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Interactions between Law and Science within the Law of the Sea: A Systems Theory Perspective

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1. INTRODUCTION

The 1982 United Nations Convention for the Law of the Sea (LOSC) is a framework convention that regulates the physical and technical use of the oceans and their resources. As Ambassador Jens Evensen reflected immediately after the LOSC was opened up for signature, '[t]he basic problems with which the Law of the Sea Conference tried to cope […] were the impact of the revolutionary developments in science and technology, and the influence of these forces in international law.'[1]

These forces of science and technology did indeed influence the negotiations of the LOSC and still influence the Convention today. Many of its provisions have a scientific flavour – they include terms borrowed from science, referring to science, or influenced by science. For example, the definition of the continental shelf in Article 76 refers to 'natural prolongation' and the delineation methods for the continental shelf beyond 200 nautical miles refer to geomorphological data such as the thickness of sedimentary rocks and the isobaths.[2] In addition, the LOSC includes provisions on marine scientific research[3] and refers to the 'best scientific evidence available'.[4] Finally, to be able to determine the distinctions between oceanic ridges, submarine ridges and submarine elevations[5], one must turn to science for answers. At the same time, the law of the sea, which includes the LOSC, has always been affected by changes and developments in science and technology. The adoption of the LOSC itself responded to new developments in science and technology with respect to exploitation of the seabed. And it is still challenged by developments in science and technology, be it climate change, the discovery of marine genetic resources in hydrothermal vents, or new technologies to conduct marine scientific research. It is thus important to understand how and to what extent law and science interact within the law of the sea.

This chapter is slightly different from others in this book. "Interaction", for the purposes of the current chapter, does not refer to regime interaction in the sense discussed by Young and others, or

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[1] J Evensen, 'The Effect of the Law of the Sea Conference upon the Process of the Formation of International Law: Rapprochement between Competing Points of View,' in RB Krueger and SA Riesenfeld (eds), *The Developing Order of the Oceans (Proceedings of the 18th Annual Conference of the Law of the Sea Institute)* (Law of the Sea Institute, University of Hawaii Honolulu 1984), 25.

[2] LOSC, Article 76.

[3] LOSC, Part XIII.

[4] LOSC, Article 61(2); Article 119(1)(a); Article 234.

[5] LOSC, Article 76.

elsewhere in this book.[6] Regime interaction in that sense concerns interaction between *legal or regulatory* regimes. In contrast, this Chapter looks at interaction between law and another discipline (science) making it even more complex to even define what interaction is. For the purposes of this Chapter, then, "interaction" refers to a social process, in which law, as an institution – a system if you will – interacts with other institutions – or systems – that exist beyond its boundaries. "Interaction" does not refer to any process occurring within one system (i.e. not between the law of the sea and international trade law for example). Rather, "interaction" is thus referred to as a process that takes place between one system (law) and another system (science). It does not presuppose *meaningful* interaction. In other words, "interaction" may thus also, for the purposes of this Chapter, refer to miscommunication. The process of interaction helps understand how law and science can influence each other, and what effects one has on the other. But it can also help us understand when that interaction is unsuccessful, or when miscommunication occurs. At its core, "interaction" is a process between two bodies of knowledge trying to make sense of the world in their own way.

To explain how different systems may or may not interact with each other, this contribution uses Luhmann's systems theory as a lens.[7] Although section 4 will more adequately explain the components of his theory applicable to the topic, for now it suffices to say that Luhmann believes society is split up into various systems, which each have an "environment" that surrounds them. In this case, it concerns the social system of law and its "environment". Each system fulfils a different role in society.[8] The key of his theory is this distinction between "system" and "environment". A system may interact with its environment (and this environment may include other systems), which Luhmann calls "structural or operative coupling", but throughout this interaction, each system sees the other system (or the environment) only throughout its own lens. They can therefore never truly communicate.

Law and science are two very different creatures. Yet, in the context of ocean governance, they often operate within the same sphere. However, there are various examples in the LOSC that reflect some form of miscommunication between law and science. Therefore, Luhmann's systems theory may help explain how law and science interact, or aim to interact within the context of the law of the sea. Although Luhmann believed that the "functional differentiation of society" was both crucial and necessary for democracy to thrive, a consequence of this miscommunication is that there are terms

[6] See MA Young (ed), *Regime Interaction in International Law: Facing Fragmentation* (Cambridge University Press Cambridge 2012); MA Young, *Trading Fish, Saving Fish: The Interaction between Regimes in International Law* (Cambridge University Press Cambridge 2011).
[7] See generally N Luhmann, *Social Systems* (Stanford University Press Stanford 1995); N Luhmann, *Law as a Social System* (Oxford University Press Oxford 2004); N Luhmann, *Theory of Society, Volume 1*, tr Rhodes Barrett (Stanford University Press Stanford 2012); C Borch, *Niklas Luhmann* (Routledge Abindgdon 2011).
[8] He calls this the 'functional differentiation'. N Luhmann, *Ecological Communication* (Polity Press Cambridge 1989) 106–114; Borch, n 7, 70.

included in the law, which perhaps have a different legal meaning from their scientific meaning. In a sense, they become "false friends" – the same word that occurs in two different languages with two different corresponding meanings. This can be problematic. It may mean that the legal regime applies to circumstances it might not have been intended to apply to or vice versa. Furthermore, the management and governance of the oceans often involves players from various disciplines, and if they are not aware of the different disciplinary meaning of these terms, confusion and different expectations might lead to ineffective governance.

This Chapter aims to explain the interactions between law and science, by putting those interactions in the context of Luhmann's systems theory. [9] To achieve these aims, the following section introduces the two systems of law and science, and how they are so very different. Section 3 looks at where and how the LOSC refers to science, how it is influenced by scientific developments, and how it regulates the conduct of science. It also zooms in on three examples of false friends, namely the continental shelf, sedentary species, and highly migratory species. These examples are a helpful way of demonstrating when interactions between law and science in the law of the sea are actually examples of miscommunication. Section 4 sets out those components of Luhmann's systems theory that help explain law-science interactions within the law of the sea, and especially why true communication may never be possible. Section 5, then, offers some concluding observations, problematizing the miscommunication between law and science, and how we may facilitate more meaningful interaction between law and science within the law of the sea.

2. LAW AND SCIENCE: TWO DIFFERENT CREATURES

Law and science are two different creatures. Law, on the one hand, favours stability, predictability, and is generally of normative character, prescribing how society ought to function. On the other hand, science is based upon the premises of innovation and change, and is of descriptive character, describing how the world actually functions. Authors writing about the relationship between law and science have identified various differences between the two, of which some are set out below.

The first difference between the two relates to that of truth and justice. It is a common belief that science aims to find the truth, and law seeks to do justice.[10] According to Jasanoff, this is certainly

[9] In the context of the expanding literature concerning the role of science in international law, many scholars have started writing about the role of experts and/or scientific evidence or fact-finding in international adjudication. However, this Chapter is concerned with law-science interactions in the more general context, rather than in specific situations of dispute settlement. Therefore, analysis on the role of scientific experts, evidence and/or fact-finding in international adjudication has been excluded from this Chapter.

[10] S Jasanoff, 'The Intersections of Science and Law' in *Science at the Bar: Law, Science, and Technology in America* (Harvard University Press Cambridge 1997) 7; PH Schuck, 'Multi-Culturalism Redux: Science, Law, and Politics' (2015) 11 *Yale Law & Policy Review* 1, 21–22; CC Gilson, *The Law-Science Chasm: Bridging Law's Disaffection with Science as Evidence* (Quid Pro, LLC New Orleans 2012) 32.

the way scientists describe the difference between law and justice: science is considered to be committed to the truth, whereas the law is considered to focus around 'winning adversarial games at any cost'.[11] However, even from a more nuanced perspective, the difference stands. Although both law and science are, or include, fact-finding missions, fact-finding within law is always 'contingent' on delivering justice.[12] Scientific fact-finding is mainly concerned with 'getting the facts "right"'.[13] Legal fact-finding also wishes to establish facts correctly, but as a means to settle disputes or deliver justice.[14] The search for "truth" thus does not serve the same aims.[15]

A second difference between law and science relates to their relative prescriptive and descriptive functions, or, in other words, the difference between "is" and "ought". Law and science are considered to have 'essentially different philosophical orientations.'[16] In other words, science is descriptive, whereas law is prescriptive.[17] Where science is the 'is' of human experience, law is the 'ought'.[18] Legal principles are 'normative propositions about which particular states of the social world *should* be sought,' and not positive statements about 'how the natural or social world *does* in fact work'.[19] According to one scholar, science 'is limited to the relatively modest task of describing the "real world" or what the law refers to simply as "the facts",' although he comments that science can never do so definitively.[20] On the other hand, law is 'an engine of normativity', using information from the world to generate 'rules and goals for controlling the world'.[21] Science has a '*know-how* preoccupation' – it is driven by technological concerns. Law, on the other hand, is concerned with 'prescription and proscription of actions', and thus values a '*know-what* focus'.[22] To take climate change as an example, science tells us that sea levels are rising and that, as a result, the low later line will shift landwards due to this rise in sea level. This is on observation, a description. However, science cannot tell us that, accordingly, the legally determined baselines must also shift landwards. That would be a prescription, which would be up to law (and policy) to determine.

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[11] Jasanoff, n 10, 6.
[12] Ibid, 7; See also DM Brosnan, 'Science, Law, and the Environment: The Making of a Modern Discipline' (2007) 37 *Environmental Law* 987, 988–989. Although finding the "truth" may be a form of justice, the important distinction in this regard is that fact-finding in law is a means to an end, whereas it is the end itself in the realm of science.
[13] Jasanoff, n 10, 9.
[14] Ibid.
[15] National Research Council, 'Introduction' in *A Convergence of Science and Law: A Summary Report of the First Meeting of the Science, Technology, and Law Panel* (2001) 1 <https://www.nap.edu/catalog/10174/a-convergence-of-science-and-law-a-summary-report-of>.
[16] DL Faigman, *Legal Alchemy: The Use and Misuse of Science in the Law* (W H Freeman & Co New York 1999) 190.
[17] Jasanoff, n 10, 7; Gilson, n 10, 32. However, Faigman believes that law can be both descriptive and prescriptive, see Faigman, n 16, 33.
[18] S Jasanoff, 'Making Order: Law and Science in Action' in EJ Hackett et al (eds), *The Handbook of Science and Technology Studies* 3rd edn (MIT Press Cambridge 2007) 767; Faigman, n 16, 6.
[19] Schuck, n 10, 21.
[20] Faigman, n 16, 190.
[21] Ibid, 191.
[22] D Wilkinson, 'Science, Law and the Environment' in *Environment and Law* (Routledge Florence 2002) 199.

A related difference is the distinction between facts and policy/law. According to Feldman, '[s]cience can tell us the ways in which things are the same and the ways in which they differ, but it cannot tell us whether that sameness or difference should have any meaning from a legal perspective.'[23] Similarly, Faigman explains how science could help us make a distinction between 'children' and 'adults', but the law decides whether these categories should be treated the same or differently.[24] Science can give us a lot of information, but it cannot tell us 'how to combine this information to make a decision'.[25] In an environmental law perspective, '[r]esearch can produce information on the state of a stock or an ecosystem and provide factual inputs for determining sustainable harvest levels,' but 'there is no way it can resolve the issue of whether it is morally right or wrong to utilize a particular species for consumptive purposes.'[26] Science does not determine whether or not there should be a hunting ban on cetaceans. Science may tell us that some species are endangered, or that all cetaceans are very intelligent and thus similar to human beings.[27] But it cannot conclude that, because of this, the harvesting of cetaceans is lawful or unlawful. Law and policy, on the other hand, in determining whether or not to put such a hunting ban in place, can ask of science to provide the scientific information, but it is ultimately up to the law to decide how to regulate the protection, conservation and/or management of the species. The law may take into account other considerations as well, such as the rights of indigenous people, cultural interests, sustainability considerations, or even economic and/or subsistence needs.

Another observed difference between science and law relates to time. Faigman believes that perhaps 'the most basic difference' between law and science relates to the 'very dissimilar schedules for decision making' and the 'different timetables of law and science'.[28] Jasanoff agrees, that interconnected cultural institutions such as science and law 'develop at uneven paces, so that the slower are necessarily out of step with the quicker'.[29] This has been referred to as the "law lag".[30] For example, the discovery of marine genetic resources happened around the turn of the century. And, even though there has been an international initiative to regulate such resources under an implementing agreement to the LOSC since 2005, such a treaty has still not been finalized.[31] Perhaps somewhat

[23] R Feldman, *The Role of Science in Law* (Oxford University Press Oxford 2009) 6.
[24] Faigman, n 16, 43.
[25] Ibid, 56.
[26] S Andresen and JB Skjærseth, 'Science and Technology: From Agenda Setting to Implementation' in D Bodansky, J Brunnée and E Hey (eds), *The Oxford Handbook of International Environmental Law* (2008) 193.
[27] For a discussion on science as a 'legitimizing factor' in this respect, see K Sykes, 'The Appeal to Science and the Formation of Global Animal Law' (2016) 27 *European Journal of International Law* 497.
[28] Faigman, n 16, 51.
[29] Jasanoff, n 18, 768.
[30] Ibid.; WF Ogburn, 'Cultural Lag as Theory' (1957) 41 *Sociology & Social Research* 167.
[31] In 2005 the UN General Assembly (UN GA) created an ad hoc open-ended informal working group to study the issue of marine genetic resources, amongst others. See UN Division for Oceans Affairs and Law of the Sea, 'Ad Hoc Open-

relatedly, science and law also share a difference with respect to definitiveness.[32] Science and technology 'seek knowledge through an open-ended search for expanded understanding' where these 'truths' can be revised endlessly.[33] Law is also concerned with an open-ended search for expanded understanding, but it requires a conclusion, or 'definite findings of fact at given points in time'.[34]

Law's primary concern is process, whereas science commits to progress.[35] The prestige of law depends largely on 'adhering to the traditions of the past,' whereas the prestige of science turns on 'how swiftly it advances into the future'.[36] In other words, science 'builds on experience', whereas law 'rests on it'.[37] Whereas the law's rhetoric of justification is 'primarily backward looking', science 'unabashedly embraces innovation'.[38] The consequences from this difference include the legal system's 'commitment to building consensus, or at the very least to airing diverse points of view,' whereas science 'pursues the nature of reality, come what may'.[39]

A final difference between law and science discussed here relates to language. Jasanoff identifies a difference between law and science by looking at language. In her view, the language of law is a 'human language', or in other words, a 'prime achievement of culture, situated in both place and history'.[40] On the other hand, science's language claims some form of universality 'that transcends culture, time and place'.[41] As will be demonstrated in section 4, those scholars referring to Luhmann's systems theory will agree to this difference. Gilson agrees with Luhmann that law only speaks in the 'binary distinction or code' of legal/illegal, or, in practice, guilty/not guilty.[42] Science, on the other

Ended Informal Working Group to Study Issues Relating to the Conservation and Sustainable Use of Marine Biological Diversity beyond Areas of National Jurisdiction' <https://www.un.org/Depts/los/biodiversityworkinggroup/biodiversityworkinggroup.htm>. Subsequently, the UN GA decided to develop an international legally binding instrument, and to that end, established a preparatory committee in 2015. See UN Division for Oceans Affairs and Law of the Sea, 'Preparatory Committee Established by General Assembly Resolution 69/292: Development of an International Legally Binding Instrument under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction' <https://www.un.org/depts/los/biodiversity/prepcom.htm>. In 2017, the UN GA decided to convene an intergovernmental conference. For the latest updates, see UN, 'Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction' <https://www.un.org/bbnj/>.

[32] See EE Deason, 'Incompatible Versions of Authority in Law and Science' (1999) 13 *Social Epistemology* 147, 157; S Haack, 'Irreconcilable Differences? The Troubled Marriage of Science and Law' in *Evidence Matters: Science, Proof, And Truth In The Law* (Cambridge University Press New York 2014) 79–80.

[33] National Research Council, n 15, 1.

[34] Ibid.

[35] S Goldberg, *Culture Clash: Law and Science in America* (NYU Press New York 1996) referred to in Jasanoff, n 18, 769. See also L Wolpert, 'What Lawyers Need to Know About Science' in H Reece (ed), *Law and Science: Current Legal Issues 1998 Volume 1* (Oxford University Press Oxford 1998) 289.

[36] Faigman, n 16, 6.

[37] Ibid.

[38] Jasanoff, n 18, 768.

[39] Ibid, 769.

[40] Ibid, 762.

[41] Ibid.

[42] Gilson, n 10, 15, 59. However, Gilson provides a clear example of when law is asked to decide upon true/false, namely when the scientific status of expertise is at issue. See ibid, 28.

hand, evaluates propositions according to the distinction or code of true/false, or, operationally, fact/non-fact.[43]

Law and science do not only share differences – they also have some things in common.[44] Both law and science are concerned with rules and order,[45] they are both formal systems of inquiry[46] – they both claim to be the authority to go through evidence and derive conclusions from that evidence[47] – and they both contain mechanisms for 'information dissemination'.[48] In addition, both fields 'undergo massive shifts' – the rules governing the assessment of facts change in science through 'paradigm-transforming pioneers' and in law they often change through the actions of legislatures.[49] However, the differences between law and science are greater than the similarities, reinforcing the idea that law and science are two different creatures, or two different systems. As Faigman submits, '[w]e might be tempted to conclude that, institutionally, these two professions are so alien to one another that there is little prospect of their ever finding accommodation.'[50] There thus seems to be a "gap" between law and science. Yet, the LOSC functions as an interface in which these two come together and interact in various ways.

3. THE LOSC: THE INTERFACE OF LAW AND SCIENCE

The LOSC is certainly a reflection of the interaction between law and science. The oceans possess vast natural resources, resources we know about thanks to research activities and scientific studies. Thus, the LOSC tries to regulate human activities in relation to these resources. However, for these regulations to be effective, the law must incorporate scientific knowledge and rely on science to determine the substance of these regulations. This section will look at where and how the LOSC refers to science (3.1), how the LOSC may be influenced by scientific developments (3.2), and how the LOSC regulates the conduct of science (3.3). This section will end by zooming in on a very clear example of miscommunication between law and science, namely that of false friends (3.4).

3.1. Scientific References in the LOSC

[43] Gilson, n 10, 15, 59.
[44] See MJ Saks and SL Neufeld, 'Convergent Evolution in Law and Science: The Structure of Decision-Making under Uncertainty' (2011) 10 *Law, Probability and Risk* 133.
[45] Jasanoff, n 18, 763.
[46] Gilson, n 10, 32; Jasanoff, n 10, 8.
[47] Jasanoff, n 10, 8.
[48] Wilkinson, n 22, 197.
[49] Jasanoff, n 10, 8–9.
[50] Faigman, n 16, 6.

There are many scientific references in the LOSC. These can either be explicit references, implicit references, or "borrowed" references. The LOSC contains some references that directly refer to science or research, such as the 'best scientific evidence available',[51] 'marine scientific research',[52] 'marine biology',[53] 'study',[54] amongst others. These examples directly refer to scientific knowledge, processes or studies. Examples of implicit references, on the other hand, are 'harm to the marine environment',[55] 'maximum sustainable yield',[56] and perhaps 'conservation'[57] and 'preservation'[58]. These terms do not refer to science directly, but to interpret these terms, one needs to turn to science. One cannot know whether there is harm to the marine environment without a scientific study showing the impacts of an activity on the marine environment. Thirdly, the LOSC includes terms "borrowed" from the natural sciences. These are terms that do not directly refer to science, nor do they implicitly refer to scientific knowledge or processes, but they are terms originally used in science, referring to scientific concepts. An example in this regard is the 'continental shelf'.[59]

We find references to science, whether explicit, implicit, or "borrowed" terms, throughout the entire Convention. However, there are some areas of the law of the sea in which we see more scientific references than others. First of all, the rules pertaining to the delineation and delimitation of maritime zones and boundaries contain many scientific references. To measure the extent of a coastal State's sovereignty, sovereign rights and jurisdiction, one begins with establishing baselines. Baselines normally constitute the 'low-water line' along the coast as marked on large-scale charts recognized by the coastal State.[60] Where the coastline is deeply indented and cut into, or where there are islands in the immediate vicinity of the coastline, a coastal State may designate straight baselines, in accordance with Article 7 LOSC.[61] Where there are reefs, rivers, bays, or low-tide elevations, the Convention sets out specific regulations for establishing baselines in these scenarios.[62] At this stage, science plays a role in determining what kind of baselines may be used, and where they must be. Although most maritime zone entitlements are based on distance (which in itself relies upon geodetic measurements, and can thus also be viewed as a reference to science), entitlement to a continental shelf beyond 200

[51] LOSC, Article 61(2); Article 119(1)(a); Article 234. Note the difference between 'best scientific evidence available' in Articles 61(2) and 119(1)(a) and 'best available scientific evidence' in Article 234.
[52] LOSC, Part XIII.
[53] LOSC, Article 277(a).
[54] LOSC, Preamble, Fourth Recital; Article 65; Article 277.
[55] See for example LOSC, Article 145; Article 234; Article 290.
[56] LOSC, Article 61(3); Article 119(1)(a).
[57] See for example LOSC, Preamble, Fourth Recital; Article 21(1)(d); Articles 61-66; Articles 117-120; Article 123(a); Article 145(b); Article 150.
[58] See generally LOSC, Part XII.
[59] LOSC, Article 76.
[60] LOSC, Article 5.
[61] Ibid., Article 7.
[62] See LOSC, Article 6; Article 10; Article 13.

nautical miles is dependent upon scientific information. A coastal State has such an entitlement when the sea-bed and subsoil of the marine areas that extend beyond the territorial sea throughout the 'natural prolongation' of its land territory to the 'outer edge of the continental margin' stretches beyond 200 nautical miles.[63] If that is the case, they can submit information to the Commission on the Limits of the Continental Shelf (CLCS), who will then review the submissions and provide recommendations.[64] Coastal States should then establish the limits of the continental shelf based on those recommendations.[65] Where there are submarine highs on the seabed, science may help determine the legal status of these features, and how the continental shelf should be delineated accordingly.[66]

After a coastal State has established its baselines and entitlements to maritime zones, these maritime entitlements may overlap with those of another coastal State. In these cases, the LOSC, complemented by relevant case law, prescribes a certain methodology as to how to resolve these overlapping maritime entitlements.[67] This methodology needs scientific information in order to delimit the area between the States in such a way that it leads to an equitable solution.[68] Other areas in which we find many scientific references in the LOSC are the regulations concerning the protection and preservation of the marine environment (mostly in Part XII), the deep seabed mining regime (Part XI as well as the Part XI Implementing Agreement),[69] Part XIII on marine scientific research, and the provisions concerning the development and transfer of technology, mainly set out in Part XIV of the LOSC.

When taking a closer look at these scientific references, one notices that the LOSC refers to different natural sciences. For example, the LOSC refers to mathematics, geography, hydrography, geology, biology, and arguably ecology, amongst others. Mathematics is referred to in the case of

[63] LOSC, Article 76(1).
[64] LOSC, Article 76(8).
[65] LOSC, Article 76(8).
[66] See the reference to 'oceanic ridges' in LOSC, Article 76(3); and 'submarine ridges' and 'submarine elevations' in Article 76(6).
[67] LOSC, Article 15 (territorial sea); Article 74 (EEZ); Article 83 (continental shelf). This "delimitation methodology", in the case of overlapping entitlements to the EEZ or continental shelf, as first set out in the *Black Sea* case between Romania and Ukraine involves three stages. The first stage is the establishment of a provisional equidistance/median line. The second stage is the consideration of factors that may warrant an adjustment of the provisional line in order to achieve an equitable result. Thirdly, the Court would verify that the (adjusted) line does not lead to an inequitable result 'by reason of any marked disproportion between the ratio of the respective coastal lengths and the ratio between the relevant maritime area of each State by reference to the delimitation line'. DR Rothwell and T Stephens, 'Delimitation of Maritime Boundaries' in *The International Law of the Sea* 2nd edn (Hart Publishing Oxford 2016) 412, 429; *Maritime Delimitation in the Black Sea (Romania v Ukraine) (Judgment)* [2009] ICJ Rep 61, [115-122]. In all three stages, law must rely on science, whether that is to determine the equidistance line, or how to determine what factors may warrant an adjustment of the provisional line, or to determine the ratios required for the third stage.
[68] See LOSC, Articles 74 and 83 for the reference to 'equitable solution'.
[69] Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, adopted 28 July 1994, entered into force 16 November 1994, 1836 UNTS 3.

bays[70], archipelagos[71], and delimitation[72]. Geography is referred to when the Convention mentions 'geographically disadvantaged States'[73] and also inferentially in the context of straight baselines[74] and archipelagos[75]. Hydrography is referred to in relation to charts and maritime boundaries.[76] The Convention refers to geology especially in the case of the continental shelf beyond 200 nautical mile.[77] Biology and arguably ecology are referred to especially in relation to fisheries management, through the reference to interdependence of stocks.[78]

3.2. The Influence of Scientific Developments on the LOSC

It is not just that the LOSC refers to science. The LOSC is influenced by scientific developments and/or new scientific knowledge.[79] One may even argue that developments in science and technology is one of the main reasons why we now have the LOSC the way it is. After the 1958 Geneva Conventions were adopted, developments in science and technology opened up the oceans, the seabed and the subsoil to a 'mode and rate of exploitation hitherto undreamed of.'[80] The 1958 Geneva Convention on the Continental Shelf had given coastal States rights to the seabed up to the point where exploitation was no longer possible.[81] With the increase in scientific knowledge, and the technology to exploit the seabed further out to sea, this definition became problematic, especially for those countries that did not yet have such technologies. In this context, Ambassador Arvid Pardo of Malta famously argued that the mineral resources of the seabed should be declared the common heritage of mankind.[82] His speech ultimately triggered the UN General Assembly to convene a third UN Conference on the Law of the Sea (UNCLOS III), which adopted the LOSC in 1982.

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[70] LOSC, Article 10.
[71] LOSC, Article 47.
[72] LOSC, Article 15; Article 74; Article 83. With respect to the delimitation of the continental shelf and the exclusive economic zone, the reference to mathematics is most visible in the customary practice of international courts and tribunals, rather than the specific articles included in the LOSC.
[73] See for example LOSC, Article 70; Article 254.
[74] LOSC, Article 7.
[75] LOSC, Article 47.
[76] See for example LOSC, Article 16; Article 75; Article 84.
[77] LOSC, Article 76; Annex II.
[78] LOSC, Article 61(3); 119(1)(a).
[79] See CA Thomas, 'Addressing the Turn to Science in International Law' (2014) 63 *International & Comparative Law Quarterly* 236, 236–237 who writes, '[t]he ways in which science and international law have affected one another through [interaction] are complex. On the one hand, international law has changed in response to developments in scientific knowledge. On the other hand, international law has affected how such knowledge is generated and understood.'
[80] Evensen, n 1, 24. See also S Nandan, 'The Relationship Between the United Nations Convention on the Law of the Sea and Developments in Science and Technoloy' in LM Alexander, S Allen and LC Hanson (eds), *New Developments in Marine Science and Technology: Economic, Legal and Political Aspects of Change: Proceedings of the 22nd Annual Conference of the Law of the Sea Institute* (Law of the Sea Institute, University of Hawaii Honolulu 1988) 7.
[81] Adopted 29 April 1958, entered into force 10 June 1964, 499 UNTS 311, Article 1.
[82] See *Note Verbale Dated 17 August 1967 from the Permanent Mission of Malta to the United Nations Addressed to the Secretary-General* (No UN Doc A/6695, 18 August 1967) available at <http://digitallibrary.un.org/record/849472>.

Thus, the law of the sea has always responded to scientific developments, new knowledge and changing circumstances. And this is still true today. The legal initiative concerning the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (the BBNJ process) may be the prime example,[83] in which an international governmental conference was initiated to negotiate a new implementing agreement to the LOSC, with has as one of its goals to regulate marine genetic resources – resources that we only know about thanks to developments in science and technology.

A similar case is that of climate change, which will have significant implications for the law of the sea.[84] With sea levels rising, the low-water line – upon which the normal baseline is determined – will change, as may other coastal areas used to determine baselines.[85] This then begs the question whether the extent of the maritime entitlements will also change.[86] Furthermore, warming of the oceans may lead to fish stocks moving further up North or to different areas, which may challenge the regulatory framework in place.[87] New shipping routes will become available in the Arctic, challenging the interpretation and application of Article 234 of the LOSC, and the adequacy of the current legal regime.[88]

There are many other examples in which developments in science and technology have challenged the existing legal provisions or have led to new interpretations. There are new ways to conduct marine scientific research, which were not envisioned at the time of drafting the LOSC.[89] States have been developing measures to combat climate change such as carbon capture storage or ocean fertilization.[90] There have been initiatives for constructing artificial islands as a response to

[83] For the latest updates, see UN, 'Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction', n 31.
[84] See for example A Boyle, 'Law of the Sea Perspectives on Climate Change' (2012) 27 *The International Journal of Marine and Coastal Law* 831; R Rayfuse, 'Climate Change and the Law of the Sea' in R Rayfuse and SV Scott (eds), *International Law in the Era of Climate Change* (Edward Elgar Publishing Limited Cheltenham 2012).
[85] See for example C Schofield, 'Holding Back the Waves? Sea Level Rise and Maritime Claims' in OC Ruppel, C Roschmann and K Ruppel-Schlichting (eds), *Climate Change: International Law and Global Governance: Legal Responses and Global Responsibility* (Nomos Baden-Baden 2013) 593; SV Busch, 'Sea Level Rise and Shifting Maritime Limits: Stable Baselines as a Response to Unstable Coastlines' (2018) 9 *Arctic Review* 174.; SV Busch, 'Law of the Sea Responses to Sea-Level Rise and Threatened Maritime Entitlements: Applying an Exception Rule to Manage an Exceptional Situation', in E Johansen, SV Busch and IU Jakobsen (eds) *The Law of the Sea and Climate Change – Solutions or Constraints?* (Cambridge University Press Cambridge, forthcoming).
[86] See Schofield, n 85; Busch, n 85.
[87] Rayfuse, n 84, 159–161.
[88] Ibid, 158.
[89] See for example H Woker et al, 'The Law of the Sea and Current Practices of Marine Scientific Research in the Arctic' (2020) 115 *Marine Policy*; K Bork et al, 'The Legal Regulation of Floats and Gliders—In Quest of a New Regime?' (2008) 39 *Ocean Development & International Law* 298; T Hofmann and A Proelss, 'The Operation of Gliders Under the International Law of the Sea' (2015) 46 *Ocean Development & International Law* 167.
[90] Rayfuse, n 84, 165–172.

people losing their homes and livelihoods due to climate change.[91] Private actors have developed new technologies to rid the oceans of plastic.[92] These are only some examples of how developments in science and technology have influenced the law of the sea, but none of them were envisioned when the LOSC was negotiated. As new scientific and technological developments take place, the existing legal framework is challenged and law will thus need to respond accordingly.

3.3. The LOSC Regulating the Conduct of Science

Finally, the law of the sea also influences how science is conducted. The LOSC sets out a legal framework for the conduct of marine scientific research and the transfer of technology. This is especially set out in Part XIII on marine scientific research and in Part XIV on the development and transfer of marine technology. Yet, there are various other provisions throughout the LOSC that also regulate the conduct of science, for example in Part XI on the Area[93], or in Part XII on the conduct of environmental impact assessments and monitoring.[94]

Very often, these provisions simply encourage, facilitate, or promote the conduct of marine scientific research or the development and transfer of technology.[95] These provisions usually do not add any qualification on *what* the science or technology should look like. They simply are an obligation of conduct to encourage, facilitate, or promote the conduct of marine scientific research and/or technology transfer and development. However, in other provisions we see references to the qualification of science, such as '*best available* scientific evidence',[96] or '*appropriate* scientific

[91] See for example J Vidal, 'Artificial Island Could Be Solution for Rising Pacific Sea Levels,' *The Guardian*, available at <https://www.theguardian.com/environment/blog/2011/sep/08/artificial-island-pacific-sea-levels>.
[92] 'The Ocean Cleanup', *The Ocean Cleanup*, available at <https://theoceancleanup.com/>; See also R Roland Holst, 'The Netherlands: The 2018 Agreement between The Ocean Cleanup and the Netherlands' (2019) 34 *The International Journal of Marine and Coastal Law* 351.
[93] LOSC, Article 143.
[94] LOSC, Articles 204-206.
[95] See for example LOSC, Preamble, Fourth Recital; Article 61; Article 119; Article 143; Article 144; Article 202; Article 238; Article 239; Article 243; Article 244; Article 246; Article 252; Article 255; Article 266; Article 268; Article 269; Articles 275-277; Annex II, Article 3; Annex III, Article 2; Annex III, Article 5; Annex III, Article 13; Annex III, Article 15. However, there are also some provisions that may limit the conduct of marine scientific research, when the LOSC balances this activity with others. See for example LOSC, Article 240 (providing that marine scientific research shall not 'unjustifiably' interfere with other legitimate uses of the seas and oceans), Articles 245 and 246 (requiring consent from the coastal State for marine scientific research in its maritime zones), and Article 19 (providing that the carrying out of research or survey activities is considered non-innocent passage).
[96] LOSC, Article 61(2); Article 119(1)(a); Article 234 (emphasis added). Again, note the difference between 'best scientific evidence available' in Articles 61(2) and 119(1)(a) and 'best available scientific evidence' in Article 234. Arguably, there is a difference in meaning. '[B]est scientific evidence available', in the context of Articles 61 and 119 refers to the best scientific evidence, which is available to the State concerned. Here, the adjective 'best' refers to 'scientific evidence'. '[B]est available scientific evidence' in the context of Article 234, on the other hand, refers to scientific evidence that is best available. In other words, the adjective 'best' could be interpreted to refer to 'available' rather than 'scientific evidence'.

methods and means'.[97] Here, the LOSC does not merely regulate the *conduct* of science, but also the *content* of science. These provisions add a qualifying threshold to the conduct of marine scientific research. Not just any scientific evidence should be taken account, only the 'best available'. Marine scientific research should not be carried out by any scientific method and means, only those that are 'appropriate'. The LOSC, however, does not clarify what these qualifying terms mean. What are the criteria for determining whether scientific evidence is 'best available' or whether scientific methods and means are 'appropriate'?[98] Should these qualifying terms be interpreted in their scientific context, or rather in a legal context? In the context of Luhmann's systems theory, is the system of law even able to evaluate such information coming from a different system?

3.4. 'False Friends' in the LOSC

The law of the sea and science interact in many ways. As demonstrated above, there are various references to science in the LOSC, the LOSC is influenced by developments in science and technology, and the LOSC regulates the conduct of science. These are all examples of interactions between law and science within the law of the sea. Sometimes, these interactions are actually examples of miscommunication between law and science, where the interaction was not successful. The purpose of this section is to zoom in on one type of such miscommunications, namely that of false friends.

A clear example of the miscommunication between law and science concerns the use of terms in law "borrowed" from the natural sciences. When the same or similar words have different meanings in different languages, these words are often called false friends.[99] This phenomenon also occurs within the law of the sea when different concepts have a legal meaning as well as a scientific meaning. Often, these meanings do not coincide. There is thus a "gap" between law and science.

There are various false friends in the LOSC. In other words, there are many terms in the LOSC that have both a legal meaning as well as a scientific one, often not coinciding. For example, the terms

[97] LOSC, Article 240(b) (emphasis added). For an analysis on why this provision may be problematic when applying it to current practices of marine scientific research, see Woker et al, n 89.

[98] For a discussion on the meaning of 'appropriate scientific methods and means', see AHA Soons, *Marine Scientific Research and the Law of the Sea* (Kluwer Law And Taxation Publishers Deventer 1982) 136; N Matz-Lück, 'Article 240' in A Proelss (ed), *United Nations Convention on the Law of the Sea: A Commentary* (BECK Munich 2017); Woker et al, n 89.

[99] False friends, otherwise known as false cognates, is a term used in linguistics when comparing different languages. *A Dictionary of Linguistics and Phonetics* defines false friends as 'a term describing words in different languages which resemble each other in form, but which express different meanings'. An example is the French word 'demander', which means 'to request' in English, rather than the English word 'demand'. See D Crystal, 'false friends' in *A Dictionary of Linguistics and Phonetics* 6th edn (Blackwell Publishing Ltd Oxford 2008) 185. People from one language hear the term in the other language, and falsely assume that they know what it means just because it resembles the term they already know. See also DMH Freeland, 'Speaking Science to Law' (2012) 25 *Georgetown International Environmental Law Review* 289, 289 who speaks of 'homonyms' - 'terms that are superficially identical in law and science [...] but which have deeply different meanings in their respective disciplines.'

"continental shelf", "sedentary species", and "highly migratory species" are terms used in both science and law. The same may be said for the reference to 'ice-covered areas' included in Article 234, the technical terms included in the archipelagic regime set out in Part IV, or the three different kinds of ridges mentioned in Article 76. For all these terms, there exists a legal meaning set out either in the LOSC or throughout the implementation and/or development of the law of the sea, as well as a meaning within the natural sciences which is often different.

The expression "continental shelf" is both a legal term of art and a well-defined scientific concept. The legal definition of the continental shelf seems very technical to a lawyer, whilst a geologist will not feel familiar with this legal definition. Article 76 defines the continental shelf as the 'seabed and subsoil of the submarine areas that extend beyond [the] territorial sea [of the coastal State] throughout the natural prolongation of [the] land territory to the outer edge of the continental margin' or otherwise to a distance of 200 nautical miles from the baselines.[100] The continental margin is then legally defined as 'the submerged prolongation of the land mass of the coastal State, and consists of the seabed and subsoil of the shelf, the slope and the rise'.[101]

The miscommunication between law and science in this respect is obvious in two ways. First, one of the ways in which the continental shelf is legally defined refers to the 200 nm distance limit. This means that a coastal State could have sovereign rights and jurisdiction over an area which may not coincide with the scientific continental shelf if it does not extend that far. The legal continental shelf would then physically comprise parts of the deep ocean floor in addition to a narrow geophysical continental shelf. Secondly, within the scientific context, the continental shelf may be defined as a 'zone adjacent to a continent (or around an island), extending from the low water line to the depth at which there is usually a marked increase of slope to greater depth'.[102] In other words, the scientific concept of the continental shelf only refers to one element of the continental margin. The legal definition of the continental shelf refers to all three elements of the continental margin: shelf, slope and rise. This second form of miscommunication is reinforced by the other provisions of Article 76, setting out formula lines to determine the outer edge of the continental margin, constraint lines determining the absolute cut-off points for the (legal) continental shelf, and different rules for the different categories of seafloor highs (oceanic ridges, submarine ridges, and submarine elevations that are natural components of the continental margin).

[100] LOSC, Article 76(1).
[101] LOSC, Article 76(3).
[102] International Hydrographic Organization, *Hydrographic Dictionary (online)* 'continental shelf', available at <http://hd.iho.int/en/index.php/continental_shelf.>

Evidently, the rules set out in Article 76 LOSC are greatly influenced by science, but not to such an extent that the legal definition is exactly the same as the scientific one. At the same time, Article 76 LOSC confuses this distinction between the legal continental shelf and the scientific one, insofar as subparagraph 3 of Article 76 provides that the continental margin, to determine the legal continental shelf, comprises the 'shelf', the slope and the rise.[103] In other words, the physical continental shelf is part of the legal continental shelf, but the legal continental shelf includes more.

How did the continental shelf end up having two different meanings? The legal development of the continental shelf shows the tension between movements towards keeping the legal definition as close as possible to the scientific definition on the one hand, and deviations from the scientific concept on the other hand. The legal origins of the continental shelf can be found in the Truman Proclamation of 1945, where President Truman of the United States of America claimed jurisdiction and control to the natural resources of 'the subsoil and sea bed of the continental shelf beneath the high seas but contiguous to the coasts of the United States'.[104] The continental shelf was considered to extend to a water depth of 100 fathoms (roughly 200 metres).[105] According to the proclamation, 'the continental shelf may be regarded as an extension of the land-mass of the coastal nation and thus naturally appurtenant to it, since these resources frequently form a seaward extension of a pool or deposit lying within the territory'.[106] Since then, the legal definition of the continental shelf has developed according to various elements. The International Law Commission proposed an outer limit of the continental shelf based on exploitability first,[107] then an outer limit based on depth (200 metres),[108] and ultimately combined the two in its 1956 definition.[109] Interestingly, the ILC was very much aware that the legal definition of the continental shelf differed from that known to scientists. It explained the departure from the geological concept of the term with two arguments: the varied use of the term "continental

[103] LOSC, Article 76(3).

[104] *Presidential Proclamation No. 2667, Concerning the Policy of the United States with Respect to the Natural Resources of the Subsoil and Sea Bed of the Continental Shelf 1945* ('Truman Proclamation (1945)').

[105] See the accompanying White House press release at 'Proclamation 2667—Policy of the United States With Respect to the Natural Resources of the Subsoil and Sea Bed of the Continental Shelf | The American Presidency Project', available at <https://www.presidency.ucsb.edu/documents/proclamation-2667-policy-the-united-states-with-respect-the-natural-resources-the-subsoil>.

[106] Truman Proclamation (1945) (n 104).

[107] ILC, *Report of the International Law Commission,* 3rd session, UN Doc A/1858 (1951), Annex: Draft Articles on the Continental Shelf and Related Subjects, 141, Article 1. In fact, the ILC's commentary on the draft articles highlights the departure from the geological concept of the term, and justifies doing to because '[t]he varied use of the term by scientists is in itself an obstacle to the adoption of the geological concept as a basis for legal regulation of the problem'. Ibid, Annex: Draft Articles on the Continental Shelf and Related Subjects, 141, Article 1, Note 1.

[108] ILC, *Report of the International Law Commission,* 5th session, UN Doc A/2456 (1953) 212, [62], Article 1.

[109] ILC, *Report of the International Law Commission*, 8th session, Un Doc A/3159 (1956) 264, Section III Continental Shelf, Article 67.

shelf" by scientists was an obstacle to using the geological concept for legal regulation, and the use of the geological concept was found to be discriminatory to those States with exploitable submarine areas that may not satisfy the requirements of the geological concept.[110] The 1958 Convention on the Continental Shelf incorporated the ILC definition.[111] However, the definition was not proven satisfactory, and in this context it was subject to scrutiny by the International Court of Justice (ICJ) in the NSCS cases of 1969, where the ICJ emphasised the element of 'natural prolongation' in the definition of the continental shelf.[112] It was on this basis, coupled with increased scientific knowledge[113], that UNCLOS III developed the highly technical, sophisticated definition of the continental shelf in Article 76. So, despite the return to more scientific oriented definitions of the continental shelf in the NSCS cases and Article 76, as demonstrated above, the legal definition is still different from the concept of the continental shelf in the natural sciences.

Sedentary species are another example of where the law borrowed a term from science, but where the meaning in law ended up being different from the meaning in science. Article 77 in Part VI of the LOSC defines sedentary species as 'organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or the subsoil'.[114] These resources are subject to the sovereign rights of the coastal State over its continental shelf.[115] The definition in the LOSC allows for two kinds of sedentary species: species that are by definition 'immobile', and species that are mobile, but which need the physical contact with the seabed or subsoil to be able to move. This second case stresses the mobility of this species.

[110] Ibid, 297, Commentary to Article 67, [5-6]. See also [7] where the ILC provided that '[w]hile adopting, to a certain extent, the geographical test for the "continental shelf" as the basis of the juridical definition of the term, the Commission therefore in no way holds that the existence of a continental shelf, in the geographical sense as generally understood, is essential for the exercise of the rights of the coastal State as defined in these articles.'

[111] Article 1.

[112] The ICJ held that '[w]hat confers the *ipso jure* title which international law attributes to the coastal State in respect of its continental shelf, is the fact that the submarine areas concerned may be deemed to be actually part of the territory over which the coastal State already has dominion, – in the sense that, although covered with water, they are a prolongation or continuation of that territory, an extension of it under the sea.' *North Sea Continental Shelf Cases (Federal Republic of Germany/Denmark; Federal Republic of Germany/Netherlands) Judgment* [1969] ICJ Rep 3, [43].

[113] See for example F Mørk, 'Classification of Seafloor Highs in Accordance With Article 76 of UNCLOS – Consequences of the Commission on the Limits of the Continental Shelf Recent Modifications of Its Interpretations' (2018) 49 *Ocean Development & International Law* 368, 368–369 who explains that the concept of seafloor spreading and plate tectonics had become 'widely accepted' in the early to mid-1960s. See also DP O'Connell, *The International Law of the Sea*, IA Shearer (ed) (Clarendon Press Oxford 1982) Vol I, 447 who writes that '[g]rowth of knowledge about the seabed, growing awareness of the complexities and uncertainties of the matter, coupled with the fact that the seabed is exploitable at great depths […] has led to a rephrasing of the definition of the continental shelf'.

[114] LOSC, Article 77(4).

[115] LOSC, Article 77(4).

Furthermore, the requirement of being sedentary only applies to when the species is at the 'harvestable stage'.[116] It is generally understood that the legal definition of sedentary species includes 'chanks, clams, oysters, mussels, scallops, sponges, corals, and crustaceans such as shrimps, prawns, lobsters and crabs'.[117] However, there has been some controversy about the inclusion of crustaceans.[118] In any case, lawyers seem to agree that the definition does not cover 'so-called bottom-fish and other fish, which, although living in the sea, occasionally have their habitat at the bottom of the sea or are bred there'.[119]

Outside of the legal context, the term "sedentary" refers to immobility more than it does to mobility. Originally a Latin word, "sedere" means to sit, and "sedens" sitting. In the strict sense, sedentary species are normally considered to be 'fixed to one spot.'[120] Within biology, sedentary is often juxtaposed to 'mobile'.[121] At other times, scientists refer to 'more sedentary' or 'less sedentary', implying that sedentary is at one end of the sliding scale, and mobile is at the other.[122] Scientific examples of sedentary species are sponges and corals, but also, some authors have named the sea horse a 'prime example' of sedentary marine fish.[123] Similarly, the coastal fish *Labrus bergylta* has been called a sedentary fish.[124]

The term "sedentary species" thus means different things in the two different languages of science and law. In science, sedentary species are considered to refer to those species that do not move. In law, however, the definition includes both immobile species and species that are mobile, to some extent. The negotiating history shows that at several times, scientists warned against the current legal

[116] Molenaar has argued that 'at the harvestable stage' should not be interpreted to exclude organisms 'that are not (yet) intended for exploitation'. EJ Molenaar, 'Unregulated Deep-Sea Fisheries: A Need for a Multi-Level Approach' (2004) 19 *The International Journal of Marine and Coastal Law* 223, 245.

[117] C Koijma, 'Fisheries, Sedentary' in *Max Planck Encyclopedia of Public International Law*, available at https://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1163?fromCrossSearch=true; AR Maggio, 'Article 77' in A Proelss (ed), *United Nations Convention on the Law of the Sea: A Commentary* (BECK Munich 2017) 604, 613, note 25. The Arbitral Tribunal in the *Chagos* case confirmed that coral was a sedentary species, and thus excluded from the regime of the exclusive economic zone (EEZ). *Chagos Marine Protected Area Arbitration (Mauritius v United Kingdom)* (2015) PCA Case No 2011-3, [304].

[118] See for example J Kindt, 'The Law of the Sea: Anadromous and Catadromous Fish Stocks, Sedentary Species, and the Highly Migratory Species' (1984) 11 *Syracuse Journal of International Law and Commerce* 23.

[119] ILC, *Report of the International Law Commission*, 8th session (1956), n 109, 297, Commentary to Article 68, [3].

[120] WR Welch, 'Sedentary Bottom Animals' (1967) 29 *The American Biology Teacher* 465.

[121] See for example JD Allan, AS Flecker and NL McClintock, 'Prey Preference of Stoneflies: Sedentary vs Mobile Prey' (1987) 49 *Oikos* 323; ME Hay, PE Renaud and W Fenical, 'Large Mobile versus Small Sedentary Herbivores and Their Resistance to Seaweed Chemical Defenses' (1988) 75 *Oecologia* 246.

[122] For example, Young concludes that 'in nature there is no simple line of demarcation between sedentary and other fish, but only a long series of gradations from the unquestionably fixed at one extreme to the unquestionably free at the other'. R Young, 'Sedentary Fisheries and the Convention on the Continental Shelf' (1961) 55 *American Journal of International Law* 359, 366.

[123] IR Caldwell and ACJ Vincent, 'A Sedentary Fish on the Move: Effects of Displacement on Long-Snouted Seahorse (Hippocampus Guttulatus Cuvier) Movement and Habitat Use' (2013) 96 *Environmental Biology of Fishes* 67, 68.

[124] D Villegas-Ríos et al, 'Life-History and Activity Shape Catchability in a Sedentary Fish' (2014) 515 *Marine Ecology Progress Series* 239.

definition and argued for a more ecosystem-based approach where the definition would reflect the biological interdependence of the species with the subsoil and seabed, rather than focusing on permanent attachment to it. The negotiating history of the provision on sedentary species demonstrates different suggested definitions, ranging from being compared to crops on land[125], and biological interdependence[126], to permanently being attached to the seabed[127], ending up with the provision as we now know it being included in the 1958 Convention on the Continental Shelf[128] and adopted verbatim in the 1982 LOSC.

Highly migratory species are a third example of false friends within the LOSC. These types of species are subject to special regulations, stipulated in Article 64 of the LOSC. The definition of these species, however, is subject to some uncertainty. It has been stated that the term "highly migratory" has been 'so widely used in legal writings that any biological meaning it originally carried has become not only obscure but possibly irrelevant.'[129] Unlike sedentary species or the continental shelf, the legal definition of highly migratory species is provided through a list of species and families.

Article 64 provides specific obligations for coastal States and other States, whose nations fish for 'the highly migratory species listed in Annex I' with the aim of ensuring conservation of such species. [130] Annex I thus reflects the legal understanding of highly migratory species, which consists of a list of seventeen species (although technically, three of these listed entities are families, rather

[125] Young, n 122, 361; LFE Goldie, 'Sedentary Fisheries and Article 2(4) of the Convention on the Continental Shelf 1 — A Plea for a Separate Regime 2' (1969) 63 *American Journal of International Law* 86, 89.

[126] During the ILC discussions it was proposed that the condition of "permanent attachment to the seabed" should be mentioned in the sedentary species provision itself. However, the opinion was expressed that coastal State sovereign rights could extend to any marine flora and fauna that would "live in constant physical and biological relationship with the seabed and the continental shelf". ILC, *Report of the International Law Commission,* 8th session, (1956), n 109, 197–198, Commentary to Article 68, [4]. Also during the discussions at UNCLOS I, there were delegations that suggested that continental shelf fisheries should also include bottom-fish and perhaps all fish in the waters of the shelf, and used an FAO report to argue that the biological interdependence on the shelf was 'an essential feature of life for many free-swimming fish as well'. Young, n 122, 367.

[127] The ILC, after long discussions, decided to grant coastal States sovereign rights to 'natural resources' of the continental shelf, rather than the previously discussed term 'mineral resources'. These 'natural resources' were also to include sedentary fisheries, as the products of these fisheries 'in particular, to the extent that they were natural resources permanently attached to the bed of the sea should not be left outside the scope of the regime adopted'. ILC, *Report of the International Law Commission*, 8th session, (1956), n 109, 297, Commentary to Article 68, [3].

[128] During UNCLOS III there were various differing positions regarding sovereign rights over the resources of the continental shelf. One group aimed for a compromise, supposedly resulting from 'close consultation between lawyers and biologists', and suggested the language that (for the most part) ended up as the final provision. The representative of Ceylon, a member of this group, explained that they had divided marine organisms into three groups, mobile species, species that only moved 'a few feet or less', and those which moved 'considerable distances', and it seemed reasonable to draw a line between the second and third group. Young, n 122, 367.

[129] R Hilborn and J Sibert, 'Is International Management of Tuna Necessary?' (1988) 12 *Marine Policy* 31, 32.

[130] LOSC, Article 64(1). These specific obligations include the obligation to cooperate, either directly or through 'appropriate international organizations', 'with a view of ensuring conservation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the [EEZ]'. LOSC, Article 64(1). These species are also governed by the 1995 UN Fish Stocks Agreement (UN FSA), which stipulates even more extensive obligations in relation to these species. See in particular, UN FSA, Article 8.

than species[131]), including different kinds of tuna species, mackerel, pomfrets, swordfish, dolphin fish, and cetaceans.[132]

The scientific understanding of highly migratory species is a little different. They are characterized as 'having vast geographical distributions, with extensive individual migrations often spanning entire oceans'.[133] Scientifically speaking, highly migratory species include those listed in Annex I of the LOSC, but also generally refer to *'Euthynnus lineatus,*' and three other tuna-like species, namely '*Acanthocybium solandri, Allothunnus fallai',* and '*Gasterochisma melampus*'.[134] Other species that have been referred to as highly migratory in the scientific field are marine turtles, such as the leatherback turtle (*Dermochelys coriacea*),[135] Atlantic herring (*Clupea harengus)*[136], and flying fish.[137]

The Food and Agricultural Organisation of the UN (FAO), in particular, has been very critical of the "definition" of highly migratory species in Annex 1 of the LOSC. It has stated in two separate reports that the list in Annex I is 'unsatisfactory', as new scientific information has become available and there are species which are undertaking 'large-scale migrations' that have not been included in the list in Annex I.[138] In addition, the composition of families can change over time corresponding to developments in taxonomy.[139]

Furthermore, the FAO claimed that the scientific names of some species have changed in the meantime, again demonstrating that the list in Annex I is 'unsatisfactory' and 'sometimes arbitrary.'[140] An example of this is the Bluefin tuna, the second listing in Annex I. Bluefin tuna, or "*Thunnus thynnus,"* seems to refer to only one species. However, the FAO has divided Bluefin tuna (*Thunnus thymus)* into two separate species. In a technical paper, it stated that 'since the drafting of [the LOSC], Bluefin tuna in the northern Pacific has been identified as a different species, Pacific bluefin tuna

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[131] D Owen, 'Annex I' in A Proelss (ed), *United Nations Convention on the Law of the Sea: A Commentary* (BECK Munich 2017) 2049, 2056, note 27; A Serdy, 'One Fin, Two Fins, Red Fins, Bluefins: Some Problems of Nomenclature and Taxonomy Affecting Legal Instruments Governing Tuna and Other Highly Migratory Species' (2004) 28 *Marine Policy* 235.

[132] LOSC, Annex I.

[133] PD Lynch et al., 'Challenges in the Assessment and Management of Highly Migratory Bycatch Species: A Case Study of the Atlantic Marlins' in WW. Taylor et al., *Sustainable Fisheries: Multi-level Approaches to a Global Problem* (American Fisheries Society, 2011), 197, 197.

[134] FAO Fisheries Department, 'World Review of Highly Migratory Species and Straddling Stocks' *FAO Fisheries Technical Paper* No. 337 (FAO Rome 1994), section 1.

[135] S Fossette et al, 'Pan-Atlantic Analysis of the Overlap of a Highly Migratory Species, the Leatherback Turtle, with Pelagic Longline Fisheries' (2014) 281 *Proceedings of the Royal Society B: Biological Sciences.*

[136] DE Ruzzante et al, 'Biocomplexity in a Highly Migratory Pelagic Marine Fish, Atlantic Herring' (2006) 273 *Proceedings: Biological Sciences* 1459.

[137] Owen, n 131, 2063, note 55.

[138] United Nations General Assembly, *Some High Seas Fisheries Aspects Relating to Straddling Fish Stocks and Highly Migratory Fish Stocks*, UN Doc A/CONF.164/INF/4 (1993), [30]; FAO Fisheries Department, n 134, section 1.

[139] Owen, n 131, 2059, note 36.

[140] FAO Fisheries Department, n 134, section 1; section 2.1.1.

(*Thunnus orientalis*) while bluefin in the Atlantic has been re-named Atlantic bluefin tuna'.[141] The fact that *Thunnus thynnus* has now evolved into two species raises the question of whether Article 64 of the LOSC applies to both subdivisions, or only the 'new' *Thunnus thymus*.

The legal definition of highly migratory species, from a scientific perspective, is confusing. Out of the seventeen categories listed in Annex I, only fourteen of these listings refer to species. The remaining three refer to one or more families.[142] Even the fourteen species categories either refer to one species each or to more species.[143] For those listings that only refer to one species, both the common name as well as the Latin name is provided. For those listings that refer to multiple species, only the Latin names are given for those species.[144] The name listed in Annex I often does not correspond to the common names of the Latin species. For example, listing number 9 is called 'Frigate mackerel', whereas the common names of the Latins species are Frigate tuna and Bullet tuna.[145] In addition, the sixteenth listing is 'oceanic sharks'. The question arises whether the word 'oceanic' in this listing is meant to qualify which species from the four families mentioned (*Alopiidae, Carcharhinidae, Sphyrnidae* and *Lamnidae*) fall under the scope of Annex I, implying that there could be some species in those families that are not 'oceanic', or whether the term 'oceanic' implies that all species listed in those families are 'oceanic sharks'.[146] In any case, the different listings in Annex I thus do not follow the same hierarchical structure.

Since the start of LOSC negotiations, highly migratory species have been defined in the LOSC through a list, rather than a working definition. In the early stages of the UNCLOS III negotiations, the American delegation was the first to suggest a specific provision for highly migratory species. This provision referred to 'highly migratory oceanic stock identified in Appendix A', although the appendix was not yet included.[147] However, this shows that from the early beginnings of the provision, the legal notion of highly migratory species was characterized by an Appendix or Annex. There have, however, been some initiatives in favour of adopting a working definition, rather than the list, or at the very least making the list easily amendable.[148]

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[141] JJ Maguire et al., 'The State of World Highly Migratory, Straddling and Other High Seas Fishery Resources and Associated Species,' *FAO Fisheries Technical Paper* No. 495 (FAO Rome 2006), 8. See also WL Klawe, 'What is a Tuna?' (1977) 39 *Marine Fisheries Review*, 1, 4; Serdy, n 131.
[142] Owen, n 131, 2056, 2058–2059, notes 27, 36; Serdy, n 131.
[143] LOSC, Annex I.
[144] Owen, n 131, 2057, note 31.
[145] Ibid, 2058, note 32.
[146] See ibid, 2060–2061, notes 47-48.
[147] Virginia Commentary, Article 64, page 650.
[148] For example, in 1977, Japan proposed a provision that would define highly migratory species as follows: 'tuna, cetaceans, and such other species as may be designated by the relevant regional or global organization on the basis of their ocean-wide range of migration and the need for their regional or global management by reason of multinational participation in the fishery of such species.' Owen, n 131, 2053, note 13. This proposal was not accepted, but would have allowed for more flexibility with regards to the legal notion of highly migratory species. Furthermore, the 1979 Convention

In all these examples of false friends, the negotiation history of the concept showed a tension between staying true to the scientific definition on the one hand, and adapting the definition to states' interests on the other. However, in none of the three examples does the legal definition exactly match the understanding of the term in the scientific "language". This may be due to the differences between the two "languages", or "systems", and their incommensurability.

4. LAW-SCIENCE INTERACTIONS THROUGH THE EYES OF LUHMANN

These interactions between law and science give rise to one important conclusion in particular: there seems to be a gap between the two institutions, or in other words, it seems as if the two systems are not truly communicating. This "gap" or miscommunication may be analysed according to Luhmann's systems theory. Because it is impossible within the space of this Chapter to set out a fully representative explanation of Luhmann's theory, this section will only focus on some aspects of his work that are relevant to the current discussion. First, section 4.1 will describe the relationship between the law and its environment, according to Luhmann's distinction between "system" and "environment". Then, this section will explain how law and science are two operationally closed systems, due to their "autopoietic" nature (4.2). Section 4.3 will then use Luhmann's work (complemented by others following in his footsteps)[149] on interaction between systems which may help us understand the interactions between law and science in the law of the sea.

4.1. The Law and its Environment

Law cannot exist without a context. The law of the sea cannot exist without oceans to protect, human activities to regulate, or without the State infrastructure. As sections 2 and 3 have demonstrated, the law of the sea thus encounters other bodies of knowledge, including science, but they each operate differently. This is true in Luhmann's systems theory as well. In fact, this is one of the crucial

on the Conservation of Migratory Species of Wild Animals (CMS) (adopted 23 June 1979, entered into force 1 November 1983, 1651 UNTS 333) includes a working definition of migratory species, namely 'the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries' (Article I(1)(a)). Adopted three years before the LOSC was adopted, delegates were most likely aware of this definition. However, it was probably too late, considering the strong reliance on the Annex, to change the definition of the LOSC to anything based on the CMS definition. See Owen, n 131, 2055, note 22.

[149] Luhmann's theory has been developed, summarized and reflected upon by other scholars. Those contributions are equally helpful in understanding the interaction between law and science through the lens of Luhmann's systems theory. As one Luhmann scholar observed, Luhmann's approach to theorising 'suggests that working with systems theory is an open invitation to continuously developing it further by combining it with new theoretical bits and pieces.' Borch, n 7, 141.

components of the theory. According to Luhmann, the world is split up into systems, and their corresponding environments.[150]

Systems are oriented by their environment, and 'they cannot exist without an environment'.[151] So, the system of law cannot exist without its environment. Systems 'constitute and maintain themselves by creating and maintaining a difference from their environment'.[152] This distinction between system and environment is thus crucial to Luhmann's theory of society. Every system has a unique environment, as each system only excludes itself from its environment.[153] The environment of the law of the sea is thus different from the environment of international criminal law, or the environment of the system of biology. A system 'totalizes itself' by referring to the environment and by leaving the environment undetermined.[154] A system's environment is not a system in itself, it is rather delimited by open horizons, and has no self-reflection or the capacity to act.[155] The environment is simply 'everything else'.[156]

How does that distinction help explain the interaction between law and science? A system's environment may include other systems (and their environments). So, the environment of the system of law will also include the systems of politics, science, economy, and so on. The same applies for the law of the sea. The environment of the law of the sea includes the systems of science, politics and economics, and arguably many others as well. Yet it is important to realize that those other systems in the system of law's environment (politics, science, economy etc.) are formed by the distinction between themselves and their environment. Therefore, as Luhmann submits, 'the environment of any system is given to it [the system] as a confusedly complex structure of reciprocal system/environment relations'.[157] In other words, the system of law's environment may include the system of science and its environment, of which the system of law (and its environment) is a part of.

4.2. Law and Science as Operationally Closed Systems

Although the environment of law may include the system of science (and vice versa), this does not mean that they are able to communicate. In fact, Luhmann submits that two different systems are not able to communicate at all.

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[150] Luhmann identifies three kinds of systems: living systems, psychic systems, and social systems. Ibid, 20; Luhmann, *Social Systems*, n 7, 2. Law and science are both considered social systems.
[151] Luhmann, *Social Systems*, n 7, 17.
[152] Ibid.
[153] Ibid.
[154] Ibid, 181.
[155] Ibid, 17.
[156] Ibid, 181.
[157] Ibid, 18.

All systems are characterized by their own operations. Social systems such as law and science have "communications" as their type of operations.[158] Luhmann submits that all systems are "autopoietic". "Autopoiesis" refers to the 'self-production' of systems.[159] Thus, Luhmann's theory of autopoiesis contends that 'an autopoietic system is one which produces and reproduces its components through a closed network of its components'.[160] What Luhmann means when he applies this term to social systems is that these systems produce and reproduce their own operations (communications).[161]

Because each system is autopoietic, it cannot suddenly incorporate operations from other systems, whether these systems have the same form of operations (communication) or not (consciousness or life).[162] This inability to incorporate operations from other systems is a consequence of the systems' "operational closure": each system is closed around its own operations.[163] As one Luhmann scholar stated, '[t]he operational closure of [the systems of science and law] means that the system of science cannot accept the legal system's operations as its own, and vice versa.'[164] A legal judgment is 'not a scientific judgment, and legal procedures are not scientific procedures'.[165]

As has already been discussed in section 2 of this Chapter, law and science seem to speak a different language. This assertion can be supported by Luhmann's theory of autopoietic systems. He submits that each system communicates in a binary code.[166] This binary code is what the system uses to see and interpret the world.[167] The legal system receives its autopoiesis through its binary code of legal/illegal.[168] No other system operates according to this code.[169] The binary code of the system of science, on the other hand, is that of true/false.[170] Thus, not only are systems operationally closed, they

[158] Living systems are characterized by operations that focus on life. Psychic systems are constituted on consciousness. Borch, n 7, 22.
[159] For a discussion of the meaning of the term 'autopoiesis', see N Luhmann, *Introduction to Systems Theory*, Dirk Baecker (ed), Peter Gilgen (tr) (Polity Press Cambridge 2012) 76–83.
[160] Borch, n 7, 26. Luhmann himself writes that 'an autopoietic system by means of the network of its own operations generates the operations that it needs in order to generate operations'. Luhmann, n 160, 77.
[161] Borch, n 7, 27.
[162] See Luhmann, n 160, 77.
[163] Luhmann writes, '[o]perations are from beginning to end […] always possible only inside a system, and they cannot be used to make an intervention in the environment'. Ibid, 64; See also Borch, n 7, 23.It is important to note that the 'closure' here only refers to the operational aspect. In fact, Luhmann submits that systems are characterized by operational closure, but cognitive openness. Perhaps somewhat paradoxically, "social systems are open toward their environment *because* (not in spite) of their operational closure. It is this closure that enables systems to perceive their environment, although this perception will always be processed according to the system's own internal premises." Ibid 23–24.
[164] Borch, n 7, 23.
[165] Ibid.
[166] Ibid, 71.
[167] Ibid.
[168] Luhmann, n 8, 64.
[169] Ibid.
[170] Ibid, 76.

are closed around their binary codes 'which prevents them from adopting the perspectives of other systems'.[171]

This operative closure means that systems cannot communicate with each other. A communication system can 'communicate *within* itself, *about* itself, or *about* its environment, but never *with* itself and never *with* its environment'.[172] The law of the sea can thus communicate *about* the system of science, but can never communicate *with* it. A system cannot incorporate operations from another system, nor can it communicate in the binary code of another system. Within the context of law and science, the consequence is that there is no relation between legal/illegal and true/false 'with neither the possibility of a translator device nor a meta-narrative that could organize their congruence'.[173] Law and science are thus 'incommensurable' – they are 'not capable of being compared or measured, especially because lacking a common quality necessary for a comparison to be made.'[174] A consequence of their incommensurability is the 'distortion of meaning that can occur when attempts to transfer knowledge between social systems are made'.[175]

The term incommensurability is a common term within the philosophy of science, frequently used by Kuhn to explain paradigm shifts in science,[176] but also within systems theory.[177] As exemplified in Luhmann's systems theory, there is no means of communication between social systems due to their autopoiesis.[178] Likewise, in Kuhn's discussion of paradigm shifts, there is no way to compare a new theory replacing a previous one.[179] Although Gilson's concept of incommensurability is inextricably linked with autopoiesis, there are differences. Autopoiesis 'denies the possibility of meaningful system inter-communication due to factors ordaining closure,' whereas incommensurability implies 'that systems attempting to communicate have no common basis on which to do so.'[180] In either one scenario, however, we are confronted with systems that are unable to communicate with each other. Does that mean inter-system or system-environment interaction does not exist? In other words, does that mean that law-science interaction within the law of the sea may never occur?

4.3. Interaction between Law and Science

[171] Borch, n 7, 71.
[172] Luhmann, *Theory of Society, Volume 1*, n 7, 52.
[173] Gilson, n 10, 16.
[174] *Encarta World English Dictionary* (Bloomsbury, 1999) cited in Gilson, n 10, 16.
[175] Gilson, n 10, 9.
[176] See TS Kuhn, *The Structure of Scientific Revolutions* 3rd edn (University of Chicago Press Chicago 1996).
[177] Gilson, n 10, 16.
[178] Ibid.
[179] Ibid 17; Kuhn, n 177.
[180] Gilson, n 10, 54.

As has just been concluded, law and science cannot communicate due to their respective autopoietic nature. Yet, Luhmann's theory includes ways to explain how different systems – including that of law and science – may still interact *to some extent* when they are "coupled". Autopoiesis means that systems cannot include operations from the outside, those that are not its own. So, a social system cannot suddenly introduce the operations of cells or the immune system.[181] The same is true for relations *between* social systems. Although they share the same kind of operation, namely that of communication, each social system has a different binary code. Each system will create its own '*specific* communicative operations'.[182] For example, whether something is beautiful or not (the binary code for the system of art) is not relevant when making scientific assessments about true or false (the binary code for the system of science).[183] Similarly, whether the hypothesis that warming oceans lead to fish stocks moving up North is true or false, is not (directly) relevant when making statements about whether or not a flag State carried out an illegal act in another State's territorial waters.

However – and keeping in mind that each system is part of the environment of another system – one system may have some interaction with another system. There may thus be some interaction between law and science. The terms used by Luhmann to explore these relations are "interpenetration", "structural coupling", and "operative coupling".[184] For all these terms, one must keep in mind that these phenomena do not threaten the autopoiesis of the system. In other words, the system remains distinct from its environment. The environment merely provides an "irritation", which the system itself then deals with through its own self-established structures.[185] Irritation, in this context, should not be understood as 'annoyance', but rather 'as an itching that calls for action'.[186] However, "irritations" do not 'determine' action.[187] In fact, as stressed by Luhmann, irritations are always self-irritations: even though they are provoked externally, they only appear in the system as a 'construct of the system itself'.[188] In other words, the 'system interprets the irritation in its own language'.[189] So, if climate

[181] Borch, n 7, 27.
[182] Ibid.
[183] Ibid, 28.
[184] "Interpenetration" was the term Luhmann used in his earlier work. It refers to an 'intersystem' relation between systems that are environments for each other. One speaks of "penetration" 'if a system makes its own complexity […] available for constructing another system.' Interpenetration, then, exists when this occurs reciprocally, namely 'when both systems enable each other by introducing their own already-constituted complexity into each other'. Luhmann, *Social Systems* (n 7) 213. However, Luhmann later 'dropped' this term for the term "structural coupling", and therefore this Chapter will only focus on the latter concept. See A Philippopoulos-Mihalopoulos, *Niklas Luhmann: Law, Justice, Society* (Routledge Abindgdon 2010) 130, note 111.
[185] See Luhmann, *Theory of Society, Volume 1*, n 7, 66–67. For an analysis by Luhmann himself on the existence of ecological problems and the ways in which they trigger resonance in the system of law, see generally Luhmann, n 8, 63–75.
[186] Borch, n 7, 31. Luhmann also employs different terms to refer to the same or similar effects, such as "disturbance", "stimulus", or "perturbation". See for example Luhmann, *Introduction to Systems Theory*, n 160, 89.
[187] Borch, n 7, 31.
[188] Luhmann, *Theory of Society, Volume 1*, n 7, 66–67.
[189] Borch, n 7, 31.

change and rising sea levels produce an irritation from the system of science, the system of law will interpret this irritation in the language of law, and law itself will decide whether and how it would like to respond.[190] Similarly, if science tells us that we now know that marine genetic resources exist in hydrothermal vents in the Area, this provides an "irritation" to law as it must now decide how to legally regulate such resources.[191]

Structural couplings occur when 'a system presupposes certain features of its environment on an ongoing basis and relies on them structurally'.[192] However, one must remember, structural couplings only supply "irritations" for the system.[193] In structural couplings, a system only 'presupposes' states of its environment – i.e. operations of other systems – rather than 'directly perceiving them'.[194] As an example, Luhmann explains that walking 'presupposes the gravitational forces of the earth', but that 'gravitation does not contribute any steps to the movement of bodies'.[195] Ultimately, structural coupling refers to 'the co-evolution of different systems (of whatever kind) whereby each includes the other in its environment, interpreting the outputs of the other in its own terms on a continuous basis'.[196]

"Operative couplings" are distinguished from structural couplings.[197] Operative couplings are couplings of operations with operations.[198] Operative coupling is a 'coupling of the operations of the system with operations that the system attributes to the environment'.[199] Luhmann offers the example of fulfilling a legal obligation by making a payment.[200] However, operative couplings between the system and the environment 'are possible only for the duration of the event'.[201] Even in the example he gave, we can still see differentiation. The economic aspect of making the payment (within the

[190] See for example the recent developments within the ILC and the International Law Association. The ILC decided to include the topic of sea-level rise in relation to international law in its programme of work, and established a Study Group on the topic. See ILC, *Report of the International Law Commission*, 71st session, UN Doc A/74/10 (2019) 263–273, Chapter X. The International Law Association has established a Committee to study the impacts of sea level rise and the implications under international law, and to 'develop proposals for the progressive development of international law' in relation to loss of state territory or maritime zones due to sea level rise. See International Law Association, Committee on International Law and Sea Level Rise, *Sydney Conference Report* (2018), available at https://www.ila-hq.org/index.php/committees.
[191] See UN, 'Intergovernmental Conference on Marine Biodiversity of Areas Beyond National Jurisdiction', n 31.
[192] Luhmann, *Law as a Social System*, n 7, 282.
[193] Luhmann, n 160, 88.
[194] Philippopoulos-Mihalopoulos, n 185, 131.
[195] N Luhmann, 'Operational Closure and Structural Coupling: The Differentiation of the Legal System' (1991) 13 *Cardozo Law Review* 1419, 1432.
[196] M King and C Thornhill, *Niklas Luhmann's Theory of Politics and Law* (Palgrave Macmillan Basingstoke 2003) 33. For an alternative perspective, whilst building upon Luhmann's theory, see G Teubner, *Law as an Autopoietic System* (Blackwell Oxford 1993).
[197] Luhmann, *Law as a Social System*, n 7, 381.
[198] Ibid.
[199] Ibid.
[200] Ibid.
[201] Ibid; See Borch, n 7, 73.

system of economy) is quite different from the legal aspect of fulfilling a legal obligation (within the system of law).[202] Operative couplings thus are different from structural couplings, as the latter implies the reliance of the system upon the environment on an ongoing basis, whereas the former only refers to couplings in the moment of the event.

Whether one uses the concept of interpenetration, structural coupling, or operative coupling, the important point here is to illustrate that law and science may influence each other. They may not directly communicate, but they may offer "irritations" for each other, which then function as an interaction between the two systems. Any one of these terms means that in the encounters between law and science, 'each autopoietic system reconstructs the other in its own terms'.[203] This is precisely what may explain the "gap" between law and science, or their miscommunication. When the law of the sea responds to "irritations" (such as sea level rise, or the discovery of marine genetic resources) offered by science, it does not interpret those "irritations" in the context they are offered to it (namely the scientific context). Rather, the legal system interprets those "irritations" within the legal context, and this may lead to a different result. There is no transfer of understanding from science to law.[204]

The operational closure of the two systems thus must remain emphasized, as the concept of structural couplings does not create a causal relationship between system and environment. It is not the case that new scientific knowledge, or scientific developments "cause" legal responses within the law of the sea. The two systems remain autopoietic systems. However, it may mean that the law of the sea depends on 'specific environmental traits which so to speak work as structural preconditions'.[205] In other words, in the context of the definitions of the continental shelf, sedentary species, and highly migratory species, the law is structurally coupled with science as it provides structural preconditions. However, because law and science both construct each other in their own terms, miscommunication exists and the problem of false friends arises.

5. CONCLUDING REMARKS

The law of the sea is witness to many interactions between law and science. The LOSC itself functions as the interface in which these two bodies of knowledge, or systems, come together. Not only does the Convention often refer to scientific information, knowledge and/or processes, it is also influenced by scientific developments and/or new knowledge, whilst at the same time regulating the conduct of science.

[202] Luhmann, *Law as a Social System*, n 7, 381.
[203] Gilson, n 10, 62.
[204] Ibid.
[205] Borch, n 7, 30–31.

However, as this Chapter has shown, law and science are two very different creatures. One can apply various distinctions to the two: justice/truth, prescription/description, "ought"/"is", process/progress, specific/general, policy or law/facts, definitiveness/endless revision and so on. Law and science differ in the context of time, and they operate according to a different language. Science and law perform different functions in society. The natural sciences, as a discipline, need to be flexible, adaptive to change. It is characterized by the operation of determining whether something is true or false. On the other hand, the nature of law is that it must be consistent, predictable, and establish legal certainty. It is concerned with communicating about whether something is legal or illegal.

In other words, one may conclude that law and science are two different systems, performing different functions in society, with different operations and codes. This is indeed what Luhmann submits: that each system is operationally closed, and may only interact with another system through its environment. In other words, one system can only interact with the shadow or mirror image of another system. Applied to science and law, law thus never communicates with science (or vice versa). Rather, law only responds to "irritations" provided by the system of science that are presented to law through law's environment, which the system of law then interprets in its own language. Thus, although inter-system relations may occur through the phenomena of structural and operative coupling, the two systems will never fully be in touch. In that sense, they are asymptotic.

However, even if law and science may never truly overcome those system boundaries, there are still techniques in place to limit the incommensurability between them. The LOSC itself already refers to two scientific institutions that inform legal decisions relating to various aspects of the law of the sea. The CLCS, comprised of scientific experts, is crucial for establishing final and binding outer limits of the continental shelf beyond 200 nautical miles. The Legal and Technical Commission of the International Seabed Authority also performs a crucial role in the deep seabed mining regime. Furthermore, the LOSC provides for the possibility of scientific experts to sit with the Judges on the bench when a dispute arises.[206] The Convention even introduces a possibility of having a dispute of a scientific nature settled by a special tribunal, in accordance with Annex VIII, rather than it being decided by the ICJ, ITLOS, or an Annex VII tribunal.[207] However, neither one of these options have been used so far.

Trying to reconcile law and science in the context of the law of the sea is thus not an easy task. Although it is important for legal regulations to be based on scientific knowledge, for the law to

[206] Article 289 of the LOSC provides that '[i]n any dispute involving scientific or technical matters, a court or tribunal exercising jurisdiction under this section may, at the request of a party or *proprio motu*, select in consultation with the parties no fewer than two scientific or technical experts chosen preferably from the relevant list prepared in accordance with Annex VIII, article 2, to sit with the court or tribunal but without the right to vote.' LOSC, Article 289.
[207] LOSC, Article 287(1)(d); Annex VIII.

respond to new knowledge and scientific developments, and for the law to regulate the conduct of science in an effective way, it is inevitable that some miscommunication between law and science exists. Furthermore, we should also not overestimate the roles of law and science in society. Science cannot answer the question whether or not to make something legal or illegal, in the same way that law can never determine whether a hypothesis is true or false.[208] Neither system is superior to the other – they are complementary. In that sense, Luhmann's systems theory provides a helpful lens to understand the interactions between law and science in general, why those interactions are sometimes examples of miscommunication, and how perhaps one can bring law and science closer together in the interests of effective oceans governance.

[208] See J McEldowney and S McEldowney, 'Science and Environmental Law: Collaboration across the Double Helix' (2011) 13 *Environmental Law Review* 169, 197 who provide: 'A necessary borrowing and sharing between law and science [...] needs to respect the boundaries of each discipline and recognise its potential vulnerability to misinterpretation.'