# Seafood businesses' resilience can benefit from circular economy principles

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**Suggested citation:**

Fletcher CA, St Clair R, Sharmina M. Seafood businesses' resilience can benefit from circular economy principles. *Nature Food* 2021, doi:10.1038/s43016-021-00262-4

## Abstract

Seafood is expected to become increasingly important in future food systems and healthy diets. This transition will require the seafood sector to adapt business practices to respond to environmental and social challenges while increasing resilience. Here, we develop the Circular Economy-Resilience Framework for Business Models (CERF-BM) and, through exploring current literature, apply this framework to business models in the seafood sector. We find that the majority of business models incorporate elements of circular economy and resilience in a limited way. The reviewed business models often fail to consider other supply chain actors and, instead, focus on the business itself and its customers. The CERF-BM helps to elucidate this disconnect through assessing business models against company-level actions towards circularity in combination with systems-level resilience mechanisms. To reap the synergies between the circular economy and resilience mechanisms, seafood businesses could extract more value from organic waste and dematerialise their business models.

## Main

The global seafood industry, which includes capture fisheries and aquaculture, is a vital source of food, income, livelihoods and culture [1]. Despite a marked decline in wild fish

stocks, the seafood market continues to grow – reflecting a steady increase in production from aquaculture against a relatively static level of production from wild capture sources [1]. Seafood represents a global economic value of 10% for total agriculture products and a nutritional value of over 20% for animal protein intake – a particularly important protein source in low-income and food-insecure countries [2,3].

With demands on global food supply expected to intensify due to population growth, greater wealth and increasing per capita consumption[1,3], seafood has been identified as a key component of a healthy diet and a contributor to future food systems [4]. Existing literature acknowledges a trade-off between the health benefits related to seafood consumption and the associated environmental impacts of production [4]. Efficient feed conversion ratios can enhance sustainability [4], but overexploitation of fish in capture fisheries production and in the production of fishmeal for aquaculture can result in ecological collapse of fish stocks. Additionally, the financial viability of seafood production businesses is threatened [5,6], creating vulnerability within the sector.

**Improving resilience through the circular economy principles**

A resilient system is robust, flexible and adaptable enough to withstand shocks and external pressures while maintaining basic structures and processes, and thus functionality [7-9]. Food security (utilisation, accessibility and availability of food), environmental welfare (ecosystem stock, flows and services) and social welfare (employment, income, non-economic capital) contribute to resilience [10]. As an operational principle, resilience can be considered through a four-part framework: ‘resilience of what’, ‘resilience to what’, ‘resilience of whom’ and ‘over what timeframe’ [11]. ‘Resilience to what’ refers to the part of the system impacted during a disturbance, e.g. the primary production system, any secondary processing and distribution channels and/or final retail and consumption. In relation to ‘resilience of whom’, three levels of ‘actor’ can be considered: the main actor directly impacted by the disturbance, downstream stakeholders who are not directly impacted by disturbances but rely on the products and services provided by the main actor, and upstream stakeholders, who again would not be directly impacted by the disturbance but would supply services or products to the main actor [11].

To overcome these vulnerabilities, we suggest four resilience mechanisms [8]: diversification (across the value chain including the products available, how products are distributed and

what products are consumed), utilising ecosystem and ecological functions (e.g. natural carbon cycles), use of local systems (such as knowledge of local environments and conditions) and increased knowledge exchange between stakeholders and actors within established and new value chains (see Supplementary Table 3).

The circular economy is regenerative by design, builds long-term resilience and generates economic opportunities alongside environmental and societal benefits by designing waste out of processes, extending the life of products and materials, and regenerating natural systems [12]. However, it has been described as an "Essentially Contested Concept" due, in part, to its relative novelty within academic research and its development from a practitioner perspective [13]. While academic literature is still emerging, leading to criticisms over the lack of consistency and clarity in its use [14], research has become more prolific, and frameworks and measures of circular economy are becoming more clearly defined [15].

**Business models as a change management tool**

The business model concept, defined as a systematic analytical device that captures the rationale of how a company creates, delivers and captures value [16,17], can be used to change how companies operate (for example by maximising material and energy efficiency, creating value from waste, and adopting a stewardship role) [18]. Change management tools can facilitate the application of circular economy principles [19]; for example, force-field analysis, Kotter's cycle of change and Beckhard's formula encourage organisational change by identifying, reducing and/or eliminating barriers [20].

Here, we provide an overview of literature on business models within the seafood sector to identify existing business models and assess them against circular economy principles and resilience mechanisms. This is a first tentative step in exploring this research niche – and in setting out a future research agenda. Our objectives are to build a conceptual framework combining these principles with the 'business model' concept, to use this framework to identify examples of good practice (where for instance companies within the sector have adopted interventions to increase circularity) and to highlight areas across the sector where circular economy principles and resilience mechanisms are lacking, thereby identifying areas of priority for policy makers and researchers in the future.

## Circular Economy-Resilience Framework for Business Models

The Circular Economy-Resilience Framework for Business Models (CERF-BM) combines the business model canvas with circular economy principles and resilience mechanisms (see Figure 1). Business model frameworks are used to describe and develop business strategies and are commonly used in research and teaching [21]. The business model canvas is an example of such a framework and acts as a visualisation, assessment and change management tool – recognised for its frequent use in studies that link business models to circular economy [22].

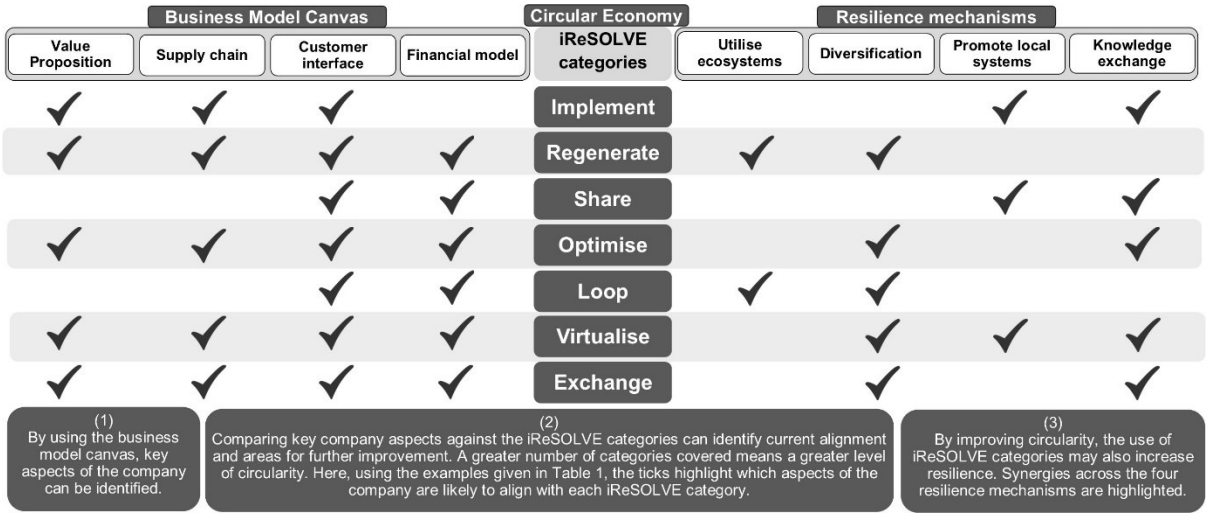


**Figure 1: Circular Economy-Resilience Framework for Business Models (CERF-BM)**. *Based on existing literature, the ticks on the left-hand side show which parts of the aggregated business model canvas are likely to align with the iReSOLVE categories. The right-hand side highlights the interactions between circular economy principles and the four resilience mechanisms (which are not specific to any one business model aspect).*

The canvas describes a business model through four areas: value proposition, supply chain, customer interface and financial model [16]. Value proposition is the value embedded within the product and/or service offered by a company, supported by both the supply chain and customer interface. The supply chain identifies in-house activities and upstream relationships with suppliers, whereas the customer interface identifies the structure and management of downstream relationships with customers. The financial model identifies the costs and benefits within the previous three areas and across associated stakeholders [23].

To assess business models against circular economy principles, and thereby facilitate change towards those principles, the iReSOLVE checklist was developed by the Ellen MacArthur Foundation [24] and later adapted by Fernandez Mendoza, et al. [15] to encompass seven categories: implement, regenerate, share, optimize, loop, virtualize and exchange. Supplementary Table 4 shows specific actions within each category and application of the iReSOLVE checklist to the seafood sector as a whole and to its two subsectors (capture fisheries and aquaculture), based on practical advice given to Fisheries Local Action Groups by Veronesi Burch, et al. [25]. With the exception of direct dematerialisation, businesses in capture fisheries and aquaculture could theoretically apply all seven iReSOLVE categories. For example, to promote actions that “Optimize”, companies would work to reduce the waste generated. To promote “Exchange” actions, businesses would diversify the technology and processes used and the products and/or services delivered.

To embrace circularity fully, all seven iReSOLVE categories should be considered and implemented, involving stakeholder engagement across the value chain. While the traditional structure and function of the seafood sector allow some actions to be realised, they limit the applicability of others. For example, the “Virtualize” actions naturally resist direct dematerialisation because the sector is based on the production, distribution and delivery of a physical item. However, the sector can achieve indirect dematerialisation by employing systems that manage these stages electronically or online.

After mapping a company using the business model canvas, the next stage of CERF-BM identifies the level of alignment with circular economy principles using iReSOLVE categories (or actions, for a more detailed perspective). Using the seafood-specific examples given in Supplementary Table 4, the ticks in Figure 1 show which parts of the aggregated business model canvas are likely to align with the iReSOLVE categories, i.e. which part of the business model would undertake these actions. A greater number of actions within a business model would achieve a greater level of circularity. To align fully with the circular economy, a business model would need to engage with all actions across the four aggregated business model blocks. The right-hand side of Figure 1 highlights the interactions between circular economy principles and the four resilience mechanisms. Resilience mechanisms are not specific to any one business model aspect but are instead applied across the whole company. Each of the iReSOLVE categories contributes differently to the four resilience mechanisms, with some contributing to more than one. To strengthen circularity or resilience, a business – after assessing its current business model against the

iReSOLVE categories – can implement any missing iReSOLVE actions to specific aspects of the business model. Alternatively, the business may choose to apply one or more of the resilience mechanisms across the whole company.

We test this framework through mapping seafood companies from the reviewed literature to the business model canvas, the iReSOLVE categories and the resilience mechanisms, aiming to detect whether and where the circular economy and resilience actions overlap (Figure 2). A comprehensive description of how we apply CERF-BM in three stages is supplied in the Supplementary Information.

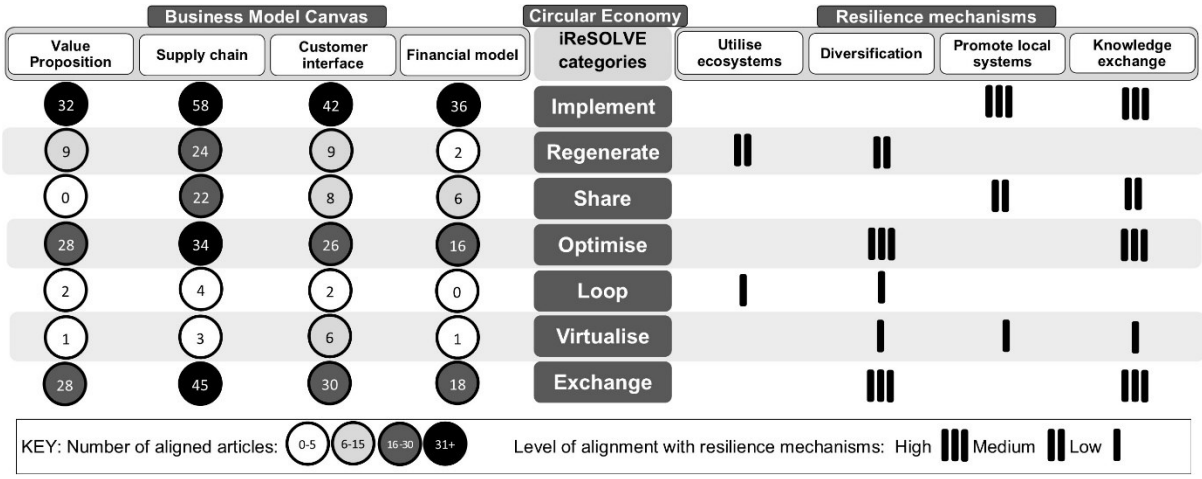


**Figure 2: Alignment of reviewed articles against the Circular Economy-Resilience Framework for Business Models (CERF-BM).**
*Number of articles where extracted text aligns specific business model aspects with the iReSOLVE categories (left-hand side) that, in turn, correspond to some of the resilience mechanisms (right-hand side).*

Overall, we found that research on business models within the seafood sector is an emergent theme. Among four types of business models [26], including product models, solutions models, matchmaking models and multi-sided models, the product models appear most frequently (see Supplementary Figure 2). Little research exists on matchmaking and multi-sided models in this sector, particularly on companies that source products exclusively from either a wild-capture source or through aquaculture.

We found a limited alignment of these business models with circular economy principles (see Supplementary Figure 3). Although the level of alignment differed between the companies, it was generally restricted to the actions needed to optimize non-circular business models. There was clear scope for improvement in recycling materials, extracting value from organic waste, and dematerialising the business models. The reviewed literature often failed to include the entire supply chain, particularly upstream stakeholders, and instead tended to focus on one company at a time and its customers, which can affect diversification and have consequences for both circular economy and resilience (Figure 3).

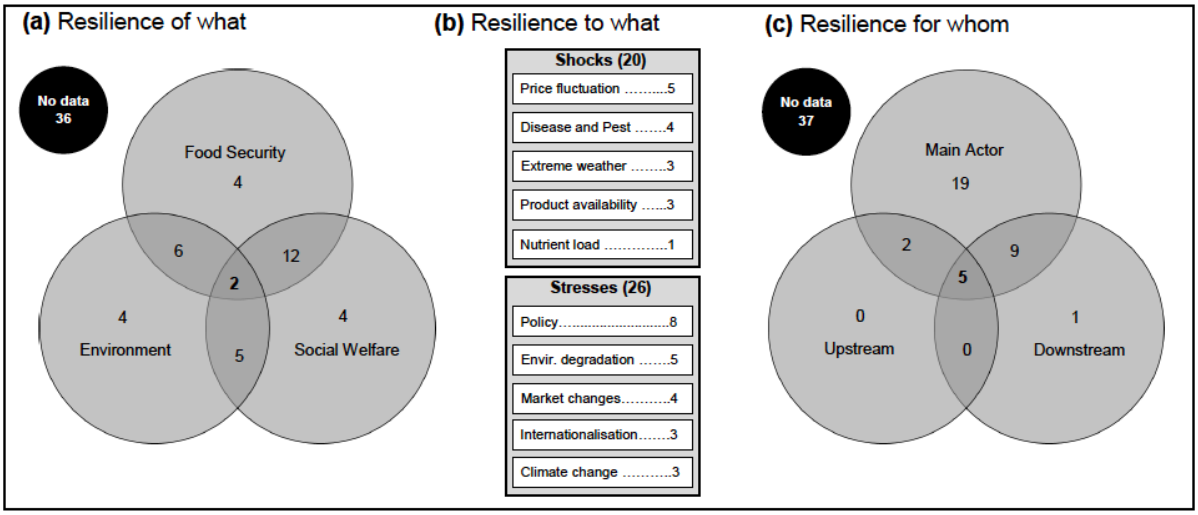


**Figure 3: Alignment of reviewed articles against elements of resilience.**
*Number of articles where extracted text aligns with the three elements of resilience: (a) resilience of what, (b) resilience to what and (c) resilience for whom.*

### Recommendations for business, policy and international cooperation

By applying the CERF-BM, our results suggest there might be a link between the concepts of circular economy and resilience. Business models that took actions towards circularity also tended to demonstrate enhanced adherence to resilience mechanisms. Consideration of circular economy principles should extend across supply chains, where companies should assess how well their suppliers and partners align with the circular economy. Assessment of supply chains should be tailored so that in the case of short supply chains, the focus is predominantly on reducing the impact (rather than the likelihood) of risks. Where it is not already happening, companies should ensure that other actors involved improve their resilience – and the resilience of the system as a whole – through greater collaboration and

knowledge exchange [27,28]. In the case of long supply chains, assuming that multiple actors and activities already include the diversity to reduce the impact of risks, the focus should be on assessing the multiple points of vulnerability, to reduce the likelihood of risks affecting the company and increasing the generalised capacity of the system to respond to unforeseen adverse events.

In a broader sense, the adoption of circular economy principles through a business model-based framework can help to displace these activities from a corporate social responsibility agenda and place them within mainstream business. While the principles of circular economy are designed for systemic change, the use of iReSOLVE actions facilitates implementation of specific activities at the company level that can contribute to this wider transition. Resilience mechanisms are also derived in response to systems-level vulnerabilities, and allow for business activities to be considered within the resilience of the wider system.

Although the implementation of environmentally and socially progressive activities may have longer-term benefits such as improved performance or higher product quality, the initial costs incurred, such as additional labour or expensive resources, may prove insurmountable for companies operating on tight margins [29]. Therefore, policy changes should be introduced at a governmental level to facilitate necessary changes in business. We recommend the development and introduction of policies rewarding business models aligned with circular economy principles and resilience mechanisms, and a high level of integration across governmental departments. For example, in the UK numerous departments including the Department for Environment, Food and Rural Affairs, the Department for Business, Energy and Industrial Strategy, Her Majesty's Revenue and Customs, and Her Majesty's Treasury influence activities within the seafood sector and will be required to develop, fund and regulate any policies promoting circular economy and resilience principles. Assigning cross-departmental policy teams to consider issues such as circular economy and resilience would facilitate a more joined-up effort than the traditional approach has enabled to date.

Cooperation across sectors, departments and organisations should take place at international level. Examples of international initiatives include the Marine Stewardship Council (MSC) for sustainable fisheries and the Aquaculture Stewardship Council (ASC) sustainable farms. While we acknowledge criticisms of certification schemes such as their

focus on the marketization of sustainability, their tendency to privilege higher income countries and questions over their ability to drive continued improvement post-certification [30-32], in principle the standards developed by MSC and ASC align with our recommendations above, such as a need to consider the full value chain. As a characteristic already identified within the sector, both councils tend to interpret sustainability as 'environmental responsibility'. However, within both sets of standards, other elements of sustainability, such as 'ongoing financial viability' and 'secure source of food' are also included. The circular economy terminology can help to interpret sustainability with some precision within existing standards. In addition, the CERF-BM can provide guidance for international and supranational policy levers such as in the development of EU procurement schemes [33,34].

The process of establishing a standard supports the collaboration and engagement of actors across the value chain [35]. While the early stages of production and capture within the value chain remain separate for aquaculture and wild caught fisheries, products from both chains tend to merge and compete with each other at the final distribution and retail levels [36]. Thus, the use of certification schemes across a range of products should address the complexity associated with different production stages. Particularly in the case of wild caught fisheries, the mobile, transboundary habit of target species creates further traceability and jurisdiction issues [37]. To date, the MSC and ASC have only one joint standard: the sustainable and socially responsible use of seaweed resources. With the growth of aquaculture expected to support the increased consumption of seafood in the future, additional joint standards should be published with the individual product focus of the ASC standards and the traceability endorsed by MSC standards. The publication of joint standards would also align with circular economy principles by implementing a wider vision, leveraging big data, employing full systems thinking and sharing assets. These interventions would be recommended alongside efforts to reform certification schemes and processes more generally, for instance by removing barriers for participation for smaller-scale businesses [38,39] and trialling alternative models of certification [31], particularly those that take account of variations in companies' size, resources and location [40].

The integration of circular economy principles with the concept of resilience should follow policy lessons from other grand societal challenges such as climate change. In particular, where the circular economy principles and resilience mechanisms do not overlap, they have parallels in climate change mitigation and adaptation: implementing the circular economy is equivalent to mitigation, while implementing resilience mechanisms is equivalent to adaptation. Climate change mitigation has so far been relatively underfunded [41], and it is

important for policy-makers to avoid this mistake when allocating resources to studying and implementing circular economy principles and resilience mechanisms.

**Limitations and implications for future research**

A key contribution of this review is the development and application of the Circular Economy-Resilience Framework for Business Models (CERF-BM) to compare business models identified within the literature. The literature reviewed derives from a clearly defined search strategy and, as such, results presented here are limited within these bounds. To broaden the scope of this work and to test the CERF-BM against a wider literature sample, the inclusion criteria could be expanded.

As with the application of any framework, limitations include time and resource requirements, generation of large amounts of data and legitimacy of data interpretation [42,43]. The integration of circular economy principles and resilience mechanisms within the framework is based on our own interpretation of secondary sources not originally designed to answer research questions on circular economy and resilience. Therefore, the integration of these two concepts would benefit from empirical evidence. Such primary data collection could include in-depth case studies of business models combining the two concepts. The focus could be, for example, on assessing how resilience mechanisms can enhance circular economy, to test whether the relationship between the two concepts is bidirectional. A more ambitious study could design a randomised control trial with companies allocated to one group implementing circular economy actions and another implementing resilience mechanisms. Future research could measure the resilience of companies implementing circular economy principles, and measure the circularity of companies implementing the resilience mechanisms. The CERF-BM only measures resilience with respect to food systems. While within the scope of this small-scale study a focus on the food sector only is appropriate, a cross-sectoral view of resilience may be required. This approach would support a systems perspective on the transition to a resilient circular economy.

Here, we explored one way of identifying resilience through the following operational framework: ‘resilience of what’, ‘resilience to what’, ‘resilience of whom’ and ‘over what timeframe’ [11]. Future research could draw on other conceptualisations of resilience, such as business resilience, social-ecological resilience or systemic resilience. It would be important to explore how standards and policies can comprehensively reflect the circular economy and

resilience mechanisms and their trade-offs. Further research should consider the costs of adopting such policies - and who is most affected by those costs - as part of assessing any unforeseen externalities resulting from new activities. Future policy research should focus on improving the current single-sector standards and on presenting empirical evidence of best practice for combining circular economy and resilience across multiple sectors within and outside seafood.

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## Acknowledgements

This research is part of the ‘Diverseafood: Evaluating the potential of multi-trophic aquaculture to improve nutrition and ecosystem sustainability in the UK’ research project funded by UK Research & Innovation (grant reference BB/S014144/1), and has benefitted from the supportive and collegiate atmosphere of the Tyndall Centre for Climate Change Research (Manchester). We are particularly grateful to Dr Sarah Mander for her thorough and insightful comments on a revised version of this paper.

## Author contribution statement

M.S. and C.A.F. conceived, framed and designed the research. C.A.F. conducted the literature search and analysis, and produced the figures. All authors jointly wrote the paper: C.A.F. led the writing; M.S. and R.S.C. contributed text and extensive comments on the structure and content of several drafts of the paper. M.S. supervised the research project.

## Competing interests

The authors declare no competing interests.