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The many sizes and characters of the Blue Economy

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Abstract

This article analyses the economic size and resilience of five established definitions of the Blue Economy across two geographical locations: Scotland (UK) and Michigan (USA). The article analyses sector-level employment, labor productivity and Gross Value Added (GVA) data, and uses graphical representations to highlight the differences in conceptualizing the Blue Economy in ways that affect its weight and contribution to regional economies. Further, it analyses how each definition has fared in the post-2007/2011 crisis, assessing their resilience. This novel work tackles the emerging discourse around the Blue Economy by highlighting its regional character, and by problematizing the divergent definitions of the concept.

Keywords (six): Blue Economy; Regional analysis; employment; wages.

1. Introduction: from Blue Economy to the case for a Blue Economy

The "Blue Economy", and its associated dynamic economic paradigm, "Blue Growth", have emerged from an increasing awareness of the role of the oceans in national economies, alongside the need to protect the oceans (Silver et al., 2015; Winder and Le Heron, 2017; Golden et al., 2017; Garland et al., 2019). These closely linked concepts have been built on the principles of social justice and environmental sustainability, aiming to achieve the same outcomes as those desired in the Rio +20 Green Economy (UNCSD, 2012). As an emerging regional development concept, the Blue Economy is still conceptualized and operationalized heterogeneously, with variations not just between countries but within regions (Silver et al., 2015; Choi, 2017). Indeed, there is a rich body of literature attempting to define which industries comprise the Blue Economy. Scholars and policymakers alike have developed multiple ways to operationalize the Blue Economy, each time expanding or restricting the list of industries considered as 'Blue' (Garland et al., 2019). These differences are common among recent development paradigms conjugating social, economic, and ecological sustainability. For example, in the case of the Green Economy, understanding what defined "green jobs" and their geographies has recently become pivotal for identifying the effects of recovery policies in the aftermath of the 2009-2011 recession (Vona et al., 2019) and, more generally, to understand the labor-market consequences of major multi-sectoral transitions (Popp et al., 2020; Lee and van der Heijden, 2020). Since 2009, and more recently during the COVID-19 pandemic and the discourse around the U.S. 'Green New Deal', the capacity of governments to create or destroy employment and wealth via economic and environmental regulations has regained centrality across social sciences. While it

is not uncommon for Blue Economy policies and their underlying discourses to also drive investments in the marine space (Doloreaux, 2017; Alexander and Graziano, 2018), these landscapes are particularly adept at hosting a combination of unexploited resources and competing spaces. In the case of the BE, different actors are co-opting the term Blue Economy (and Blue Growth) in often conflicting ways leading to a divergence in opinions over the legitimacy of individual sectors of the Blue Economy, such as carbon intensive industries like oil and gas (Voyer et al., 2018). Moreover, in defining the boundaries of the Blue Economy, policymakers will subsequently route funding, promote certain industries and embed disruptive relationships which may harm the ability to achieve the sustainabilities upon which the Blue Economy is built (Graziano et al., 2019).

As Blue Economy policies and critical frameworks emerge globally, understanding how to identify underlying industries of the Blue Economy means there is a need to identify the scales, policies, actors, stakeholders, socioecological interactions affected by the Blue Economy itself. Looking at the course charted by Bennett et al. (2019), the importance of understanding the nature and composition of the Blue Economy emerges quite clearly. Their call for inclusive governance requires an understanding of both industry-by-industry characteristics and a holistic capture of inter-industry and industries-to-society interactions. The authors' call for the UN to "*… establish or designate a commission or agency within the Economic and Social Council system to be responsible for developing best practices and establishing international guidelines for the implementation, monitoring and management of blue economy activities*" (Bennett et al., 2019, p. 992) immediately highlights the need to identify best practices to be replicated globally. However, these best practices need to incorporate local (however defined) specificities in relation to both national and internationalized sectors. Additionally, when dealing with national

legislative and institutional gaps, governments do not act in a vacuum. Rather, public institutions begin or end the regulation of specific sectors, and/or focus on prioritizing specific sectors (e.g., renewable energy) based on national or regional objectives (Graziano et., 2019). Bennett et al. (2019) also focus on the respect of local populations. This element may have an easier conceptualization in coastal regions where aboriginal populations face discrimination. However, in several developed nations the composition of 'local communities/populations' are the result of exclusionary policies and/or wide socioeconomic inequalities (see e.g., Rothewell and Massey, 2009; Phoenix et al., 2020), while benefits for developing specific industries part of the Blue Economy may be distributed to the society at large (see e.g., Firestone et al. 2012; Flannery et al., 2016). Finally, the call for interdisciplinarity and inclusiveness in governance requires an understanding of the scales involved in a nation's Blue Economy. For example, regions or nations developing sustainable coastal tourism whose offer relies on international travelers will invest, govern, and rely on a value chain whose scales are globalized (Brandão, et al., 2019), and, at the same time, can evolve in local opportunities or conflicts (Almeida et al., 2018; Hjalger, 2020). Simply put, if we do not understand what it means to use the myriad definitions of the Blue Economy, we cannot identify which version of a sustainable Blue Economy we desire, nor measure the extent, weigh the importance, or investigate the drivers of the Blue Economy.

To fill this gap, we measure the size of the Blue Economy from two coastal regions, Scotland (UK) and Michigan (USA), using five definitions from five different national and international institutions, across three major indicators, and investigate how salaries across these definitions have fared in the decade following the Great Recession of 2007-2009. In using this regional approach, we highlight the contradiction and sectoral differences among these definitions, and conclude by identifying how economic geography, regional sciences, and marine

social science methods and concepts can help in operationalizing and measuring a Blue Economy capable of fulfilling its promises.

The use of two regions allows us to compare how local measures of the scale of the Blue Economy would change if transferred elsewhere and explore emerging sources of conflict. By describing and contrasting the effects of these definitions in two coastal regions, we also aim to highlight the perils and shortcomings of the current absence of recognized guidelines and hard understandings for determining the composition of the Blue Economy. As our results suggest, different formulations lead to dramatically different sizes and qualitative compositions of the Blue Economy. U.S.-based and Scotland-based formulations leading to are relatively small compared to the rest of the economy, and they include mostly low-wage/low-productivity industries. In addition, issues emerge in terms of competing water uses, both in terms of space and quality of the resource (see e.g., Voyer, et al., 2018; Alexander, 2019; Lee et al., 2020). For example, energy uses are often seen as encroaching fishing and aquaculture rights (Alexander, 2019). These issues lead us to formulate a proposal for understanding the Blue Economy from a new perspective: that of an economic paradigm built upon values shared globally, and implemented following dynamic regional approaches. That is, a Blue Economy built upon its objectives, and implemented within new, dynamic regions, identified around both economic and ecological linkages, capable of fulfilling the promises of economic, social, and ecological sustainability.

The remainder of the paper is organized as it follows: in Section 2 we describe and motivate the definitions used in this analysis, and provide context for Michigan and Scotland; in Section 3 we analyze overlaps among definitions, and introduce the data used; in Section 4 we present our results. In Section 5 we discuss the consequences of differing extents of the Blue

Economy and of their resilience, including issues for researchers and policymakers arising from the multiple definitions used. Finally, in Section 6 we provide policy implications and present an agenda to further research in Economic Geography for overcoming the issues we identified.

2. Selecting definitions of the Blue Economy.

Currently, the Blue Economy (BE) does not have one recognized, operational definition, nor one where industries or economic sectors are listed as 'blue' (Graziano et al., 2019). Nevertheless, several agencies, governments, whether national or local, and international organizations have identified specific industries in their own definitions (Garland et al., 2019). In this work, we focused on operational (rather than academic) definitions of the BE, as these typically facilitate policies (or potential investment) to drive growth within the BE. Based on the work of Garland et al. (2019) (Table 1), we included both policy-based and geographically relevant definitions, developed by regional or national agencies, including the National Ocean and Atmospheric Administration (NOAA) for the United States (using NOAA, 2018 and Colgan, 2007), and the Scottish Government (Marine Scotland, 2020). Additionally, we included the definitions of BE used by transnational organizations that influence policy and operations in North America and Europe, including the World Bank (World Bank, 2016; 2017), the Organisation for Economic Cooperation and Development (OECD, 2016), and the European Union, using the expanded definition of Ketels and Protsiv (2016), which expands upon the original definition of 2012 (EU, 2012).

Additional operational definitions were considered from other regions of the world, including the World Wildlife Federation (WWF) - which does not include specific sector identification - and the Australian Government's Blue Economy Cooperative Research Centre, which adopted the UN definition. As a result, both were omitted from our own analyses. Several

of these definitions failed to include specific industrial codes to link directly to either UK Standard Industrial Classification (SIC, for Scotland) or North American Industrial Classification System codes (NAICS,[1] for Michigan). However, they had groups of industries, which have been matched with NAICS and SICs, as detailed in the following sections.

STUDY	SECTORAL APPROACH	SCALE/REGION
Ketels and Protsiv (2017)	"Blue Growth" is defined as development and use of the potential of oceans, seas, and related infrastructures; any inland freshwater sources and their exploitation. "Blue Growth industries" include all sectors and industries related to maritime environment and freshwater sources.	European Union
NOAA (2018)	Ocean economy includes six sectors: (1) living resources; (2) marine construction; (3) marine transportation; (4) offshore mineral extraction; (5) ship and boat building; (6) tourism and recreation.	USA
OECD (2016)	Ocean economy encompasses ocean-based industries (e.g. shipping, fishing, offshore wind, marine biotechnology), but also natural assets and ecosystem services that the ocean provides.	Global with Small Developing Island Nations focus.
World Bank (2016; 2017)	BE consists of sectors whose returns are linked to the living "renewable" resources of the oceans (such as fisheries) as well as those related to non-living and therefore "non-renewable" resources (including extractive industries, such as dredging, seabed mining, and offshore oil and gas, when undertaken in a manner that does not cause irreversible damage to the ecosystem). It also includes activities relating to commerce and trade in and around the oceans, ocean monitoring and surveillance, and coastal and marine area management, protection, and restoration.	Global with Small Developing Island Nations focus.
European Union (2012)	All economic activities that depend on the sea. Identification of 'Blue Economy' and 'Blue Growth' industries.	European Union
Scottish Government (2020)	The marine economy is defined as economic activity linked to the oceans, seas, bays, estuaries and other major water bodies, and the ecological and physical systems associated with them.	Scotland
Colgan (2007)	Ocean economy is defined as all economic activities that derives all or part of it inputs from the ocean or Great Lakes. CE is defined as all economic activity in the near shore region, coastal zone counties, and coastal watershed.	USA

Table 1. Summary of definitions and their selected sectors. Adapted from Garland et al. (2020).

[1] North American Industry Classification System.

2.1 Regional Overviews.

In operationalizing the BE, Scotland and Michigan are at two very different stages. Scotland has long-recognized the economic potential of its water resources, while simultaneously preserving the ecological integrity of both its fresh and marine waters. Its iconic industries of fish farming, whisky and golf all rely to a greater or lesser extent upon its natural environment, however Scottish industry has also been linked to its position as a coastal nation. Glasgow developed as the "second city of the British Empire" through the 19th century, leading the world in shipbuilding production from its connected and skilled labor and firms along the River Clyde. The demise of shipbuilding through the 20th century was followed in the latter half of the 1960s with the discovery of oil and gas reserves in the North Sea, which turned Aberdeen into the energy capital of Europe. The development of the Hydro Nation Programme in 2012 as part of the Water Resources (Scotland) Act 2013 (The Scottish Government, 2012) sought to maximise "…the development of the value of Scotland's water resources.". Since implementation, the Hydro Nations programme has expanded, undertaking substantial research into the ways in which water is used within Scotland and providing funding annually for developing the next generation of researchers working on water problems facing society. Since 2008, the Scottish Government's 'Marine Economy' has been quantified (Scottish Government, 2019) however the definition fails to consider the widespread use and value associated with water resources more generally, including the Scotch Whisky sector where freshwater supply is a prerequisite to production. While marine activities are critical to the Scottish economy (especially around oil and gas extraction, fisheries, tourism), many of the policies in place for Scotland's water environment consider both fresh and marine water environments. For example, the European Union Water Framework directive (European Union, 2001) ensures good quality freshwater environments by setting standards of

contaminant levels in all rivers, lakes and coastal waters. This addresses many legacy challenges surrounding Scotland's freshwater environment whereby diffuse agricultural pollution historically contributed to high concentrations of in-stream nutrients, limiting the potential use across all other sectors.

Management of marine resources around Scotland remains a topical issue, with multiple state actors and policy interacting around access, ownership and regulation. The European Union currently (pre-Brexit) has control over landing quotas and resulting revenues of fisheries operating around Scottish coastal waters, while the UK Government manages the operations around extractive industries on the UK Continental Shelf and the flow of oil and gas for the UK as a whole. Scotland's seas extend from 3 nautical miles off the coast up to 200 nautical miles for permissible fish capture, covering a total marine area of 420,863 km2 (The Scottish Government, 2011). The Marine Scotland Act 2010 was introduced to aid in the implementation of the European Union Marine Strategy Framework Directive, designed to ensure good environmental indicators around biodiversity, seawater chemistry, and waste management strategies. A further governance factor is the MARPOL convention from the United Nations, responsible for ensuring minimal pollution from marine vessels and the discharge of any plastics into the sea (International Maritime Organisation, 2020). These multitude of governance agencies have presented challenges to accelerating development of BE sectors within Scotland, though an increasing policy focus and a transition toward offshore renewable energy (particularly offshore wind) have stimulated new areas of economic growth within Scotland's marine environment.

In contrast to Scotland, Michigan has only recently showed interest in mobilizing the potential of its waterscape. This recognition has materialized primarily through restoring and preserving the ecological capital of the Great Lakes, which has been deeply affected by centuries

of industrial and agricultural pollution (Burton et al., 2010). Starting in 2011, Michigan has benefited from the broader Great Lakes Restoration Initiative (GLRI), the largest federal ecological restoration effort currently ongoing in the USA (Ehrlich et al., 2017). The program has created renovated interest in the state for building upon the ecological capital of the Great Lakes (Austin and Steinman, 2015; Graziano et al., 2019). In spite of some policy proposals and initiatives led primarily by supranational (USA and Canada) organisms like the Great Lakes Commission (GLC), the state has not developed a comprehensive BE plan under any definitions, and most initiatives (whether funded through GLRI or other programs) have been left primarily to sub-state governments (e.g. counties). However, conflicts over existing oil and gas, water infrastructure (Masten et al., 2016; Melstrom et al., 2019), and continuous issues of poverty and economic depression in the most rural areas[2] of the state and its prominent inner-city regions (Sugrue, 2005; Butler et al., 2016), contribute to maintain an active interest in regional development, including Blue Economy activities (Graziano et al., 2019). Michigan, and more broadly, the Laurentian Great Lakes of North America (GLR), are an extremely interesting case of comparison for economic geographers and marine social scientists trying to understand the components of the BE. Firstly, the GLR surrounding Michigan contain fresh water: its uses are, therefore, very different from sea water, with implications for planning and competition affecting human consumption both directly (e.g. drinking water) and indirectly (e.g. agriculture). In addition, and differently from many of the regions in the more BE-developed North Atlantic, Michigan's relation with this waterscape had moved away from fishing already by the 1890s, while tourism has not played a major role until recently, and only for selected counties. Thus, the 'good jobs' have been often associated with manufacturing and, to a lesser extent, mining (see e.g.

[2] See https://eig.org/dci/interactive-map?path=state/MI.

Alanen, 2007 and Sutherland, 2015). Like overfishing in several regional seas, these activities also have negatively impacted water resources, primarily depleting the quality of water in several areas (see e.g. Sweeney, 1993; Tremblay and Gilman, 1995; Feldman and Heasly, 2007; Allan et al., 2012; Friedman et al., 2015).

Finally, the nature of several industries recorded by NAICS in Michigan differ from what we may expect to find in marine coastal areas (see Sections 4 and 5): for example, the Oil & Gas sector is dominated by transporting (primarily via pipeline, see Graziano et al., 2017) and refining oil and gas products rather than extracting these resources as in the case of Scotland or Norway (Graziano et al., 2019).

From an organizational perspective, Michigan has authority over its waters up to 6 miles from the coast, and treaties are in place between the state and neighbouring states, Canadian provinces, and indigenous tribes. In this sense, the jurisdictional limitations and challenges faced for operationalizing the BE are similar between the state and Scotland, an aspect making the comparison more relevant.

In terms of maritime activities, Scotland and Michigan are not completely different: both have hosted shipbuilding in the past, although in Michigan shipyards were distributed across the Lower Peninsula rather concentrated in within the largest settlement (in Glasgow and along the River Clyde, in the case of Scotland). In addition, both regions suffer from spatial inequality, where the majority of economic activities are located across the southern strip connecting the major urban areas (from East-to-West: Detroit, Lansing, Grand Rapids in Michigan and the "Central Belt" between Edinburgh and Glasgow in Scotland).

Comparing two regions where the BE, as a unified regional economic strategy, is at very different stages, and whose waterscapes differ in nature (salt vs. fresh water) and historic past

(manufacturing vs. fishing and shipping) is an interesting exercise for highlighting shortcomings with existing operational definitions of BE, and, thus, to propose ways in which measurements and analysis can be improved and generalized, still maintaining the underlying drivers of sustainability and justice first expressed in the concept of BE.

2.2 Data Sources and sectoral identification.

With the exception of NOAA, none of the other policy-driven definitions of the BE had specific broken-down sectors. Additionally, on reviewing five policy-oriented definitions of the BE, we found substantial differences regarding the maritime clusters (subsets of marine and maritime industries, see Doloreux, 2017) incorporated into each definition. Consequently, for each region we had to link each definition to a set of measurable industries. To do so, we decided to use local (i.e. UK-based and US-based) industrial classification methods, respectively the United Kingdom Standard Industrial Classification of Economic Activities (henceforth SIC) and the North American Industrial Classification System (NAICS).

2.1.1 Scotland's B.E.

We acquired employment data for Scotland from the Business Register and Employment Survey (BRES) database, hosted by the Office of National Statistics, for 2017 (the most recently available publication). The data is broken down into 739 sub-sectors (at the level of 5-digit SIC) of the Scottish economy, providing estimates of employees (both full- and part-time) and total employment (including working owners and self-employed workers registered for VAT and PAYE liabilities) in each of these industrial classifications. Using the corresponding sectors identified in the selected definitions, total employment figures were extracted and mapped to the each of the respective BE industries and aggregated for each of the alternative BE definitions. Simultaneously,

we retrieved Gross Value Added (GVA) data from the Scottish Government for 2017. These data are aggregated, necessitating an estimate of GVA for each of the sectors identified from the definitions. In order to do this, we adopt a proportional approach using each sectors contribution to employment at the higher level of aggregation. The proportion of employment for a given sub-sector relative to the total employment within that sector was used to disaggregate the GVA from the 10 clusters. This method is widely used to proxy sub-national economic activity given the lack of information on GVA below national levels. This enabled each sub-sector to have mapped value of employment and estimated GVA. Taking each of the definitions outlined in the previous sections, a full table was constructed representing the number of sectors, respective employment figures and GVA estimates.

While we were able to collate employment, GVA and number of sectors for each definition, difficulties arose in attempting to replicate regional definitions based on geographical thresholds. Interestingly, one element of the Scottish Government definition is Marine Tourism, yet this is determined by applying a spatial threshold to identify economic activity in specific (tourism) industries occurring within a 100m radius of the coast. It wasn't possible to recreate this approach using 5-digit SIC codes for both cases, as data at that level would have led to the identification of individual companies and was not accessible to the authors.

For Scotland, the median gross weekly wages were obtained from Annual Survey of Hours and Earning (ASHE) database (Office for National Statistics, 2020), which publishes at a 2-digit SIC level. We took the median gross weekly wage per employee at the higher (two-digit) level and applied this to the number of employees identified in each 5 digits SIC under each of the 2-digit categories. We used median pay for employment in Scottish 2-digit SICs unless there were gaps in the data – in which either averages on each side of an industry/year gap were used – or UK

2 digit SIC figures. Using 2-digit figures rather than for the 5-digit level, we unfortunately lose variation in wages within industries categorised under the same 2-digit SIC category. We calculated the average wages using employment shares across each of the relevant two-digit categories, and created a time series of median gross weekly wages in 2018 prices for each of the five definitions of the BE for Scotland.

2.2.2 Michigan B.E.

For Michigan, we used cluster data based on the 'Harvard Clusters' within the Economic Modelling database EMIS (version 2017.3). These clusters are defined according to the methodology of Harvard Business School's U.S. Cluster Mapping Project (http://www.clustermapping.us/) and Delgado et al. (2014), and they group together 6-digit NAICS codes based on value chain analysis. From the EMSI dataset, we chose to focus on Gross Regional Product (GRP, calculated as Gross Value Added for each cluster), and employment for the year 2016. GRP and employment were extracted by cluster, and then used to derive labor productivity. This is calculated following recommendations by Shreyer and Pilat (2001) as:

$$GRP \text{ in } \$, i / Employment, i \qquad (1)$$

Where i indicates the cluster. We matched each of the definitions outlined above with the clusters within our database: to do so, we used keywords to match those definitions that had few specific indicators in terms of industrial sectors (see Appendix A1 and A2).

When matching clusters with the sectors indicated by each definition, we were careful not to double count clusters, and considered the cluster where the sector was represented only once. The matching process was conducted analyzing each definition and the content of each cluster: in the end, the impacts reported here can be interpreted as 'at most' scenarios (similarly, albeit for a different reason, in relation to the definition used by the Scottish Government). What we mean by

this is that we included clusters with relevant industries carrying the entire cluster, rather than only parts of it, because linkages could not be disentangled. The sensitivity of this approach is, in part, carried in our result because, as discussed in the following section, the definitions under analysis have some overlapping activities, and yet they differ dramatically.

For those cases where more than one cluster matched a World Bank sector, we counted it only once. The use of clusters rather than stand-alone NAICS codes allows us to include related industries, and it simultaneously fulfils three roles. Firstly, the concept of the clusters used in this work is still strongly based upon geographical-industrial connectedness, which relate to the "*array of linked industries and other entities important to competition*" (Porter, 1998), closer to Porter's later works related to territorial clustering (Belussi, 2006). Secondly, clusters are widely used as an applied methodology for capturing physical concentration and inter-industrial linkages in regional analysis rather than a managerial analysis of the socioeconomic relations among firms and institutions, very much like the approach used by, among others, Kelton et al. (2008). Finally, the stricter concept of 'maritime/marine/ocean clusters' has been consistently used to analyze coastal and water-based economic activities from a systemic perspective (see e.g. Koliousis et al., 2017; Shi et al., 2020; Li and Luo, 2020), sometimes within an explicit connection to the Blue Economy (Doloreaux et al. 2016; Doloreux, 2017).Therefore, using 'clusters' allows us to compound industry and geographical relatedness, while avoiding to double-count contributions from/to industries within the region of analysis.

In the case of Scotland, we were not able to restrict the geographic extent of the Scottish-based definition (all tourism businesses within 100m distance from the coast). Similarly, the NOAA definition is a higher-bound estimate because data were collected for the state without discriminating between water/near-water counties. It should be noted though that in Michigan the

latter would account to only a minority of counties in the central Lower Peninsula. Finally, this 'near/on the water' approach was not applied to Scotland because of the jurisdictional mismatch between sub-state/country subdivisions between the two regions and the presence of rivers separating lower administrative units in it.

For Michigan, the annual median monthly earning and yearly average employment for 2007-2018 were instead extracted from the U.S. Census Longitudinal Employer-Household Dynamics (LEHD) Quarterly Workforce Indicators (1990-2018) (U.S. Census Bureau, 2020). Because these data can only be extracted at best at 4-digit NAICS, we matched each 6-digit NAICS within each cluster defined as 'Blue' with the equivalent 4-digit NAICS code, and then calculated averages within each cluster using the number of employees as a weight to account for each NAICS 4-digit and cluster overall size. Finally, we created a composite of median monthly earnings for each definition expressed on 2015 U.S. dollars.

Our approach, although mildly expansive due to the lack of geographic constraints, which have been previously criticized in literature (see e.g., Graziano et al., 2019), allows us to identify the maximum extents of BE definitions, and should be interpreted as upper bounds. More importantly, though, it is our intent to show the issues emerging from the absence of operational definitions when accounting for and analyzing the BE.

3. Mapping overlaps and extents of the BE.

3.1 Scotland overlaps

Figure 1 shows both the number of SIC codes included in each of the five definitions we consider (on the left-hand side) and the "overlaps" between the definitions, i.e., the number of common SIC codes included in combinations of groupings (on the right-hand side). From the left-hand side, we see that the World Bank definition had the most SIC codes (85) followed by the

OECD definition and NOAA (with 56 and 47 respectively). The Scottish Government's definition had the fewest SIC codes, with 14. The right-hand side of Figure 1 shows that there are 28 SICs which are considered in the World Bank definition but not in the others. Other definitions have fewer unique SICs, with Ketels having 14, OECD having seven, NOAA having four, while the Scottish Government definition has no unique SICs. At the other end of the spectrum, we identify 10 SICs which feature in all five definitions, and two which are in all definitions with the exception of that of the Scottish Government.

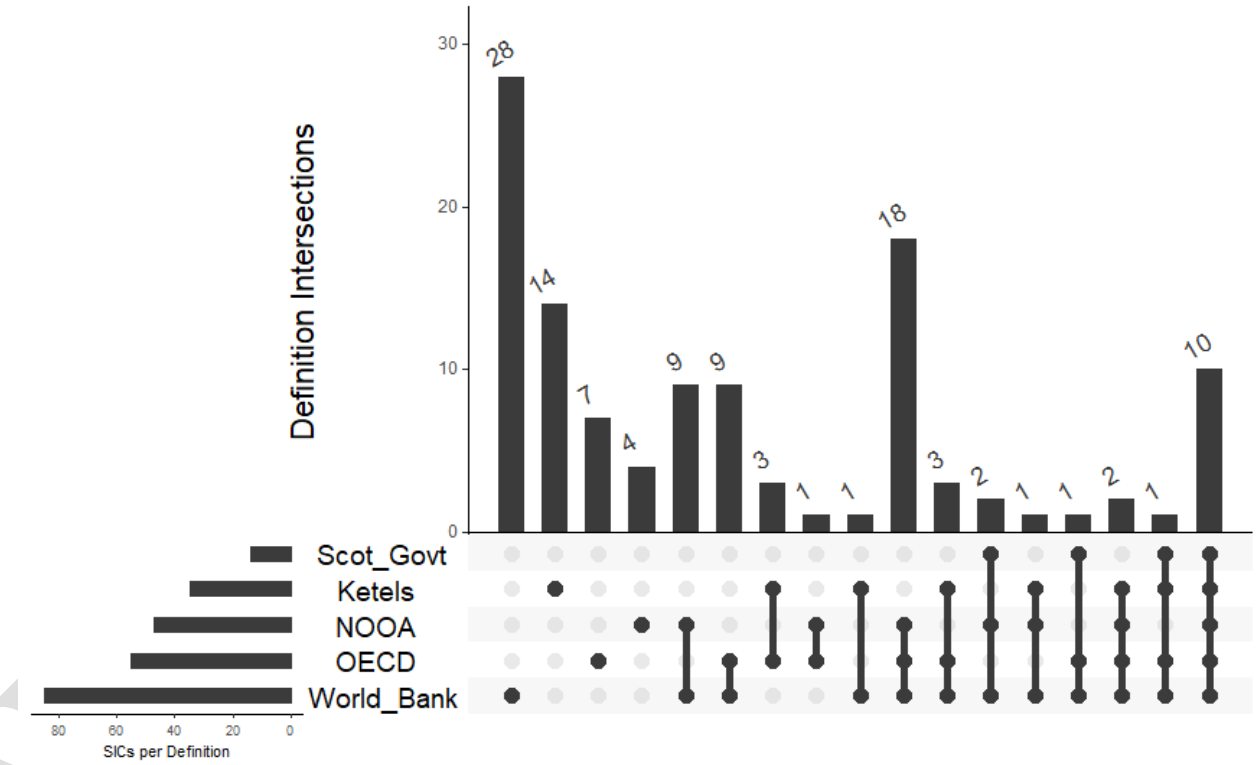

Figure 1: Upset plot showing overlaps between Blue Economy definitions and the number of maritime clusters included in each definition in Scotland.

3.2 Michigan overlaps

The Ketels and Protsiv definition (which builds upon the economic sectors identified by the European Union), and Organisation for Economic Co-operation and Development (OECD) 2030 (taken from *The Ocean Economy in 2030* report) definition were the most comprehensive in the Michigan case. The OECD definition included 18 clusters out of a total of 27 maritime clusters identified (Figure 2) whilst the Ketels and Protsiv definition included 17 clusters. The World Bank definition (from a report on the long-term benefits of marine resources for Small Island Developing States and Coastal Least Developed Countries) included 13 maritime clusters. The Scottish Government definition of the Blue Economy incorporated seven maritime clusters. The National Oceanic and Atmospheric Administration (NOAA) program, which offers a current U.S. perspective of the Blue Economy, included only six clusters. In addition, and as a reminder, both the NOAA and the Scottish definition are not bounded geographically due to data limitation, and, thus, represent the largest possible extent of the Blue Economy according to these two frameworks.

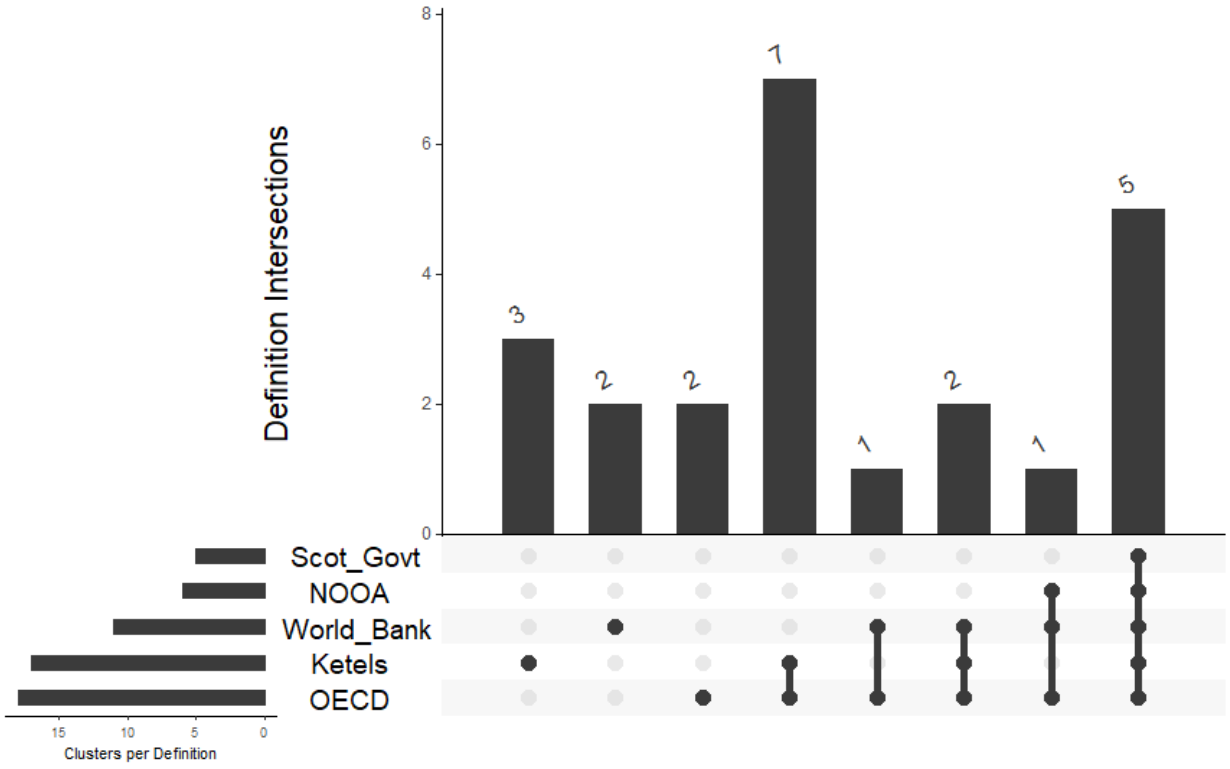

Figure 2: Upset plot showing overlaps between Blue Economy definitions and the number of maritime clusters included in each definition in Michigan (USA)

In terms of similarities across definitions, we found that all definitions included maritime activities often considered 'traditional' such as: Construction products and services, Fish and Fishing products, Hospitality and tourism, Oil and gas production and transportation, and Water transportation. Only Ketels and Protsiv/EU, the World Bank and the OECD definitions included education and knowledge creation, electric power generation and transmission, and environmental services. Less commonly considered clusters included downstream and upstream chemicals (included in the World Bank definition) and distribution and electronic commerce, performing arts and vulcanised material (included in the Ketels and Protsiv definition). The former group of clusters was included to account for chemical productions from water-sourced products (e.g., advanced antibiotics), while the latter includes clusters related to advanced water equipment

making. Finally, the Performing Arts cluster is particularly important because it includes drivers of tourist activities in coastal communities directly driven by the ecological features of coastal areas (Williams, 2016), especially in rural areas of the US (Gartner, 2004).

The differences among these definitions directly impact the extents of two social and ecological *loci* (spaces): one is *the extent of socioeconomic relevance of the Blue Economy*, whereas the second is *the extent of policy and socioecological impacts and mismatches* emerging from the interplay between the identified industries and the underlying ecosystem services.

4. Results: the socioeconomic extents of the Blue Economy

4.1 Socio-economic 'extents' of the Blue Economy

To investigate how these definitions play out in reality, we mapped the 'extents' of these definitions along four metrics (Figure 3). From this figure, we can immediately see the differences in size and, potentially, of economic impact that each conceptualization of Blue Economy would exercise if utilized as 'the' definition by private and public institutions.

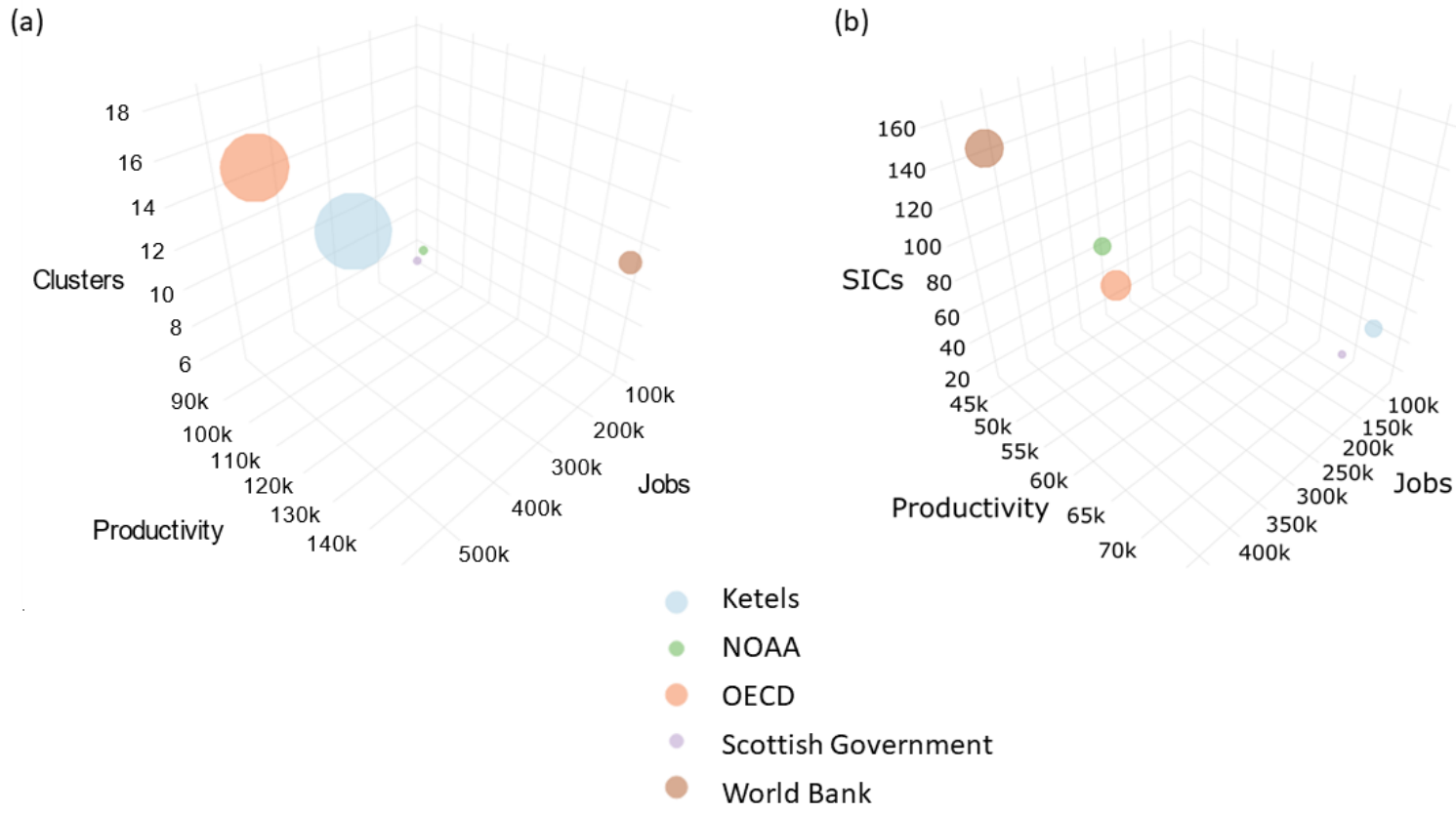

Figure 3: The socioeconomic extents of 5 definitions of the Blue Economy in (a) Michigan and (b) Scotland. Aggregations are by cluster (Michigan) and SIC (Scotland). Productivity is in 2016 USD in (a), and 2016 GBP in (b). The location of the bubbles in the plot are determined by the number of clusters, the level of productivity and the number of jobs. Gross Domestic Product (GDP) is reflected in the size of the bubble.

1

2

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The differences between definitions are staggering: in Michigan, the size the BE ranges from 2 to 11% of the labour force in 2018, while its output varies from $9 to $71 billion per year (roughly 2-16% of the state's GDP in 2016). The difference among these definitions can also be observed by the number of clusters included, and the overall labor productivity, which corresponds to the inclusion (exclusion) of more advanced sectors such as marine biotechnology and oil & gas alongside other 'living resources', like seafood production. A major cluster driving the extent and size of the definition is "Education and Knowledge Creation", which includes post-secondary institutions as well as private and public research and development activities. The inclusion of this cluster, common between 'Ketels', the OECD2030, and the UN-WRB definitions, reflects the role that human capital formation and sociotechnical research play in fostering Blue Growth initiatives. *Vice versa*, its exclusion by other definitions markedly signals a focus on more natural resource-based industries. Interestingly, this is common among the two definitions adopted so far by either federal or a local government.

In Scotland, the differences are even more pronounced, even though the labor productivity of each 'bubble' is relatively similar for most of these definitions, both their GVA and number of SICs (i.e. sectors) varies dramatically. The total GVA also varies, with the smallest definition accounting only for one-eighth compared to the more generous (£3 vs. £24 billion).

As it can be seen in both cases, there is only a very partial overlap among these definitions: this is evident in both contexts. In Michigan, the number of clusters varies 5 times between definitions, and the included macro-sectors vary dramatically, especially when knowledge-based sectors (e.g. Higher Education) are included. In Scotland, these differences are also quite evident: as we use SICs, the numbers have a different scale, but there are vast differences in conceptualizing what can be part of the BE as these range from about 20 to 180 industries. It is interesting to notice

that in both cases, broader definitions do not necessarily lead to higher productivities of larger GVAs. The reason behind this is the contributions by specific clusters and SICs, particularly those linked to the energy and the chemical/biopharmaceutical sectors, and their regional performance and nature. These figures show primarily two things: first, definitions vary dramatically in their extent regionally. More inclusive definitions do not necessarily lead to larger economic significance, as demonstrated by the relatively small extent of the EU/Ketels definition in Figure 2(b). Second, definitions based upon natural resources extractions and more traditional sectors (NOAA and Scottish Government) lead to smaller socioeconomic extents in both regions. However, where extraction of Oil & Gas occurs, these definitions lead to higher average productivity per worker. This caveat is evident by comparing Figures 2(a) and 2(b): the Oil & Gas sector in Michigan focuses primarily on refining and transporting (even underwater) these fossil resources, whereas in Scotland, Oil & Gas extraction is a traditionally established sector across multiple localities, and especially in the North-East and North.

Although we present the differences among these definitions based on three major economic metrics, these impact how the BE, its governance, and its development impact, is approached, regulated and prioritized at a regional level. In addition, these differences also make clear that even critical approaches to the concept of BE (e.g., calling for 'Blue Degrowth', see Ertor et al. (2020)) may be premature as the economic nature of this emerging paradigm can vary within the same region depending on how it is envisioned.

4.2 Job quality and resilience across definitions.

The size of each definition provides us with an idea of how relevant and complex each vision of the BE may be. However, differences exist in terms of what type of jobs are included in

each definition, both in terms of remuneration and in terms of resilience to economic shocks. The former characteristics is pivotal for ascertaining how the BE can effectively drive economic recovery and/or replace existing ecologically unsustainable activities in coastal regions. This point is of particular importance for those definitions where tourist activities (albeit formulated as 'sustainable') lead to the creation of low-income jobs, and, in the U.S., with limited or no non-income benefits such as health coverage (Lacher & Oh, 2011). The latter characteristics highlights the ability of these definitions (i.e. of their underlying industrial sectors) to withstand and/or recover from severe economic shocks.[3] To understand these characteristics, for each region we focused on the 2012-2018 period to fully account for the post-Great Recession period. As a reminder, these results are weighted by the number of workers/jobs in each SIC/NAICS to avoid the excessive influence by small but highly paying sectors (e.g., Oil & Gas in Scotland, Electricity Generation in Michigan) and the underestimation of low-paying yet large sectors (e.g., tourism in both regions).

From the perspective of wages, the five definitions are substantially different, and they mirror the general results of their productivities. In Scotland (Figure 4), two main groups of definitions emerge. The NOAA and World Bank definitions record far lower median wages than all other definitions, even though their average annual growth was larger in 2012-2018 (0.82% vs. a decrease of -0.09%). The second group, comprising the Scottish Government definition, OECD, and the Ketels/EU definition, shows far higher wages, and a more dynamic, albeit negative, change. Both the level of wages and their degrowth was primarily led by the Oil & Gas sector, which was highly hurt by declining prices from 2014, which continued through 2017. The relatively concentrated employment in these extractive sectors in the Scottish definition leads to a

[3] In this work, the concept of definitions follows the multi-faceted one proposed by Lema et al. (2019), and based upon Chandler (2014).

volatile dynamic, one that other formulations of the BE have an easier time mitigating. Interestingly, the mean gross weekly wage of all industries in Scotland is below that for any definition of the BE (although it is very close to the NOAA level of wages in two years). This is primarily due to the concentration of employment outside of the lower wage sectors in Service activities. Additionally, we were able to include the Marine Tourism activities for the Scottish Government's own definition it is likely that the average salaries under this definition would also be lower.

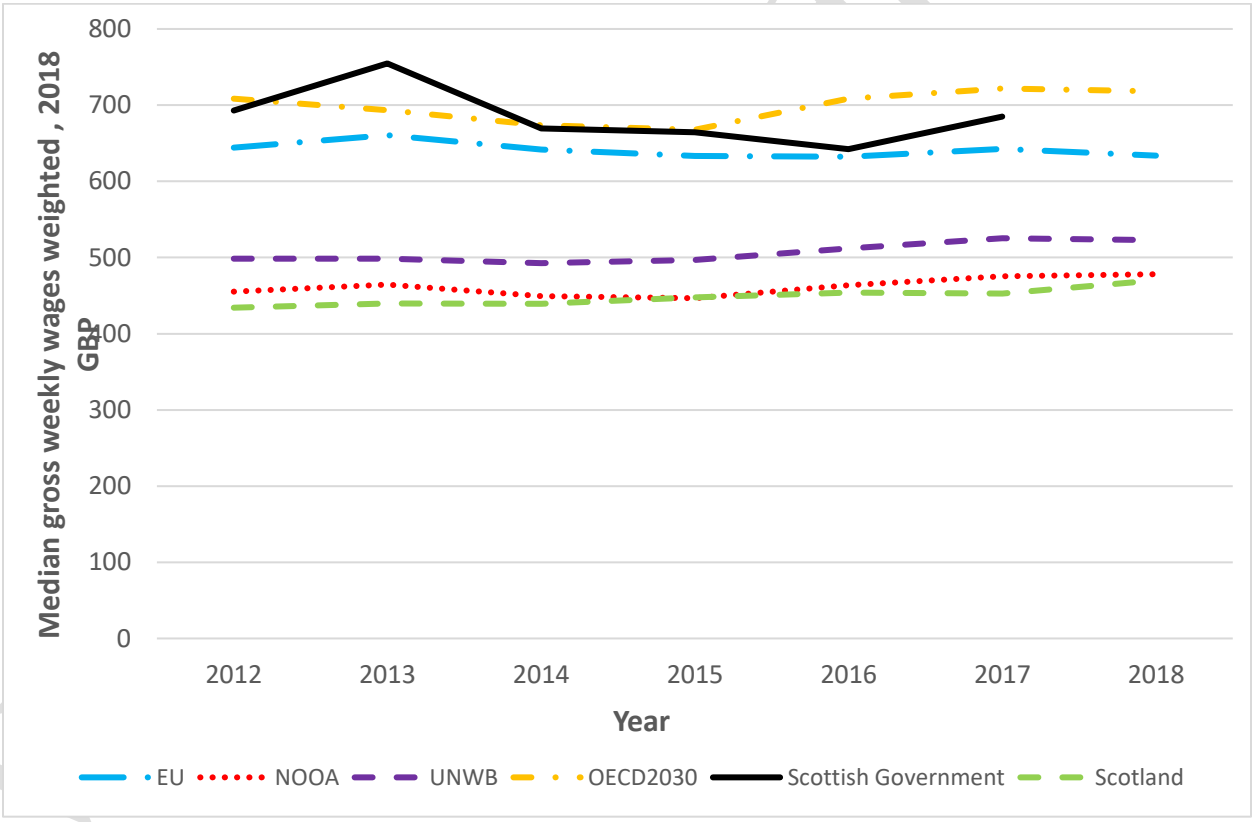

Figure 4: Median gross weekly wages weighted by employment of 5 definitions of the Blue Economy in Scotland, 2012-2018. *Scottish government measurement changed in mid-2015. Data show only post-change values.

In Michigan, wages are shown by monthly median values (Figure 5): the results once again create two clear groups, but this time with a different composition.

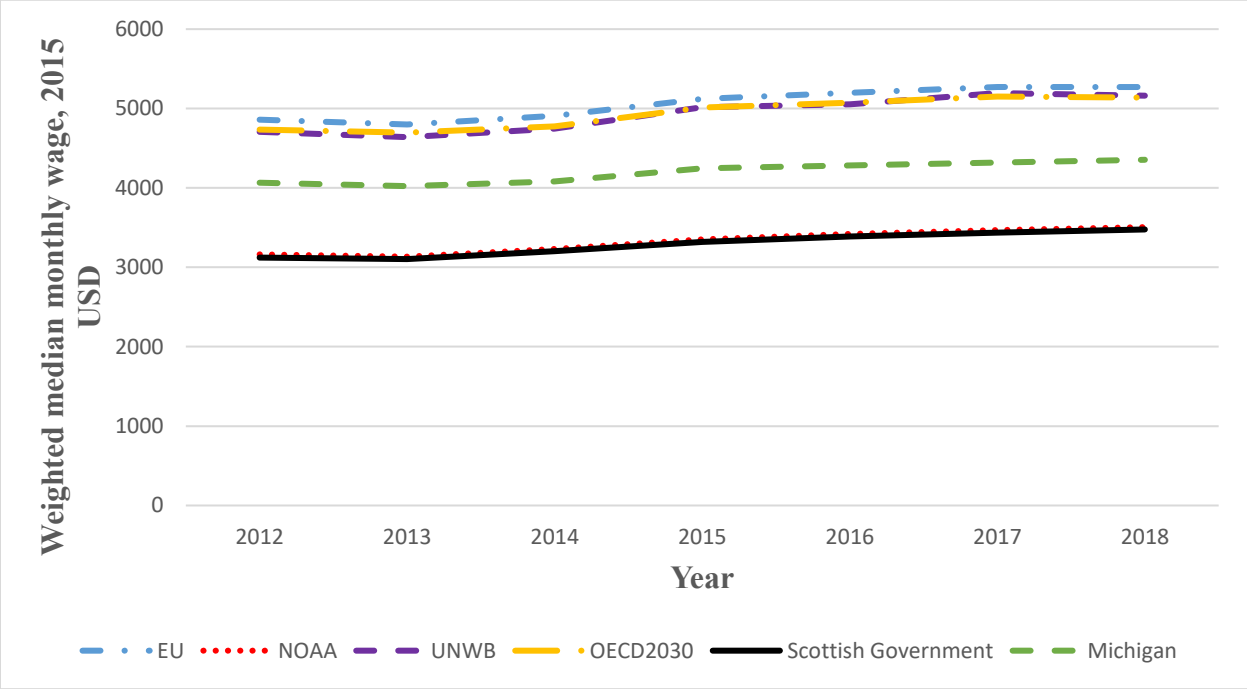

Figure 5: Weighted monthly median wage in 2015 USD of 5 definitions of the Blue Economy in Michigan, 2009-2018.

The first group, which includes the definitions used by NOAA and the Scottish Government, has the lowest monthly wages, both relative to the second group of definitions (about -$2,000 per month) and relative to the average annual wage in Michigan (-$1,000). Wages in this group of definitions have recovered slightly faster than both the average in the state and the second group: 1.78%/year vs. 1.44% (second group) and 1.16% (Michigan). The second group, comprising the EU/Ketels, UNWB, and OECD2030 definitions, records higher median monthly wages than then all other sectors in Michigan have recorded in 2012-2018: of the three definitions in this group, the one used by the EU recorded the highest wages, and although they have grown

at a slower pace than any other definition (1.37%/year), they still outperformed the average growth of wages in the state.

In Scotland, the employment dynamics across the five definitions also varies substantially (Table 2). Even though the overall ranking remains unchanged, each definition includes sectors that performed substantially differently throughout the recovery.

The extremely different behaviour of these definitions in terms of wages in our two regions once again highlight the need for regional-based, globally-grounded definitions of the BE. The nature of each industrial sector directly affects its performance, and, in return, lead to different compositions of the BE across regions.

Total employment	2012	2013	2014	2015	2016	2017	2018	Change 2012-2018	Average Annual Change, 2012-2018
World Bank	434,780	454,515	460,260	475,490	458,610	462,830	466,030	7.19	1.20
Scottish Government*	69,545	73,856	75,037	79,100	76,002	74,543	N/A	7.19	1.48
NOOA	229,795	252,530	252,155	274,225	256,500	255,225	263,295	14.58	2.45
OECD	253,705	280,055	283,195	300,610	279,010	281,540	284,300	12.06	2.06
EU	129,760	128,650	141,625	145,710	144,260	147,430	143,750	10.78	1.80

Table 2. Employment levels and changes in Scotland by definition of Blue Economy, 2012-2018.

Driven by the expansion in Construction and Restaurants, the NOAA definition is the most dynamic, growing 14.58% during the recovery, followed by the OECD definition, which has similar overall levels of employment. The broader definitions by EU and the World Bank display slower annual changes and slightly slower growth, suggesting that several sectors may have been more mature. An interesting aspect in Scotland is that overall every definition went through a decrease in employment in 2016, and in the case of both NOAA and the Scottish Government's definitions these decline continued in 2017. This is primarily due to the reduction in employment

in support activities for oil and gas extraction, which fell by 6,000 between 2014 and 2020. The EU definition, although also recording three years of negative growth (2013, 2016 and 2018) grew extremely fast right in 2013-2014, and it displays a more volatile character.

In Michigan, the employment dynamics across the definitions varies less: the growth rates in employment reflect the nationwide fast-paced recovery (Table 3). Once again, resource-based definitions display a slightly faster growth pace, with the Scottish Government definition recording both the fastest average annual change and the overall larger growth, driven by gains in the tourist industry. These gains, which are only slightly larger than those recorded by broader definitions, correspond to far smaller levels of employment. The OECD and the EU definitions record levels 7 times higher than both NOAA and the Scottish Government definitions, even when these are accounted for with no geographical limitations. Overall, the growth of employment in Michigan under any definitions has been steady throughout the post-crisis period, outpacing the average annual growth in employment for each year between 2012 and 2018 which peaked at 2.075% in 2015 (BLS, 2020).

Median Annual Employment	2012	2013	2014	2015	2016	2017	2018	Change 2012-2018	Average annual change
World Bank	594,889	622,575	638,063	663,641	673,093	674,028	675,486	13.55	2.15
Scottish Government	146,167	152,045	155,577	158,936	163,993	169,238	172,273	17.86	2.78
NOOA	148,262	154,234	157,792	161,118	166,270	171,574	174,602	17.77	2.77
OECD	1,036,133	1,080,128	1,109,223	1,149,955	1,171,507	1,177,948	1,188,818	14.74	2.33
EU	1,086,828	1,132,597	1,164,911	1,203,920	1,226,257	1,241,407	1,253,150	15.30	2.41

Table 3. Employment levels and changes in Michigan by definition of Blue Economy, 2012-2018.

In both regions, the underlying composition and formulation of BE have profound impacts on the stability and the quality of the jobs they will create regionally. These effects are not

necessarily driven by the divide between resource extractions vs. other sectors: rather, they are influenced by the regional profile of each macro-industrial sector.

5. Discussion: Varying sizes, varying impacts.

We have set out in the previous section some of the fundamental features of the Blue Economy under five definitions in quantitative applications for Michigan and Scotland, two very different regional economies which have put notions of blue economic growth squarely into their economic development frameworks in the last decade. What we have shown is that definitions give rise to hugely varying economic contributions for blue economic activity. The definitions of activity thus are vital in ensuring that any comparisons between regions or countries in terms of blue activity is consistent. These differences are not close, but are likely to produce hugely different interpretations of the success of economic policy targeted at blue growth and policy actions towards the Blue Economy. Second, with the huge variations in the economic narrative suggested by the alternative visions of the Blue Economy, it is also likely that the related narratives for social and environmental impact would be similarly wide. This gets at a fundamental point about Blue economic activity: coordination matters where policies have multiple objectives under the growth paradigm, and so definitions of impacts must help to align actions to measurable outcomes. Third, we have shown the value of economic multisectoral industrial surveys and statistics. Looking back through time on a consistent industrial basis we can understand the evolution of this current definitional boundary of interest to policy groups. This highlights the importance of economic and social statistics which are robust to future areas identified in policy, so require a "backwards compatibility" to new data. On this point, we suggest that the Scottish Government's inclusion of a subset (by proximity) of specific activities is the least reproducible

as geographic location would not normally be gathered as part of the process of the construction of economic accounts, and so would require linking more than one dataset to perform this analysis (e.g., firm statistics and their geographical locations). Interestingly, both definitions applied in each region by their respective governments, NOAA and the Scotland, are the ones to include a specific geographical "hurdle" rather than an identified industrial activity, and shows that this is not conventional within blue accounting metrics to this point. As a side note, it would also imply that the measured scale of the Blue Economy under these definitions could seek policy actors to look for outcomes which would not be optimal from the firms' perspective on the location decision.

In terms of the information shown, we have demonstrated a "traditional" collection of activities included in measures of the Blue Economy which are consistent across each definition. There are nine such SICs in Scotland and five in Michigan which are shared in all of the definitions in those regions. It is worth noting that these simple statistics – while showing the elements included in each region – do not relate to the economic embeddedness these activities within the regional economy (or their wider economic contribution). These could be explored via appropriate Input-Output modelling analysis, for instance were such economic accounts to be available for the regional economies. By exploring the concepts of resilience, we demonstrate the value in economic statistics, and see how the definitional boundary changes the insights for policymakers on this question.

A particularly interesting aspect of the definitions of the Blue Economy we have explored uses economic data at the level of industries, where we can identify and trace impacts on GVA and employment, as well as wages. This approach omits – due to a lack of data – information on occupations and skills utilised by those working in the Blue Economy. There are "green economy" measures of occupations (e.g., O*NET, see Consoli et al., 2016) relating to the specific roles by

those working in green economic activities, new green occupations and activities where demand is likely to increase due to expansion of green products. Such a classification has a powerful story for labour market planning and the scale of skills and training required. Critically, as the unit of account in such surveys are the individual rather than the firm, such a perspective for the Blue Economy could permit an identification of blue-based activities in firms which are not themselves categorised as Blue.

Finally, our analysis shows how diverging definitions may directly lead to conflicts over regional sustainability objectives and competition over the access to water/coastal space, or the acceptable risks associated with degrading water quality. Our work did not seek to solve these conflicts: instead, by analysing the extents of the Blue Economy we have provided a possible way for understanding the economic overlaps and sectoral relationships associated with different formulations of this paradigm.

6. Policy implications: Challenges and potential for regional sustainable development in a world of varying Blue Economies

In this work, we have compared the sectoral extent, economic performance, and employment quality of five different definitions of the Blue Economy. Our work highlights the extreme operational differences among the existing definitions of this regional economic paradigm, which lead to the emergence of relevant implications to both researchers and policymakers.

The ‘scale’ of the bubbles we show raise two broad themes. The first theme deals with nurturing the Blue Economy, a policy action often labelled ‘Blue Growth’. Because of a lack of overlap among SICs, the very nature of this growth differs: these discrepancies are reflected in the stakeholders that governments will want to include and support, effectively creating ‘ins’ and

'outs', especially where and when ocean resources (e.g. space) are competitive and exclusive. This shares limitations with industrial policies more generally, which by focusing on specific sectors/activities can neglect the role that interconnections between industries play in raising economic activity across the whole economy. Additionally, it mirrors concerns about definitions used in Renewable Energy (e.g. Lowitzsch et al., 2020). Fundamentally, given pressures to demonstrate the positive consequence of activities focused on developing the Blue Economy, defining Blue Economy becomes fundamental to the perception of policy success. Drawing too small a boundary around the concept risks alienating stakeholders and focusing on narrow goals; while too large a boundary, however, brings the challenge of distinguishing the separate consequences of policies targeted at specific activities. A combination of "narrow" and "broad" definitions, which are dynamic would be most useful (we return to this below). The second theme deals with fostering the socioecological sustainability both at the planning stage of Blue Economy and once the industries have been deployed. In practice, major differences in the scale and nature of these industries can create conflicts and generate an unclear path towards different socioeconomic and socioecological landscapes. The conflicts are not only related to the use of water and coastal space: some industries pose risks to others, whether through accidents or through their normal course of operation (Graziano et al., 2019). In recent years, scholars and policymakers have developed and deployed governance tools to regulate and plan the use of water spaces: drawing from the principles of ecosystem-based management (Douvere, 2011), marine spatial planning (MSP) has emerged as the most prominent among these tools (Douvere, 2011; Domingues-Tejo et al., 2016). However, this planning framework has been found to lack the ability to connect decision-making processes taking place across multiple jurisdictions, departments, and scales (Flannery et al., 2016; Alexander et al., 2018). The use of driver-scale socioecological

frameworks like the Driver-Pressure-State-Welfare-Response framework (Cooper, 2013) may offer a path to recognize these issues in advance, and to help develop mitigation/adaptation policies at the appropriate scale.

From the contrasting scales, natures, and economic extents of the definitions used in this work, we can draw three major conclusions, which serve as items for advancing the research agenda for implementing and governing the Blue Economy. First, each definition of the Blue Economy fails to account for the regional nature of 'Blue Industries' and the way they operate and intersect within each region. The existing metrics used for defining all economic activities by sector provides a valuable organizing framework which has served analysts, modelers and policy well for understanding industries for many decades. Blue Economy is therefore in a sense required to align itself on the same grounds so it can be compared to other industries; to be familiar to policymakers it should speak in the same language of industrial sectors. This leads to the need for developing ways in which the regionality of the Blue Economy is recognized, and yet built upon shared values and common supra-regional objectives.

This need leads to the second item: the reconceptualization of the scale at which water-coastal regions are analysed, and the Blue Economy is governed. Devolutionary or centralizing processes may not be as adequate as thought in terms of overall control over the Blue Economy: rather, multi-scalar approaches under an overall, common umbrella of socioecological objectives could be used for understanding risks, impacts, and benefits associated with each sector within regional definitions.

This need leads us to our third conclusion: the need to operationalize the Blue Economy as an iterative, dynamic paradigm, where definitions not only change across (new) spaces, but also through time as emerging industries become incumbents, thus determining the direction in which

each region will select its own set of 'Blue Industries'. This additional dynamic still makes the operational Blue Economies comparable within the same region, in the same way we compare aggregate sectors through time, accounting for the emergence of new technologies, which then may create new industries (and new NAICS/SIC).

This operationalization of the Blue Economy suggests that frameworks integrating regionalism, regional sciences, and (sustainable) transition theory, a process partly emerged in the past for technical regimes (Smith et al., 2005), can effectively be used to determine, measure, and compare the results of Blue Economy policies across regions. Practically, this means stronger collaborations between regional scientists and marine social scientists, something that Geography as a discipline is well-equipped to do.

Concretely, we suggest two initial approaches. First, the Blue Economy must be politicized: that is, its elements must be determined by elected officials at the national level, with clear objectives and definitions about what is 'blue' and what it is not. Secondly, scenario developments (Reed et al., 2013) at the regional level (*latu sensu*) can help bypassing the issue related to stakeholder identification and un-, or partially-, informed decision making. These scenarios should be developed in via mixed bottom-up/top-down approach, similar to the one suggested by Kerr et al. (2018) for marine energy developments. Of course, these are not silver bullets, but rather, first steps.

Per se, the new regionalism that we have identified here, which has been already called for in marine spatial planning (Alexander and Graziano, 2018) explicitly seeks to make it possible to scale up analyses and conduct comparisons, yet it allows for de-scaling processes to determine the characters of the Blue Economy. Borrowing from one of the fathers of Regional Sciences and

Economic Geography, Thorstein Hägerstrand, the conclusions presented here could be summarized asking "What about regions in the Blue Economy?".[4]

[4] Based on the title of Hägerstrand (1970).

7. References

Alanen, A.A. (2007). *Morgan Park: Duluth, U.S. Steel, and the forging of a company town.* Minneapolis (MN), USA: University of Minnesota Press.

Alexander K.A. (2019). *Conflicts over Marine and Coastal Common Resources*. London: Routledge. https://doi.org/10.4324/9781315206424

Alexander, K. and M. Graziano (2018) Scale mismatches: Old friends and new seascapes in a planning regime, in Heidkamp, C.P., Morrissey, J. (2018) *Towards Coastal Resilience and Sustainability*. Nerw York: Routledge. 230-247.

Allan, J.D., McIntyre, P.B., Smith, S.D.P., Halpern, B.S., Boyer, G.L., Buchsbaum, A., Burton Jr., G.A., Campbell, L.M., Chadderton, W.L., Ciborowski, J.J.H., Doran, P.J., Eder, T., Infante, D.M., Johnson, L. B., Joseph, C.A., Marino, A.L., Presevich, A., Read, J.G., Rose, J.B., Rutherford, E.S., Sowa, S.P., Steinman, A.D. (2013). Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. *Proceedgins of the National Academy of Sciences of the United States of America*, 110(1): 372-377. https://doi.org/10.1073/pnas.1213841110

Almeida, J., Costa, C., da Silva, F. (2018). Collaborative approach for tourism conflict management: A Portuguese case study. *Land Use Policy*, 75, 166-179. https://doi.org/10.1016/j.landusepol.2018.03.034

Bennett, N.J., Cisneros-Montemayor, A.M., Blythe, J., Silver, J.J., Singh, G., Andrews, N., Calò, Christie, P., Di Franco, A., Finkbeiner, E.M., Gelcich, S., Guidetti, P., Harper, S., Hotte, N., Kittinger, J.N., Le Billon, P., Lister, J., López de la Lama, R., McKinley, E., Scholtens, J., Solås, A-M., Sowman, M., Talloni-Álvarez, N., The, L.C.L. Voyer, M., Sumaila, U.R. (2019). Towards a suastainable and equitable blue economy. *Nature Sustainability*, 2: 991-993.

Brandão, F. ,Breda, Z., Costa, C. (2019). Innovation and internationalization as development strategies for coastal tourism destinations: The role of organizational networks. *Journal of Hospitality and Tourism Management*, 41: 219-230. https://doi.org/10.1016/j.jhtm.2019.10.004

Burton, G.A., Scavia, D., Luooma, S.N., Love, N.G., and Austin, J. (2010) *Leveraging the Great Lakes Region's water assets for economic growth*. Metropolitan Policy Program, New York, NY: Brookings Institute.

Butler, L.J., Scammell, M.K., Benson, E.B. (2016). The Flint, Michigan, Water Crisis: a case study in regulatory failure and environmental injustice. *Environmental Justice*, 93-97. https://doi.org/10.1089/env.2016.0014.

Campling, L., Havice, E., McCall Howard, P. (2012). The Political Economy and Ecology of Capture Fisheries: Market Dynamics, Resource Access and Relations of Exploitation and Resistance. *Journal of Agrarian Change*, 12(2-3): 177-203. https://doi.org/10.1111/j.1471-0366.2011.00356.x

Chandler, D. (2014) *Resilience – the governance of complexity*. Abingdon: Routledge.

Choi, Y.R. (2017) The Blue Economy as governmentality and the making of new spatial rationalities. *Dialogues in Human Geography*, **7**(1): 37-41.

Cooper, P. (2013) Socio-ecological accounting: DPSWR, a modified DPSIR framework, and its application to marine ecosystems. *Ecological Economics*, 94:106-115.

Colgan, C. S. (2007). A guide to the measurement of the market data for the ocean and coastal economy in the National Ocean Economics Program. National Oceans Economics Program.Edmund S Muskie School of Public Service, University of Southern Maine.

Conference of Great Lakes and St. Lawrence Governors and Premiers (CGLSLGP) (2016).

Consoli, D., Marin, G., Marzucchi, A., Vona, F. (2016). Do green jobs differ from non-green jobs in terms of skilss and human capital? *Research Policy*, 45(5): 1046-1060. https://doi.org/10.1016/j.respol.2016.02.007

Delgado, M., Porter, M.E., Stern, S. (2014) Defining clusters of related industries. NBER Working Paper 20375. National Bureau for Economic Research.

Doloreux, D., Shearmur, R., & Figuereido, D. (2016). Québec' coastal maritime cluster: Its impact on regional economic development, 2001–2011. *Marine Policy*, 71: 201-209. https://doi.org/10.1016/j.marpol.2016.05.028

Doloreux, D. (2017) *What is a maritime cluster?* Marine Policy. 83: 215-220.

Domingues-Tejo, E., Metternich, G., Johnston, E., and Hedge, L. (2016) Marine spatial planning advancing in the Ecosyste-Based approach to coastal zone management: a review. *Marine Policy*, 72: 115-130.

Douvere, F. (2008) The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy*, 32(5): 762-771.

Ehrlich, G., Graziano, M., McWilliams, M., Liesch, M. (2017) The socioeconomic impacts of the great lakes restoration initiative – phase 1 report. Great Lakes Commission.

Ertör, I., Hadjimichael, M. (2020). Editorial: Blue degrowth and the politics of the sea: rethinking the blue economy. Sustainability Science 15: 1–10.

European Commission. (2012) *Blue growth–scenarios and drivers for sustainable growth from the oceans, seas and coasts*. Brussels: European Commission.

European Union (2001) Directive 2001/42/EC of the European Parliament and of the Council of June 27, 2001 on the assessment of the effects of certain plans and programmes on the environment. *Official Journal of the European Communities* 21/07/2001: 30-37.

Flannery, W., Ellis, G., Nursey-Bray, M., van Tetenhoven, J.P.M., Kelly, C., Coffen-Smout, S., Fairgrieve, R., Knol, M., Jontoft, S., O'Hagan, A. M. (2016) Exploring the winners and losers of marine environmental governance. *Planning Theory & Practice*, 17(1): 121-151.

Gartner, W.C. (2004) Rural tourism development in the USA. *International Journal of Tourism Research*, 6(3): 151-164.

Feldman, J., & Heasley, L. (2007). Recentering North American Environmental History: Pedagogy and Scholarship in the Great Lakes Region. *Environmental History*, 12(4): 951-958. https://doi.org/10.1093/envhis/12.4.951

Firestone, J., Kempton, W., Blaydes, M., Lilley, M.B., Samoteskul, K. (2012). Public acceptance of offshore wind power across regions and through time. *Journal of Environmental Planning and Management*, 55: 1369-1386. https://doi.org/10.1080/09640568.2012.682782

Friedman, K.B., Laurent, K.L., Krantzberg, G., Scavia, D., Creed, I.F. (2015). The Great Lakes Futures Project: Principles and policy recommendations for making the lakes great. *Journal of Great Lakes Research*, 41(1): 171-179. http://dx.doi.org/10.1016/j.jglr.2014.11.026

Golden, J.S., Virdin, J., Nowacek, D., Halpin, P., Bennear, L., Patil, P.G. (2017) Making sure the blue economy is green. *Nature Ecology & Evolution*, 1, 17.

Graziano, M., Gunther, P., Lema, E. (2017) The economic impacts of crude oil transportation across the Great Lakes-St. Lawrence Seaway Region. Great Lakes Commission.

Graziano, M., Alexander, K.A., Liesch, M., Lema, E., Torres, J.A. (2019) Understanding an emerging economic discourse through regional analysis: Blue economy clusters in the US Great Lakes basin. *Applied Geography*, 105: 111-123.

Hägerstrand, T. (1970). What about people in Regional Science?. *Papers of the Regional Science Association* 24: 6–21. https://doi.org/10.1007/BF01936872

Hjalager, A-M. (2020). Land-use conflicts in coastal tourism and the quest for governance innovations. *Land Use Policy*, 94: 104566. https://doi.org/10.1016/j.landusepol.2020.104566

International Maritime Organizaion (IMO) (2020) International Convention for the Prevention of Pollution from Ships (MARPOL). IMO.

Kelton, C.M.L., Pasquale, M.K. & Rebelein, R.P. (2008). Using the North American Industry Classification System (NAICS) to Identify National Industry Cluster Templates for Applied Regional Analysis. *Regional Studies*, 42(3): 305-321. http://dx.doi.org/10.1080/00343400701288316

Kerr, S., Watts, L, Brennan, R., Howell, R., Graziano, M., O'Hagan, A.M., van der Horst, D., Weir, S., Wright, G., and Wynne, B.. Shaping Blue Growth: social sciences at the Nexus between marine renewables and energy policy. (2018). In Foulds, C., and Robinson, R. (eds.). *Advancing energy policy: lessons on the integration of social sciences and humanities*. London, UK: Palgrave-Macmillan.

Ketels, C., & Protsiv, S. (2016). *Priority sector report: Blue economy - European cluster observatory Report*. Stockholm: School of Economics-Center for Strategy and Competitiveness.

Lacher, R.G., Oh, C-O. (2011) Is Tourism a Low-Income Industry? Evidence from Three Coastal Regions. *Journal of Travel Research*, 51(4): 464-472.

Koliousis, I.G., Papadimitriou, S, Riza, E., & Stavroulakis, P.J. (2017). Strategy, policy, and the formulation of maritime cluster typologies. *Marine Policy*, 86: 31-38. http://dx.doi.org/10.1016/j.marpol.2017.09.010

Lee, T., van der Heijden, J. (2018) Does the knowledge economy advance the green economy? An evaluation of green jobs in the 100 largest metropolitan regions in the United States. *Energy & Environment*, 30(1): 141-155.

Lee, K-H., Noh, J., Khim, J.S. (2020). The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. *Environment international*, 137: 105528. https://doi.org/10.1016/j.envint.2020.105528

Lema, E., Liesch, M., Graziano, M. (2019). *Pathways for Resilience in Four Great Lakes Legacy Cities*. In: Burayidi, M., Allen, A., Twigg, J., and Wamsler, C. (eds.). *The Routledge Handbook of Urban Resilience*. Abingdon: Routledge.

Lowitzsch, J., Hoicka, C.E. and van Tulder, F.J. (2020) Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? *Renewable and Sustainable Energy Reviews,* 122: 109489.

Li, M, & Luo, M. (2020). Review of existing studies on maritime clusters. *Maritime Policy & Management*, 48(6): 795-810. https://doi.org/10.1080/03088839.2020.1802786

Marine Scotland (2020) Marine Economic Statistics 2017: Updated April 2020. Marine Scotland.

Masten, S.J., Davies, S.H. Shawn, P.M. (2016). Flint Water Crisis: What Happened and Why? *Journal AWWA – Water Treatment Processes*, 108(12): 22-34.

Melstrom, R.T., Reeling, C., Gupta, L., Miller, S.R., Zhang, Y., Lupi, F. (2019) Economic damages from a worst-case oil spill in the Straits of Mackinac. *Journal of Great Lakes Research*, 45(6): 1130-1141.

National Oceanic and Atmospheric Administration (NOAA) (2018) NOAA Report on the U.S. Ocean and Great Lakes Economy. Charleston, SC: NOAA Office for Coastal Management.

Organization for Economic Cooperation and Development (OECD) (2016) *The Ocean Economy in 2030*. Paris: OECD Publishing.

Office for National Statistics (2020) Earnings and Hours Worked, UK Region by Industry by Two-Digit SIC: ASHE Table 5. U.K. Office for Nationa Statistics.

Phoenix, C., Bell, S.L., Hollenbeck, J. (2020). Segregation and the Sea: Toward a Critical Understanding of Race and Coastal Blue Space in Greater Miami. *Journal of Sport and Social Issues*, 45(2): 115-137. https://doi.org/10.1177%2F0193723520950536

Popp, D., Vona, F., Marin, G., Chen, Z. (2020). The Employment Impact of Green Fiscal Push: Evidence from the American Recovery Act. NBER Working Paper No. 27321, National Bureau of Economic Research.

Porter, M. (1998). Clusters and the new economics of competition. *Harvard Business Review*, 76: 77-90.

Reed, M.S., Kenter, J.O., Bonn, A., Broad, K., Burt, T.P., Fazey, I.R., Fraser, E.D.G., Hubacek, K., Nainggolan, D., Quinn, C.H., Stringer, L.C., & Ravera, F. (2013) Participatory scenario development for environmental management: A methodological framework illustrated with experience from the UK uplands. *Journal of Environmental Management*, 128: 345-362

Rothwell, J., Massey, D.S. (2009). The effect of density zoning on racial segregation in U.S. urban areas. *Urban Affairs Review*, 44(6): 779-806. https://doi.org/10.1177%2F1078087409334163

Scottish Government (2019) Scottish Annual Business Statistics 2017. Scottish Government.

Shreyer, P., Pilat, D. (2001) Measuring productivity. 33:2001/11OECD Economic Studies. Organization for Economic Cooperation and Devleopment.

Shi, X., Jiang, H., Li, H., & Xu, D. (2020). Maritime cluster research: Evolutionary classification and future development. *Transportation Research Part A*, 133: 237-254. https://doi.org/10.1016/j.tra.2020.01.015

Silver, JJ., Gray, N.J., Campbell, L.M. (2015) Blue economy and competing discourses in international oceans governance. *The Journal of Environment & Development*, 24(2): 135-160.

United Nations Conference on Sustainable Development (2012))Blue Economy Concept Paper. United Nations.

Smith, A., Stirling, A., Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, 34: 1491–1510.

Sutherland, F. (2015). Community-driven mining heritage in the Cuyuna Iron Mining District: Past, present, and future projects. *The extractive industries and society*, 2(3): 519-530. https://doi.org/10.1016/j.exis.2015.04.003

Sugrue, T.J. (2005). *The origins of the urban crisis – race and inequality in postwar Detroit.* Princeton, NJ (USA): Princeton University Press.

Sweeney, R.A. (1993). Introduction: "dead" sea of North America? Lake Erie in the 1960s and 70s. *Journal of Great Lakes Research*, 19: 198-199.

The Scottish Government (2011) *Scotland's Environemnt*, LIFE 10 ENV-UK-000182. The Scottish Government.

Tremblay, N.W., & Gilman, A.P. (1995). Human health, the Great Lakes, and environmental pollution: a 1994 perspective. *Environmental Health Perspective*, 103(9): 3-5.

U.S. Bureau of Labor Statistics (BLS) (2020). Current Employment Statistics - CES (National). U.S. Bureau of Labor Statistics.

U.S. Census Bureau. (2020). *Quarterly Workforce Indicators (1990-2018) - Longitudinal-Employer Household Dynamics Program*. Washington, DC: U.S. Census Bureau.

Vona, F., Marin, G., Consoli, D. (2019) Measures, drivers and effects of green employment: evidence from US local labor markets, 2006–2014. *Journal of Economic Geography*, 19(5): 1021-1048.

Voyer, M., Quirk, G., McIlgorm, A., Azmi, K. (2018) Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance? *Journal of Environmental Policy & Planning*, 20(5): 595-616.

Winder, G.M., Le Heron, R. (2017) Assembling a Blue Economy moment? Geographic engagement with globalizing biological-economic relations in multi-use marine environments. *Dialogues in human geography*, **7**(1): p. 3-26.

Williams, G. (2016) Economic Impacts from Development of the Coastal Town in Queensland on Tourism and Regional Economy. *Resources*, 5(4): 48-64.

World Bank. (2016). *Oceans 2030, financing the blue economy for sustainable development*.Washington, D.C.: World Bank Group.

World Bank. (2017). *The potential of the blue economy, increasing long-term benefits of the sustainable use of marine resources for small island developing states and coastal least developed countries*. Washington, D.C.: World Bank Group

APPENDIX

Definition	GDP	Jobs	% Employment	SIC	Labor Productivity
World Bank	24,230,000,000	468,130	18.08	88	51,759

Scottish Government	5,139,697,186	74,543	2.88	15	68,949
NOAA	11,216,000,000	256,225	9.90	48	43,774
OECD2030	19,167,000,000	347,315	13.42	58	55,186
EU	11,170,000,000	148,475	5.73	37	75,232

Appendix 1: Sectors and values.

Table A1. Aggregate metrics of definitions for Scotland (2016).

Table A2. Aggregate metrics of definitions for Michigan (2016).

Definition	Jobs	GDP (added Value)	# Clusters	Labor Productivity
Scottish Government	111,984	9,413,419,715	5	84,061
NOAA	114,330	9,932,727,987	6	86,878
OECD2030	563,535	64,618,139,665	18	114,666
EU	537,237	71,995,470,875	17	134,011
World Bank	151,700	23,073,818,673	12	152,101

Appendix 2: Cross-walk table.

Table A5. Clusters overlaps within definitions for Scotland.

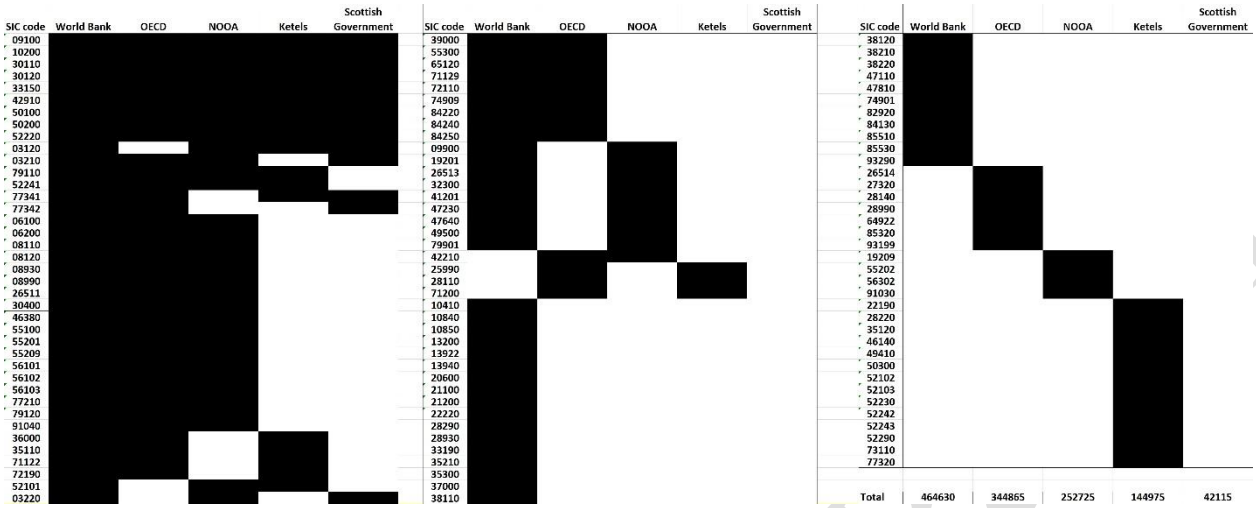

Table A6. Clusters overlaps within definitions for Michigan.

Definition	Clusters				
	EU	NOAA	UN-WB	Scottish	OECD2030
EU	17	6	9	5	14
NOAA	6	6	6	5	5
UN-WB	9	6	12	5	9
Scottish	5	5	5	5	5
OECD2030	14	5	9	5	18