Conceptualising a Resilience Based Approach to Shipping Sustainability

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ABSTRACT

Similar to other organisations, for shipping companies to be sustainable, they need to persist and grow over time in the face of continuous change even though a variety of threats exist to their long term survival and growth. These threats can range from rapidly unfolding short term shocks such as industrial accidents, and natural or manmade disasters, to relatively slowly occurring stresses over the longer term such as climate change and regulatory changes. Sustainability therefore depends upon how shipping companies cope with shocks and stresses resulting from change. However, in the twenty-first century world characterised by complexity, volatility and uncertainty, conventional management techniques with their focus on linear, predictable change may be unsuitable for the sustainability challenge. This paper goes beyond the current broader societal focus undertaken by many organizations in general and the environmental focus of shipping sustainability in particular, to: (i) explore the relationship between resilience and sustainability; (ii) gather insights from studies of social-ecological systems to guide managers in developing strategies for creating sustainable and resilient shipping companies; and (iii) gain an understanding of sustainable shipping.

Keywords: Sustainability, resilience, shipping companies, social-ecological systems

1. INTRODUCTION

International trade is a key driver of economic prosperity, social development and poverty reduction. Since ancient times, international trade has been facilitated by ships bringing together goods, people, technology, knowledge, ideas and values from all corners of the world. In the modern era, ships have maintained their ubiquitous presence in global supply chains, carrying about 80 per cent of global trade by volume and 70 per cent by value (UNCTAD 2012). Today, as debate flourishes about international trade and its consequences on society and the environment, the shipping industry finds itself at the forefront of challenges and solutions for sustainable development. Shipping is an essential component of sustainable development because the world relies upon efficient transportation of goods and

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people by sea (Sekimizu 2013). In its role as the key enabler of international trade (Stopford 2009), the shipping industry has the potential to be a key contributor to anthropocentric sustainability, provided that the organisations who own, manage and operate ships – the shipping companies - are themselves sustainable.

The current discourse on sustainability in shipping is skewed towards the sustainability of the marine environment at the expense of shipping (see, for example, Gold 2006; ICS 2008). Societal interest is directed at the impact that shipping activities have on the marine environment such as operational and accidental discharge of oils and chemicals into the sea, emission of pollutants and carbon dioxide from marine diesel engines, transportation of alien invasive species through ballast water used by ships, ship sourced garbage, and damage to sea beds and coral reefs by anchoring and dredging activities. As a consequence, a culture of compliance has been created by governments and marine authorities through a regime of rules, regulations and codes (Kristiansen 2005) to reduce the impact of shipping on the marine environment (see, for example, AMSA 2013). However, compliance with environmentally friendly shipping practices enforced through regulations may not be sufficient to ensure the sustainability of shipping or the shipping companies. In its most basic form, sustainability implies persistence over time (Garrido 2009) and shipping companies, like many other organisations, face a variety of threats to their long term survival and growth. For shipping companies to be sustainable, it is crucial that they overcome such threats without much harm or failure as a business. If shipping companies are not sustainable and therefore unable to provide the type of transportation service that the world desires, it will be difficult for humanity to achieve its aspirational sustainable development goals. Therefore, the discourse on shipping sustainability must include sustainability at the organisational level and not just at the societal level.

The threats that shipping companies face to their survival and growth are varied and eclectic. Shipping companies have long been exposed to the perils of operating in the maritime environment and the consequences of losing their ships due to storms, navigation hazards, fires, collisions with other ships, piracy and similar events. However, the environment in which they operate today is increasingly shaped by socio-technological complexity (Perrow 1984), individual, organisational and community interconnectivity (Fiksel 2003), and volatility in natural, economic and social systems (Gibson & Tarrant 2010). As a consequence, new forms of threats have emerged and the nature of change itself has become more turbulent, complex and uncertain (Smith & Fischbacher 2009). Shipping companies face the risk of disruptions and threats of failure from rapid onset, low probability, high consequence short term events such as industrial accidents, natural disasters, financial meltdowns, sabotage and terrorism. However, they also deal with events occurring over the long term such as climate change, regulatory changes and market changes which are creating pressures that can only be relieved through adaptation, innovation, and in some cases a complete transformation of the company. Additionally, in today's globalised world, shipping companies are an integral part of global supply chains, with the consequence that even remotely occurring events such as pandemics or cyber failures have the potential to cause wide spread disruption and chaos as their effects cascade through interlinked supply chain partners. Adding to the complexity is the reality that whereas in the past societal interest in shipping was mainly directed towards prevention of catastrophic accidents, shipping company practices are now coming under increased scrutiny through the lenses of corporate social responsibility and sustainable development. Essentially, the challenge of managing shipping companies for sustainability in the twenty first century is to ensure that they survive

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and thrive in the long term in the face of changes that at times can be slow and predictable but at other times turbulent and unpredictable.

The standard human approach to sustaining what humans find valuable is to reduce risk and vulnerabilities, and to become more efficient in crisis response (Martin-Breen & Anderies 2011). Conventional management techniques are largely designed to ensure organisational stability, efficiency and predictable performance based on the assumption that organisations are like machines (Jansen, Cammock & Conner 2011). However, in a rapidly changing world where organisational vulnerabilities are increasing (Gibson & Tarrant 2010) and unpredictable change is a more accurate reflection of today's operating environment (Friedman 2005), traditional management approaches may be of limited value when unanticipated threats occur (Parsons 2010). As organisations behave less like machines and more like complex adaptive systems (McDaniel 2007), the dynamic nature of emergent properties in complex systems makes it difficult to design systems that can anticipate all future disruptions (Fiksel 2003). However, there now exists a body of literature that is based on a view of the world in which humans and ecological systems are inextricably linked in the form of social-ecological systems (SES) that are also complex adaptive systems (Walker & Salt 2006). According to this body of literature, system sustainability is determined by the manner in which the system navigates through shocks and other disturbances even as it continually adapts through cycles of change (Walker & Salt 2006). In the SES literature, the key to a system's sustainability lies in its resilience – the ability of a system to absorb disturbance and still retain its basic function and structure (Folke 2006). This paper gathers insights from the concept of resilience in SES literature to discuss how shipping companies may be managed for sustainability through greater understanding of system dynamics and the nature of change.

2. THEORETICAL FOUNDATIONS

Schoon (2005, p. 3) explains that most sustainability focussed definitions of resilience relate to a system being exposed to stress, disturbance, change, perturbation or similar influence where resilience is the ability of the system to 'rebound, return, or recover its original state, structure, equilibrium, or state of nature or to persist, maintain, retain, or remain in its original state'. In the SES literature, resilience and sustainability are conceptualised under four key ideas. First, SES can exist in more than one kind of stable state (Holling 1973) and resilience is defined and determined by the location of the SES relative to the thresholds that form the boundaries of alternate stable states (Folke 2006; Gallopín 2006; Gunderson 2000; Holling 1996). Second, SES change over time and can be conceived as continually moving between four phases of a cycle known as the adaptive cycle (Berkes, Colding & Folke 2003; Holling 2001). Third, adaptive cycles operate over different temporal and spatial scales and the linkages between the scales affect the dynamics of the whole set – the set being called a panarchy (Gunderson & Holling 2002). Fourth, for a fuller understanding of SES sustainability, the notion of resilience as persistence must be considered together with related concepts of adaptability and transformation – collectively referred to as resilience thinking by Folke et al. (2010). The following subsections explain these principles in more detail.

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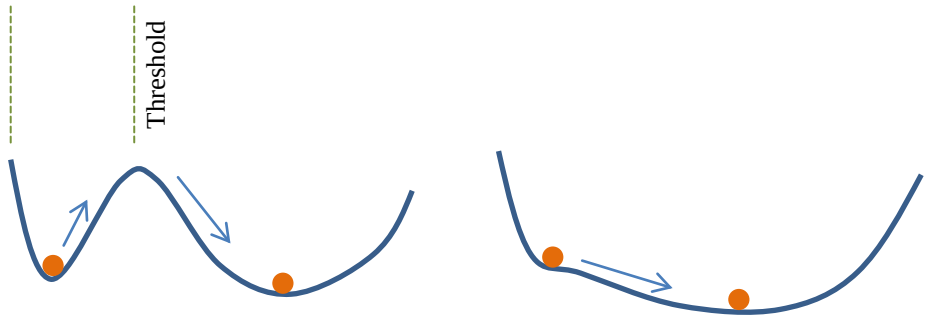
2.1 Thresholds and resilience

The first key idea of SES relates to the use of the concepts of basins of attraction and thresholds to explain resilience. The state of a system at any given time is defined by the current values of variables that constitute the system (Gallopín 2006). The aggregate of all the possible states resulting from combinations of the variables can be represented as the state space of the system (Walker et al. 2004). Within the state space, a basin of attraction is a region which contains an attractor towards which the system tends to remain in equilibrium or return following a disturbance (Gallopín 2006; Walker et al. 2004). Therefore, a basin of attraction corresponds to a stable state of the system. The state space may contain multiple basins of attraction corresponding to alternative stable states (Holling 1973).

A useful way to illustrate basins of attraction is by using a ball and cup analogy (Gunderson 2000; Holling 1996). As shown in Figure 1, the ball represents the system state, the cups represent basins of attraction, and the lowest point in each cup represents the attractor for that basin. When the ball is at the bottom of the cup, it is in a stable state. If disturbed, the ball will tend to roll back to the bottom of the cup. The ball can be moved to another basin provided the disturbance is large enough to make the ball cross the threshold of the basin. Another way to move the ball into the next basin is by altering the shape of the basin.

Figure 1
Ball and cup analogy of system stability



(a) Transition due to disturbance

(b) Transition due to changed landscape

Source: Adapted from Gunderson (2000, p. 427) and Holling (1996, pp. 34-35).

In one of the most cited papers in the journal *Ecology and Society* (Folke et al. 2010), Walker et al. (2004, art. 5) define resilience as 'the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks'. This definition highlights that the resilience of a system is the system's ability to persist within a particular basin of attraction. Hence the size of the basin and the position of the system relative to its thresholds determine how much disturbance the system can absorb before it gets pushed into another basin of attraction. The

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deeper the basin, the more difficult it is to change the system. The wider the basin, the more the number of states the system can exist in while still maintaining its identity.

2.2 The adaptive cycle

The second key idea of SES resilience and sustainability concerns the adaptive cycle. The adaptive cycle is conceived as a continuous cycle of growth, maturity, crisis and renewal where sustainability means a persistent pattern of change rather than a steady state (Holling 2001). In the adaptive cycle, a system commonly moves from a phase of growth where resilience is high and resources freely available, into a phase where there is little flexibility due to increasing rigidity of the system, followed by a sudden collapse into a phase of chaotic dynamics that finally leads to a phase of reorganisation (Berkes, Colding & Folke 2003; Darnhofer, Fairweather & Moller 2010; Folke et al. 2010; Holling 2001; Pisano 2012). The four phases are referred to as exploitation, conservation, release and reorganisation phases respectively (Holling 2001). As shown in Figure 2, the exploitation and conservation phases form the forward loop that is characterised by a fairly predictable pattern of growth whereas the release and reorganisation phases form the back loop characterised by unpredictability and reorganisation (Scheffer 2009). SES spend most of the time progressing along the forward loop, becoming increasingly efficient but less flexible until inevitably, the conservation phase ends, triggered by a shock (Walker & Salt 2006). The longer the conservation phase, the smaller the shock required to end it (Walker & Salt 2006).

The adaptive cycle model however, may not necessarily represent all the different types of cycles that the SES may go through, but it does highlight that specific events, such as crises, may be viewed not as end points, but as one phase of a cycle (Berkes, Colding & Folke 2003). The adaptive cycle model emphasises that crises may create the opportunity for innovation (Scheffer 2009). Also of note is that a system does not necessarily follow the sequence of phases illustrated in Figure 2. Systems can move from any one phase to another except from the release phase back to conservation phase (Pisano 2012; Walker et al. 2004). This means that clever managers of ecosystems and organisations are able to move the system back to the exploitation phase from the conservation phase by generating small scale release and reorganization phases (Walker and Salt 2006). The importance of scales in relation to system dynamics is further examined in the following section.

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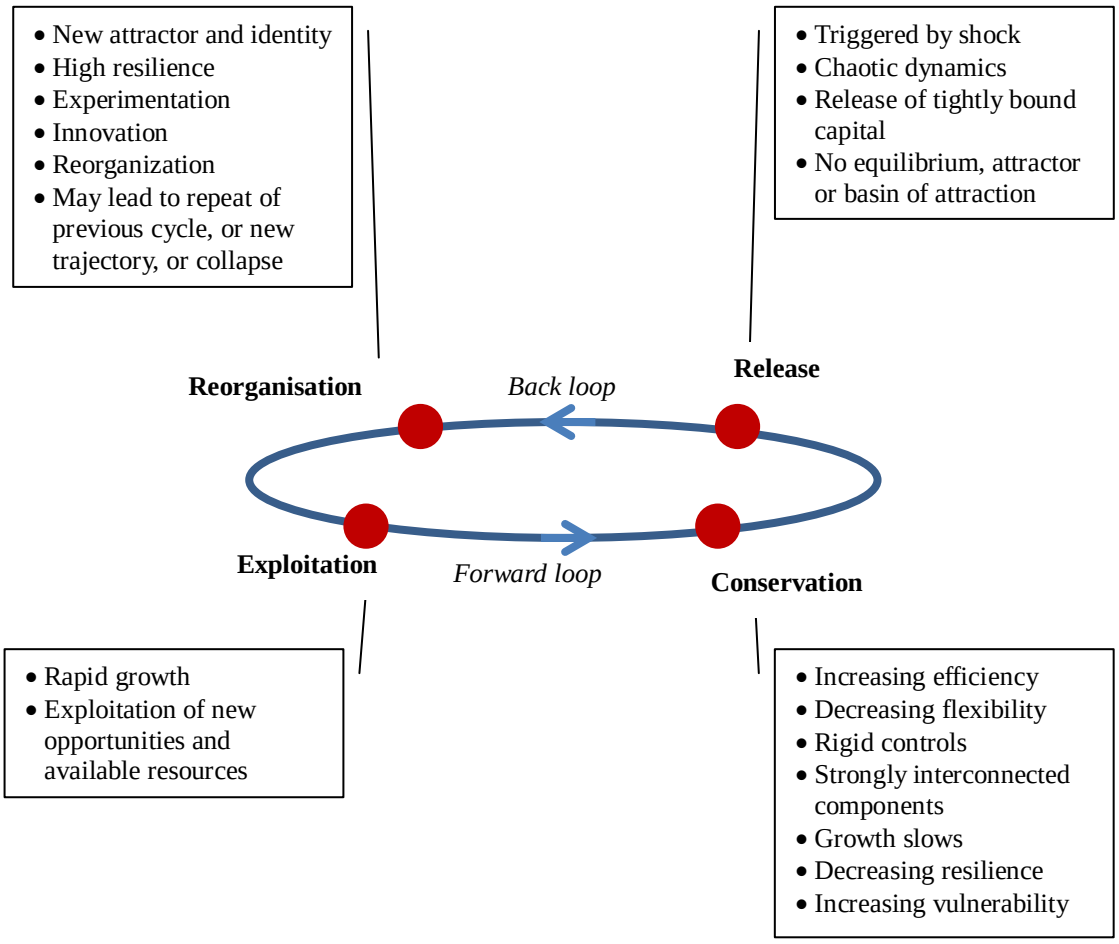
Figure 2
The adaptive cycle



Source: Adapted from Berkes, Colding and Folke (2003); Darnhofer, Fairweather and Moller (2010); Folke et al. (2010); Holling (2001); Pisano (2012).

2.3 Panarchy

In the third key idea within SES, adaptive cycles operate over many different temporal and spatial scales, which is represented by 'panarchy', a hierarchical set of nested adaptive cycles (Gunderson & Holling 2002) as shown in Figure 3. According to Holling (2001) the sustainability of a system is determined by the functioning of these cycles and the communication between them. Two interactions between the adaptive cycles at different levels of the panarchy, 'revolt' and 'remember', are particularly important. The revolt interaction represents the situation whereby a critical change in one system, which is at the release phase of its cycle, may cascade up to the next higher and slower level and trigger a crisis at its conservation phase where resilience is low (Folke 2006; Holling 2001). The remember interaction represents the situation whereby a system, which is at the renewal phase of its cycle following a crisis, may be able to draw upon the potential accumulated and stored by the larger slower level above it which is at its conservation phase (Folke 2006; Holling 2001). The memory of the system, that is, its accumulated experience and history,

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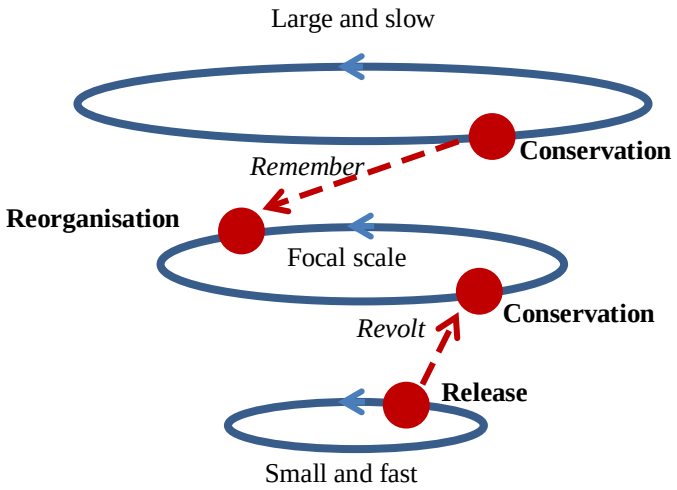
provides the source for renewal and reorganisation following a disturbance (Berkes, Colding & Folke 2003; Pisano 2012). A healthy system is invigorated from below by smaller, faster cycles of innovation, while being protected by the accumulated processes and resources of the slower, larger levels above (Holling 2001). The cross scale interactions in panarchy illustrate how sustainability is affected by the interplay between change and persistence. Innovations and new ideas created during the release and renewal phases of the adaptive cycle drive changes at the scale above via the revolt connection, whereas persistence is facilitated by the remember connection (Holling 2001).

Figure 3
Panarchical connections



Source: Adapted from Holling (2001, p. 398)

2.4 Adaptability and transformability

The fourth key idea in SES sustainability concerns the role and influence of human actors. Although by definition complex adaptive systems as a whole self-organise without intent, the human actors in the system do exhibit intent and their actions affect resilience (Walker et al. 2004). There are three possible scenarios that may influence human actions. In the first scenario, a system may be located within a desirable basin of attraction. In this case, managers may attempt to increase resilience by making the basin wider and deeper as well as changing the current state of the system so that it moves further away from a critical threshold. In the second scenario, a system may be located in an undesirable basin, where the management actions may be targeted at overcoming the resilience of the system so that it crosses a threshold into a desirable basin. The capacity of humans in a system to influence resilience is termed 'adaptability' (Walker et al. 2004). In the third scenario, a system may be so deeply entrenched in an undesirable basin that it may become necessary to reconfigure its entire stability landscape by introducing new state variables. Walker et al. (2004, art. 5) term the capacity to create a new stability landscape 'transformability' or 'the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable'. Thus, the notions of resilience, adaptability, and transformability together constitute a theoretical framework for understanding system

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dynamics and sustainability (Folke et al. 2010). Scale is the distinguishing feature between resilience, adaptability and transformability. Resilience relates to one basin of attraction whereas adaptability spans multiple basins of attraction of a system. Transformability on the other hand relates to the change of the system itself. Fundamentally, managing for transformation is similar to managing for resilience except that the system is viewed at a different scale (Martin-Breen & Anderies 2011). However, the placement of thresholds around the concept of resilience makes it less abstract and thereby less likely to be difficult to measure and operationalize.

In order to manage for sustainability, managers may find it helpful to have a good understanding of the four key ideas described above. As previously discussed, resilience is defined by thresholds. Sustainability depends upon knowing where the thresholds are (Walker & Salt 2006) and having the capacity – adaptability and transformability - to keep the system in a desirable basin with reference to these thresholds. Understanding how and why systems change on different spatial and temporal scales may help in identifying where, when, and what kind of management strategies are likely to be effective or not (Walker & Salt 2006).

3. APPLICATION OF SES RESILIENCE CONCEPTS TO SHIPPING

The concepts and metaphors of resilience thinking such as basins of attraction and adaptive cycles can be useful in understanding and explaining the dynamics of change in shipping. For example, Table 1 uses the ball and cup model to illustrate how liner shipping[1] changed from a loose break bulk dominated service in the 1950s to a containerised service by the end of the twentieth century. In the post World War II years, liner shipping serviced the demand for the transport of manufactured goods by utilising the general cargo ships. Although such ships were versatile, cargo handling was slow, labour intensive and likely to damage the cargo. By the 1960s, the landscape had begun to change with the most notable change being the increasing use of the shipping container. Once globalisation of production created global supply chains and businesses started to implement just in time inventory strategies, general cargo ships were no longer able to provide the desired reliability and speed of transportation. Specially built cellular container ships designed to handle and carry shipping containers, together with the installation of specialised container handling infrastructure at container ports, came to dominate liner shipping and do so to this day.

[1] Liner shipping is the segment of the shipping industry which transports general (break bulk) cargo, usually manufactured and semi-manufactured goods, on ships with fixed routes and schedules.

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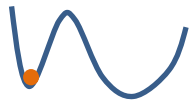
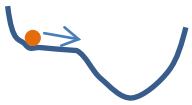
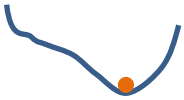
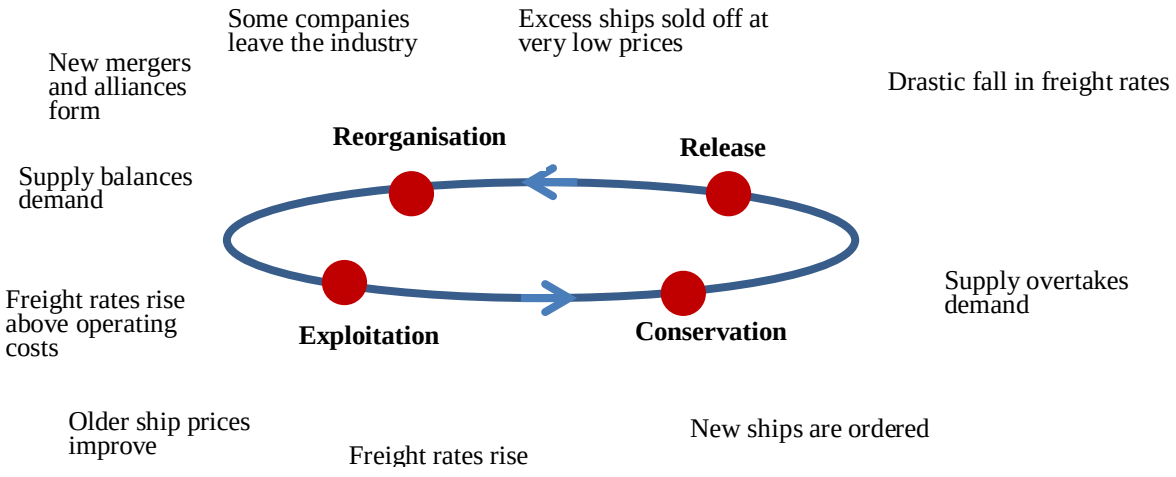
Table 1
Change in liner shipping from loose break bulk carriage to containerized carriage

Break bulk liner shipping	Changing landscape	Disturbance	Containerised liner shipping
1950s	1960s	1980s	1990s+
			
Demand for transport of goods manufactured in industrialised economies Domination of general cargo ships	Innovations in transport technologies Development of shipping container Lowering of transportation costs Growth in intermodal transport	Globalisation of production Establishment of global supply chains	Demand for fast, reliable, low cost transport for manufactured goods Domination of cellular container ships

Source: Adapted from Adger (2007, p. 81)

Similarly, the four stages of a typical shipping market cycle (Stopford 2009) can be related to Holling's (2001) adaptive cycle model as shown in Figure 4. Shipping cycles are the emergent features of the interactions between actors such as shipping companies, shippers, ship builders and ship recyclers. Although they interact with each other, the actors act independently and respond differently to change. It is difficult to predict the cycle by studying the behaviors of individual groups of actors. Thus uneven supply and demand for shipping services creates boom and bust conditions leading to wide variations in the income earned by shipping companies at different stages of the cycle.

Figure 4
Typical shipping market cycle



Source: Adapted from Stopford (2009, p. 98)

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Not only does resilience thinking offer a framework to understand the dynamics of change in shipping, it may also provide guidance for managing shipping companies for sustainability. Resilience thinking shuns a command and control type management style and instead focusses on adaptation, innovation and transformation (Walker & Salt 2006). In order to be sustainable, shipping companies need to be able to absorb shocks, adjust to changing environment, and transform themselves to a new identity if conditions make the current state untenable. There may be times when a shipping company may already be following a trajectory desired by its stakeholders. Sustainability strategies in such cases may aim for resisting change that threatens the achievement of organisational objectives. Managers may aim to keep the organization within the forward loop of the adaptive cycle by a judicious use of strategies that increase efficiencies but not at the cost of the ability to exploit new opportunities. At other times, changes in stakeholders' expectations for example, may create the need for new organisational objectives and strategic vision. In such cases, shipping companies will need to draw upon their adaptive capacity to adjust to the new norm. Resilience may deliberately need to be lowered so as to enable the organization to easily cross the threshold into a new desirable basin of attraction. Finally, when environmental conditions create such severe pressure that adaptation may be insufficient for survival, shipping companies may need to transform themselves by diversifying into activities beyond the scope of conventional shipping. Transformation goes to the very heart of the reason why an organisation exists – effectively changing its mission.

Based upon the nature of change (stress or shock) and the response approach (persistence on current trajectory or adaptation), Darnhofer, Fairweather and Moller (2010) identify four strategies that may be employed by shipping companies to successfully manage change. The four strategies – exploit, adjust, absorb and transform – are summarised in Table 2. The differences between the strategies highlight the point that no shipping company can be sustainable if it just relies on one type of strategy exclusively. Systems are continuously undergoing change and companies need to choose or alter their strategies accordingly. As mentioned previously, the fundamental choice is between persisting within the current basin of attraction, crossing the threshold to a more desirable basin, or transforming to a new identity altogether. The exploit strategy may be useful at the early stages of the forward loop of the adaptive cycle where predictable slow change makes improving efficiencies through specialisation and economies of scale an attractive proposition. However, managers need to be mindful of the dangers of excessive focus on efficiency: decreasing flexibility, decreasing resilience and increasing vulnerability to disturbances. The absorb strategy may be suitable for specific threats that are identified with reference to the key variables that affect the state of the company. The adjust strategy may be useful in taking the company from the conservation phase back to the exploit or renewal phase of the adaptive cycle. The adjust strategy facilitates the transition to a new basin of attraction. Finally, the transform strategy represents an altogether new trajectory for the company.

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Table 2
Strategies for managing change

Nature of change	Approach	Strategy	Description
Stress (predictable, slow change)	Persistence: little or no change	Exploit	The shipping company exploits its current strengths suited to the present environment and predictable change. E.g. focus on efficiencies, specialisation and economies of scale.
Shock (sudden, major disturbance)	Persistence: little or no change	Absorb	The shipping company absorbs shock without changes being required. E.g drop in freight rates is absorbed due to financial health.
Stress (predictable, slow change)	Adaptation	Adjust	The disturbance requires adjustment by the shipping company. This may involve changes to its resources and activities. E.g. replacing older ships with newer, more environmentally friendly ships, introduction or removal of trading routes, entering or leaving particular shipping segments, product differentiation.
Shock (sudden, major disturbance)	Adaptation	Transform	Conditions make the existing state untenable. The shipping company transforms itself to a new identity. E.g. diversifying into multi-modal transport.

Source: Adapted from Darnhofer, Fairweather and Moller (2010, p. 193)

4. CLOSING COMMENTS

The notions of resilience and sustainability, as conceptualised for SES, can provide valuable insights to managers of shipping companies. It is important to ascertain the thresholds that define the strategic vision of the company. Managers need to identify the variables that affect the state of their company and then determine the present state of the company in relation to the thresholds as indicated by the status of those variables. However, managers need to be aware that managing for resilience goes beyond managing for specific variables and disturbances (Walker & Salt 2006). Resilience against unforeseen disturbances can be enhanced by addressing those characteristics of the conservation phase of the adaptive cycle that reduce resilience: efficiency, rigidity of controls, and interconnectedness of components. Situational awareness of the system and its panarchies including exogenous and endogenous factors that may cause disturbances, as well as the capability to implement an appropriate response strategy are the two other factors that may influence how effective managers are in managing for sustainability.

Martin-Breen and Anderies (2011) suggest that outside of SES, there is little empirical support for how complex adaptive systems should be managed in other fields. More studies are needed to examine whether there is a clear link between resilience thinking and sustainability in the management of shipping companies. As stated in the introduction, the current discourse on shipping sustainability neglects sustainability at the organisational level. Insights from SES literature may lead to the first steps in providing an alternative approach to increasing the awareness of shipping companies in relation to becoming sustainable organisations. To build on this approach will require further studies on: the construct of resilience and sustainability in shipping; the relationship between resilience and

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sustainability; indicators of resilience; costs of developing resilience capabilities; managerial interventions to avoid undesirable basins; case studies of sustainable shipping companies.

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