Something old, something new: historical perspectives provide lessons for blue growth agendas

Running title: Lessons from history for blue growth

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Abstract

The concept of 'blue growth', which aims to promote the growth of ocean economies whilst holistically managing marine socio-ecological systems, is emerging within national and international marine policy. The concept is often promoted as being novel, however, we show that, historical analogies exist which can provide insights for contemporary planning and implementation of blue growth. Using a case study approach based on expert knowledge, we identified 20 historical fisheries or aquaculture examples from 13 countries, spanning the last 40–800 years, that we contend embody blue growth concepts. This is the first time, to our knowledge, that blue growth has been investigated across such broad spatial and temporal scales. The past societies managed to balance exploitation with equitable access, ecological integrity, and/or economic growth for varying periods of time. Four main trajectories existed that led to the success or failure of blue growth. Success was linked to equitable rather than open access, innovation, and management that was responsive, holistic, and based on scientific knowledge and monitoring. The inability to achieve or maintain blue growth resulted from failures to address limits to industry growth and/or anticipate the impacts of adverse extrinsic events and drivers (e.g., changes in international markets, war), the prioritisation of short-term gains over long-term sustainability, and loss of supporting systems. Fourteen cross-cutting lessons and 10 recommendations were derived that can improve understanding and implementation of blue growth. Despite the contemporary literature broadly supporting our findings, these recommendations are not adequately addressed by agendas seeking to realize blue growth.

Keywords

Ecosystem services; Environmental history; Fisheries; Historical ecology; Marine policy; Sustainable development.

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Introduction

The oceans are and have long been of great value to human societies. Half the global population lives within 200 km of the coast, and, of this, half live within 100 km and <100 m above mean average sea level (IPCC, 2019). Seventeen percent of the animal protein we consume is sourced from our oceans, while nearly 80% of all trade goods are transported by sea (FAO, 2018, United Nations, 2016). Including food and trade, the goods and services provided by the oceans were valued at US $49.7 trillion per year in 2014, which was approximately two thirds of the global GDP (Costanza et al., 2014). This value, however, excludes many of the important services the oceans provide that are difficult to quantify, such as the production of oxygen and the sequestration of anthropogenically produced CO_2 (Stocker, 2015, United Nations, 2015).

In the process of acquiring benefits and services from the sea, we have significantly impacted ocean systems. Humans are responsible for widespread coastal development, habitat loss (United Nations, 2005), pollution (Frid and Caswell, 2017), overfishing (FAO, 2018) and the collective consequences of climate change (IPCC, 2019). In some cases, our effect on marine ecosystems has reduced their ability to provide the ecosystem goods and services we depend upon, such as food, jobs, oxygen, coastal defences, climate regulation and CO_2 sequestration (Costanza et al., 2014, United Nations, 2016). Some of these outcomes might be remediated, and sustainably managing marine resources may enhance the delivery of goods and services (United Nations, 2005).

The term 'blue economy' originated from discussions around the concept of a 'green economy' during the United Nations Conference on Sustainable Development (Rio+20) in 2012 (United Nations Environment Programme, 2012). The latter term arose in response to recent economic growth being described as 'brown': highly industrial, with high-energy demands, often destructive and unsustainable, and based on inequitable employment. A 'green economy' was agreed at Rio+20 that aims to "*improve human wellbeing and social equity, whilst significantly reducing environmental risks and economic uncertainties*" (United Nations Environment Programme, 2011). Subsequently, the United Nations (UN) adopted a resolution comprising 17 sustainable development goals (SDG) (United Nations, 2015). In particular, SDG 14 sought to "*conserve and sustainably use the oceans, seas and marine resources for sustainable development*", and the targets for achieving it included: conserving and restoring marine and coastal systems, ending perverse subsidies and developing capacity in marine science and technology transfer. The 'Decade of Ocean Science for Sustainable Development' UN General Assembly mandate (2017) seeks to support the achievement of SDG 14 from 2021–2030.

A 'blue economy' for the oceans is analogous to a green economy on land: it aspires to achieve economic growth that has low energy demands and carbon emissions, and is sustainable and socially inclusive (United Nations Environment Programme et al., 2012). A blue economy also promotes environmental regulations that are integrated across sectors and regions, sustainable maritime business models, and accessible high and low-skilled labour opportunities (Ecorys, 2012). Globally, the oceans were estimated to have provided 31 million jobs and US$ 1.5 trillion in 2010 (OECD, 2016). Estimates from 2016 indicate that the livelihoods of at least 200 million peoples are linked directly and indirectly to fisheries and aquaculture (FAO, 2018). In Europe, the ocean-related economies support nearly 3.5 million jobs and generate an annual turnover of € 566 billion from activities including coastal tourism, transport, oil and gas, fisheries and shipbuilding (EC, 2018). Large shifts in employment between maritime sectors are now occurring within Europe as new industries grow and traditional industries contract (EC, 2018).

Related to the idea of the 'blue economy', the concept of 'blue growth' has increased in prevalence in recent years (Mulazzani and Malorgio, 2017). The blue growth concept assumes that we can develop strategies to grow our marine and maritime economies in ways that are more sustainable and equitable in the future (Ecorys, 2012), although what is emphasized and how to achieve it varies among organizations and institutions. The European Commission (EC) describes blue growth as an "*initiative to harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth"* (EC, 2012), with objectives to "*promote smart, sustainable and inclusive growth and employment opportunities in Europe's maritime economy*" (EC, 2017a). The EC approach originally targeted five overall sectors as being central to future blue growth: coastal and maritime tourism, renewable energy, aquaculture, minerals and biotechnology (EC, 2010). This initial approach explicitly excluded capture fisheries, implying that there is little room for growth in these sectors in Europe, but this notion was challenged (e.g., Boonstra et al., 2018). More recently, the European Union (EU) has highlighted the "*potential and importance of all relevant sectors of* *the blue economy*", and now explicitly includes fisheries and places greater emphasis upon innovative approaches across sectors more broadly (EC, 2014, EU, 2017). Contrastingly, the Food and Agriculture Organization (FAO) of the United Nations sees blue growth as a framework that is locally adaptable, but driven by fundamental principles of balancing sustainable and socioeconomic management (FAO, 2017). In 2013, the FAO launched the *Blue Growth Initiative* (BGI) to facilitate sustainable growth of food production in lower-income nations that now produce ~80% of global seafood (Potts et al., 2016). The stated goals of FAO's BGI are to "*maximize economic and social benefits while minimizing environmental degradation from these sectors*" (FAO, 2017). The concept has also attracted attention from the private sector who might profit from projects that seek to restore and reform marine fisheries production, innovation, and management (Encourage Capital, 2016, EKO Asset Management Partners, 2014).

In both the EU and FAO agendas, there is an implied and underlying assumption that blue growth is a new way forward for the maritime sector, and that it may be achieved via avenues not previously attempted. In particular, the FAO contrasts its initiative against "business as usual" (FAO, 2017). However, while the potential of proposed future growth sectors, such as biotechnology and renewable energies, largely depend on contemporary technological innovations (OECD, 2016), other sectors have historical precedents for achieving blue growth. For example, maritime sectors such as fisheries and transport have been revolutionized by new technologies many times in the past (e.g., Engelhard, 2008, Garstang, 1900, Graham, 1956, Jones, 2018), and efforts at balancing growth with community needs, equity, and resource sustainability have previously succeeded (e.g., Fortibuoni et al., 2014, Kittinger et al., 2011).

Historical instances of blue growth may offer an important opportunity to learn from the past. The value of history has long been asserted, and is illustrated by a wide and growing literature (e.g. beginning with Pauly 1995 and Jackson et al.,2001) that has provided detailed historical perspectives and data on marine system dynamics, socioecological feedbacks, and marine exploitation and management over time (e. g., Alexander et al., 2017, Eero et al., 2011, Fortibuoni et al., 2017, MacKenzie et al., 2011, Sguotti et al., 2016). Historical perspectives have contributed to, e.g. marine planning and policy formulations (e. g., Engelhard et al., 2016, McClenachan et al., 2012, Schwerdtner Máñez, 2016, Schwerdtner

Máñez et al., 2014), management (e.g., Engelhard et al., 2016; Wortmann et al., 2018, Grisel 2019), conservation (Kittinger et al.,b2015, Ganias et al.,b2017, Ojaveer et al., 2018, Buckley et al., 2019), and understanding of human responses to sudden and unexpected environmental change (Alexander et al., 2017). Despite the demonstrable value of historical perspectives for contemporary ocean science, management, and conservation most assessments of blue growth potential rely on 5–10 year monitoring baselines, and discussions on how past successes and failures might inform current blue growth agendas are lacking. We posit that the past holds critical lessons on prior successes and failures from which society might learn how to achieve blue growth in the future. This advice is crucial now because there are limited examples of recent blue growth from which we can learn, and blue growth agendas are presently in the early stages of development.

While the Anthropocene is unprecedented in many ways, not all of the challenges we face today are unique. For centuries to millennia, human beings have impacted, and managed, the natural world (e.g., Jackson et al., 2001, Hoffmann, 2005, Lotze, 2007, Rick and Erlandson, 2008, Lepofsky and Caldwell, 2013, Thurstan et al., 2016), and past societies have been revolutionized by technological changes (e.g. Squires and Vestergaard, 2013) as well as population growth and the mass redistribution of people (Magee and Thompson, 2010, Grisel et al., 2019). They have experienced natural disasters (e.g., epidemics and environmental change), and been globally connected by markets, trade, and culture (e.g. Taylor 2002, Erikson and Bearman 2006, Magee and Thompson 2010). Comparable social and environmental changes are occurring now, often at larger scales, and our history is the only resource from which we may obtain insights on how to address such challenges and learn from past mistakes. A longer-term view is crucial as human influences on the environment accelerate (Ven der Leeuw et al., 2011), and we seek to sustainably exploit the natural world.

In this paper, we used examples from across disparate historical periods, social-ecological systems, and geographic locations around the world. Focussing on historical fisheries or aquaculture, given our expertise, we first asked if historical examples existed of attempts by people to sustain and/or diversify coastal services, enhance the growth of marine economies, and if they succeeded or failed in balancing objectives we would today recognize as akin to blue growth. Of the historical precedents found, we identified the social, economic and ecological drivers behind historical blue growth success and failure, and the trade-offs that occurred for case studies spanning 40–800 years. We then used these examples to develop lessons and recommendations for planners and policy makers today, and compared outcomes with the current literature and blue growth agendas. Collectively, we go beyond merely demonstrating the historical precedent of blue growth – we use that precedent to provide advice, thereby showing how the past holds insights directly relevant to present-day policy and management.

Methods

Our overall process is outlined in Figure 1. Firstly, the overarching criteria included within established blue growth agendas were identified. Subsequently, these criteria were used to guide the selection of historical case studies, and to answer the following three questions:

- **Q1**: Did past management strategies and approaches achieve outcomes that reflect the aspirations of the current blue growth agendas?
- **Q2**: What, if any, lessons do the examples from the past contain for blue growth agendas today?
- **Q3**: If found, are historical lessons being actioned within contemporary blue growth agendas?

Determining the overarching criteria common to blue growth agendas

Definitions of blue growth vary between regions and organisations, reflecting differing social, economic or governance priorities (EC, 2017a, Eikeset et al., 2018, FAO, 2017). Moreover, policies for many regions are still under development. Therefore, we used the relatively well-established blue growth agendas of the EU and FAO (EC, 2017a, FAO, 2017) as a framework for this study (Fig. 1). In accordance with their remit, the FAO's blue growth policies focus more on social issues (e.g. equity, access to resources), small-scale fisheries, rural areas, and economically-developing nations and explicitly includes capture fisheries. In contrast, the EU agenda concentrates more on the economic growth of emerging sectors (e.g. seafloor mining, renewable energy). Despite these differences, the agendas overlap in a number of areas. Firstly, they are both generally concerned with forms of growth (e.g. increases in catch, revenue or other value, jobs) that have minimal negative impacts either environmentally or socially (i.e. the growth is "sustainable"). Secondly, both agendas place significant importance on technology, innovation, and efficiency, and often note these as key to ensuring sustainability. In light of these similarities, we determined the overarching blue growth criteria for use in this study as:

1. **Achieving growth** of marine economies while minimising the risks of negative environmental impacts that adversely affect sustainability.

2. **Achieving and maintaining balance** among ocean resource use, equitable access among users, efficiency within the supply chain (e.g., food security, employment), and ecological and environmental well-being (e.g., maintaining or improving biodiversity, and ecosystem functioning).

3. **Implementing smart solutions**, where human innovation increases efficiency while supporting a balance between sustainable use and economic growth.

4. **Achieving integration** among regions, sectors and stakeholders, where the activities and impacts of the different maritime sectors are interconnected (including consideration of competing interests) via holistic overarching legislative policy(ies) for which stakeholder consultation is inherent. These policies also drive coordination among stakeholders, nations, and transboundary areas (e.g., planning instruments such as spatial planning, international/inter-sectoral agreements such as blue growth cluster partnerships).

In the following sections, all references to 'blue growth' relate to growth or actions that reflect/result in two or more of the defined criteria above. Any reference to blue growth *agendas* refers to existing policies or organizational strategies being proposed (EC, 2017a, FAO, 2017).

Collation of case studies

Historical case studies were originally elicited from researchers working with the International Council for the Exporation of the Seas (ICES) Working Group on the History of Fish and Fisheries (WGHIST) and the EU-COST Action on Oceans Past Platform (OPP).

These two groups consisted of academics, government scientists, and practitioners working in the marine ecology, marine fisheries, historical ecology, archaeology and environmental history disciplines, or a combination of these. Initiating the study with experts in these two groups meant the case studies were limited in geographic scope, hence additional experts outside these groups were approached to expand the global perspective.

Researchers were asked to provide historical case studies based on their own research or expert knowledge where past management strategies and approaches achieved outcomes that reflected the aspirations of current blue growth agendas, as defined for this study (Q1). To make this distinction, the researcher used their expert opinion to determine whether two or more of the overarching blue growth criteria were met in each case study (Fig. 1). The achievement of the criteria did not have to result from historical policies purposefully aimed at growth, balance etc., but could incidentally result from multiple events and/or policies put in place for reasons unrelated to the criteria we identified. Examples of historical blue growth could, therefore, result from either purposeful or unintended actions, and arise from policies or events that were either intrinsic or extrinsic to the system of interest. Researchers identified their case study by stock, system, and time period, and denoted which blue growth criteria it exemplified. Our case studies primarily focused on historical fisheries or aquaculture for which the historical literature was replete with examples (Fig. 2).

Expert knowledge is commonly used when empirical or comparable data are scarce (e.g., Selkoe et al., 2008; Pascoe et al., 2009). Researchers expert in the requested topic may be requested to make judgement calls about the reliability of sources of differing quality or uncertainty, including cases where data are missing, or to interpret non-quantitative or context-dependent data according to their understanding of a particular system (Knol et al., 2010; Dessai et al., 2018). In this study, researchers chose periods and systems for which they were familiar with relevant historical literature, the context and socioecological events surrounding the case studies. Each researcher presented their interpretation of the outcomes that were analogous to blue growth in accordance with the four criteria identified above. Information was requested in a predetermined tabulated format that facilitated comparisons between case studies (Table 1, SOM Table S1) and this included the primary drivers that facilitated or restricted blue growth, backed by historical evidence. Each researcher produced an accompanying descriptive summary and a list of key sources (SOM S1). Due to the context-dependent interpretation of historical sources, which can be biased by the cultural and/or academic background of the researcher, or change over time as new evidence comes to light, the above approach is not as readily reproducible as some published in the natural sciences. However, this approach is in line with established expert elicitation protocols (Selkoe et al., 2008; Pascoe et al., 2009).

Determining cross-cutting Lessons from historical case studies

To determine what, if any, lessons the examples from the past contained for blue growth agendas today (Q2) researchers first provided case study-specific lessons (e.g., social, ecological, political, economic etc.) (Table 1, SOM Table S1). To assess whether these lessons had broad implications, three of the authors identified those that cut across multiple case studies ("Lessons"). These cross-cutting Lessons did not need to apply across every case study, but to increase our confidence in their applicability to blue growth agendas more broadly, Lessons needed to apply to case studies from more than one time period and more than one region and/or fishery.

Developing recommendations from cross-cutting Lessons

We used the 14 cross-cutting Lessons to construct a list of recommendations (actionable statements that reflected the sum of the cross-cutting Lessons, hereafter "Recommendations") that were deemed relevant for blue growth agendas today. In some cases, the Lessons were relevant to, and were thus incorporated into, multiple Recommendations. To assess whether the cross-cutting historical Lessons were being actioned within blue growth agendas (Q3) we evaluated whether similar statements/subject matter were, or were not, already included in the established high level EU and FAO blue growth agenda documentation (Fig. 1) (EC, 2012, EC, 2014, EC, 2017a, EC, 2018, FAO, 2017), and so whether these Recommendations did or did not constitute new knowledge.

Results

Q1: Did past management strategies and approaches achieve outcomes that reflect the aspirations of the current blue growth agendas?

We obtained 20 historical case studies from thirteen countries. These focused on capture fisheries (14 case studies) or aquaculture (6 case studies), and all exemplified at least two of the four blue growth criteria identified from the EU and FAO documents (Table 1, Table S1 SOM 1). Nine case studies focused upon growth in the context of a single species being fished or cultured, while 11 related to multi-species fisheries or aquaculture. Examples of blue growth were observed across multiple locations and cultures during many past periods, with case studies spanning 40 to 700 years duration (median = 80 years; Fig. 2).

Four common blue growth trajectories were identified across the case studies (Fig. 3). Three trajectories exhibited some form of unbalanced growth, where economic growth was prioritized over social equity and/or sustainability, whereas the fourth balanced growth with social equity and ecological sustainability. In five case studies (1, 3, 7, 8 and 13), growth was observed initially, but was not maintained as economic investment occurred at the expense of social equity and/or ecological sustainability (unbalanced growth, Fig. 3a). In five case studies (5, 6, 9, 18 and 20), the same pattern occurred but the eventual contraction of growth was delayed due to innovation (delayed unbalanced growth, Fig. 3b). In six case studies (4, 10, 11, 12, 14 and 16), an initial period of growth was followed by stasis or contraction after which growth (or at least the potential for it in the future) was re-established due to improvements in ecological sustainability and/or social equity (recovery, Fig. 3c). In four case studies (2, 15, 17 and 19), the factors contributing to growth were largely balanced, hence growth was observed throughout the case study period (balanced growth, Fig. 3d). In these cases, growth might be punctuated by extrinsic and/or intrinsic political and/or economic events, or be bolstered by innovations and/or new markets, but factors contributing to growth remained largely balanced and thus growth continued.

Q2: What, if any, lessons do the examples from the past contain for blue growth agendas today?

We identified a total of 118 case study specific lessons, with each case study providing between 2 and 7 specific lessons (for worked example, see Fig. 4). From these, 14 cross-cutting Lessons were identified that were common to multiple case studies (Table 2). Each of these Lessons is described below, with cross reference to the relevant case studies denoted in parentheses. Lesson 1 focused on the different scales across which blue growth can occur; Lessons 2−5 considered the factors that may undermine, inhibit or complicate growth; Lesson 6 described what is required to translate innovation into growth; Lessons 7−10 described the relationships between stakeholders and blue growth and the challenges to these relationships; Lesson 11 considered issues of equitability; Lessons 12−13 illustrated some of the management requirements for the achievement of blue growth. Finally, Lesson 14 portrayed the inevitable trade-offs inherent to blue growth, particularly in degraded ecosystems.

Lesson 1. *To determine whether blue growth has occurred, outcomes should be assessed over a range of scales.*

From the case studies, we observed blue growth trajectories and outcomes varying across temporal and spatial scales. Firstly, while it could be realised over long periods, achieving blue growth in the short term did not necessarily mean it would be maintained. Some case studies did demonstrate prolonged periods, even hundreds of years (e.g., case studies 3, 10, 17) over which blue growth appeared to be sustained, and in others blue growth was sometimes re-established after being lost. For example, in Hawaiʻi, blue growth was arguably maintained for many centuries (10a), but overexploitation accelerated following colonization by Europeans in the 18th century (10b–d). More recently, blue growth is slowly being re-established through the increased protection and regulation of marine habitats and fisheries (10e). However, in other case studies, blue growth was maintained for a shorter period of time before being undermined, after which little or no recovery was evident (e.g., 5−7, 13).

Secondly, we found that spatial and economic scales were also important in determining whether blue growth was realised. In Ireland's Galway Bay (1), local blue growth in mixed capture fisheries halted when management shifted from a local to a regional and national focus. In New England (8), the loss of blue growth was precipitated when small-scale fishers were out-competed by larger commercial fishers driven by the demands of a larger, regional market, during the late-19th century. The importance of acknowledging the impacts of spatial and economic scales are echoed in other case studies, including those in the Lagoon of Venice (3) and in the Adriatic Sea (5). These examples suggest that, although blue growth is often described as a notable increase or scaling up of production, such growth at large spatial or economic scales can inhibit blue growth at smaller or local scales.

Lesson 2. *The prioritisation of short-term gains can lead to long-term losses in blue growth.*

While dovetailing Lesson 1, we found this Lesson significant enough to delineate. The case studies demonstrated that the prioritization of short-term gains could have had long-term consequences that ultimately destabilized blue growth. Marine use in Galway Bay (1) achieved blue growth in the early half of the 19th century, but larger-scale concerns (i.e., feeding a growing population) aided by the development of novel technologies prioritized swift economic growth over the sustainability concerns of local fishermen and, in time, resulted in overexploitation at local and ultimately regional scales. Management in the Adriatic (5, 6), Venice Lagoon (3), and Sweden (9) similarly lost elements of blue growth when they adopted a focus on short-term gains, prioritizing the ambitions of certain stakeholders and markets over longer-term ecological sustainability and social equity. In contrast, regulations in the Lagoon of Venice prior to the 19th century (3) maintained objectives that favoured long-term sustainability, with associated societal benefits, that spanned centuries (Fig. 4). This was also the case in Hawaiʻi before European colonization (10a). In both Venice and Hawaiʻi, later shifts to emphasize shorter-term gains degraded fisheries resources, as well as traditional rules of access (Fig. 4). These case studies show the need to consider both the immediate and long-lasting costs and benefits of new management regimes or novel technologies for blue growth.

Lesson 3. *Failure to understand and address the limits to industry growth may have ecological, social and economic consequences, including system collapse.*

Our historical examples demonstrated that, where economic concerns, markets, or some stakeholder demands are prioritised over the ecological and environmental limits to the expansion of industry and/or human use, severe ecological, social and/or economic consequences can result. For example, overexploitation and other stressors driven by technological advancement and economic priorities resulted in the sequential collapse of oyster (*Crassostrea virginica*, Ostreidae) fisheries in the United States (16). Similarly, uncontrolled industry growth in fisheries of the Irish (1), Adriatic (6), North (12) and Baltic (13) seas led to the collapse of stocks and/or sub-populations, consequently limiting blue growth.

Lesson 4. *The nature of blue growth can be unpredictable, nonlinear, and attributed to multiple factors.*

Several case studies demonstrated that blue growth does not necessarily proceed in a linear fashion (i.e., via the stepwise accumulation of knowledge and skills, or in line with population growth). Instead, opportunities can be non-linear and originate unexpectedly. The most common example across our case studies was the facilitation of rapid periods of economic growth by technological or scientific innovation (1, 4–6, 8–10, 12–17, 18, 20), although such innovations were often accompanied by unsustainable practices or a lack of regulation, leading to a halting or reduction in the rate of blue growth (1, 6, 8–9, 13–14, 16). Sudden and often unexpected blue growth in some case studies was also precipitated by product development, new markets, and/or developments in scientific understanding. For example, research and technological innovations coincided with growing demand, leading to rapid increases in production of nori (genus *Porphyra*, Bangiaceae) in Japan post-World War II (17). In Columbia, scientific innovation produced shrimp larvae *Penaeus* sp. (Penaeoidea) resistant to the white spot virus, which – up until the advent of unfavourable economic conditions – enabled extremely high yields to be attained (20). In South Australia, the production of a once marginal Southern Bluefin tuna (*Thunnus maccoyii*, Scombridae) industry grew and became mainstream due to individuals' willingness to speculatively invest and undertake product development (4). Changing industry dynamics can also present opportunities for blue growth: technological innovation and investment in aquaculture in the Adriatic was aligned with and partially stimulated by declining wild fisheries production in the region (5).

Lesson 5. *Drivers and events occurring outside the immediate system can critically impact the achievement and maintenance of blue growth.*

Events and factors that are external to a maritime sector, in this case fisheries and aquaculture, can impact whether blue growth criteria are met or maintained. These external drivers and events include international or regional shifts in market demand and the corresponding industrial effort (4, 7), growth (8) or decline (5) of other fisheries, as well as ecosystem or environmental changes (13), periods of political change (3, 8, 10a–b), war (17), epidemics (10b), and international or regional policies or management (4). In Hawai‘i (10b), a sustainable ocean economy had been maintained for centuries, but was undermined with the advent of colonist rule, and later market pressures and associated shifts in modes of production. In the Lagoon of Venice (3), political instabilities in the wider region contributed to the loss of social structures and management regulations that had previously maintained blue growth (Fig. 4). Blue growth in Hong Kong oysters (*Crassostrea hongkongensis*, Ostreidae) (18) was undermined by numerous extrinsic forces, including natural disaster, pollution, rapid coastal development, disease, and shifts towards alternative employment for the younger work force, namely the financial trading and technology sectors. The Hong Kong case study illustrates the importance of culture and perception for blue growth and its success; whereby the above factors precipitated a cultural shift, from oyster aquaculture as a means of economic growth, towards its value primarily being as a heritage industry. These examples show how such changes can inhibit blue growth through reduced demand, disruption to overseas trade, or via impacts on the workforce. Parallel expansion in non-fishery sectors, such as agriculture (7, 10b) and tourism (10d) can also inhibit blue growth, as can the diversion of local labour (10b, 17) to fisheries in other regions or nations, or to other industries.

Extrinsic drivers can also have positive outcomes for blue growth. The growth of sustainable seaweed culture industries (15, 17) was facilitated by regional and global demand for seaweeds as food and for alginate products. Environmental concerns and an increasing awareness of conservation challenges aided cultural and social shifts and management enforcement, leading to greater sustainability in the recreational fisheries of Queensland, Australia (2). International overexploitation of Southern Bluefin tuna, together with industry innovation, precipitated the growth of an aquaculture industry there as well (4). Runoff of excess agricultural fertilisers in Japan facilitated nori culture, allowing it to expand into offshore areas, increasing production (17). In some cases, related ecosystem services may confer additional benefits, for instance oyster reef restoration in the United States not only serves to increase oyster production, but also related wild finfish populations by providing habitat for juveniles, and contributing to improvements in local water quality (16).

Lesson 6. *Supporting systems may be important for translating innovation into blue growth.*

Support that extends beyond direct management or policy may also be valuable for blue growth, such as related technological developments and research, or existing or developing markets and infrastructure. For instance, the early growth of the Southern Bluefin tuna fishery (prior to ranching) in South Australia was supported by product innovation (i.e., canning) (4). In Japan, government support for innovation, and the expansion of growers' unions provided infrastructure (culturing and drying facilities) and policies to help supply demand and increase production of nori (17). The success of oyster restoration projects and knowledge gained from this process in North America has been leveraged for restoration projects and subsequent blue growth opportunities in Australia and Europe (16). Finally, careful management and monitoring of the introduced Kamchatka king crab (*Paralithodes camtschaticus*, Lithodoidea) by both Norway and Russia, combined with favourable climate conditions, has thus far facilitated growth of a productive industry benefitting local fishing communities in Norway and commercial industry in Russia. This case study provides a rare example of blue growth based on invasive species (19).

Lesson 7. *Stakeholders hold diverse perspectives and socio-ecological knowledge, and this can be leveraged to support the achievement of blue growth.*

Our case studies indicate that both respect for stakeholder knowledge and encouraging their engagement can be valuable for achieving and maintaining blue growth. In several historical case studies (1, 3, 6–7), a shift away from community-based or community-managed fisheries and overlooking the concerns of local or traditional resource users played a role in weakening blue growth. For example, the lack of engagement with Aboriginal perspectives and knowledge may have contributed to collapse in the dugong (*Dugon dugong*, Dugongidae) fisheries in South Queensland (7). In Hong Kong (18), ongoing local pride in oyster cultivation does not hold sufficient societal value to attract new fishers and thus encourage growth. In others, stakeholder engagement was key to the promotion of blue growth, e.g. the Norwegian seaweed sector (15) benefitted from stakeholder engagement coupled with strong management, research, and investment in monitoring.

Our case studies also revealed that stakeholders and resource users hold a wide variety of perspectives and values beyond maximizing harvesting, extraction, or profit. For example, in Queensland's recreational fisheries (2), cultural and social incentives were critical in the shifts towards more sustainable exploitation strategies. Similarly, in the past, stakeholders within a number of fisheries have been aware of the need to limit harvesting for long-term sustainability, and vocal in opposing what they considered to be overly destructive gear (1, 3, 10a).

Lesson 8. *Environmental stewardship can support blue growth and may be facilitated by cultural and social attributes as well as economic incentives.*

Our examples from the past show that environmental stewardship can support blue growth. Providing economic incentives is one way of encouraging people to shift from consumptive to conservationist behaviours, but our case studies suggest additional ways forward. Hawaiian communities had a long legacy of environmental stewardship that helped maintain many sustainable reef fisheries prior to colonialism (10a), indicating the importance of existing social systems and cultural norms. In Queensland, Australia (2), shifts in cultural norms were aligned with changes in the management of recreational fisheries, which collectively led to increased environmental stewardship and the likelihood of community members recognising the need for responsible fishing practices to maintain stocks. In the Lagoon of Venice (3), long-term sustainability and local needs were valued by society as a whole, and together with co-management structures, resulted in centuries of sustainable use that supported societal well-being. Contrastingly, in Hong Kong changes in cultural values and motivations undermined the long-term sustainability of oyster aquaculture (18), which had previously been maintained for centuries. In these case studies, environmental stewardship was supported by cultural and social structures, not simply economic incentives (Fig. 4).

Lesson 9. *The benefits of blue growth may be unequal or incompatible across stakeholder groups, which can create conflict or limit growth if one group's needs are prioritised over others.*

In the Swedish commercial fisheries (9), a focus on the growth of industrial fisheries encouraged the prioritization of economic gains over other goals, including equitable access. Consequently, it became too difficult for small-scale fisheries to compete, and they exited the fishery. The overcapitalization of the fleet driven by particular stakeholders also ultimately aided overexploitation and the erosion of blue growth that existed in the early 20th century. Dugong fisheries in Southern Queensland (7) had the potential to embrace blue growth via collaboration across resource user groups, specifically with local indigenous communities. However, these communities were quickly excluded from the fishery (both in terms of economic gains and access to the resource), which resulted in a loss of equity and indigenous ecological knowledge. In the Baltic Sea (11), grey seal (*Halichoerus grypus*, Phocidae) population recovery has increased opportunities for eco-based tourism, but also seal-fisher conflict. Conversely, the growth in commercial harvesting of wild seaweed in Norway was facilitated by a lack of inter-sectoral conflict, supported by strong management regulations (15). Collectively, these case studies highlight the significance of understanding user groups and their needs, the potential importance of outside regulations to maintain equity, and, ultimately, anticipating that actions may not benefit all groups equally or simultaneously.

Lesson 10. *Equitable access does not always correspond with open access nor produce the same outcomes.*

Several of the historical examples demonstrated that equitable access was not the same as open access. In these case studies, economic gains resulting from shifts to open access often occurred at the expense of long-term sustainability and stakeholder equity. For example, the dependence of local communities on the Lagoon of Venice (3) resulted in strict regulation of the fishery and markets, and this was key to centuries of sustainable use akin to what would be blue growth today. When de-regulation later led to open access and the loss of these regulatory structures, overexploitation and destructive fishing practices undermined blue growth there (Fig. 4). In Sweden's lobster (*Homarus Gammarus*, Nephropidae) fishery during the 19^{th} and early 20^{th} centuries (14), fishing rights were often assigned to local fishers. Together with seasonal and minimum size regulations, this restricted access helped to maintain the sustainability of the fishery. As with Venice, when access was expanded after the 1950s, fisher numbers grew and lobster populations declined due to unsustainable levels of exploitation.

Our case studies further caution that groups with less representation in stakeholder engagement frameworks and political discourse may be particularly disadvantaged under open access. For example, Galway fishers' concerns about the economic and ecological impacts of bottom trawling on their local ecosystem (1) were initially dismissed as 'foolish prejudices' by the regulating authorities, not least to encourage the growth of highly capitalized trawling companies (Commissioners of Fisheries, 1854, Thurstan et al., 2014). Similar dynamics between wealthy users and political power were at play in the Swedish fisheries where small-scale fishers were ultimately outcompeted (9). Substantial ecological knowledge and traditional fishing practices were transferred from Aboriginal Australians to early Europeans (7), yet ingrained racial prejudices resulted in Aboriginal contributions to these early fisheries being quickly minimised and erased from societal memory (Kerkhove, 2013). In all these cases, groups with less political influence were the most disadvantaged under open access, thus undermining equity and therefore blue growth.

Lesson 11. *Management based on scientific knowledge and supported by ongoing monitoring may be key for blue growth.*

Scientific understanding and continued monitoring were key to past blue growth. In the Southern Queensland dugong fisheries (7), the potential for blue growth was in part diminished by a lack of scientific understanding about the stock. Similarly, a lack of ecological knowledge meant that autumn and spring spawning herring (*Clupea harengus,* Clupeidae), two distinct stocks, were inappropriately managed together in the Gulf of Riga (13). As the herring stock did not show a considerable overall change, the overexploitation of the autumn spawning stock was not recognised until after biomass had severely decreased. Swedish lobster fisheries (14) demonstrate the importance of monitoring recreational fisheries, and Russian and Norwegian crab fisheries demonstrated the possible opportunities associated with introduced fisheries species (19). In contrast, in both the Norwegian *Laminaria hyperborea* and Japanese *Porphyra* spp. seaweed fisheries, blue growth was bolstered by ecological knowledge and investment in scientific research and monitoring (15, 17). In Columbia, marine shrimp aquaculture was enhanced by scientific investigations into and the subsequent production of virus-tolerant shrimp larvae (20), while an appreciation of the connections between habitats and ecosystem services supported blue growth through the restoration of oyster habitats in the United States (16).

Our case studies show the significance of scientific knowledge and monitoring for maintaining blue growth in the face of technological change in particular. Investments in ecological knowledge helped increase product quality and farming efficiency within the Southern Bluefin Tuna (*Thunnus maccoyii*, Scombirdae) aquaculture industry in South Australia (4). Aligned with strong and consistent management, this allowed for sustainable resource use alongside technological advancement and economic growth, whereas a lack of knowledge corresponded with overexploitation. These case studies indicate that scientific knowledge and monitoring may be key to understanding how innovation can facilitate blue growth strategies while avoiding overexploitation (Lessons 2 and 3). This is especially significant given the potential for unchecked advancement to exceed the natural limits of a system (e.g. 9; Lesson 3).

Lesson 12. *For blue growth to be maintained, policy and management should be flexible, responsive, and adopt a whole-system view, including across multiple jurisdictions when required.*

A whole-system view (including the human component, Lessons 3 and 8) may be important for maintaining blue growth over the long-term, and management should strive to be responsive and flexible to change. For example, traditional management in Hawai‘i acknowledged the linkages between different systems (e.g., between ecological and social), which enabled long-term blue growth (10a). Taking into account the potential for sudden and unexpected change (Lesson 6) and the significance of extrinsic factors (Lesson 4), it is also important that management is able to respond and adapt to changes at a systems level. Finally, in cases where fish populations straddled multiple jurisdictions, management and policy must go beyond the prescribed jurisdictional boundaries. Transnational oversight has proven to be effective at sustainably managing some stocks (4, 12, 19), although multi-jurisdictional management can be challenging and it can take time for its effectiveness to be demonstrated (12).

Lesson 13. *Regulations (whether top-down or bottom-up) can facilitate and maintain blue growth, but adequate enforcement and community buy-in can be critical.*

Our case studies suggest that the regulations for resource use can help to maintain stock biomass and facilitate aspects of blue growth, especially over the longer-term. How regulations were decided upon, who enforced them, and how successful the various strategies were differed between case studies. In those where regulations played a role in helping achieve blue growth, we found adequate enforcement and community buy-in also occurred. For example, in the Lagoon of Venice (3), strong, top-down regulations promoted sustainable exploitation and maintained ecosystem services (e.g., fish habitat), and ensured equitable access to markets as well as fishery resources. Critically, these regulations were also strictly enforced. In case studies where this was not the case, regulations sometimes fell short of ensuring long-term blue growth (e.g., 6, 7, 12). In other case studies, fisheries community buy-in played an equally important role in ensuring the success of regulations. Such community engagement was facilitated by adherence to long-standing cultural or social norms and controls (e.g., on the consumption of certain reef fauna in Hawai'i, 10a), emerging cultural norms (e.g., increased stewardship in recreational fisheries in Australia, 2), or realized via shared ownership, i.e. co-management between state and fishers in the Lagoon of Venice (3) and/or local control of the resource (e.g., control of Galway Bay's resources by local fishermen in the pre-trawling era, 1).

Lesson 14. *Growth, ecological sustainability, and social equity may not be achieved simultaneously; trade-offs may be necessary.*

Our case studies caution that aspects of blue growth may not always be mutually compatible, indicating the potential for trade-offs among aims under blue growth agendas and the need for clear consideration and prioritization of goals. For example, a common theme within the historical case studies was the loss of small-scale fisheries due to the emergence and dominance of larger-scale fisheries (1, 8, 9, 10b–d, 12). While these fisheries can promote economic growth and may more rapidly engage advancing technology, this often came at the expense of other blue growth criteria, such as social equity and ecological sustainability (Lessons 1–2). Lesson 10 also speaks to the potential for trade-offs between resource user needs, access, and well-being. Taken together, the case studies suggest that not all needs or blue growth criteria may be met simultaneously.

The North Sea fisheries demonstrated other possible trade-offs, particularly within the context of recovering degraded ecosystems (12). During the 1970s, it was recognized that weak management and over-capacity in the fleet had led to the deterioration of North Sea fish stocks. The enactment of the Common Fisheries Policy after 1983 introduced restrictions in fishing effort and landings, with the aim of enabling the recovery of depleted stocks. While the status of North Sea fish stocks did indeed shift from deterioration to recovery during the 2000s, trade-offs included the loss of jobs and of some traditional fishing communities and cultures (also in 9).

Q3: If found, are historical lessons being actioned within blue growth agendas?

Many of the cross-cutting historical Lessons aligned and were readily organized into actionable statements, i.e. the Recommendations. Ten Recommendations (A–J) were produced from the 14 cross-cutting Lessons (Table 3), with most Lessons applying to more than one Recommendation. Four of the Recommendations (A–D) applied to the planning process of blue growth, four (E–H) were relevant to management that supports the implementation of blue growth, while two (I–J) were applicable to blue growth agendas after ratification (Table 3). Recommendations highlighted the significance of considering and balancing short- and long-term outcomes, and the needs of local and regional stakeholders during the planning process (Recommendations A–B). Our case studies also suggest that stakeholders hold a multitude of diverse values that have implications for blue growth (e.g. Lesson 7). On the one hand, it may be challenging to address all user group needs, but on the other, variation in stakeholder values indicates that some or many of these values may align with blue growth principles and goals. In either case, engaging stakeholders in decision-making can fortify blue growth (B), especially when it illuminates social and cultural values that can be used to align regulations, technological advancement, and economic growth (C). Yet trade-offs among groups and goals can make it challenging to achieve all blue growth criteria simultaneously, and it will be crucial to have a plan for assessing those trade-offs (D). Collectively, recognition of trade-offs and diversity amongst stakeholders is needed for management to effectively support blue growth and equity (E). Finally, and for all of these reasons, active, enforceable, adaptable and holistic management (F–H), supported by monitoring and scientific inquiry and a long-term perspective is necessary for blue growth to be sustained (I–J).

All of the Recommendations were partially addressed in the EU blue growth agendas (SOM 2, Table 3), and five were partially addressed in both EU and FAO agendas. Only one Recommendation was comprehensively represented in both the EU and the FAO blue growth agendas (B – identifying and engaging stakeholders in the decision-making process) (FAO, 2017, EC, 2012), with one other included in the FAO agenda alone (E – focus on facilitating equitable access). Three Recommendations (A – defining scale, D – planning for trade-offs, and J – ensure continuous monitoring) were not included in the FAO high-level blue growth documentation (Table 3).

Discussion

Prior resource exploitation and the sustainability challenges of a rapidly growing global population are already constraining our ability to derive benefits and services from ocean resources (Costanza et al., 2014, Hirons et al., 2016, OECD, 2016, Stocker, 2015, United Nations, 2016, WWF, 2015). Today, blue growth is discussed as a novel concept and approach for sustainable ocean governance (OECD, 2016) that will maintain and perhaps expand these benefits in the future (e. g., EC, 2017a, FAO, 2017). Our synthesis contextualises contemporary conversations on blue growth and provides novel insights for its advancement in several ways. Firstly, the range of case studies, covering disparate social-ecological systems, time periods, and locations (Fig. 2), demonstrates that whilst the term 'blue growth' is new its achievement and aims are not. What we today refer to as blue growth has previously spanned decades to centuries in some cases, with earlier societies embracing new technology and balancing resource exploitation with equitable access, ecological integrity, and economic growth. These examples show that what is considered blue growth today has been inherent in people's use and engagement with the sea for centuries, and suggest there are significant lessons to be learned from history. Secondly, the perspectives and insights from the 20 case studies and 13 different countries, considered in this study, show how blue growth can be achieved and, equally critically, be maintained. We determined four general trajectories of blue growth (Fig. 3), and identified 14 significant Lessons and 10 Recommendations that are broadly relevant for today's blue growth agendas.

One critical outcome of our work is that the Recommendations we resolved are not comprehensively addressed in either the EU or FAO blue growth agendas (Table 3). These are the most well-established international blue growth agendas presently available. However, there is real need for such advice: because blue growth programs are still in their infancy, and examples of how blue growth might operate in practice and what successful outcomes may look like are very limited (Lasner and Hamm, 2014, Pinto et al., 2015, Potts et al., 2016, She et al., 2016, Zhao et al., 2013) and do not refer to history. The insights from the present study therefore can start to address these gaps in our knowledge and give direction to future work.

The opportunities and challenges for blue growth

Blue growth agendas aim to diversify marine resource use in countries with medium-to high-income economies, and fully or over-exploited resources (EC, 2018), but also represent a basis for furthering sustainable resource use in lower-income economies (FAO, 2017). Technological innovation is expected to play a crucial role in the development and management of future blue growth (OECD, 2016), and this could include the expansion of the wild capture fisheries that are presently overfished/fully exploited (e.g., FAO, 2018). Our case studies demonstrated that blue growth *can* occur even when a resource is fully exploited or the wider ecosystem is degraded, either via product development, added value, and/or innovation (if supporting systems exist). In these ways, additional novel revenue streams may be possible without undermining the longer-term provisioning of those species or stocks that are already fully or overexploited (e.g. Condie et al., 2014). These observations support the estimates of Costello et al., (2016), who suggested that fisheries reform could increase global capture fisheries production by 16 million metric tons and $53 billion annually (see also Hilborn and Costello, 2018). Others propose that value can be added to existing capture fisheries through certification, more efficient use of resources, and specialization (Boonstra et al., 2018, Lasner and Hamm, 2014, Potts et al., 2016). Further, novel revenue streams such as the 'restoration economy' can create jobs, restore valuable coastal habitats and the associated ecosystem services (Abelson et al., 2016, Conathan et al., 2014). Therefore, despite the degraded or fully exploited state of some marine ecosystems, opportunities for blue growth in the fisheries and aquaculture sectors certainly exist. However, the present study also cautions that, to achieve blue growth, such opportunities need to be assessed within the context of past and present stressors, socio-ecological factors, and trade-offs.

Insights from across our historical case studies also suggest there are critical challenges for today's blue growth agendas. Firstly, blue growth can be both achieved and lost over time, and different trajectories may be observed depending on a range of factors (Fig. 3). What might be deemed blue growth over the short-term (years to decades) may not be sustainable for longer periods (Lesson 1), or it may be undermined by decisions that prioritise short-term goals or benefits (Lesson 2). In the majority of our case studies, blue growth was sustained for limited periods only. For instance, in 40% of case studies, blue growth occurred for less than four decades, and in a further 20% of cases growth was maintained for five or six decades and was then undermined because of a failure to understand and address limits to industry growth (Lesson 3). Thus, we caution against assuming that, once reached, blue growth will be maintained. Moreover, our results indicate failure is usually followed by slow recovery that can undermine future blue growth; for example, in these cases between 50–400 years had elapsed before wild fish and shellfish populations attained comparable state to those preceding exploitation.

Secondly, our case studies highlight that perspectives on whether (or not) blue growth is achieved are highly dependent on the scale of observation (Lesson 1). Success in one location or for one group may be detrimental to growth in another; blue growth nationally may come at the expense of achieving blue growth locally. Thirdly, our findings illustrated that the achievement, and sometimes failure, of blue growth historically was often at least partly attributable to natural and socioeconomic drivers that were extrinsic to the system of concern (Lesson 5). In particular, market demand, political instability, activity in other sectors and environmental change were important in a range of case studies. Contemporary blue growth agendas should therefore try to: identify the connections between global markets, understand geopolitical dynamics and other socio-ecological linkages (e. g., Burgess et al., 2018, Lasner and Hamm, 2014, OECD, 2016) so that their effects can be anticipated and adjustments made if required.

Alignment with current research and blue growth agendas

Some results from the historic case studies are unsurprising given that ecosystems are not static, they transcend jurisdictional boundaries, and are inherently variable through both space and time (Kritzer and Sale, 2004, Lees et al., 2006, Levins, 1970), as are socio-ecological outcomes and management approaches (e. g. Jackson et al., 2001, Kittinger et al., 2015, Pandolfi et al., 2003, Pinto et al., 2015, Rick and Erlandson, 2008, Waycott et al., 2009). Similarly, in the historical case studies technological change followed nonlinear and/or unexpected trajectories rather than gradual and incremental transformation (Lesson 4) (e. g., as proposed by Squires and Vestergaard, 2013). The temporal and spatial scale (Steneck and Wilson, 2010) as well as the interconnections between systems were important in our historical case studies (Lessons 4-6) and present clear challenges for management (Brown et al., 2001, Fulton et al., 2011, Goodsir et al., 2015). Our findings parallel current debates surrounding the achievement of the Sustainable Development Goals (SDGs): the SDGs may be synergistic, but will probably require trade-offs that vary regionally and/or case by case (Nilsson et al., 2016).

Principles from resilience thinking (Biggs et al., 2015) were echoed in our findings, and included the broadening of participation to include all relevant stakeholders (Lessons 7 and

9), and the management of slow variables and feedbacks across social and ecological systems (Lessons 4-6). We concluded that achieving the integration and balance required for blue growth will depend upon the success of holistic approaches (Lesson 12) such as Ecosystem Based Management (EBM; Levin et al., 2009), ecosystem-based fisheries management (EBFM; Pikitch et al., 2004, Smith et al., 2007), and ecosystem-centric approaches to aquaculture (Brugère et al., 2018). EBM principles themselves include the need to consider the dynamic nature of marine ecosystems, the importance of adaptive management (Long et al., 2015; 2016), and the effectiveness of aligning top-down and bottom-up controls (Wondolleck and Yaffee 2017). (Although we note that EBM principles differ among management frameworks and stakeholders - e.g., Long et al., 2016). Finally, monitoring and scientific advice were critical in the historic case studies (Lesson 11), and are accepted as being fundamental for EBM and are now codified in marine policy worldwide (Day, 2008, Van Hoey et al., 2010).

Collectively, therefore, our findings are expected given present understanding of social-ecological systems. Despite this, we found only one of our ten Recommendations was comprehensively addressed in both the EU and FAO agendas (EC, 2017a, FAO, 2017) (Table 3): Recommendation B, including and consulting stakeholders early in the process and in ways that empower them as stewards of the marine environment (EC, 2014, United Nations, 1992). Yet, our work indicates even this inclusion may not go far enough. Historical case studies highlighted the diversity of values and needs that different stakeholder groups may have - but neither blue growth agenda explicitly considers this diversity. While the involvement of stakeholders is a necessary feature of fisheries management (e.g., EU, 2002, United Nations, 1992, Reed, 2008, Stephenson et al., 2016), our findings indicate that when the desires of only a subset of stakeholders are considered, short-term ambitions may be prioritized over long-term sustainability, and the perspectives and needs of the weakest stakeholders may be overlooked (Lesson 9). Again, while not addressed in the FAO or EU agendas, this possibility *has* previously been identified (e.g. Cardinale et al., 2017, Cohen et al., 2019). Finally, we determined that these concerns may in fact be exacerbated, by equal – but not equitable - or open access (Lesson 10).

We found our other nine Recommendations were at best only indirectly considered in the EU and FAO blue growth agendas, and several were not taken into account at all (see Table 3 and

SOM 2). Our Recommendations are supported by case studies that span broad geographical, ecological, social, and temporal ranges and are echoed in the wider scientific literature. Our results suggest that there is a considerable misalignment between blue growth agendas, the lessons provided by history and our current understanding of the social-ecological systems they aim to support. Managers and decision-makers interested in blue growth should carefully consider the Recommendations from the historical case studies presented herein and determine how blue growth agendas can be improved based on these lessons from history.

A final important outcome of our work is that not all of the objectives of a blue growth agenda may be achievable simultaneously (Recommendation D). The historic case studies clearly showed an inherent paradox within the concept of blue growth: whereby economic growth is claimed to be compatible with ecological sustainability and social equity. This situation is rarely achieved in the present-day (e.g., Andriamahefazafy et al., 2019; Bogadóttir et al., 2019), and we show that this was also the case in the past. This reality is not addressed in the blue growth agendas considered in this study, but also unlike many of our other findings, it is not conveyed within ecosystem-based approaches and mandates. We therefore contend it is crucial that blue growth agendas accept these realities and distinctly articulate how they aim to address them. For example, well-defined prioritization of aims will be essential for decision-making, and trade-offs among goals and user groups (Brown et al., 2001, Jennings et al., 2016) will be inevitable if blue growth is to be achieved. Moreover, we encourage proponents of blue growth agendas to avoid *assuming* all aims can be achieved simultaneously, and, in particular, to carefully consider whether and how the proposed economic growth is compatible with social and ecological goals.

Placing historical perspectives into present-day contexts

Our historical case studies focused on wild capture fisheries and some aquaculture systems, and these provided broad Recommendations for blue growth agendas, however they were limited in overall scope and reflect only a subset of possible blue growth opportunities (e.g., OECD, 2016, United Nations, 2015, United Nations, 2016). Further valuable insights are certain to arise from historical study in other sectors, e.g. freshwater fisheries, mining and materials, renewable energy generation, and recreation (Carpenter et al., 2009, United Nations, 2005). One of the greatest challenges to blue growth will be managing the interactions among the different industries and sectors (e.g., Klinger et al., 2016), a theme not well covered by the historical case studies, but one that is in critical need of attention (Goodsir et al., 2015, United Nations, 2005, United Nations, 2016). Hence, our Recommendations should not be considered a complete review of historical blue growth, but rather an exemplar of the rich resources available from history.

The agendas that seek to achieve blue growth are relatively new (EC, 2012, FAO, 2017). Thus, while we did not find most of our cross-cutting Lessons and Recommendations adequately represented in either the EU or FAO agendas, they might be under consideration at regional or national levels, or within other emerging agendas. However, where appropriate regional documentation was sourced (e.g., EC, 2013, EC, 2017b), we found that they were not considered in greater depth (Table 3). This study offers an approach for the explicit analysis of historical blue growth, and study within additional regions and cultural contexts will provide further broad lessons from history that may help to achieve blue growth. Such work could provide further insights in other sectors, and address regionally specific cultural factors, customs, stakeholder perspectives and goals. Variations in the achievement of blue growth at different spatial scales, and the likely future challenges and opportunities in specific areas may be elucidated. This should indicate which Recommendations are most applicable in a given locale. We therefore suggest future agendas would benefit from engaging historians and social scientists in assessments of past local marine resource use or that from analogous ocean regions.

As with all information sources, historical resources contain uncertainties. Common concerns include the incompleteness of data, the diversity of data types or sources, or uncertainties and biases that are unfamiliar to marine resource managers and practitioners (e.g., McClenachan et al., 2015). Despite these very real issues, increasing examples from the literature highlight that best practices can be used in overcoming these challenges (e. g., Fortibuoni et al., 2010, MacKenzie and Ojaveer, 2018, McClenachan et al., 2015, Sguotti et al., 2016, Thurstan et al., 2016). Thus, we urge managers to work with researchers that are well-versed in the historical and social sciences, who can aid in understanding historical resources and their interpretation, as opposed to assuming that novel sources render historical data unreliable.

Conclusions

Today's blue growth agendas aim to maintain and expand the benefits we derive from the oceans, and to do so in a balanced, integrated and equitable way. Blue growth principles are closely aligned with ecosystem-based approaches and resilience thinking, and so should help support the achievement of the UN's sustainable development goals. So far, these agendas have sought to develop approaches and achieve outcomes without reference to examples of successful and/or unsuccessful blue growth. We identified 20 historical cases of blue growth, and, from these determined fourteen Lessons and 10 broadly-applicable Recommendations for blue growth agendas. This is the first time, to our knowledge, that questions have been asked about the novelty of blue growth, and whether what is considered to be 'blue growth' today is reflected in people's use of the sea through time. We are aware of no other research on blue growth with the geographical and temporal breadth, or covering a similar range of social-ecological systems, as that explored in the present study. Our findings are supported by the wider literature, showing that they are scientifically sound, however despite this, the Recommendations we propose are poorly addressed in the current agendas. Given that blue growth is emerging as a concept at the forefront of modern ocean management and policy, and because knowledge on the pathways to success and failure are lacking, such advice is urgently needed.

The Lessons and Recommendations cross-cut the case studies disparate in location, time period, and social-ecological system and are supported by the literature, indicating their broad applicability. They indicate that achieving blue growth requires appreciation of differing temporal, spatial, economic, and other scales, and knowledge of the interconnections and feedbacks within the socio-ecological system of concern as well as of extrinsic political, economic and environmental factors. These results can inform viability and risk assessments for blue growth, and can help to build resilience and adaptive capacity. Critical appraisal and prioritization of the aims of blue growth will be essential for decision-making, and trade-offs among goals and user groups will be inevitable if blue growth is to be achieved – but the attainment of all goals simultaneously may not be possible. Collaboration between different sectors and neighbouring regions will greatly improve the chances for success. Decision makers must also be aware that blue growth can be gained and lost, and its maintenance over time once achieved is not guaranteed.

Reflecting, engaging and capturing historical knowledge within our present-day understanding of socioecological systems is a timely step, because we live in a unique moment in human history. We have not previously consumed such a large proportion of the Earth's resources so quickly, but neither have we held so much knowledge about the consequences of our own actions (Krause, 2018). By assimilating past experiences with current knowledge we identified crucial aspects of blue growth that need to be addressed in the agendas. We hope this research will motivate further future exploration of past human engagement with the seas, that may elucidate other lessons for blue growth, and so avoid the collective cultural amnesia that often causes us, as a society, to repeat past mistakes.

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Data Availability Statement

Data sharing is not applicable to this article as no new data were created rather data were acquired from existing published sources (all sources are cited in the text) or are described, figured and tabulated within the manuscript or supplementary information of this article.

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Tables

Table 1. Selected case study overviews with positive and negative outcomes and drivers in relation to blue growth, together with lessons for blue growth agendas today. Blue growth (BG) overarching criteria are (1) achieving growth, (2) maintaining balance, (3) implementing smart solutions and (4) achieving integration. Full case study examples (with references) can be found in SOM1.

	Stock, system, or service	**Period**	**Successes in blue growth context**		**Failures in blue growth context**		**BG Criteria**	**Lessons for Blue Growth**
			Outcomes	**Drivers**	**Outcomes**	**Drivers**		
1	Galway Bay, Ireland: mixed capture fishery	1820–1860s	*Pre-1850s and pre-trawl:* • Community-based management of fishery • Equitable access • Sustainable use of marine resources	• Local democratic control of resource • Desire for social equity and to retain economic control • Desire to maintain resource sustainability • Local stakeholders' traditional ecological knowledge valued by management regime	*Post-1850s and post-trawl:* • Overexploitation of the resource • Decline in social-economic equity due to power imbalance (trawlers in a financial and practical position to force out non-trawling locals)	• Shift from local to national political control • Desire for economic growth and use of new technology • Local stakeholders' traditional ecological knowledge no longer valued by management regime	(1), (2)	• Importance of stakeholder engagement, value of traditional knowledge • Prioritizing one value (economic) over all others can undermine BG success • Without appropriate management controls, technological innovation can lead to overexploitation • Failure to understand and address limits to industry growth has consequences, including system collapse • Benefits to stakeholders may be unequal/incompatible, creating conflict
7	Dugong fisheries in SE Queensland (focus on oil)	1800–1969	• Rapid industrial growth • Successful merging of new technology with traditional practices • Equitable access at times • Dugong fishery contributed positively to key periods of social change	• Transfer of traditional knowledge • Importance of fishery for local needs • Collaboration across resource groups	• Failure to grow industry despite potential global demand • Overexploitation • Inequitable access and decline of stakeholder engagement • Lost cultural services for indigenous peoples (spiritual & cultural value)	• Inability to maintain consistent supply • Adulteration of product with other oils • Failed management and lack of scientific understanding, especially challenging biological characteristics of stock (life history, behaviour) • Technological advances impacted social equity	(1), (2)	• Importance of appropriate management supported by ecological knowledge. • Importance of stakeholder engagement and knowledge. • Importance of multiple drivers beyond economic growth, relevance of extrinsic drivers. • Value of fisheries for social change. • Failure to understand and address the limits to industry growth may cause system collapse
14	Lobster fisheries, West coast of Sweden	1870–	Pre-1890s: • Landings and exports increased without impacting sustainability Modern time: • Shift to sustainable fisheries	• Technological advance and regulation reduced lobster mortality and stabilised populations encouraging growth • Rights assigned to local fishers, limited access	Post-1951: • Expanded access to fishery led to growth in numbers of fishers • Decline in stock size, despite management measures	• Technological advance enabled exploitation beyond biological limits • Lack of restrictions in access and monitoring of recreational sector • Inadequate management	(1), (2)	• Open access is not the same as equitable access, and does not produce the same outcomes. • Monitoring and regulation of all sectors is necessary for sustainability.

Table 2. The fourteen cross-cutting Lessons for blue growth and the historical case studies that contributed to the formation of each lesson. Details of all numbered case studies are listed in ***SOM 1*** (with sources), and example case studies are included in Table 1.

Cross-cutting Lessons for blue growth	Case studies used
1. To determine whether blue growth has occurred, outcomes should be assessed over a range of scales.	1, 3-7, 10, 13, 17
2. The prioritisation of short-term gains can lead to long-term losses in blue growth.	1, 3, 5-9, 10b-c, 13
3. Failure to understand and address limits to industry growth may have ecological, social and economic consequences, including system collapse.	1, 6-7, 9, 10c, 16
4. Marine socioecological systems are dynamic: growth can be unpredictable, nonlinear, and can be attributed to multiple factors.	4, 5, 7, 8, 10a-b, 10e, 16, 17, 18, 20
5. Drivers and events occurring outside the immediate system can critically impact the achievement and maintenance of blue growth.	2-8, 10a-d, 11, 15-17, 18
6. Supporting systems may be important for translating innovation into blue growth.	4, 6, 9, 10b, 17, 19
7. Stakeholders hold diverse perspectives and socioecological knowledge, and this can be leveraged to support blue growth.	1-3, 6-7, 10a, 15-17
8. Environmental stewardship can support blue growth and may be facilitated by cultural and social attributes as well as economic incentives.	1-5, 10a-b, 16, 18
9. The benefits of blue growth may be unequal or incompatible across stakeholder groups, which can create conflict or limit growth if one group's needs are prioritised above others.	1, 7, 9, 11
10. Equitable access does not always correspond with open access nor produce the same outcomes.	1, 3, 7, 14, 20
11. Management based on scientific knowledge and supported by ongoing monitoring may be key for blue growth.	4, 6-7, 11-13, 14-17, 19
12. For blue growth to be maintained, policy and management must be flexible, responsive, and adopt a whole-system view, including across multiple jurisdictions when required.	3, 7-9, 10a, 12, 19
13. Regulations (whether top-down or bottom-up) can facilitate and maintain blue growth, but adequate enforcement and community buy-in can be critical.	1-4, 10a, 13-15
14. Growth, ecological sustainability and social equity may not be achieved simultaneously meaning trade-offs may be necessary.	1, 8, 9, 10b-d, 12

Table 3. Ten Recommendations for future blue growth derived from the cross-cutting Lessons and their representation within FAO and EC blue growth agendas (EC, 2012, EC, 2014, EC, 2017a, EC, 2018, FAO, 2017). For full discussion of the Recommendations see SOM 3.

Recommendations	Lessons	In EC documents?	In FAO documents?
When planning for future blue growth…			
A. Define the temporal and spatial scales across which blue growth will be measured.	**1-3, 4, 9**	**Somewhat:** Spatial boundaries delineated e.g., the Baltic Sea region; maritime spatial plan implies spatial scales will be defined.	**Not mentioned:** Recognises the need to work across global and national scales, but does not mention the importance of scales to blue growth measurement.
B. Identify and engage stakeholders in the decision-making process as early as possible.	**7, 8, 13**	**Yes**: Regional blue growth strategies e.g., the EU strategy for the Adriatic and Ionian regions, have involved key stakeholders from the early stages of development, while consultation with stakeholders is a core principle of the EU's blue growth policy.	**Yes:** Objectives include creating conditions that enable and empower resource user groups, where they are also stewards.
C. Aim to align technological advancement and economic growth with other system attributes (e.g., social and culture values, community supported regulations).	**2, 3, 6, 8, 13**	**Somewhat**: Some regional strategies highlight the importance of fostering regional cultural heritage and resilient coastal communities e.g., the Adriatic and Ionian region. Small-scale fisheries development is prioritized in some regional initiatives.	**Somewhat:** Suggests blue growth should be a catalyst for innovation and investment that supports food security. Promotes efficient seafood value chains, as well as empowering communities and improving their resilience to crises.
D. Be aware that not all blue growth criteria may be achievable simultaneously; have a plan for deciding trade-offs	**9, 14**	**Somewhat:** A consensus that multiple factors affect growth that will need to be dealt with in various ways, both within and across industries. But little about how trade-offs will be addressed or priorities determined.	**Not mentioned:** Individual countries identify priority blue growth areas that they wish to strengthen, but no further detail is provided.
In enacting management to support blue growth…			
E. Focus on facilitating equitable access, but recognise the potential for actions to impact user groups in different ways and mitigate appropriately.	**7, 9, 10, 14**	**Somewhat:** The EU Cohesion Fund aims to reduce economic and social disparities, European Social Fund aims to promote job creation, and other funds will focus upon outer or lower-income regions; however, it is unclear how differing needs of user groups will be addressed (including greater/lesser ability of some to access opportunities).	**Yes:** Noted that blue growth should be a catalyst for poverty alleviation, improve livelihoods and food security.

F. Adopt a holistic view of the system based on the best available science, specifically include people.	**1-5, 7-8, 12**	**Somewhat:** A holistic approach is championed via the Integrated Maritime Policy, but implementation of holistic management is rarely explicitly mentioned in reference to blue growth.	**Somewhat:** Blue growth implementation incorporates the 3 pillars of sustainable development: social, environmental and economic, yet the integration of these pillars into a holistic view is less well developed.
G. Enact regulations that are enforceable, appropriately resourced, and align top-down and bottom-up controls.	**6-9, 13**	**Somewhat:** Awareness that enforcement and resourcing adequacy are not presently aligned across member states, but actions to overcome this are not mentioned. Awareness that investment in top-down regulation and bottom-up initiatives are of value, but little on the potential to align the two.	**Somewhat:** Promotes sustainable growth, implementation of code of conduct for responsible fisheries and 'related instruments to restore stocks', and combat IUU. Dependents should be empowered and approaches to promote growth should be incentivized.
H. Enact management that can respond and adapt to changing socioecological conditions.	**4-5, 11-12**	**Somewhat:** Maritime spatial plans aim to adapt to changing conditions, aided by ongoing monitoring.	**Somewhat:** Suggests blue growth should be a catalyst for policy development and sustainable management; promotes ecosystem service regulation and restoration.
After blue growth agendas are ratified…			
I. Ensure short-term gains do not undermine longer-term growth.	**2, 3**	**Somewhat:** Aim to ensure resources can be enjoyed by future generations, but trade-offs between short and long-term gains are not mentioned.	**Somewhat:** Promotes responsible growth. Notes that when individual interests were pursued previously, these can exclude social benefits.
J. Ensure continuous monitoring of the system as well as extrinsic events and drivers, and that data are accessible and used to inform and ensure continued blue growth.	**4, 5, 11, 12**	**Somewhat:** Efforts are being made to make marine data resources freely available and to develop and maintain databases, e.g., EMODnet, but how extensive and well-resourced monitoring will be ensured across member states is unclear. In addition, the EU Commission has sought cooperation with non-EU countries that share common sea basins, the impacts of extrinsic events is not mentioned.	**Not mentioned:** Acknowledges blue growth approach must be flexible and foster co-operation between countries, but doesn't consider monitoring or drivers.

Figures legends

Figure 1. Schematic of the approach used to identify case studies from the historical literature, and derive cross-cutting Lessons and Recommendations using the EU and FAO blue growth agendas as a framework (FAO, 2017, EC, 2012, EC, 2018, EC, 2017a, EC, 2014). The full list of cross-cutting Lessons and Recommendations are provided in Tables 2 and 3, respectively.

Figure 2. Locations of the 20 historical case studies (a), and the time period that each case study spanned (b), together with key showing whether the case study refers to single species or mixed species wild capture fishery, or aquaculture.

Figure 3. Common trajectories of blue growth (left). Blue growth relies upon a balance (right) between economic growth, social equity and ecological sustainability. If one is prioritized at the expense of the other factors (indicated by the width of the arrows on the right) blue growth may accelerate or be impeded. (a) Unbalanced growth: economic investment drives rapid blue growth initially, but at the cost of social equity and ecological sustainability, which eventually forces the rate of growth to slow or even contract (case studies 1, 3, 7, 8 and 13). (b) Delayed unbalanced growth: economic investment occurs at the expense of social equity and ecological sustainability, declines in growth are delayed due to innovation, but eventually contraction occurs (case studies 5, 6, 9, 18 and 20). (c) Recovery of growth: blue growth occurs then contracts or declines (inset box indicates trajectory in (a)), but due to improvements in ecological sustainability and social equity, growth can recommence. However, in some cases recovery can only occur if ecological sustainability is prioritized, at least in the early stages (case studies 4, 10, 11, 12, 14 and 16). (d) Balanced growth: blue growth occurs by balancing economic growth, social equity and ecological sustainability. Growth may be slower compared to (a)–(c) (case studies 2, 15 and 17 and 19).

Figure 4. Timeline and diagrammatic summary of the events, outcomes (aquaculture and fisheries production), drivers and trajectories of blue growth in the Lagoon of Venice, Italy (case study 3), and the lessons for blue growth (grey speech bubbles) derived from this case study. Includes depictions of historic and traditional artisanal fishing boats and gear (from Pellizzato et al., 2011, Provincia di Venezia 1985, Silvestri et al., 2006). Data from: Libralato

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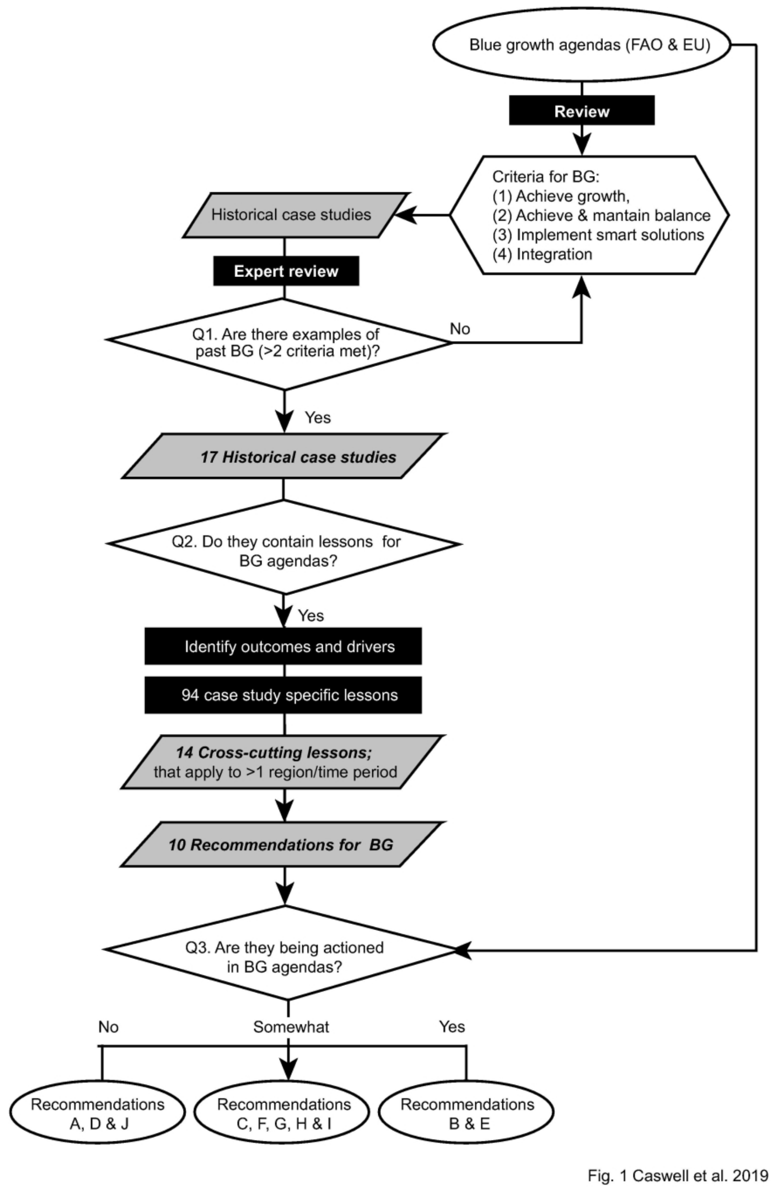

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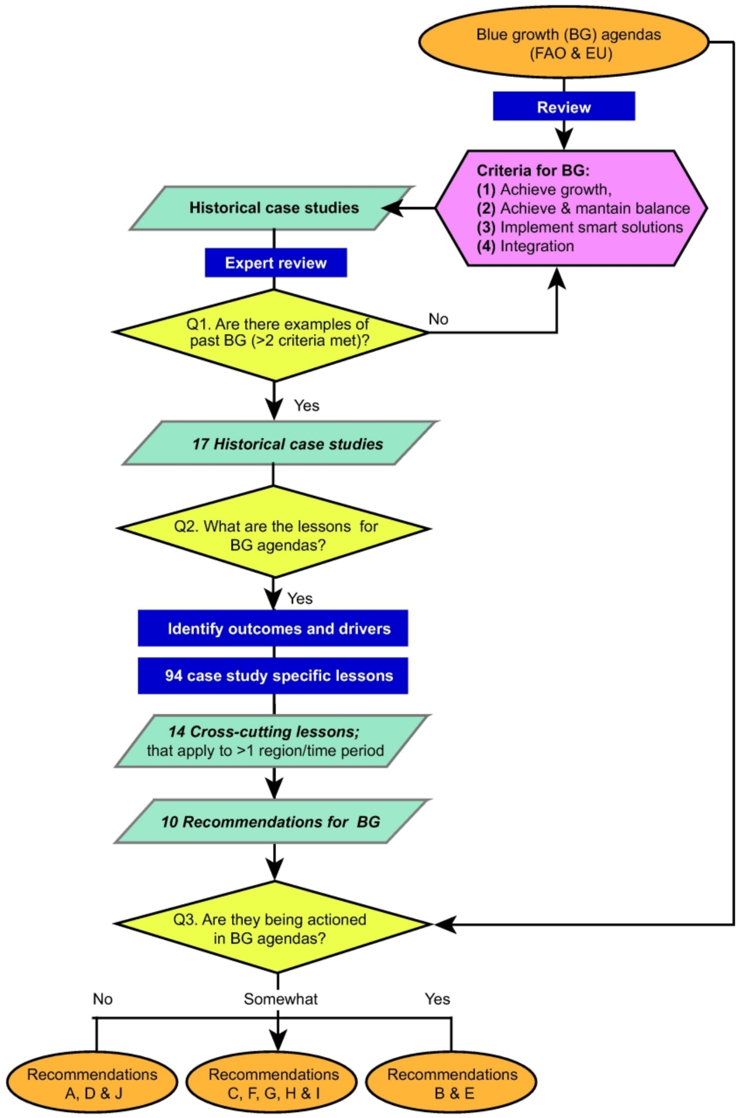

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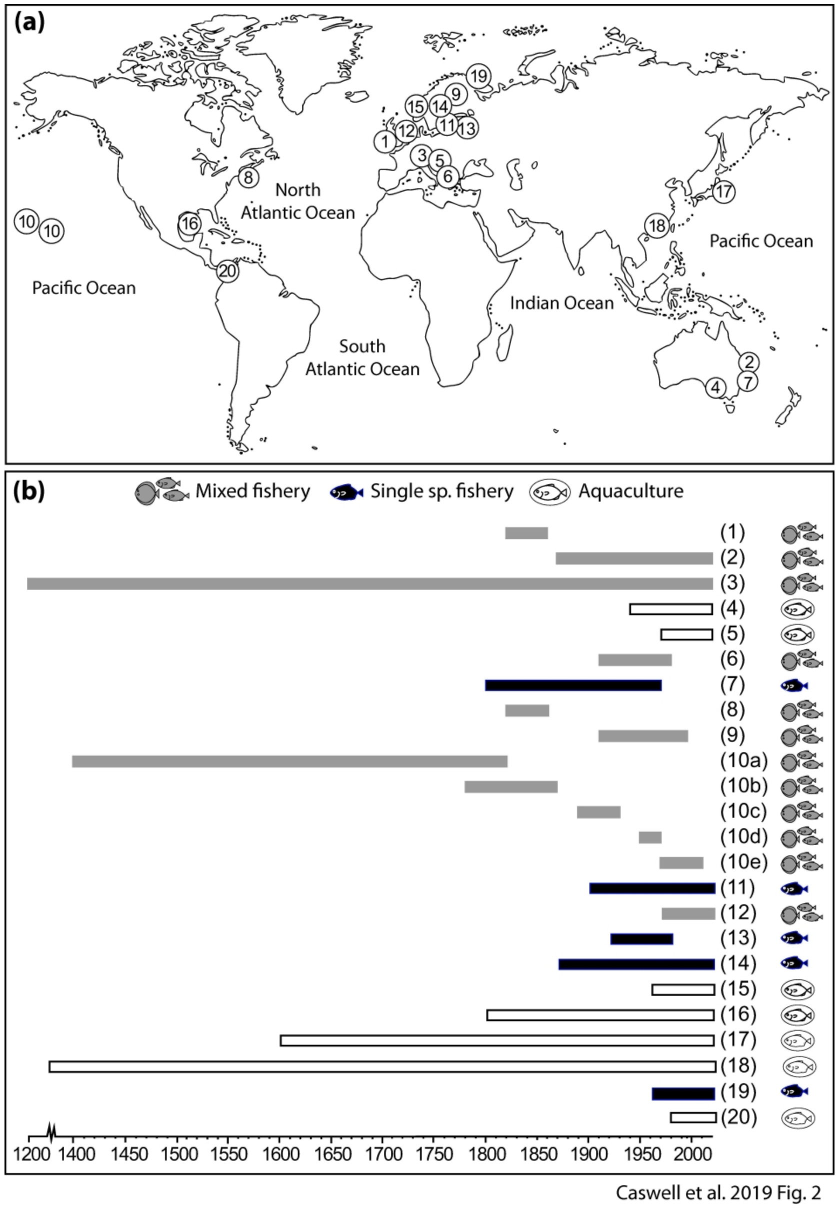

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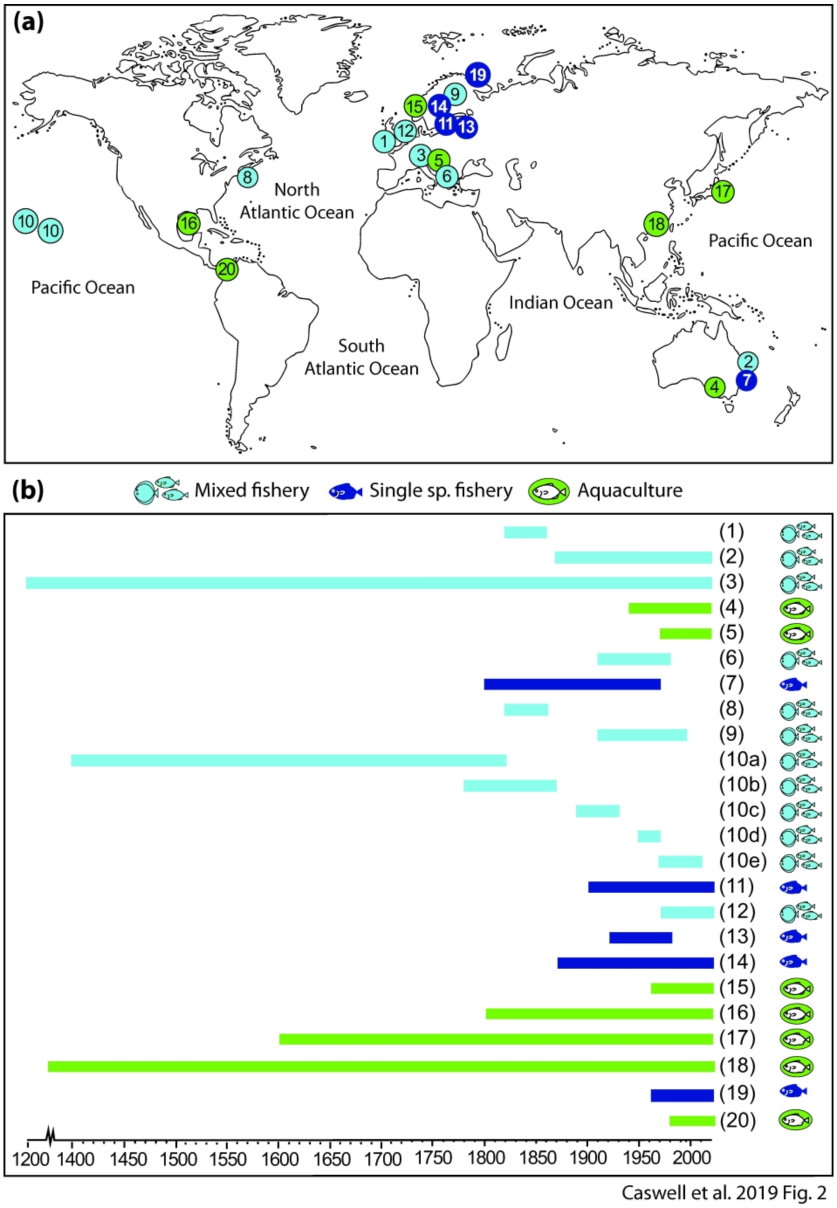

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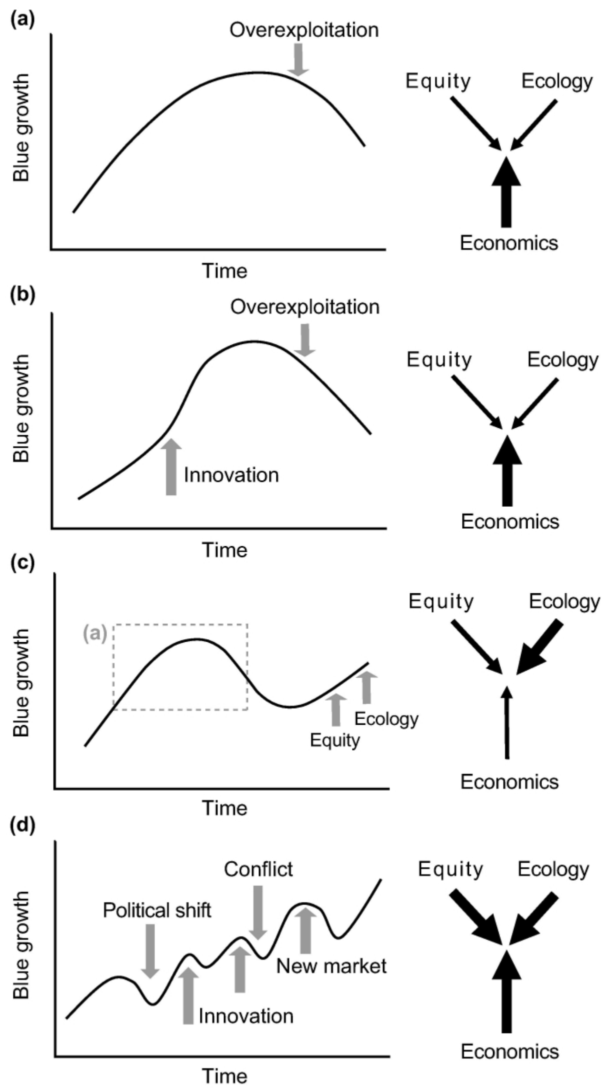

Caswell et al. 2019 Fig. 3

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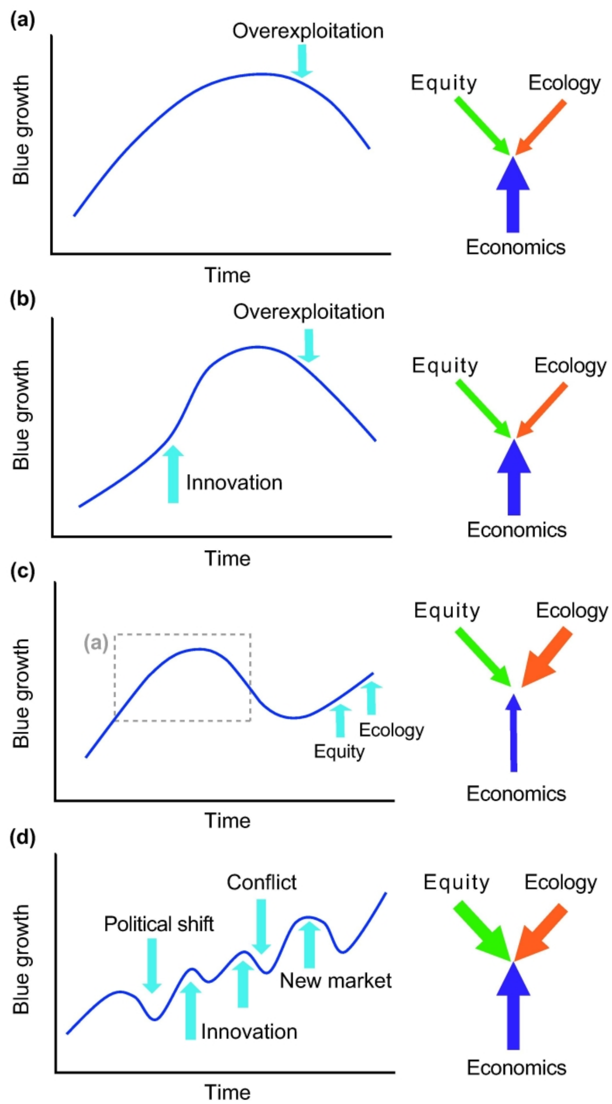

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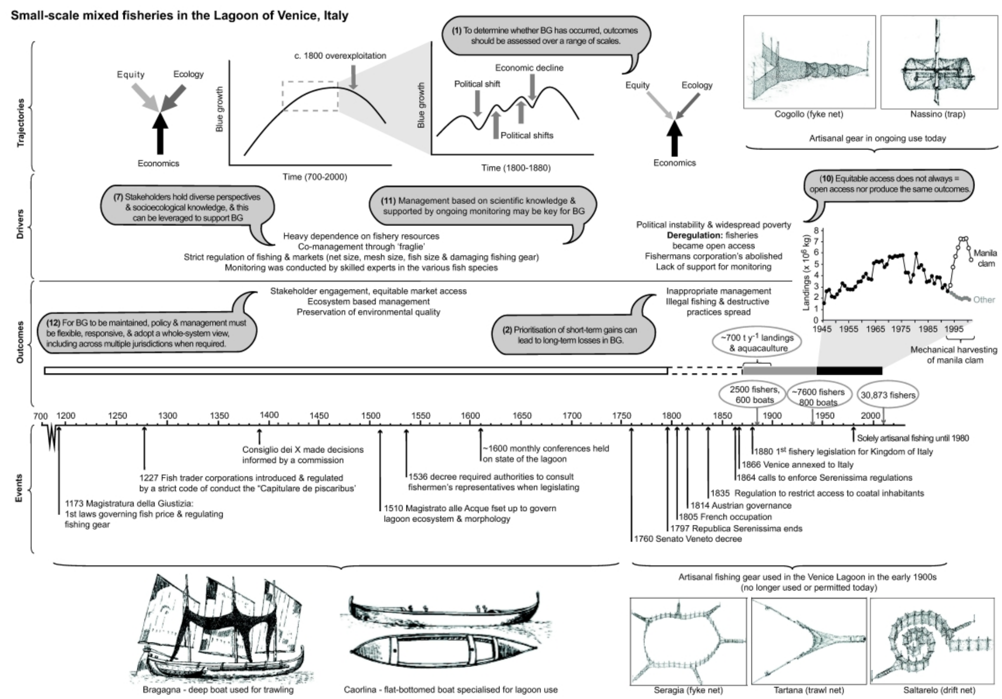

Caswell et al. 2019 Fig. 4

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