# Ships of Change: Why Seafaring Needs to Embrace Innovation

**Prashant Bhaskar, Dr Stephen Cahoon, and Dr Benjamin Brooks**

Australian Maritime College

The modern seafarer works in an increasingly regulated environment. Whether it is navigation of the ship, operation and maintenance of machinery and equipment, or carriage of cargo, a significant amount of the modern seafarer's work is related to compliance with prescriptive rules, regulations, guidelines and codes. These prescriptive requirements arise largely out of international conventions and codes, developed with the aim of improving safety and security of shipping, managing risk and preventing marine pollution by ships. As a consequence, seafarer training tends to produce seafarers who can scrupulously follow procedures, maintain systems, and respond predictably to shipboard emergencies. This approach results in an inflexible command and control type manner of operating ships whereby there is a preoccupation with process, but novelty and change is discouraged. However, the twenty-first century shipping company operates in an environment characterised by volatility in natural, economic and social systems. In order to be sustainable, the modern shipping company needs to be resilient to change that is dynamic, turbulent, uncertain and unpredictable in nature. Research suggests that the ability to innovate is a key determinant of resilience, and hence sustainability, of complex adaptive systems. This paper argues that seafarer training should place greater emphasis on learning, experimentation and exploration of opportunities during periods of change. The paper explores: (i) how shipboard innovation may contribute to the sustainability of shipping companies and hence the sustainability of the shipping industry itself; (ii) the barriers to shipboard innovation; and (iii) how shipboard innovation may be facilitated through education and training of seafarers.

***Keywords***: innovation, sustainability, resilience, seafarers, shipping companies, seafarer's education and training

## 1. Introduction

Shipping companies face a varied and eclectic mix of challenges to their survival and growth. Since the dawn of civilisation, ships have plied their trade across the seas; braving the elements and often sailing into unexplored and uncharted waters. Many of the risks taken by mariners and ship owners in the preceding millennia would be considered unacceptable by twenty-first century corporations. However the nature of shipping is such that even today, a ship's voyage is sometimes referred to as a marine adventure. As Malbon and Bishop [1] explain, a marine adventure occurs because a ship is exposed to maritime perils that include, according to the quaint description in section 9 of the *Marine Insurance Act 1909* [2], 'perils of the seas, fire, war perils, pirates, rovers, thieves, captures, seizures, restraints, and detainments of princes and peoples, jettisons, barratry' among others. Shipping companies undoubtedly face serious consequences if they lose their ships due to storms, navigational hazards, fires, collisions, piracy and similar events. However shipping accidents are not the only type of challenge to the well-being of modern shipping companies. Similar to other 21st century organisations, shipping companies are confronting a complex competitive environment shaped by globalisation and technological advances [3]. In the modern era, volatilities in natural, economic and social systems are leading to new forms of challenges and the nature of change itself has become more turbulent, complex and uncertain [4]. Thus, events such as financial meltdowns, sabotage, terrorism, climate change, market ups and downs, geo-political upheavals, and regulatory changes, can lead to unexpected and unpredictable consequences. Greater individual, organisational and community interconnectivity [5] is further adding to the complexity. In today's world of global supply chains and interconnected networks, even remotely occurring events such as pandemics or cyber failures have the potential to cause widespread disruption and chaos as their effects cascade through interconnected entities including shipping companies. The challenge for modern shipping companies is to survive and grow in this complex, dynamic and highly competitive environment. In such an

environment, conventional risk management techniques that rely on mitigating identifiable risks may be inadequate to cope with change that is unpredictable, full of surprises, and hence difficult to prepare for.

Solving complex problems requires a different approach to solving lesser problems. Consider the following simple example - the failure of an electrical power generator on a ship. If the failure occurs while a ship is tied to a wharf, the most significant consequence might be the financial loss due to delays in cargo operations. This problem is best solved by a suitably trained engineer or mechanic following the prescribed process for diagnosis of fault and rectification. The solution required to fix the generator is the same regardless of the location of the ship or the time when the mechanic or engineer is available. On the other hand, the solution for a complex problem is sensitive to time and context [6]. Thus, if the electrical power generator fails while the ship is approaching the busy entrance to the Port of Singapore, it becomes a complex problem. From the perspective of the ship's crew, dealing with the problem will require an evaluation of traffic conditions, navigation hazards, state of weather and visibility, manoeuvring options, capabilities of the ship, and communications options, requirements that may sit outside usual procedures, for example, the crew may need to quickly learn from feedback and adapt their behaviour to suit the unexpected context. The result may be a novel action which does not exist in text-books, but is nevertheless necessary to keep the ship safe at that particular time and place. Similarly, when considering management at the organisational level, reliance on existing procedures and knowledge may be inadequate to meet challenges of the modern era that typically demand an adaptive approach requiring new learning, innovation and patterns of behaviour [3].

Jansen, Cammock and Conner [7] suggest that viewing organisations as systems similar to the complex adaptive systems (CAS) found in the natural world may help develop organisational capacity to adapt to complex and changing conditions. CAS are complex because their components interact in a dynamic fashion so that system behaviour cannot be understood or predicted by studying individual components of the system [8]. CAS are adaptive because they can self-organise in a dynamic and innovative manner in response to threats and opportunities [7]. Scholarly literature on CAS can be a rich source of information to guide management thought and practice. However, it is beyond the scope of this paper to discuss how the full range of insights from CAS literature may be applied to the management of shipping companies. Instead, this paper examines how shipping companies may benefit from understanding how healthy CAS utilise their capacity to innovate to be sustainable.

## 2. The shipping company as a CAS

A shipping company may be conceptualised as a system by identifying it as a multicomponent entity that can be distinguished from its surrounding environment [9]. Similar to other business organisations, the boundaries of a shipping company are defined by the assets that it owns such as ships and buildings, as well as through its employment contracts with its employees [10]. The components (or agents) may be identified with reference to these organisational boundaries [10]. Depending upon the level of analysis, the agents in a shipping company may be identified as, for example, individual employees, seafaring staff, non-seafaring staff, administrative units or functional units. Similar agents can be identified within the sub-systems of the shipping company, that include its ships. The agents, that may act in self-interest, make local decisions from local information, but are interdependent and therefore influence each other [6]. It is the way that the agents interact and the results of such interactions that makes the system complex [11].

Complexity arises from the interconnectedness between the agents and the many possible alternative states in which the system or its components may exist [6]. In a complex system, inputs are changed to outputs in a non-linear way because the agents interact with one another via a web of feedback loops [12]. Non-linearity means that outputs are not proportional to inputs - some inputs are magnified (positive feedback) while others are counteracted (negative feedback) [6]. Figure 1 represents a shipping company as an open system that is in a constant process of taking inputs from its

environment and returning them as outputs. For simplicity, the shipping company is shown as having just four agents corresponding to its major functional units – ship operations, technical management, commercial management and human resource management. Double headed arrows indicate that each exchange of matter, energy and information contains a feedback loop. The shipping company, input suppliers and output receivers all interact with, and influence, not just each other, but also the wider ecological, social and economic environments. Therefore the system can only be understood in the context of its environment [13]. In order to understand system behaviour, it is more useful to study the interrelationships and interactions between the agents rather than the agents themselves [13].

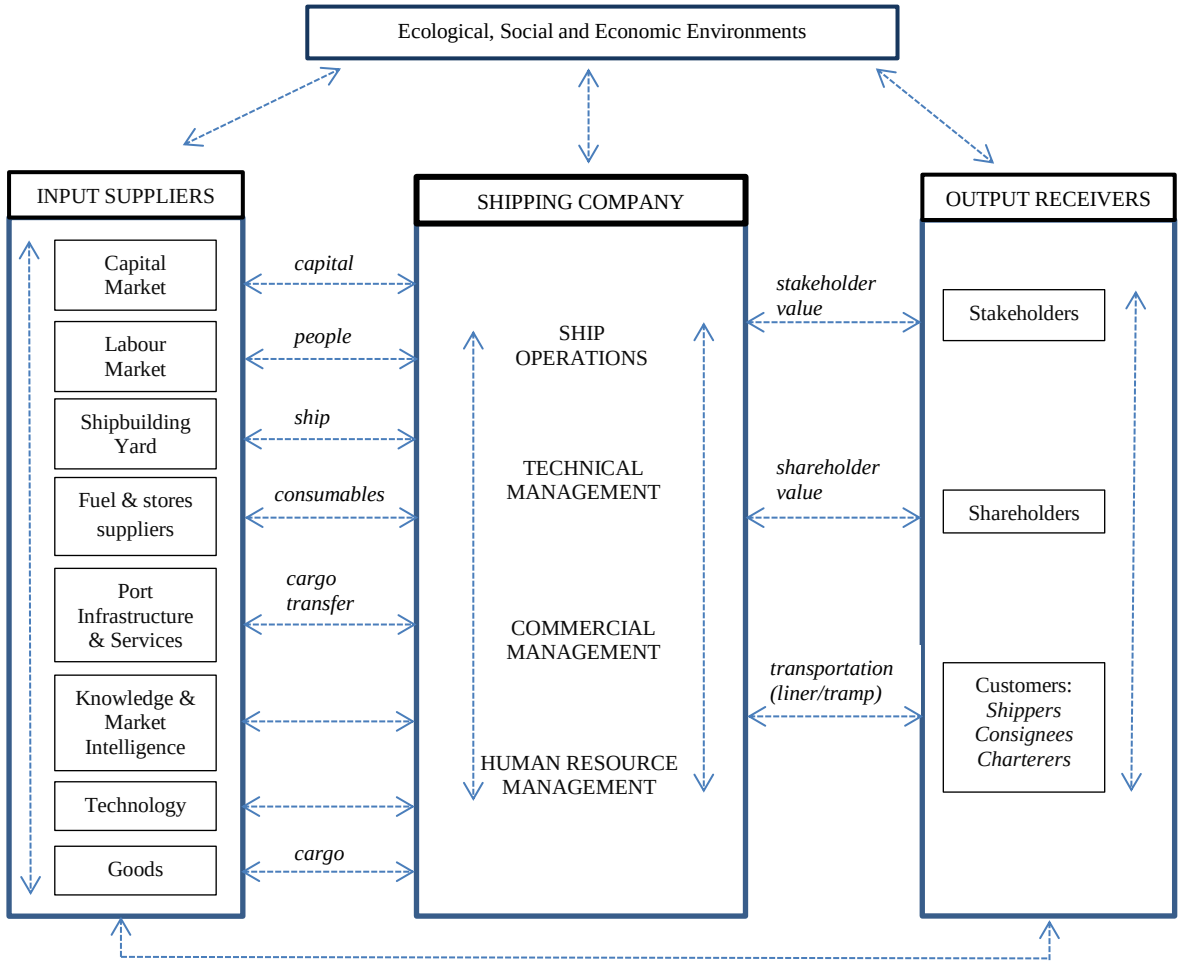


**Figure 1 A systems view of the typical shipping company**
Adapted from: [14; 15]

A characteristic feature of CAS is the phenomenon of self-organisation [12]. Self-organisation refers to the formation of holistic patterns of structures or behaviours from individual agents acting in their own interest, but little direction from the top hierarchy [11]. Even though the agents act independently, self-organisation occurs as a result of positive feedback loops whereby some behaviours are amplified over others, leading to collective behaviour [12]. In response to a threat or opportunity, independent agents self-organise to create emergence [7]. To illustrate, consider a hypothetical scenario of four ships converging at a single point from four different directions – north, south, east and west. In accordance with the international rules for preventing collisions at sea, each ship will alter course to starboard and attempt to pass astern of the ship on its starboard side. As a result, collectively the ships will move in a circular pattern as if they were going around a traffic roundabout.

## 2.1 Sustainability of CAS

Studies of social-ecological systems (SES) that are also complex adaptive systems, suggest that system sustainability is determined by the manner in which a system navigates through shocks and other disturbances while continually adapting itself through cycles of change [16]. In the SES literature, the essence of making sense of a system's sustainability lies in understanding its resilience – the ability of the system to absorb disturbance and still retain its basic function and structure [17]. System resilience is challenged by SES changing over time, continually moving between different phases of a cycle called the adaptive cycle [18; 19].

The adaptive cycle is a continuous cycle of growth, maturity, crisis and renewal where sustainability depends upon persistent change rather than a steady state [19]. In the adaptive cycle, a system commonly moves through four phases - a phase of growth where resilience is high, into a phase where the system becomes more rigid and less flexible, followed by a sudden collapse into a phase of chaotic dynamics that finally leads to a phase of reorganisation [18; 19; 20; 21]. The four phases are referred to as exploitation, conservation, release and reorganisation phases respectively [19]. The so called forward loop of the adaptive cycle is formed by the exploitation and conservation phases and is characterised by a fairly predictable pattern of growth [22]. The release and reorganisation phases form the back loop that is characterised by unpredictability and reorganisation [22]. SES spend most of the time progressing along the forward loop, becoming increasingly efficient but less flexible until inevitably, a shock triggers the start of the release phase [16]. The more efficient the system, the less is its resilience [16].

Many resilient systems go through these four phases over and over again [18]. However many systems do 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 [23]. Moreover, the reorganisation phase may lead to either a repeat of the previous cycle, or a new trajectory, or collapse. Human agents in a system play an important role as they have the ability to anticipate and act with intention [24]. Although CAS cannot be controlled in the traditional management sense, they can be managed [13]. Managers can utilise CAS characteristics to their advantage rather than trying to overcome them [25]. Applying the adaptive cycle metaphor to the management of shipping companies, one can assume that managers will try to avoid the back loop where, following a crisis situation triggered by shock, the shipping company may end up collapsing rather than reorganising as desired. This is indicated by the dashed arrow in Figure 2.

During the conservation phase, a growing business starts to move towards more specialisation and greater efficiency at the cost of decreasing flexibility and redundancy [16]. This is in contrast to the exploitation phase where innovators and entrepreneurs seize new opportunities and the business grows rapidly [16]. Therefore, the key to sustainability lies in ensuring that inventions, experimentation and creative ideas that are associated with the reorganisation phase, continue to provide fuel for growth and thus prevent the system from becoming too rigid and less resilient. The challenge for managers is how to create the right environment for innovation without the whole organisation undergoing the trauma of broken structures, networks and release of capital associated with the release phase. Walker and Salt [16] suggest that managers may be able to move the system back to the exploitation phase from the conservation phase by generating small scale, rather than system-wide release and reorganization phases.

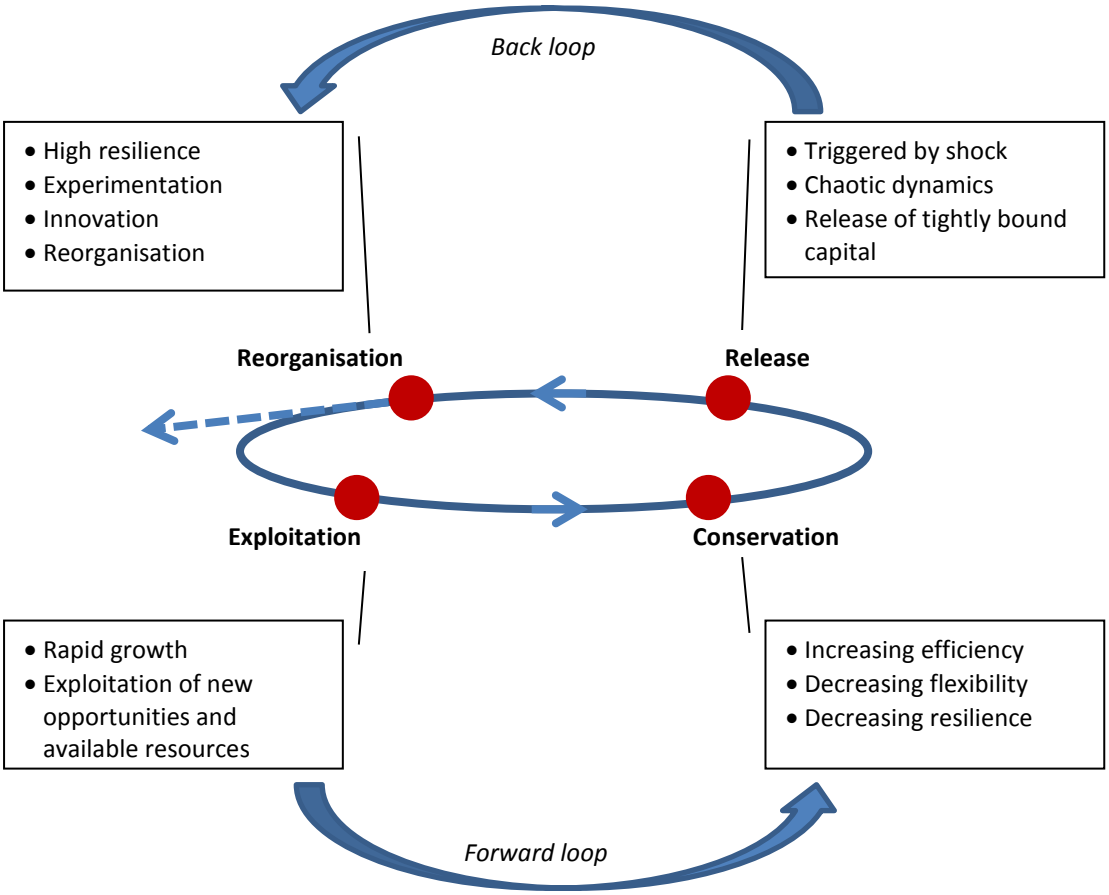


**Figure 2 The adaptive cycle**
Adapted from: [18; 19; 20; 21; 26]

In SES literature, scales are conceptualised as a 'panarchy' which is described as a hierarchical set of nested adaptive cycles operating over many different temporal and spatial scales [27]. According to Holling [19] the sustainability of a system is determined by the functioning of these cycles and the communication between them. In a healthy system, smaller and faster cycles of innovation invigorate the system above which in turn is protected by the accumulated processes and resources (memory) of the slower, larger levels above it [19]. Such cross scale interactions in panarchy show how sustainability is affected by the interplay between change and persistence. Adaptation is driven by innovations created during the release phase of the scale below, whereas persistence is facilitated by the memory of the scale above [19]. Thus it follows that innovations at the ship level may help a shipping company adapt to changing circumstances as well as seizing new opportunities for growth.

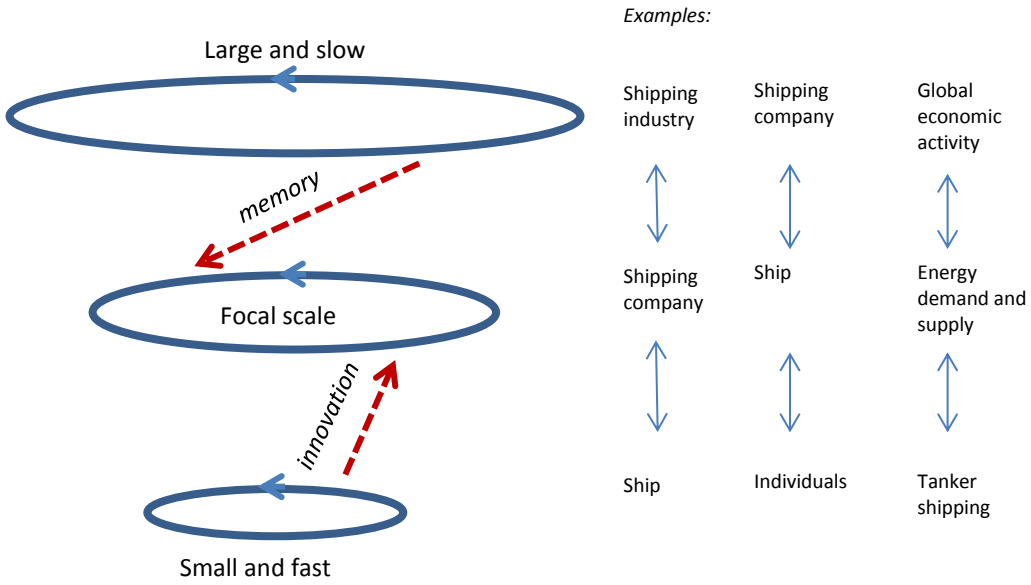


**Figure 3 Panarchical interactions**
Adapted from: [19; 26]

## 3. Shipboard innovation and the role of seafarers

Shipboard tasks and roles are heavily influenced by risk management and safety management. The emphasis on risk and safety is primarily driven by concerns about shipping accidents, as the impact of such accidents often extends beyond the confines of the affected ships. When shipping accidents result in extensive damage to life, environment and property, there is increased public attention which has a negative influence on the way shipping is perceived [28]. There is often a strong community and government response as illustrated by public anger at the loss of life resulting from the sinking of *Herald of Free Enterprise* in 1987, *Scandinavian Star* in 1990, *Estonia* in 1994 [29], resulting in new shipping regulations imposed by the United States (US) and by the European Union (EU) following the oil pollution caused by *Exxon Valdez* in 1989 and the sinking of *Prestige* in 2002 respectively [30].

Historically, safety in shipping has been regulated through prescriptive regulations set by governments and their agencies (see for example the *Marine Orders* issued by the Australian Maritime Safety Authority or AMSA). International conventions held under the auspices of the International Maritime Organisation (IMO) - a specialised agency of the United Nations (UN) - form the basis of many national regulations concerning the safety of merchant ships and seafarers. IMO conventions aim to set international standards for the design, construction, equipment, operation and manning of ships. These standards are enforced by means such as inspections, surveys and certification. Among the many international conventions and codes that focus on technical solutions, IMO's International Safety Management (ISM) code stands out for directly addressing the management and organisation of shipping companies. The ISM Code sets an international standard for the safe management and operation of ships and pollution prevention and is arguably one of the most significant documents produced by IMO [29]. The code requires shipping companies to implement a safety management system which establish safeguards against all identifiable risks. The pervasiveness of regulatory control in shipping is indicative of stakeholders' concerns about industrial accidents and their potential for wide-spread destruction. However, as a consequence of the regulatory regime, a culture of compliance has been created [29].

Hollnagel [24, p226] suggests that a compliance based approach is based on the assumption that "systems work because they are well designed and scrupulously maintained, because procedures are complete and correct, because designers can foresee and anticipate even minor contingencies, and because people behave as they are expected to – and more importantly as they have been taught or trained to do". The compliance based approach is symptomatic of a command and control type management thinking [31]. Command and control thinking is characterised by a top-down hierarchical perspective, functional specialisation and being remote from operational decision-making [32]. The command and control thinking treats organisations as machines and seeks efficiency, stability, control and obedience [33].

The typical shipboard organisation illustrates command and control thinking. There is a strict task hierarchy and the usual way of working is through instructions and orders being passed from the master to officers to the crew. Standard operating procedures are the norm and any deviation from established rules and procedures is discouraged and even penalised. Regulators determine what tasks are to be performed by seafarers, how they should be performed, and the hierarchical level of tasks – management, operational or support levels (see IMO's International Convention on Standards for Training, Certification and Watchkeeping for Seafarers [34]). Regulators oversee the training of seafarers and issue licenses to those deemed competent to perform the specified tasks. The regulators' interests, as articulated by IMO, are safety and security of shipping and prevention of marine pollution by ships [34]. Thus Regulators represent stakeholders' rather than shareholders' interests.

Some scholars (see, for example, [25; 32; 33]) suggest that the stability and efficiency seeking command and control approach provides limited ability to cope with complex, dynamic and unpredictable change. Wheatley [33] argues that a command and control management style discourages creativity by producing disengaged workers who behave like robots. Applying the CAS metaphor to organisations, the strive for greater efficiency comes at the cost of decreasing flexibility and resilience [16]. Inventions, experimentation and creative ideas occur at the reorganisation phase of the CAS adaptive cycle where agents freely seek new directions [16]. However, the environment of tension and instability conducive to innovation [13] also brings with it the threat of chaos. Jansen, Cammock and Conner [7] suggest that a management approach that is based upon an understanding of organisations as CAS is *complementary* to, and not exclusive of, the more traditional forms of organisation that are important for efficiency.

## 4. Conclusion

In order to be sustainable, shipping companies need to be able to adapt to unpredictable and unforeseeable change as well as take advantage of any opportunities presented. Reliance on existing knowledge and procedures may be inadequate to solve the new, and yet unforeseen, challenges of the twenty-first century arising from the continuing complexity of change and organisational dynamics. Complex problems cannot be solved by using techniques that assume a straightforward cause and effect relationship [35]. Conceptualising the shipping company as a CAS and understanding the importance of self-organisation and emergence may help to manage the company through change and provide competitive adantage.

Studies indicate that sustainable CAS rely on their ability to innovate – a key element of adaptability [16; 18; 19; 21; 23; 27]. In order to harness the full potential of their seafaring employees and go beyond simply expecting them to do as directed and follow instructions, shipping companies will need to create the right shipboard environment for innovation. This will require leadership, at both the company and the ship level, accepting that organisations don't always behave in the same way as Newtonian machines [25]. Self-organisation is necessary for unleashing creativity and adaptation [33]. Self-organisation does not imply that the present hierarchical shipboard organisational structure necessarily diminishes. Self-organisation can occur as a result of individuals working independently

[11]; it is the emergent phenomenon resulting from their actions that is important. For this to occur, there needs to be an engaging vision that is not imposed but has resonance with members of the organisation [7]. Management strategies that facilitate sensemaking, learning and improvisation are essential to take advantage of the chracteristics of CAS rather than resist them [25].

The notion of panarchy illustrates the importance of scales, both spatial and temporal, to innovation and sustainability [27]. By invigorating the system through innovation at smaller scales rather than through company-wide upheaval, shipping companies may be able to successfully balance change with persistence. The ability to reorganise after change is dependent upon *memory* – the accumulated experience and history of the system [18]. Therefore knowledge management within the shipping company attains fundamental importance.

The literature on CAS provides new metaphors and language for management [13]. It also raises potential new challenges for educators, curriculum designers and regulators. More studies are needed to answer fundamental questions such as: what are the graduate attributes of 21st century seafarers?; should stakeholders involve themselves with graduate attributes that may go beyond technical standards for safety, security and environmental protection?; can creative skills be incorporated in seafarers' curricula?; when does experimentation cross the threshold of acceptable risk?; and last but not least, does the relationship between traditional maritime academia, seafarers and shipping companies need to extend beyond the confines of STCW?

## 5. References


[1] Malbon, J and Bishop, B, *Australian export: a guide to law and practice*, Cambridge University Press, New York, 2006.

[2] Commonwealth of Australia, *Marine Insurance Act 2009.*

[3] Uhl-Bien, M, Marion, R and McKelvey, B, "Complexity leadership theory: shifting leadership from the industrial age to the knowledge era", *The Leadership Quarterly*, Vol18, No4, 2007, pp298-318.

[4] Smith, D and Fischbacher, M, "The changing nature of risk and risk management: the challenge of borders, uncertainty and resilience", *Risk Management*, Vol11, No1, 2009, pp1-12.

[5] Fiksel, J, "Designing resilient, sustainable systems", *Environmental Science & Technology*, Vol37, No23, 2003, pp5530-5539.

[6] Ryan, A, "The foundation for an adaptive approach: insights from the science of complex systems", *Australian Army Journal*, VolVI, No3, 2009, pp69-90.

[7] Jansen, C, Cammock, P and Conner, L, "Leadership for emergence: exploring organisations through a living systems lens", *Leading & Managing*, Vol17, No1, 2011, pp59-74.

[8] Ellis, B and Herbert, S I, "Complex adaptive systems (CAS): an overview of key elements, characteristics and application to management theory", *Informatics in Primary Care*, Vol19, 2011, pp33-37.

[9] Halliday, A and Glaser, M, "A management perspective on social ecological systems: a generic system model and its application to a case study from Peru", *Human Ecology Review*, Vol18, No1, 2001, pp1-18.

[10] Puranam, P, Alexy, O and Reitzig, M, "What's 'new' about new forms of organizing?", *Academy of Management Review,* Vol39, No2, 2014, pp162-180.

[11] Paley, J, "Complex adaptive systems and nursing", *Nursing Inquiry,* Vol14, No3, 2007, pp233-242.

[12] Anderson, P, "Complexity theory and organization science", *Organization Science,* Vol10, No3, 1999, pp216-232.

[13] Palmberg, K, "Complex adaptive systems as metaphors for organizational management", *The Learning Organization,* Vol16, No6, 2009, pp483-498.

[14] Clipper, Performance and Solutions, "The Organization as a System: Rummler-Brache Models", *Clipper, Performance and Solutions,* accessed 23 April 2014, <http://www.psclipper.com/OrganizationasaSystem.asp>.

[15] Fischer, K and Zink, K L, "Defining elements of sustainable work systems - a system-oriented approach", *Work: A Journal of Prevention, Assessment and Rehabilitation,* Vol41, 2012, pp3900-3905.

[16] Walker, B and Salt, D, *Resilience Thinking Sustaining Ecosystems and People in a Changing World*, Island Press, Washington, 2006.

[17] Folke, C, "Resilience: The emergence of a perspective for social-ecological systems analyses", *Global Environmental Change,* Vol16, 2006, pp253-267.

[18] Berkes, F, Colding, J and Folke, C, "Introduction", in *Navigating social-ecological systems: building resilience for complexity and change,* in: (eds), F Berkes, J Colding and C Folke, Cambridge University Press, Cambridge, 2003.

[19] Holling, C S, "Understanding the complexity of economic, ecological, and social systems", *Ecosystems,* Vol4, 2001, pp390-405.

[20] Darnhofer, I, Fairweather, J and Moller, H, "Assessing a farm's sustainability: insights from resilience thinking", *International Journal of Agricultural Sustainability,* Vol8, No3, 2010, pp186-198.

[21] Folke, C, Carpenter, S R, Walker, B, Scheffer, M, Chapin, T and Rockstrom, J, "Resilience thinking: integrating resilience, adaptability and transformability", *Ecology and Society*, Vol15**,** No4, 2010, article20, accessed 15 October 2012, <http://www.ecologyandsociety.org/vol15/iss4/art20/>.

[22] Scheffer, M, *Critical Transitions in Nature and Society*, Princeton University Press, Princeton, 2009.

[23] Walker, B, Holling, C S, Carpenter, S R and Kinzig, A 2004, "Resilience, adaptability and transformability in social-ecological systems", *Ecology and Society,* Vol9**,** No2, article25, accessed 25 November 2012, <http://www.ecologyandsociety.org/vol9/iss2/art5>.

[24] Hollnagel, E 2014, "Resilience engineering and the built environment", *Building Research & Information,* Vol42, No2, 2014, pp221-228.

[25] McDaniel, R R, "Management strategies for complex adaptive systems", *Performance Improvement Quarterly,* Vol20, No2, 2007, pp21-41.

[26] Bhaskar, P, Cahoon, S and Chen, S, "Conceptualising a resilience based approach to shipping sustainability", *Review of Integrative Business & Economics Research*, Vol3, No1, 2014, pp302-314.

[27] Gunderson, L H and Holling, C S, "Chapter 2 resilience and adaptive cycles" in L H Gunderson and C S Holling (eds) *Panarchy: understanding transformations in human and natural systems*, Island Press, Washington, 2002.

[28] Baker, C C and McCafferty, D B, "Accident database review of human element concerns: what do the results mean for classification?", *ABS technical papers 2005*, American Bureau of Shipping, accessed 31 July 2010, <http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/References/Technical%20Papers/2005/AccidentDatabaseReview%20of%20HumanElementConcerns>.

[29] Kristiansen, S, *Maritime Transportation Safety Management and Risk Analysis*, Elsevier Butterworth-Heinemann, Oxford, 2005.

[30] White, M W D, *Australasian Marine Pollution Laws*, 2nd edn, Federation Press, Sydney, 2007.

[31] Zokaei, K, Seddon, J & O'Donovan, B, "Introduction", in: (eds), K Zokaei, J Seddon and B. O'Donovan, *Systems Thinking: From Heresy to Practice - Public and Private Sector Studies*, Palgrave Macmillan, Basingstoke, Hampshire, 2011.

[32] Watts, J, "The perils of command and control", *Systemic Practice and Action Research*, Vol27, 2014, pp75-89.

[33] Wheatley, M J, "Self-organized networks", *Leadership Excellence*, Vol25, No7, 2008, pp7-8.

[34] IMO, *International Maritime Organization*, accessed 22 May 2014, <http://www.imo.org/Pages/home.aspx>.

[35] Darnhofer, I, Bellon, S, Dedieu, B and Milestad, R, "Adaptiveness to enhance the sustainability of farming systems. A review", *Agronomy for Sustainable Development*, Vol30, 2010, pp545-555.