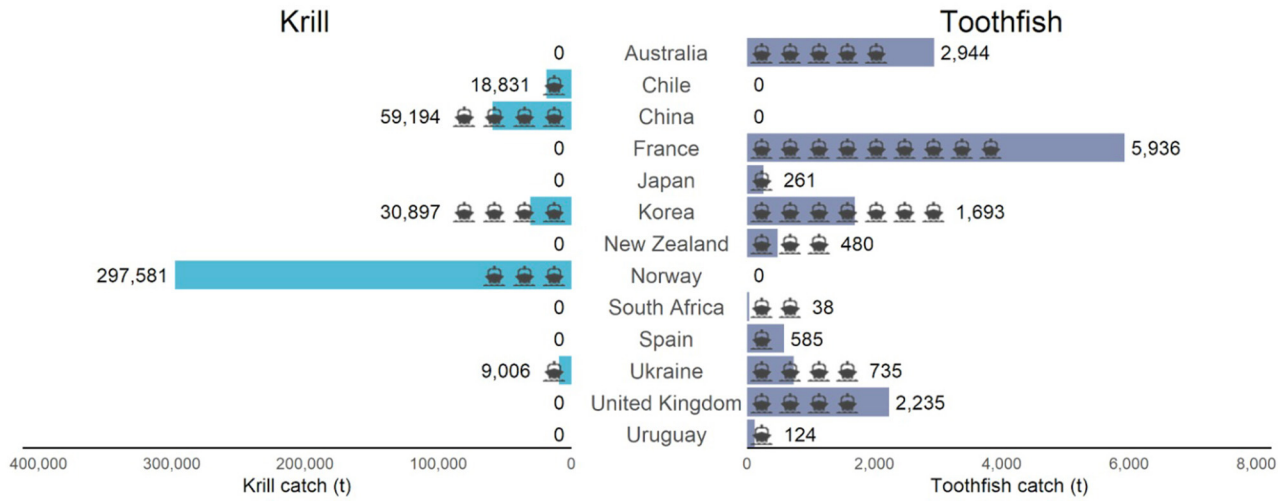

FIGURE 3
Tonnes (t) of krill and toothfish caught during the 2022 CCAMLR fishing season by the 13 Member States that notified to fish. Blue bars represent krill catches and purple bars represent toothfish catches. Black boat icons indicate the number of authorized fishing vessels per State and per fishery. Norway recorded the highest krill catch at 297,581 tonnes, while France had the highest toothfish catch at 5,936 tonnes. Catch data from CCAMLR (2023).

which include taxes, licenses, and insurance but also state and federal subsidies. Government subsidies often encourage fisheries to operate from their domestic ports, regardless of the geographic distance between their State and the international fishing grounds they target (Mallory et al., 2021). States have been shown to offer economic incentives in the form of subsidies to encourage the transportation of catch back to their home port (Mallory et al., 2021). Within the Southern Ocean, and during the period of our study, only one State, China, has been shown to do this. Government reports show that certain municipalities in China are willing to provide DWF, including those in the Southern Ocean, with subsidies of up to 200 CYN (~30 USD) per tonne of catch, along with additional exemptions from import taxes, contingent on vessels offloading their catch at local ports (Mallory et al., 2021).

Unlike most DWF, if the majority of Southern Ocean fishing vessels were to depart from the ports within their national borders, the mere act of reaching the Southern Ocean would entail a significant voyage. Even fishing companies arguably close to the Southern Ocean (e.g., New Zealand toothfish fisheries) take over 10 days just to reach the fishing grounds. Interviewee 015 mentioned that New Zealand Southern Ocean fisheries use ~380,000 L of gasoline, amounting to an estimated cost of around 340,000 USD per trip. States like China, France, Japan, the Republic of Korea, Norway, Spain, the United Kingdom, and Ukraine are more than 10,000 kilometers away from Antarctica. The combination of fuel costs, and the duration of round trips to and from the Southern Ocean, would result in a significant financial burden. Our vessel movement results suggest that DWF in the Southern Ocean continuously change their home port operations to improve profitability. Dozens of private fishery organizations operate from foreign ports closer to Antarctica. Operating within foreign jurisdictions subjects these companies to varying tax regimes, licensing requirements, and ultimately, subsidies. In many cases, as interviewee 020 argued, fisheries whose home States provide fuel subsidies (e.g., Spain), are unable to benefit from such subsidies due to refueling operations occurring in foreign territories like Cape Town or the Falkland Islands.

Subsidy results by category

Across the three categories of fishery subsidies—capacity enhancing, ambiguous, and beneficial—governments and public institutions have provided over a dozen types of subsidies to private fishery organizations (Sumaila et al., 2019). Among these, the most commonly identified within our 29 interviews include: fuel subsidies; tax breaks; discounted loans (below market rate); research, development, and innovation grants (RDI); infrastructure support; and import subsidies (Figure 1). In the following subsections, we present our results by subsidy type and discuss their role in the operations of individual Member State fisheries, drawing on our data on fishery operations and vessel movement.

Fuel subsidies

Previous research suggests that fuel subsidies destined to large-scale fisheries constitute 20% of total global fishery subsidies (Schuhbauer et al., 2020). This substantial level of support, amounting to ~7.2 billion USD annually, establishes fuel subsidies as the largest category of capacity-enhancing subsidies and currently represents the principal form of government assistance for the fishing industry (Sala et al., 2018; Sumaila et al., 2021). Within the Southern Ocean, our interview data highlight that fishing companies from China, France and Spain have received, or currently receive, fuel subsidies for their Southern Ocean fleets. Among these States, China stands out as the largest contributor to fuel subsidies. It is worth noting that fuel subsidies can take various forms, including fuel tax concessions, fixed prices, tax exemptions

on fuel consumption, sales tax reductions, and restitution payments (Rickard, 2018).

While Chinese government reports show that fuel subsidies have decreased by up to 40% from 2014 to 2019, new data shows that these subsidies are now flowing disproportionately to DWF (Mallory et al., 2021). Currently, according to interviewee 007, Chinese fuel subsidies for distant water vessels are categorized by fishing ground (location of the fishery), tonnage (vessel size), and number of days of the vessel at sea (Wang et al., 2023). Government allocation of fuel subsidies is further supported by local government subsidy incentives that encourage the transportation of catch back to mainland China. For krill specifically, the municipal governments of Weihai, Shandong Province, provide 30 CYN (4USD) per tonne of Antarctic krill plus tax exemptions for landing their catch at their municipal port (Mallory et al., 2021, p. 45). Fuel subsidies coupled with economic incentives for landing Southern Ocean catch in mainland China likely alleviate some of the financial constraints on Chinese companies engaged in round-trip voyages to the Southern Ocean. This is the case for Fu Yuan Yu 9818, a Chinese krill vessel owned by Fujian Zhengguan Fishery Development Co., and Long Fa, a Chinese krill vessel operated by Zhongyu Global Seafood Corp (ZGSC), both of which have registered multiple docks in the Shandong Province of China. Unlike Chilean, Korean, Norwegian, and Ukrainian krill vessels, those from China engage in transboundary commutes between the Southern Ocean and ports of their flag State (Figure 4), with fuel subsidies likely playing a crucial role in facilitating this operational dynamic. Data from Global Fishing Watch support these travel patterns: Chinese vessels undertake long transboundary commutes between China and the Southern Ocean, whereas vessels from other States operate from foreign home ports to minimize travel distance, cost, and enhance profitability (Figure 4).

Our results suggest that fuel subsidy allocation in France and Spain is different from those in most Member States because they are subject to both national and European Union (EU) public subsidies. In France, a study by Bloom Association and the Institute Rousseau indicated that in 2021 tax exemptions on French fuel subsidies accounted for almost 63% (∼229 million USD) of all fishery subsidies in the State (Bloom, 2024). French fisheries receive a wide range of tax benefits of which the most significant is the exemption from the "Taxe Intérieure de Consommation sur les Produits Énergétiques" (Domestic Tax on the Consumption of Energy Products, or TICPE). This is a tax on fuel prices that amounts to €0.6091 for each liter of fuel purchased (Bloom, 2024). Similarly, in response to the Ukraine War, the EU relaxed State aid rules giving governments more flexibility to support industries impacted by the war. French fisheries benefited from "discounts at the pump" of between 20 and 35 euro cents per liter of diesel (Bloom, 2024). French Southern Ocean fisheries operating from Reunion Island (Figure 2) can benefit from French national subsidies because under French law Reunion Island is classified as an "outermost territory."

This, however, is not the case for Spanish Southern Ocean fisheries. Interviewee 020 shared that because the Spanish company Georgia Seafoods LTE is not based in a Spanish territory, it does not receive the same level of subsidy support that Spanish fisheries operating from Spain do. Georgia Seafoods is a joint venture between Spain and the Falkland Islands (50/50) and mostly operates from Cape Town, South Africa (Figure 2). Its Southern Ocean vessel, the Tronio, operates eight out of 12 months a year, both in the Southern Ocean and in other ABNJ, refueling in both Cape Town and the Falkland Islands. This exposes the company to varying fuel prices, taxes, and subsidies particular to each State. While Georgia Seafoods does not currently receive any fuel subsidies for its Southern Ocean fishery, interviewee 020 mentioned that it previously received €250 thousand in 2022 from the EU. Amidst the Ukraine war, fuel prices spiked, and our interviewee detailed that "prices reached as high as 1500 per tonne, up from the usual 900 per tonne." To alleviate this financial burden, the EU enacted a legislation, included in Spain's Royal Decree (Order APA/986/2022), to alleviate the fuel costs associated with the fishing industry. Article 8 of the legislation stipulates that vessels refueling in foreign ports are also eligible for fuel subsidies (BOE-A-2022-17151). While this temporarily benefited Georgia Seafoods LTE, the legislation only offered a one-time payment for the 2022 season. According to interviews with industry and government representatives, Spanish Southern Ocean fisheries currently do not receive fuel subsidies.

Other sources of evidence suggest that States with DWF operations, such as Japan and the Republic of Korea, also benefit from fuel subsidies (OECD, 2021a,b). While the OECD data suggests that both Japan and the Republic Korea provide fuel subsidies to their fisheries (OECD, 2021a,b), these results are not specific to fisheries operating in the Southern Ocean. Data collected from Interviewees 011, 012, and 013, suggests that Taiyo A & F Co. Ltd (the only Japanese company fishing in the Southern Ocean) and TNS Industries Inc. (the largest Korean fishing company in the Southern Ocean) do not receive fuel subsidies. The Japanese toothfish vessel Shinsei Maru No. 8 operates from both Cape Town, South Africa and Punta Arenas, Chile. TNS Industries has four toothfish vessels which all operate from Punta Arenas, Chile. Interviewee 013 explained that "because their vessels do not operate from Korea, they are not subject to the same fuel subsidies that vessels operating from Korea otherwise do." The Republic of Korea has been identified as one of the top 10 nations providing harmful fishery subsidies (Skerritt and Sumaila, 2021a), however, our interview data suggests that these subsidies are likely not distributed to Southern Ocean fisheries. Home port location plays a critical role in the operation of Southern Ocean fisheries and greatly influences the distribution of fuel subsidies to fishing companies.

Several governments have opposed subsidizing fuel for Southern Ocean DWF. Our interviews with government officials from Australia, Chile, New Zealand, South Africa, Ukraine, and Uruguay indicate that these States do not provide direct fuel subsidies to fishing companies in the Southern Ocean. While some States like New Zealand indirectly support fuel subsidies through tax exemptions for road use charges, these subsidies are primarily aimed at cars, trucks, and heavy machinery. While the fishing industry indirectly benefits from these fuel subsidies for the transportation of catch, and the loading and unloading of equipment, they are part of broader sectoral support that also benefits recreational vessels, public transportation, machinery, and freight vessels (Interviewee 014). The differences in fuel subsidies

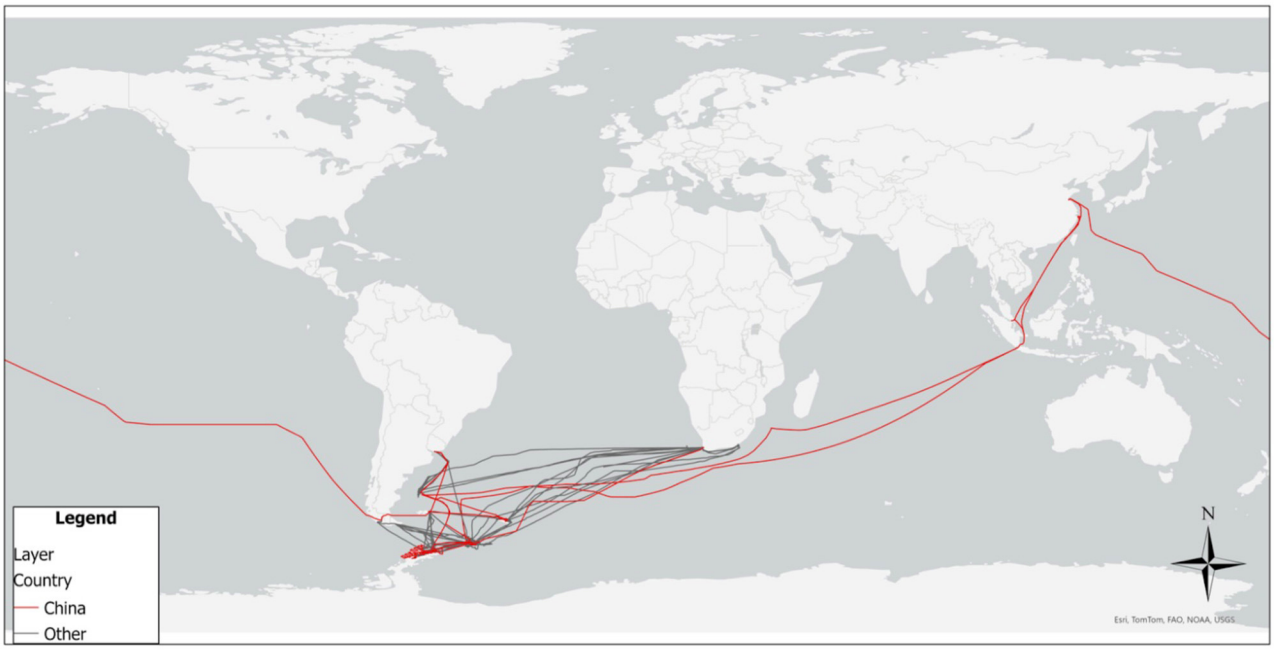

FIGURE 4
Map depicting the movements of vessels engaged in the Southern Ocean krill fisheries during the 2023 CCAMLR fishing season. Although 12 vessels were authorized to fish for krill in the 2023 CCAMLR season, Global Fishing Watch data only shows movements from nine vessels. These included two from China (Long Fa and Shen Lan), one from Chile (Antarctic Endeavor), two from the Republic of Korea (Sae In Leader and Sejong), three from Norway (Antarctic Endurance, Antarctic Sea, and Saga Sea), and one from Ukraine (More Sodruzhestva). Red lines denote the paths of the Chinese vessels, while dark gray lines represent the routes of vessels from Chile, the Republic of Korea, Norway, and Ukraine.

from some governments supporting their fisheries (e.g., China) could be a significant determinant in the profitability of their operations across the Southern Ocean.

Tax breaks

Interview data and secondary data sources suggest that Southern Ocean fisheries from China, France, and Norway benefit from tax breaks. To start, tax breaks are made possible by legislative enactments typically in the form of credits or deductions tailored to specific industries or individual behaviors. Tax breaks are implemented to stimulate certain sectors of the economy and can be industry specific such as those to the fishing sector. These subsidies ultimately reduce companies' tax burdens allowing businesses to keep a larger portion of their revenue (Rickard, 2018).

While fuel subsidies are often awarded through tax concessions, as is the case with Chinese and French Southern Ocean fisheries, our examination of tax breaks encompasses all aspects except those related to fuel. Chinese DWF, including those in the Southern Ocean, benefit from income tax exemptions with potentially as much as 522 million USD in income tax exemptions and 414 million USD in catch import tax breaks (Mallory et al., 2021). China began exempting DWF from paying corporate tax in the 1990s and more recently Article 86 of the Chinese Enterprise Income Tax Law states that catch from DWF is 100% exempted from corporate income tax (Mallory et al., 2021). Similarly, the Chinese General Administration of Customs has a long standing policy that States that fish species caught by Chinese DWF operating in the high seas or foreign EEZs are not subject to import taxes when transported back to China (Mallory et al., 2021). While this is not necessarily specific to the Southern Ocean, Chinese krill fisheries operating in Antarctica land their catch in China (Figure 4) and therefore would qualify for these tax breaks. Like fuel subsidies, these tax breaks provide an incentive for Chinese fisheries to engage in recurrent voyages to and from the Southern Ocean despite the substantial costs of travel.

A recent report from Bloom shows that French fisheries, including those in the Southern Ocean, benefit from government tax breaks to social security payments/contributions (Bloom, 2024). These subsidies represented a combined saving for fishing companies of almost 41 million USD in 2021 (Bloom, 2024). Tax exemptions from social security contributions represented the second highest subsidy for all French fisheries (Bloom, 2024), therefore potentially playing a role in Southern Ocean fisheries as well (Interviewee 009). Interviews with French researchers highlight the importance of tax exemptions related to employment, and how compared to other industrial sectors, the fishing industry often receives a higher tax advantage. In addition to employment subsidies, French DWF have also received several tax breaks for the acquisition of equipment, including the development of computerized fisheries monitoring and control tools (Bloom, 2024).

Norway also stands out as a recipient of subsidies, including tax breaks, from municipal and federal governments. Due to its proportional electoral system, subsidy allocations are prepared by each ministries budget proposal (Rickard, 2018). The Ministry of Trade, Industries, and Fisheries puts together the budget for the

fishery sector but is heavily influenced by national organizations responsible for subsidy allocation, such as "Innovation Norway," a state owned national development bank (Rickard, 2018). Our interviews with Norwegian industry representatives suggest that their Southern Ocean krill fisheries benefit from direct subsidies from Norwegian innovation funds, state and federal agencies, and tax deductions for research and development. These categories will be further analyzed in the next subsections.

Our interview data suggested that apart from China, France, and Norway, other Southern Ocean fishing Member States are not receiving government tax breaks for their fishing operations. In the six States (Australia, Chile, New Zealand, South Africa, Spain, and Ukraine) where we conducted interviews with representatives from both private industry and government sectors, interviewees stated that Southern Ocean fisheries in their respective States do not receive government tax incentives. Interviewee 006, a government official from Chile, stated that "the Chilean government has not once awarded tax breaks to Southern Ocean industrial fishery companies." Our interview data collected from the private and public sector suggests that tax breaks are likely not a significant subsidy avenue for most of these fisheries.

Discounted loans

Our interview data along with evidence from government reports (Mallory et al., 2021), suggest that Southern Ocean fisheries from China, Norway and Ukraine benefit from publicly sourced discounted loans. Discounted loans are a form of subsidy often prevalent in States with banks that are State owned, State funded, or under the leadership of a State Council, as is the case with China and Norway. This allows private companies to apply for low interest loans, long term loans, and financial guarantees. In China, for example, there is no systematic reporting for policy bank loans. However, government reports show that several industrial projects for DWF received loans from the Export-Import Bank of China (EXIM) (Mallory et al., 2021). In 2013, EXIM signed a strategic agreement with the Chinese Overseas Fishery Organization (COFA) to provide policy oriented financial support including in the construction of vessels for DWF, construction of overseas bases, and the construction of ports and processing plants in mainland China (Mallory et al., 2021). National policy banks such as EXIM have been shown to provide low-interest, long-term loans that cover up to 30% of the cost of construction and renovation of vessels for DWF, including krill vessels (Mallory et al., 2021). EXIM has further extended its support through provision of low-interest loans to the Rongcheng Oceans and Fisheries Bureau in Shandong Province, specifically designated for the establishment of fishing bases within China and overseas (Mallory et al., 2021). This initiative has been particularly advantageous for multiple Southern Ocean krill fisheries, as they frequently offload their catch in Shandong Province (Figure 4), thus capitalizing on the benefits of these preferential loans. Within China, national banks like EXIM offer notably reduced interest rates, potentially as low as 2% in contrast to the standard 5% rate charged by commercial banks (Mallory et al., 2021). Consequently, DWF, including those operating in the Southern Ocean, stand to significantly profit from these favorable loan terms.

Across industries, and through their national banking system, the Norwegian government has been known to provide loans at below market interest rates, loan guarantees, and capital injections (Rickard, 2018). As conveyed by interviewee 017, Aker Biomarine, has received guarantees on investment from the Norwegian Export Credit Guarantee Agency (Garanti Instituttet for eksportkreditt, or GIEK), finance loans for the construction of krill fishing boats from Export Finance Norway (Eksfin), research grants from the Norwegian Research Council, and investment grants for the construction of a processing facility in Norway by Innovation Norway. For the processing facility, interviewee 017 indicated that they received a 1.8 million USD government grant. While Norway's Southern Ocean fishery home port is based outside of Norway (Figure 3) this processing facility will directly benefit their operations and profitability. Norway stands out for the close collaboration between government and industry, supported by the cooperation between commercial banks and government agencies.

While Norway's Southern Ocean krill fishery has been lauded for their decarbonization efforts and sustainability operations (Misund, 2014), their yearly catch (Figure 2) eclipses that of their competition (Chile, China, the Republic of Korea, Ukraine). With three vessels operating 11 out of 12 months per season in the Antarctic Peninsula region (Area 48; Figure 2), and a cargo vessel shuttling between Montevideo and the Southern Ocean for the purpose of transporting supplies, offloading catch, crew rotation, and refueling (Interviewee 017), Aker BioMarine's operations exhibit a significantly higher level of sophistication compared to its competitors. All of this comes at a great cost. Publicly available company reports from Aker BioMarine, show that the company has consistently failed to make a profit, with a net loss of 1 million USD in 2018, 23.7 million USD in 2019, 5.4 million USD in 2020, 8 million USD in 2021, and eventually making a profit of 9 million USD in 2022 (Aker BioMarine, 2024; Orbis, 2024). The magnitude of this financial deficit underscores Aker BioMarine's substantial investment in the krill industry. Governmental support, in the form of loans, guarantees, and grants, plays a pivotal role in Aker Biomarine's strategic long-term initiatives, suggesting potential success in leveraging these subsidies for continued growth.

Ukrainian Southern Ocean fisheries also have the opportunity to apply for government loans to support their fishery operations. Unlike China and Norway, with a banking system that is State owned and State financed, interviewee 022 stated that government loans in Ukraine are the responsibility of the Ministry of Economics. These discounted loans are therefore very general and not industry specific. Our interviewees from the Fishing Company Neptuno and the International Cooperation of the State Agency of Fishery of Ukraine suggested that Ukrainian Southern Ocean fisheries have not received any government loans, although the potential for future loans remains. Interviewee 022, a Ukrainian government official, stated that "due to the war with Russia, all available funds are directed to cover security issues," indicating that there is presently no "possibility to financially support the Southern Ocean fishing industry," with future prospects uncertain.

Apart from China, Norway, and Ukraine, interviews from the 10 other CCAMLR Member States suggested that government loans are not prevalent throughout the Southern Ocean fishing industry. Instead, a significant number of these fishing companies stated that they depend on loans obtained from both domestic

private banks or international financial institutions. Interviewee 004 stated that "even the interest rates at the Chilean National Banks are too high" and that their company often looks elsewhere for bank loans. Similarly, interviewee 002, a fishery representative from Australian Longline, mentioned that their newest toothfish vessel was largely funded by a Japanese bank through a long term loan. Interviewee 013, a fishery representative from TNS industries, stated that their company works with two private banks in the Republic of Korea and a third one that specializes in fisheries industries and distributors. In the absence of discounted government loans, Southern Ocean fishery organizations seek to secure favorable terms through private banking institutions from across the world.

Research, development, and innovation grants

The CAMLR Convention requires its Member States to *inter alia* "facilitate research and comprehensive studies of Antarctic marine living resources and ecosystems" (CAMLR Convention Article IX.1a). Interviewees from Australia, Japan, New Zealand, and Norway reported robust collaborations in research between the public sector and private fishing industries. Unlike fuel subsidies, tax exemptions, and discounted loans which increase profit by reducing fishing costs, and can lead to overfishing (Martini and Innes, 2018; Sakai et al., 2019), research, development, and innovation (RDI) grants are often regarded as beneficial subsidies because they can promote fisheries resource conservation, management, and sustainability (Andreoli et al., 2023).

Interviewee 001, a government representative from Australia, clarified that while RDI subsidies are available to fishing companies, most of these subsidies are destined to research institutions and universities over industry. Interviewee 001, indicated that the fishing industry rarely gets these subsidies. Nonetheless, interviews with fishery representatives from Australian Longline show that research partnerships between fisheries and the government exist. Interviewee 002 mentioned that Australian Longline conducts stock assessment research, particularly in the Australian subantarctic islands, and has previously received government funding for its scientific endeavors. Regardless of RDI subsidies, Australian Longline engages in annual research activities, and if the findings are relevant or of interest to the Australian government, they have received financial compensation from the government for their studies.

Interviewees 011 and 012, expert researchers from Japan, indicated that RDI grants are widely distributed to the fishing industry by the Japanese government. Interviewee 012 indicated that there are several government programs supporting innovation, such as one funding the implementation of fishery infrastructure for distant water vessels, and another specifically targeting energy-saving measures for fishing vessels. Japan's Fishery Research and Education Agency (FRA) supervises research and development activities throughout Japan's fisheries sector, with a goal of integrating scientific and technological advancements into the State's fishing industry (FRA, 2023). Although government data on RDI grants in Japan is not publicly accessible, interviewees suggest that Taiyo A & F Co. Ltd, as the sole Japanese company in the Southern Ocean, likely receives government funding for research. This inference is supported by the government's widespread distribution of RDI grants (Sakaguchi et al., 2021).

Similar to Australia, RDI grants in New Zealand are mostly given to research institutions and universities, as indicated by interviewee 014 and 016. One of the major funders for fishery research are the "Crown Research Funds." These RDI grants are subject to high competitiveness, with only certain segments of the fishing industry qualifying for eligibility. The availability of RDI grants persists throughout the year, however, New Zealand interviewees representing government and industry indicated that no Southern Ocean fishing company had yet been awarded such a grant. Nonetheless, New Zealand stands out as a major funder for Antarctic research, often contributing research to the work of CCAMLR (Morten, 2017; Scott, 2022). Interviewee 016 noted that New Zealand is one of the leading States conducting the Ross Sea toothfish stock assessment, a costly research endeavor that supports CCAMLR's efforts toward sustainable fisheries management.

Norway stands out as a major recipient of RDI grants for their Southern Ocean fisheries. Our interview with an Aker BioMarine representative suggested that the company benefits from tax deductions related to research and development initiatives. According to interviewee 017, Aker BioMarine can claim tax deductions for Southern Ocean research expenses, subject to an undisclosed monetary limit. Additionally, Aker Biomarine has the option to participate in general innovation programs administered by the Norwegian Research Council, where their proposals are evaluated alongside research projects from various industries. Interviewee 017 stated that "Aker Biomarine is the recipient of a 5-year research grant (currently in its third year), covering 40% of a 1.5 million USD research endeavor in the Southern Ocean." Norway offers extensive funding opportunities for research and development, providing a vital foundation for the continuity of Southern Ocean research.

Infrastructure support

Our interviews indicated that direct financial support for the development of infrastructure, such as fishing vessels, equipment, technology, ports, and processing facilities for Southern Ocean fisheries, is limited. While our investigation focused on the 2023 fishing season, in which interviewees stated an absence of financial support for infrastructure development, it does not imply that they have not received such support in the past. For example, in 2004, the EU instituted a ban on subsidies for the construction of fishing vessels. However, interviewee 009, 010, and 028 stated that many EU registered vessels that operate across the high seas, including in the Southern Ocean, were built before 2004. This is the case for three of Sampers' fishing boats: Austral, built in 1993, and Albius and Cap Horn 1, both built in 2002. Interviewee 009 stated that today, "most of the EU fishery subsidies are limited to fuel tax concessions and tax concessions related to employment, with little to no direct subsidies for modernization." However, this analysis overlooks the substantial investment of millions of tax dollars in the construction of DWF vessels in the late 1990s and early 2000s, which continue to be operational today.

Our interviews alongside government reports suggest that Chinese and Norwegian fishing companies stand out as major recipients of infrastructure subsidies. According to Mallory et al. (2021), Chinese government reports indicate that one of the largest subsidy categories in China is for vessel renovation and construction. This subsidy program is known as the "Central

Governmental Subsidy Fund for Fisheries Development, Vessel Decommissioning and Renovation, and Fisheries Vessel Reduction and Industry Transition." Within this program, one of the major goals is to increase the application of "high performance materials" that maximize fishery operations for distant water vessels (Mallory et al., 2021). In 2016, the Chinese Ministry of Agriculture (MOA) issued a policy that mandates that subsidies for vessel renovation and construction should not exceed 30% of the total cost of renovation or construction (Mallory et al., 2021).

For the Southern Ocean specifically, the MOA document translated by Mallory et al. (2021), details that newly built Antarctic krill fishing and processing vessels have the highest maximum allowable subsidy for any DWF vessel at 150 million CNY (~21 million USD) (Mallory et al., 2021, p. 30). This is followed by renovated Antarctic krill vessels at 30 million CNY (~4 million USD) per vessel. The MOA document delineates 19 vessel categories, with Antarctic krill fishing vessels comprising the top two most heavily subsidized vessel types (Mallory et al., 2021). China's substantial subsidies not only support infrastructure development for Southern Ocean fisheries but also allocate the highest subsidies for vessel construction and renovation among all Chinese DWF. This underscores China's commitment to expanding and modernizing their Southern Ocean krill fishery, as evidenced by its significant subsidy support.

Our interview with Norwegian industry representatives showed that Norwegian public institutions have subsidized infrastructure development for boat construction and the development of a processing plant for krill. The Norwegian GIEK and Eksfin are two public institutions that offer government loans and guarantees in close cooperation with commercial banks for infrastructure development. Interviewee 017 mentioned that Aker Biomarine's largest krill vessel received a "financial guarantee" from Eksfin, indicating that if the debtor defaults on payment, the bank will assume responsibility for it. Interviewee 017 further argued that "investment guarantees" mitigate foreign political risks for investors and lenders seeking to invest abroad, providing significant benefits to Aker Biomarine's Southern Ocean fishery projects. Similarly, Interviewee 017 stated that Aker Biomarine has secured ~1.8 million USD from Innovation Norway as an investment grant to finance a new company factory. As Norway's sole Southern Ocean fishing company, Aker Biomarine has received significant infrastructure support from the Norwegian government for its current operations and future investments.

Import subsidies

Among all Southern Ocean fishing States, our interview data and analysis of government reports suggested that only two States offer import subsidies, with China offering substantial financial incentives for the importation of Antarctic catch. China not only offers national import subsidies through the MOA and the General Administration of Customs (GAC), but Chinese provinces also implement financial incentives for the import of catch through their regional ports (Mallory et al., 2021). Nationally, the MOA and GAC jointly issued a policy in 2000 stating that fish caught by DWF operating in the high seas would not be subject to import taxes when transported back to China (GAC, 2000). In 2019, research suggested that Chinese import tax incentives for DWF amounted to 2.805 billion CNY (388 million USD) (Mallory et al., 2021). At the regional level, provincial governments enhance this support by offering financial incentives to encourage DWF to import their catch at local ports. Chinese provinces spent about 40 million CNY (5.5 million USD) on import programs (Mallory et al., 2021). Import subsidies are likely pivotal for China's Southern Ocean krill fishery, serving as a primary driver for Chinese krill companies to undertake round trips to and from the region (Figure 4). Notably, no representatives from Southern Ocean fisheries that were interviewed indicated directly offloading their catch at State ports in the Northern Hemisphere, highlighting the unique subsidy dynamics that propel China's operations in the Southern Ocean.

In Australia, the Tasmanian Freight Equalization Scheme (TFES) provides financial assistance for costs incurred by shipments of eligible non-bulk goods moved by sea across the Bass Strait (TFES, 2025). Because Australian Longline unloads its toothfish catch in Hobart, Tasmania, and then ships it to Mainland Australia, they receive "net sea freight assistance" for the importation of their catch. For example, interviewee 002 shared a company report that showed that from May 2022 to September 2022, Australian Longline received 21,000 AUD in freighting subsidies. More recently, from October 2022 to January 2023, Australian Longline fishery received 23,100 AUD in freight subsidies. The objective of TFES is to "provide Tasmanian industries with equal opportunities to compete in other markets" and in 2022 TFES spent 181.7 million AUD in financial assistance (TFES, 2025). Although these subsidies are not exclusive to the fishery sector and benefit various industries, Australian Longline gains a competitive edge from government subsidies that reduce their export costs to key Australian markets.

In Uruguay, the Montevideo Port has become a popular choice for Southern Ocean fisheries to offload their catch. Interviewee 026 mentioned that Montevideo is classified as a "free port," which means that according to transit law shipments unloaded in Uruguay but not intended for distribution within the State are exempt from import taxes. Operating under the free port regime, which offers various tax benefits, incentivizes the utilization of the Montevideo Port by foreign companies. Interviewee 026 clarified that currently the only payments needed to unload catch in Uruguay are service fees, which amount to 3 USD per tonne of fish unloaded at the port. Aker Biomarine's krill fishery has taken advantage of these tax incentives, and its entire krill fishery operation is now based in Montevideo. When Aker Biomarine offloads its catch in Montevideo, it promptly exports it, circumventing the national fees applicable to vessels distributing their catch within Uruguay. While Uruguay does not provide any direct import subsidies, it provides tax incentives that aim to incentivize foreign investment within the State.

Import subsidies, however, might have only a limited impact on the extensive margin of Southern Ocean fisheries if vessels would continue to operate without them. Interviewee 002 clearly stated that "while import subsidies alleviate the costs of transporting the catch to mainland Australia, they are not detrimental to their operations." This view is further supported by Interviewee 003, who stated that moving Austral Fisheries' home port from Australia to Mauritius saved them money even in the absence of subsidies.

Therefore, the removal of import subsidies for Southern Ocean fisheries would likely have little effect on fishing activity. The exception is China, which stands out as the sole supplier of import subsidies aimed at incentivizing Southern Ocean fisheries to land their catch on the State's mainland. While States such as Australia offer financial assistance for goods transportation and Uruguay provides tax incentives for foreign companies to unload catch at its port, none of these measures rival the subsidies received by Chinese Southern Ocean fisheries. Additionally, interviews conducted with government officials from Chile, New Zealand, and South Africa, the only other States hosting Southern Ocean fisheries operating from their domestic ports, reveal that these States likely do not offer import subsidies. With the exception of China, import subsidies do not significantly impact the operations of private fishery organizations targeting krill and toothfish.

Lessons learned, knowledge gaps, and limitations

Government subsidies for Southern Ocean fishing companies are complex and diverse, varying significantly between States and among individual companies. Similarly, within the broader context of DWF, the Southern Ocean stands out as a unique region for fishery subsidy allocation, characterized by the complex operations of private companies targeting toothfish and krill. Because the vast majority of fisheries operate from home ports outside their States' national jurisdiction, the extent of subsidies they would otherwise receive becomes compromised. Several of our interviewees, including those from Australia, the Republic of Korea, Spain, Ukraine, and the United Kingdom, argued that moving fishery operations to home ports closer to the Southern Ocean, where costs are lower, proved far more profitable than staying in their original home ports and potentially benefiting from government subsidies. Similarly, many Southern Ocean fishing companies continuously adjust their operations to improve profitability, often relocating their home ports, changing their vessel maintenance locations, and docking their boats in the off-season wherever it is most cost-effective. This constant movement, and often yearly changes to their fishing routes and operations, subjects Southern Ocean fisheries to varying tax regimes, operational costs, and national policies.

Among DWF, Southern Ocean fishery subsidies must be understood on a State-by-State basis and, in many cases, on a company-specific basis. This is because there is substantial heterogeneity across States and companies. Interviews revealed that many fishing companies operating in the Southern Ocean do not receive substantial subsidies, in contrast to their national counterparts fishing within their EEZs (interviewees 005, 008, 013, 019, 020, 021, 026) or in other distant water regions, as suggested by global literature on fishery subsidies (Sala et al., 2018; Skerritt and Sumaila, 2021a; Sumaila et al., 2019; Villasante et al., 2022). Also, for States with multiple Southern Ocean fishing companies, our results indicate that subsidies are inconsistently distributed, with some companies receiving them while others do not (interviewees 002, 003).

When applied to the Southern Ocean, global subsidy datasets often do not account for the complex operational dynamics of this region and their impact on the allocation of government subsidies. Careful consideration must be given to the influence of home port locations, aspects frequently overlooked in global datasets. Applying State- and company-specific subsidies within the complex framework of Southern Ocean fisheries on a global scale presents significant challenges. However, our research highlights the importance of understanding these challenges both nationally and regionally. While our results reveal a unique distribution of fishery subsidies in the Southern Ocean, similar nuances could potentially be observed in other high seas regions. Regional studies that delve into the intricate interplay between private fisheries and governmental resources can provide valuable insights into the complexities surrounding subsidy distribution within DWF.

Primary data collection and evidence for this study was largely based on interviews. While this provided us with insightful knowledge about individual companies and the relationship between national governments and the fishing industry, it also constrained us to rely on our interviewees' own accounts. Even though our data collection was supplemented with other sources of information, and our interviewees encompassed individuals representing different organizations (e.g., industry, government, academia), it is possible that we received incomplete or biased information. However, data collected from interviews with industry representatives and government officials demonstrated a high degree of alignment. Moreover, our interviews represent only a subset of all Southern Ocean fishing companies. Despite reaching out to all authorized fishing companies, we were unable to interview representatives from every company, including those based in China. This limitation also applies to other Member States that have fished in previous seasons outside the scope of our study, such as the Russian Federation. Although the Russian Federation has been an active participant in Southern Ocean fisheries, it was not represented in our study because it had not notified to fish since 2021. However, the Russian Federation notified again in 2024, along with a new Member State, Namibia. Knowledge gaps could be addressed through more interviews and research, as well as by CCAMLR Member States increasing transparency and providing detailed information on the direct transfer of funds from government and public entities to their Southern Ocean fishing companies.

While we acknowledge the gaps in knowledge and the potential for incomplete information, our results suggest the need for a closer investigation of all distant water regions. Although global studies are valuable for representing the overall state of subsidy distribution to DWF, detailed regional analyses that assess subsidy allocations by State and, further, by individual companies, will provide a more comprehensive understanding of the current state of DWF subsidies.

Conclusion

While prior research emphasizes the significant reliance of DWF on government subsidies (Sala et al., 2018; Schuhbauer et al., 2017, 2020; Skerritt and Sumaila, 2021a; Sumaila et al., 2019, 2016, 2010a), our State-specific study suggests a surprising trend: our

interviews suggest that only a minority of Southern Ocean fisheries benefit from government subsidies, with most instead operating independently of such subsidies. This prompts the question: if fishery subsidies were eliminated, would Southern Ocean fisheries cease to exist? Our primary data collection suggests otherwise. While Southern Ocean fisheries receive some level of subsidies, these subsidies are likely insufficient to significantly alter their operations. Instead, private fishery organizations continually adjust their economic strategies and operational dynamics to enhance their annual earnings. This is frequently demonstrated by private fishery organizations choosing to operate from foreign ports, which effectively reduces their costs and travel time to reach the Southern Ocean. The economic value of these fisheries is therefore a key driver of fishing activity in the Southern Ocean.

Chinese and Norwegian fisheries, however, stand out as major recipients of subsidies, though in different ways: China heavily subsidizes its distant water fishery operations, while Norway provides support through close government-industry collaboration and financial partnerships. China's ability to conduct transpacific voyages and land their catch back at national ports is primarily enabled by a combination of national and provincial subsidies which encourage fishers to land their catch in China. National laws, regulations, and incentives provide for subsidies to be distributed through various means, including fuel subsidies, tax breaks, discounted loans, infrastructure support (e.g., vessel construction, of which Antarctic krill fishing vessels receive the highest subsidies among all DWF vessels in China), and import subsidies (Mallory et al., 2021). These subsidies aim to reduce the costs associated with Chinese DWF, ultimately incentivizing fisheries to engage in longer voyages, fish for longer periods, and expand their reach by investing in new equipment and fishing vessels financed by the government. Norway also continues to benefit from government subsidies as its proportional electoral system and state-funded banking system provide a platform for industries, including fisheries, to receive high levels of economic support. This support comes from Norwegian government innovation funds, state and federal agencies, and national banks (Rickard, 2018). Aker BioMarine, Norway's sole Southern Ocean fishing company, has received millions of dollars in subsidies from several government agencies and banking institutions in the form of tax breaks, discounted loans, research and development grants, and infrastructure support. This has facilitated their ability to dominate the krill catch in the Southern Ocean.

While the potential profitability of China's and Norway's Southern Ocean fisheries hinges upon government subsidies and government industry collaboration, the analysis of the 11 other States examined in this study presents a contrasting scenario. States with subantarctic EEZs, such as Australia and France, tend to have much larger catches and less competition for resources, than those exclusively fishing within the areas managed under the CAMLR Convention. Insights drawn from our interviews with industry representatives from Australia, France, and the United Kingdom underscored the high profitability of their toothfish fisheries. For certain companies, such as Samper from France, their toothfish fishery has evolved into a highly lucrative venture, in contrast to some of their other DWF operations (e.g., tropical tuna).

The profitability of Southern Ocean fisheries and the extent of fishery subsidies is inherently nuanced and State-specific, cautioning against broad generalizations that overlook the unique circumstances and dynamics at play within each national context. Southern Ocean fishery subsidies should thus be assessed based on their impact on individual companies' operations, within the broader context of national policies and practices. While the fishing operations of a small number of companies are greatly influenced by their government subsidies, Southern Ocean fisheries uniquely position themselves via economic and geographic partnerships that enable them to reduce costs and maximize fishing time in the absence of government subsidies.

Data availability statement

Publicly available datasets were analyzed in this study. This includes data from https://www.ccamlr.org/ru/node/74362, https://globalfishingwatch.org/map, and data from government reports (as noted in References cited). Data from interviews were conducted in accordance with local legislation and institutional approval from the University of Colorado Boulder IRB board. Further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by University of Colorado Boulder IRB Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

VC-M: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. SM: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing, Visualization. EF: Conceptualization, Data curation, Visualization, Writing – review & editing. LT: Conceptualization, Data curation, Writing – review & editing, Methodology. US: Conceptualization, Data curation, Writing – review & editing. CB: Conceptualization, Data curation, Writing – review & editing, Formal analysis, Investigation, Methodology, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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