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Global seaweed stock and Marine Protected Area assessments provide potential opportunities to protect wild seaweeds

Juliet Brodie[a], Saul Mallinson[a], Joanna Wilbraham[a], Phaik Eem Lim[b], Sze-Wan Poong[b], Nurulafifah Yahya[b], Robert J. Mrowicki[a] and Elizabeth J. Cottier-Cook[c]

[a]Natural History Museum, Research, London, UK; [b]Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia; [c]Scottish Association for Marine Science, Scottish Marine Institute, Oban, UK

ABSTRACT

Wild seaweeds and associated habitats are the basis of the world's seaweed industry, yet they lack adequate global conservation protection. A review of the industry's global distribution, production and species based on available datasets and literature searches revealed that seaweed wild harvesting and aquaculture were reported in 82 countries on five continents. However, analysis of key datasets (FAO and Phyconomy) revealed reporting inconsistencies within the industry. Widespread uncertainty as to which species are used and the quantities produced by the industry has implications for wild stock sustainability, biosecurity, product provenance and safety. This points to the need for greater standardization and wild stock protection by the industry. Analysis of the industry's global distribution in relationship to Marine Protected Areas revealed c. 50% of aquaculture and wild harvesting sites were close to conservation areas. This presents farmers and harvesters with a potential opportunity to strategically develop the MPA concept to protect wild stocks and secure the long-term future of this industry.

HIGHLIGHTS

- There is a lack of certainty of the species identity used in the seaweed industry.
- There is a need for greater standardization in the seaweed industry and protection of wild stocks.
- The discovery that c. 50% of Marine Protected Areas globally were close to seaweed farms and wild harvesting sites raises the possibility that MPAs could be developed to afford the industry potential protection.

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Introduction

Wild seaweeds (red, green and brown macroalgae) and their associated habitats support an immense biodiversity in marine ecosystems and are the basis of the global seaweed industry. Yet, they have inadequate or no direct statutory conservation protection (Cottier-Cook et al., 2023). This is in direct contrast with other marine habitats, such as mangroves or coral reefs, which have global unified conservation goals (Leal & Spalding, 2022).

Protection for wild seaweeds is critical; however, because over the last 50 years, the global seaweed industry has seen exponential growth (Cai et al., 2021; Cottier-Cook et al., 2023) and demand continues to grow for seaweed-based products, such as hydrocolloid gels, pharmaceuticals (Syad et al., 2013), food supplements, cosmetics, biofertilizers and biofuels (Chopin & Tacon, 2021; Cottier-Cook et al., 2021) (Fig. 1; sources: Supplementary table S1). At the same time, cultivated seaweeds are becoming increasingly vulnerable to pest and disease outbreaks (Faisan et al., 2021; Ward et al., 2020). This is partly due to reliance on a handful of clonal cultivars (Tan et al., 2022b; Yahya et al., 2024), but also the increasingly profound impact of the environmental climate crisis on seaweeds (Brodie et al., 2014; Corrigan et al., 2025). Increasing seawater temperatures and the subsequent loss of suitable locations for seaweed cultivation, are having a significant deleterious impact on inshore seaweed culture operations (Msuya & Hurtado, 2017). In

CONTACT Juliet Brodie j.brodie@nhm.ac.uk;
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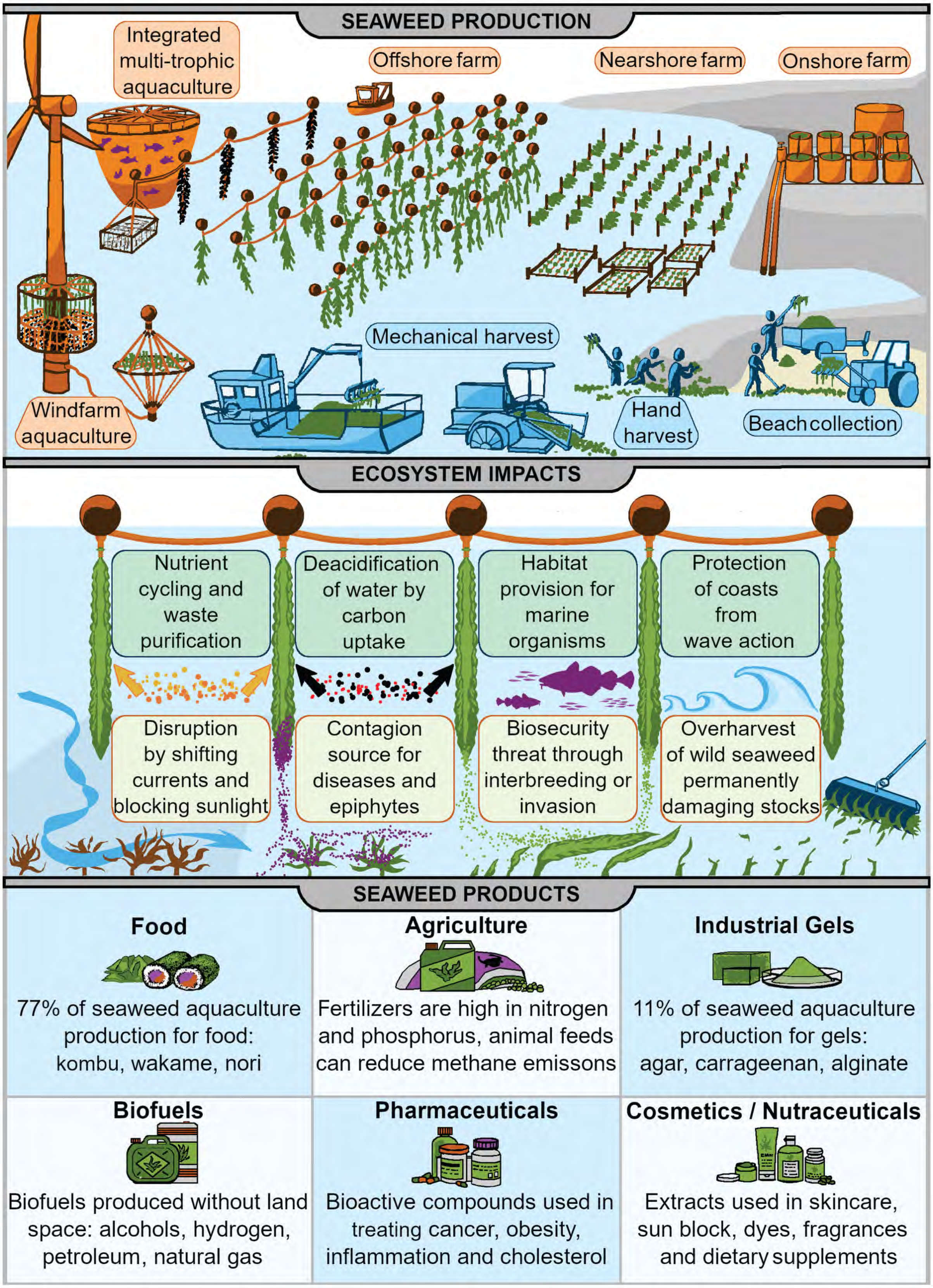

Fig. 1. Summary of the global wild harvesting and seaweed aquaculture industry. Sources in Supplementary table S1.

addition, over-harvesting of wild seaweed stocks, invasive species and pest outbreaks are leading to potentially serious impacts on the long-term sustainability of this global industry (Cottier-Cook et al., 2023).

Estimates for the value of the industry range between c. 13.4 and 14.7 billion USD (Barbier et al., 2019; FAO, 2022), with 35.1 million tonnes of seaweed produced in 2020 (FAO, 2020), representing c. 28.6% of total global marine aquaculture. The vast majority of this seaweed biomass (97%) is derived from aquaculture, predominantly in East Asia (FAO, 2022). Seaweeds not only directly provide products for the market but are crucial to the growth and survival of the cultivation industry.

Despite the importance of the seaweed industry, of >12,000 seaweed species described to date (Guiry, 2024), only about 2% are used in the wild and farmed industry (wild and farmed) with a tiny fraction (< 0.05% of species) making up more than 95% of world's cultivated seaweed (Zhang et al., 2022). Wild seaweed stocks form the basis of the global seaweed industry as they hold the genetic diversity that will enable new, more temperature resilient cultivars to be produced in the future. A search for new species/genetic variants (haplotypes) and research investment in understanding and integrating knowledge of life histories into the development of new species into the industry are of urgent need and should be prioritized (Brodie, 2024; Lim et al., 2017; Tan et al., 2022a).

The lack of international conservation measures specifically for wild seaweeds and their associated habitats have made the protection of seaweeds largely reliant indirectly on conservation designations, such as Marine Protected Areas (MPAs) designated for other purposes. An MPA is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Day et al., 2019). In terms of protection, 8.2% of the global oceans are protected [Protected Planet World Database on Protected Areas (WDPA; protectedplanet.net] and 3% fully or highly protected (Grorud-Colvert et al., 2021). Protection might be statutory or voluntary and whilst MPAs may have features which include seaweed habitats (e.g. kelp forests), there may be no direct mention of seaweed. The presence of an MPA in the vicinity of seaweed cultivation/harvesting sites raises the question as to whether this may be of benefit the industry.

Where seaweed conservation lags behind, marine habitats including mangroves and coral reefs have specific protection measures developed through the United Nations Breakthrough conservation initiative (Leal & Spalding, 2023), a potentially powerful means of protecting habitats through the UNFCCC High Level Climate Champion 2030 Breakthrough Agenda (Corrigan et al., 2025 and references therein). A Breakthrough is where measurable indicators and achievable goals are set for governmental and non-governmental organizations to collectively restore and protect habitats at a scale large enough, that it will ensure the survival of these ecosystems. The targets to be set for 2030 for each ecosystem include halting loss, protection, restoration and sustainable finance (see Corrigan et al., 2025). This Breakthrough initiative, therefore, offers a powerful way forward to potentially protect vulnerable wild seaweed stocks and habitats (Corrigan et al., 2025).

Here, we review the global seaweed industry, including wild harvesting and cultivation sites, and assess their distribution for the first time in relation to global MPAs (protectedplanet.net) to determine the current levels of protection afforded to wild seaweed stocks. We consider whether a global seaweed protection strategy could afford a more holistic approach to conserve wild seaweed stocks and how a Seaweed Breakthrough initiative could be implemented for that purpose.

Methods

Mapping the distribution of the global seaweed industry

A distribution map of the global seaweed industry was constructed to compare with global MPAs. Since no global geographic dataset is available to map the distribution of the seaweed industry, a tiered, international, European and national approach was used to develop a global map of commercial seaweed farming and wild harvesting. Three datasets, Food and Agriculture Organisation of the United Nations (FAO; https://www.fao.org/), Phyconomy (https://phyconomy.net/database/) and the European Marine Observation and Data Network (EMODnet; https://emodnet.ec.europa.eu/en), were analysed to produce a global overview of the seaweed industry. The FAO is the specialized agency of the UN with 194 member countries and the EU. Its aim to achieve global food security is supported by high-quality data to aspire to well-managed, aquatic systems for all. The aim of Phyconomy is to improve the understanding of the seaweed industry and includes a database of >1400 seaweed organizations. EMODnet is the European Commission (EC) *in situ* marine data service. It contains the EMODnet Portal (emodnet.ec.europa.eu) which includes data on macroalgae production facilities (https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas). Data were extracted from: (i) FAO production data (wet metric tonnes per country) between 2015 and 2020 (data are combined over 5 years; fao.org/fishery), (ii) Phyconomy dataset (2020–2023; annual production in metric tonnes size classes by category for each individual company, filtered for the Farming/Harvesting tag and grouped by the headquarters country; phyconomy.net) and iii) European Marine Observation and Data Network from 2020 (locations of individual algae production facilities; EMODnet; emodnet-humanactivities.eu).

To visualize the available data, the FAO and Phyconomy data sets were chosen due to their global coverage and their data were separately attached to country polygons from the World Food Programme (UN agency) world administrative boundaries dataset (https://public.opendatasoft.com/explore/dataset/world-administrative-boundaries/information/) using the R sp package 'merge' function. EMODnet data was not included here because although it has facility coordinates, it does not include production and only covers Europe. Countries having some form or mention of a seaweed industry were identified from the three datasets, based on production (i.e. FAO dataset), companies (i.e. Phyconomy) or facilities (i.e. EMODnet data set). The resulting countries formed an international baseline to which additional information was added from national datasets. Within each of these countries, using open-access datasets where available, the local aquaculture and/or wild harvesting localities were recorded. These national results were combined with the international baseline, using the QGIS 'merge' function, to produce a single localized worldview of the seaweed industry.

The type of available industry and country data varied considerably from polygon through line to point (Supplementary table S2). Therefore, to be able to compare data, it initially unified into a consistent spatial resolution and format. To achieve this, a 1 km buffer was applied, which converted all data to a similar resolution. For data reported by region, a coastline layer was made by taking the relevant polygons from the GADM administrative areas data set (gadm.org), reprojecting it to EPSG:3857, adding a 1 km buffer around the region, then removing the land from the buffer layer to make a regional coastline layer (QGIS 'reproject', 'buffer' and 'difference' functions, respectively). Data sets used are given in Supplementary table S3 and mapped in Supplementary fig. S1.

Analysis of globally farmed and wild harvested seaweed species

A list of the red, green and brown seaweed species associated with commercial farming and wild harvesting was compiled. Scientific names of the seaweed species found in these sources were checked against AlgaeBase (Guiry & Guiry, 2023), updated as necessary and a 'current name' added to the list, if required. To review higher-level taxonomic patterns, family, order and division for each species were also added. In the instances, where the seaweed was not described to species level, it was assigned where possible to the closest taxonomic concept (e.g. 'red seaweeds' were listed under 'Rhodophyta', thus keeping the ordinal name). Where seaweeds were reported using common names in national reports (e.g. Norway, USA, Korea), these were translated using online resources (Supplementary table S4). If the common name could not be resolved against a scientific name, it was listed under the most appropriate taxonomic level. For example, a kelp for which the genus/species could not be confirmed would be recorded under the order Laminariales.

A comparison was made of the number of species used in aquaculture with those wild harvested per country. A list was compiled showing the top 20 countries for highest diversity of seaweed genera being utilized in aquaculture and harvesting, and for comparison the top 20 countries for total seaweed biomass according to the FAO (2022) data set (Supplementary table S3). Taxon entries only listed to genus level, were counted as a species if they were not already been accounted for at country level or production type. Any higher taxonomic level entries or those that were unclear as to whether they were farmed, wild harvest or both in terms of production were not included.

Mapping the geographic overlap globally between the seaweed industry and Marine Protected Areas (MPAs)

To determine the spatial overlap of the global seaweed industry with MPAs (Supplementary table S6), the localized worldview map of the seaweed industry was overlaid onto MPAs classed as MARINE 1 or 2 (partial or fully marine components within the protected area) in the Protected Planet World Database on Protected Areas (WDPA; protectedplanet.net) (QGIS 'clip' function).

The surface area of overlap between the seaweed industry and the global MPAs was determined by simplifying each dataset into a single polygon (QGIS 'dissolve' function), and then had the area calculated ($area function in the QGIS field calculator). This uses a standard project setting to calculate polygon area, with the units initially set to m^2 and using an ellipsoid WGS84 to account for the earth's curvature.

Results

Overview of the global seaweed industry

Countries having some form or mention of a seaweed industry were identified based on production (i.e. FAO, 2022), companies (i.e. Phyconomy; Hermans, 2023) or facilities (i.e. European Marine Observation and Data Network [EMODnet], 2022) data set. Within these three data sets, seaweed wild harvesting and aquaculture was reported in 82 countries on five continents (Figs 2a, b). The FAO and Phyconomy datasets showed that seaweed production in Asia is predominantly by cultivation with a much smaller proportion of wild harvesting, whereas for Europe and the Americas it appears to be mainly wild harvesting. The EMODnet data set provided more specific locations for the facility locations of seaweed activities in Europe, with 43 listed facilities for aquaculture and 87 for wild harvesting across the continent (Supplementary fig. S2).

The majority of the global seaweed industry is reliant on aquaculture (FAO 97%; Table 1) and based in East and Southeast Asia. For wild harvest and aquaculture, China was found to be the largest single producer (53.7% of all production in the 5-year period), followed by Indonesia (31.0%), South Korea (4.7%), the Philippines (4.3%), North Korea (1.7%), Japan (1.3%) Chile (1.1%) and Malaysia (0.6%). After East and Southeast Asia, the other major producing areas were aquaculture in Tanzania and wild harvesting in Norway (Supplementary table S3, Fig. 3).

For aquaculture production, 74 countries were found to be involved in seaweed cultivation. The specific details, however, varied considerably between countries, with seven reporting GIS data of the exact facilities location, six reporting regional landings data, 40 providing location data in the literature or online resources and 21 countries had no further information beyond a country level entry in the international datasets (Supplementary table S2). For wild harvesting, 53 countries had some indication of commercial wild harvesting. For these countries, primary data (i.e. precise farm/harvesting locations; Supplementary table S5) were only recorded for Canada and two US States, regional production was recorded for a further nine, location information was found in the literature for 21, and another 21 had international datasets only (Supplementary fig. S2).

Although differences in the FAO, Phyconomy and EMODnet data sets made direct comparison of the results impossible, an overview of countries involved, seaweed production and species used in the seaweed industry datasets is presented in Table 1. These results showed similar country numbers for FAO (65) and Phyconomy (57), which with the EMODnet data resulted in considerably more countries being retrieved in this study (83). Almost all FAO seaweed production reported was from aquaculture, whereas Phyconomy data showed proportionally more production through wild harvest than aquaculture. Furthermore, only 25.3% of production companies in the Phyconomy data set included production data and for some countries annual production is only recorded for a small proportion of companies. For example, the combined entries of China, Japan, South Korea, Indonesia and Malaysia, 96% of the companies did not list their annual production.

The numbers of species reported to be used in aquaculture across the FAO and Phyconomy datasets, were considerably smaller (16 for the combined datasets, of which 35% were unique) than in this study (66 of which 85% were unique). More species were reported as being used in wild

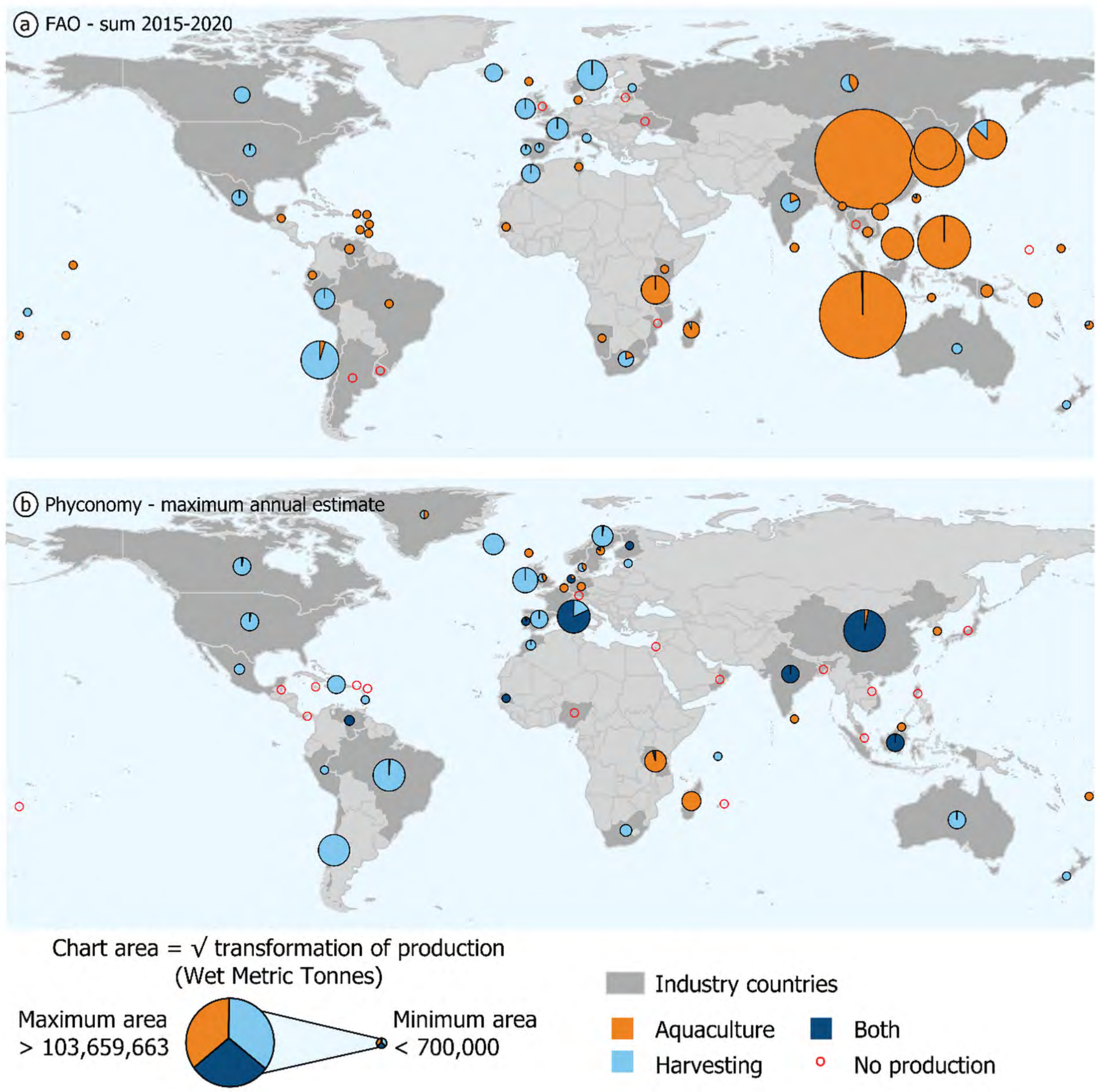

Fig. 2. FAO and Phyconomy global data sets on the seaweed industry, where chart area indicated total production grouped by country. (a) The FAO, the sum of national production data from 2015 to 2020, maximum value 103,659,663 Mt. (b) The Phyconomy seaweed company database, established in 2020 and retrieved in 2023, sum of maximum estimated annual production for each headquarters country, maximum value 3,230,000 Mt.

harvest for the combined dataset (65 of which c. 31% were unique), but more were found in this study with a high diversity of species (99 of which 77% were unique). For both aquaculture and wild harvest, Phyconomy reported >3 times more than with FAO or EMODnet, although this study found over a third more. Overall, there were 106 more species reported in this study than the combined datasets.

Seaweed species used in the global seaweed industry

The list of seaweed species contains all original and standardized seaweed names, their countries if reported, and whether the species was cultured or wild harvested (Supplementary table S5). The names used to report seaweed aquaculture and harvesting in the source data were highly disparate. The scientific names were not always up to date, and many entries only included the genus name. Of the 1,324 entries in the list, c. 26%

Table 1. A comparison summary of numbers of countries, seaweed production and the number of genera recorded for use in wild harvest and aquaculture based on the international datasets and this study. For species reporting, the number in (brackets) is the number of species entries that are unique and only mentioned in that data set. Only seven countries reported production on a national scale.

	FAO	Phyconomy	EMODnet	International Pooled	This study
Number of countries with a seaweed industry	65	57	13	82	83
Overall global seaweed production (metric tonnes)	202 886 684	8 600 120	N/D	NA	N/D*
Seaweed production aquaculture (%)	97.5	5.6	N/D	NA	N/D
Seaweed production from wild harvest (%)	2.5	43	N/D	NA	N/D
Both aquaculture and wild harvest used in production(%)	N/D	13**	N/D	NA	N/D
Number of species used in aquaculture	11 (6)	6 (3)	3 (0)	16 (4)	66 (56)
Number of species used in wild harvest	26 (10)	29 (13)	32 (4)	65 (20)	99 (76)
Number of species used in both aquaculture and wild harvest	13 (6)	39 (7)	10 (0)	47 (10)	69 (27)
Total number of species used in seaweed production	50 (22)	74 (23)	45 (4)	128 (34)	234 (159)

**Not specified as to whether aquaculture or wild harvest.

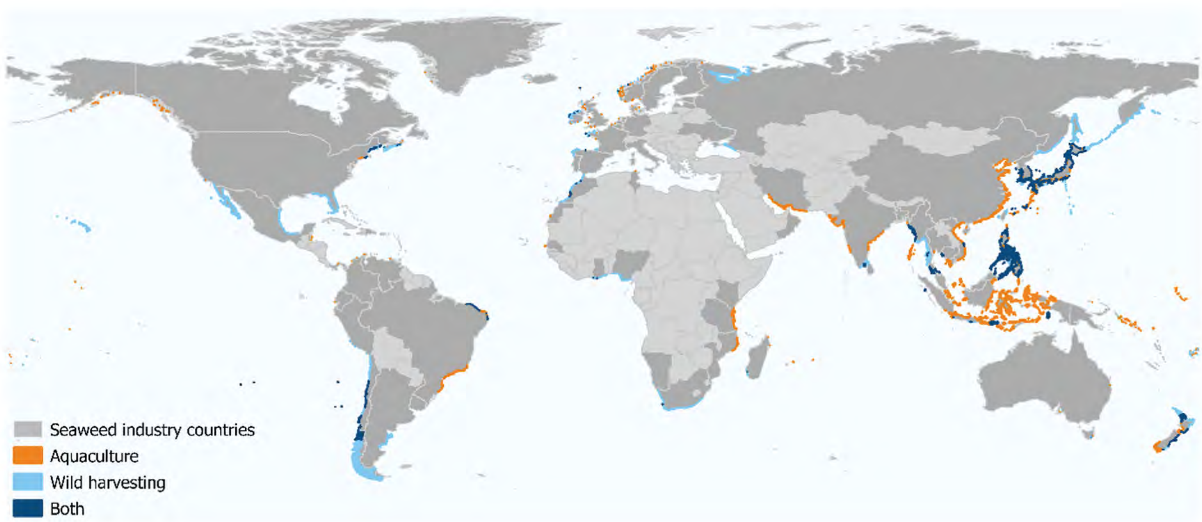

Fig. 3. Spatial distribution of the global seaweed industry at the local scale based on a compilation of national data sets.

were recorded as sp. or spp. (listed as spp. in Supplementary table S5). In total, 261 unique species were recorded as used by the industry, of which 63 were only used in aquaculture, 107 were wild harvested, 91 were used in both (Supplementary table S5).

The taxonomic diversity and production per country are shown in Fig. 4. The country with the highest seaweed diversity used in its seaweed industry was Norway (59 species). Of note is that most entries for Portugal are from the Azores rather than the mainland, and most for Spain were from wild harvesting in Galicia. Most genera were wild harvested, and countries that used many seaweed species for wild harvesting also showed a high level of overlap with those they used for aquaculture. The top 20 genera utilized in the seaweed industry according to our findings are given in Fig. 5.

Relationship between the seaweed industry and Marine Protected Areas

The geographic extent of the seaweeds compiled in this study is shown in Fig. 4. An analysis of all the MPAs that overlapped with our global data set of seaweed industry activities revealed that up to 48% of the global seaweed industry was located within 1 km of an MPA, see Fig. 6. Across the two Protected Planet World Database on Protected Areas (WDPA; protectedplanet.net) Marine layers, 17,160 MPAs were mapped, which together covered a surface area of 30,713,566 km^2. The total extent of the global seaweed industry was 294,183 km^2. The seaweed industry overlapped with 3,143 MPAs (18.3% of the 17,160 marine MPAs, listed in Supplementary table S5). The area of overlap with the global seaweed industry was 91 809 km^2 or 0.3% of the total MPA surface area.

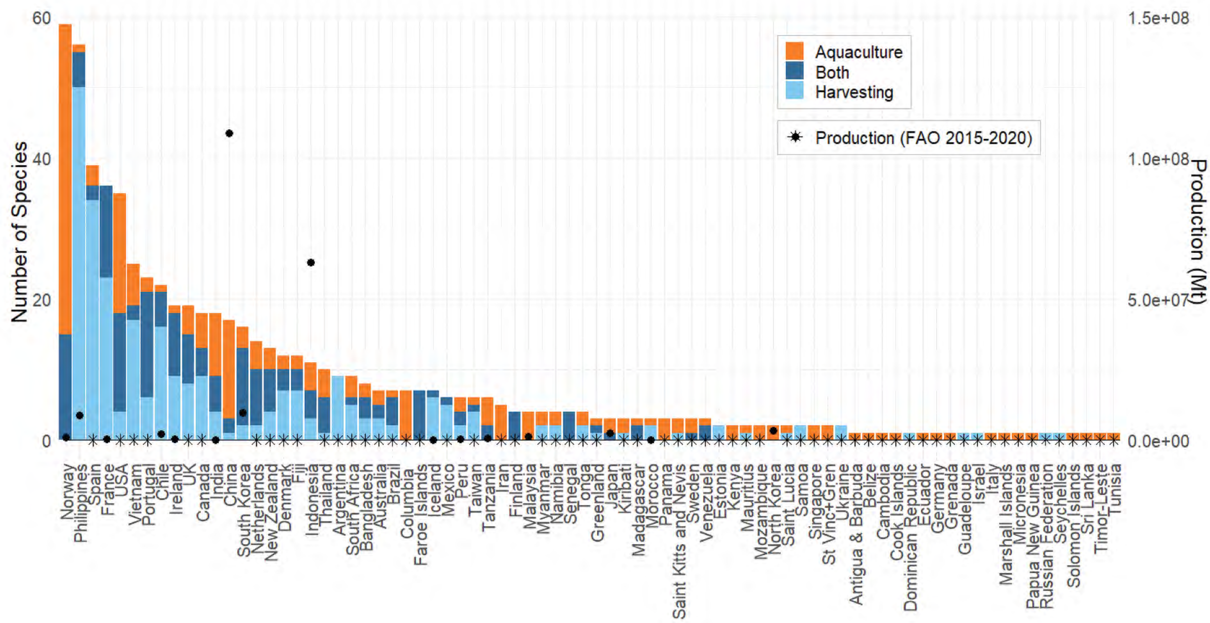

Fig. 4. Taxonomic diversity and production by the seaweed industry, based on number of genera per country and the FAO production values between 2015–2020. Points representing values of less than 100,000 metric tonnes equivalent of 0.5% of the total seaweed production are represented by a * symbol.

Discussion

By compiling and unifying a wide range of data sources on the global seaweed industry, we present an evidence-base that demonstrates the challenges of obtaining a reliable overview of the state of seaweed aquaculture and wild seaweed harvesting in the world with implications for effective conservation of species and habitats.

As well-documented, the majority of the biomass from the seaweed industry is from aquaculture. The FAO (2022) reporting that 97% of the seaweed biomass is from farming and that the amount from wild harvesting has remained constant for over 50 years. The small proportion of companies reporting production data probably reflects the local scale of the industry. For example, in Indonesia and Malaysia, most seaweed biomass is produced by individuals and families often in remote coastal communities (Ward et al., 2020). However, the difficulty of the lack of reporting consistency across the sector raises doubts as to the true extent of wild harvesting and how much is reported globally, which has implications for the impact of harvesting on wild stocks (MacMonagail et al., 2017).

The differences in the maps observed between the FAO and the Phyconomy results (Fig. 2) reflect differences in the data captured in the two databases. For example, seaweed production in China is included in FAO data but not in Phyconomy which have focussed on Europe, the Americas and Oceania so far (https://phyconomy.net/articles/state-of-the-seaweed-industry-2022). These differences also account for the difference in the number of species that are used in the industry between datasets, but compound the lack of certainty as to exactly which species are being grown or harvested. This in turn has implications for the conservation management of the wild stocks where what is being harvested or used in cultivation is unknown.

The difficulties of correctly identifying the seaweed species that are being farmed or harvested and not knowing for certainty the actual crop that is being sold is a major handicap for the industry (Bolton, 2020). It has huge implications for the properties of the crops, quality, provenance and indeed potential safety of the resulting products. Groups that present major taxonomic challenges include many that are the backbone of the seaweed industry, such as species of *Porphyra* sensu lato, *Gracilaria* (often just referred to as *Gracilaria* spp.) and the eucheumatoid genera *Eucheuma* and *Kappaphycus*, which stand out in this regard. All are notoriously difficult or impossible to identify based on morphological characters (Lim et al., 2017; Tan et al., 2022a; Yang et al., 2018) and it is well recognized that there are many cryptic seaweed species

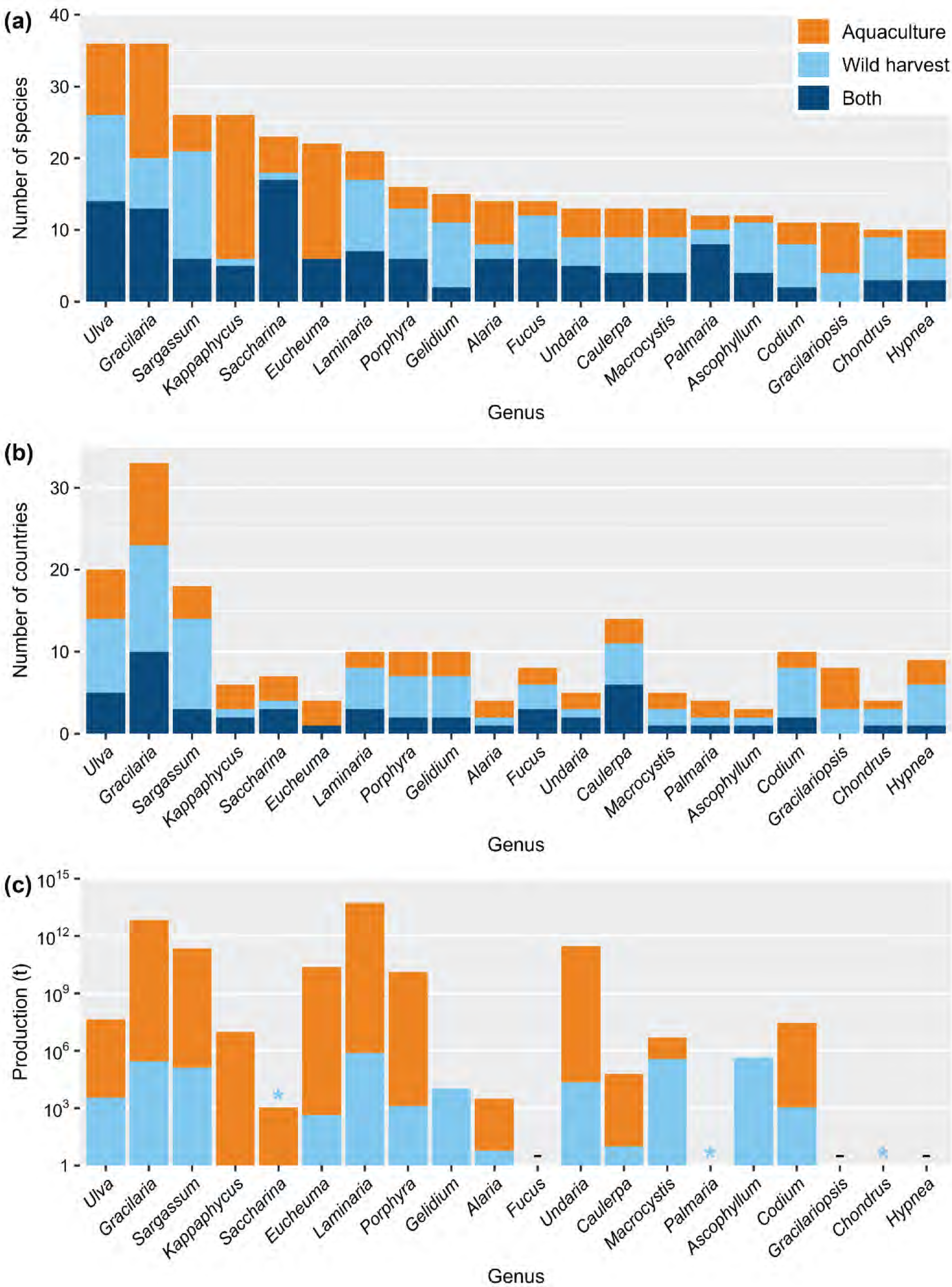

Fig. 5. The top 20 genera used by the seaweed industry countries around the world, with total production according to the FAO 2015–2020 data set. NA entries were not mentioned. In (c), asterisks (*) indicate non-negative production values (<1 t) for wild harvesting, and hyphens (-) denote genera that were not mentioned in the FAO data.

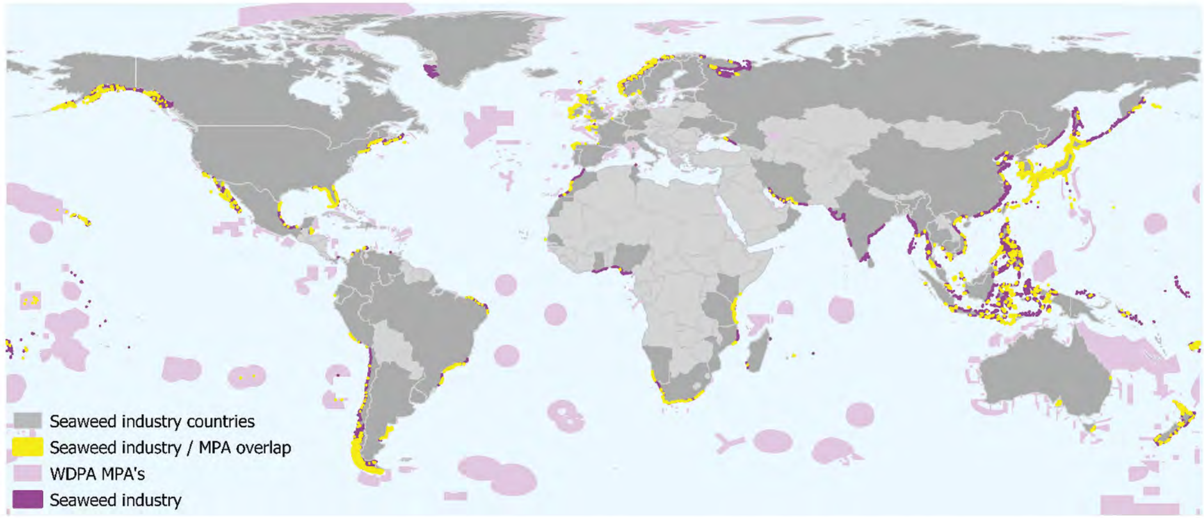

Fig. 6. The overlap of the global seaweed industry in relation to the marine projected area layers of the WDPA data set. Note that all global seaweed industry data was first converted into regional coastline data so that the format and resolution was consistent for all countries.

(Brodie et al., 2009). Furthermore, there are huge gaps in the global taxonomic understanding of many of these groups (e.g. Lim et al., 2017; Bolton, 2020; Corrigan et al., 2025 and references therein), although the number of taxonomists with these skills is highly limited (Guiry, 2024). We know from our work on the eucheumatoids in Malaysia and the Philippines that the farmers do not necessarily know which species they are farming (Dumilag et al., 2022; Tan et al., 2022b; Tan et al., 2024); and this highlights the urgent need for rapid and reliable diagnostic techniques to distinguish between different species, including the use of cheap and effective molecular barcoding methods (Tan et al., 2024). There is also a need for more training of seaweed taxonomists if the seaweed industry is going to reach its full potential.

Reasons for the lack of international conservation measures specifically for wild seaweeds and their associated habitats are explored in Beattie et al. (2025). An underlying theme in this regard is that seaweeds have largely been overlooked in favour of focusing on a handful of marine taxa and habitats, including fish, mammals, coral reefs, mangroves and seagrass beds. Whilst these might be viewed as charismatic megafauna or charismatic ecosystems, work by the kelp forest alliance has put the seaweeds – or at least the kelp forests (Corrigan et al., 2025) on the international agenda (Eger et al., 2024). The dearth of recognition in international policy and legislation has also not been helped by the way seaweeds have been treated by international bodies, such as by the FAO (Chopin & Tacon, 2021). Here, seaweed aquaculture has been treated separately from other aquaculture sectors. Whilst this may or may not directly influence the conservation of wild seaweeds and their habitats, there is an underlying sense that seaweeds do not count in the mainstream. These factors, and the relatively small number of seaweed researchers (Corrigan et al., 2025) have made the protection of seaweeds largely reliant indirectly on conservation designations.

Finding that approximately half the seaweed farms or harvesting regions identified in this study are within the vicinity of MPAs, with an overlap of 0.3%, raises the possibility that if these conservation areas were to specifically include seaweed habitats, they may afford some protection of wild seaweeds. These seaweeds may include sources of new cultivars, which will be of benefit to the industry. Marine Protected Areas are considered to be valuable tools for marine conservation and it has been proposed that strategically designed MPAs could be beneficial for seaweed farming (Jankowska et al., 2022).

Increasingly, humans are looking to the seaweed aquaculture sector to relieve pressure on the land and to contribute towards Sustainable Development Goals (SDGs), especially in relation to food security, decent work and economic growth, climate action and life below water (Corrigan et al., 2025; Spillias et al., 2023; Troell et al., 2023). The SDGs provide an alignment tool, which could enable rural communities and seaweed farmers to become key protectors of wild stocks. Therefore, linking the protection of the wild seaweed habitats with local farmers and harvesters as custodians of these sites, could ensure a more secure future and economically stable livelihoods in the long term. Making use of the existing global MPA network and working with the local farmers to expand and/or adapt or create their local MPA to incorporate protection specifically for the wild stocks, could provide a foundation for their conservation, if not already present in an area.

As the seaweed industry relies on stock from local seaweed habitats, sourcing them close to seaweed farming areas in a sustainable way will also enable the development of new cultivars that have traits for survival in that region (Lim et al., 2017; Ward et al., 2020). Relying on local species/strains will also promote a more biosecure industry by preventing the introduction of new pests and pathogens associated with the deliberate introduction of non-indigenous seaweed cultivars from different parts of the world that has had devastating impacts in some parts of the seaweed industry (Brakel et al., 2021).

However, coupling the conservation of wild seaweeds with seaweed farms assumes that such habitats exist in that space which will not necessarily be the case. This points to the need to take a more holistic approach and work towards a global seaweed protection strategy for the conservation and management of wild seaweeds and their habitats.

Global protection measures for wild seaweed stocks needs both baseline data on the seaweeds and habitats – reiterating the need for training in relevant skills and conservation policies and practice. Capacity and capability building are needed along with raising stakeholder awareness and means of engaging with communities through, for example community science initiatives (Brodie et al., 2022). Utilizing tools such as the IUCN Red List can be useful if datasets are available but can be problematic for seaweeds which do not fit the criteria well (Brodie et al., 2023). Instead, conservation approaches such as expert-elicitation or horizon scanning (Roy et al., 2019) and integration of local knowledge can be developed and deployed where base-line species data are limited.

This is where a Seaweed Breakthrough offers the holistic approach required to give seaweeds and their habitats the global protection they desperately need both for their conservation as globally important habitats and to support a long-term seaweed industry. This year (2025), in response to this need, a Seaweed Breakthrough was initiated by the authors J. Brodie, E. Cottier-Cook and P.E. Lim, following the approach that has been used in Ocean Breakthroughs for corals, mangroves and seagrass beds (https://ocean-breakthroughs.org/). Whilst following the Breakthrough process used for other marine habitats, including coral reefs, mangroves and seagrass beds, initial discussions that took place at a first meeting of an expert panel indicate that blanket targets will be inadequate. For example, a target such as 'protect 30% of seaweeds by 2030' will be totally ineffective unless there is a better understanding of such factors as to which seaweed habitats to protect (e.g. rhodolith beds, fucoid bed, kelp forests), where they are located and their condition.

In conclusion, there is a greater need for standardization of the seaweed industry as a whole, including more reliable/comparable data collection within and between organizations, a robust taxonomic framework for species farmed and wild harvested and effective global protection of wild stocks. The results also provide evidence of the small fraction of seaweed species that are used globally. There needs to be a much better understanding of wild seaweed harvesting and regulation, including species collected and the impact that this practice has on the wider environment. Ultimately, protection of the wild seaweeds and their habitats is crucial for the long-term sustainability of the seaweed industry.

Disclosure statement

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Author contributions

J.B.: developed the concept and led the manuscript writing; S.M.: performed analyses and contributed to writing the manuscript; J.W.: created the species list and edited the manuscript; E.J.C.C. and P.E.L.: contributed to the concept and edited the manuscript; S.-W.Poong and N.Y.: edited the manuscript; R.J.M.: performed analysis and contributed to editing the manuscript.

Data availability statement

All data were sourced from freely available datasets. Please see Supplementary tables and figures and for further information, please contact the corresponding author.

ORCID

Juliet Brodie http://orcid.org/0000-0001-7622-2564
Joanna Wilbraham http://orcid.org/0000-0003-4101-0611
Phaik Eem Lim http://orcid.org/0000-0001-9186-1487
Sze-Wan Poong http://orcid.org/0000-0003-4033-864X
Nurulafifah Yahya http://orcid.org/0000-0001-8755-0328
Robert J. Mrowicki http://orcid.org/0000-0001-7767-9259
Elizabeth J. Cottier-Cook http://orcid.org/0000-0002-1466-6802

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