The Economics of the Law of the Sea

Till Markus, Gerd Markus

(Oxford Research Encyclopedia of Environmental Sciences, 2021, forthcoming)

Summary

The Economics of the Law of the Sea (LoS) quite generally investigates how the LoS has developed in the past, how it functions at present, and how it could serve in the future. It explores economic factors that shape the LoS, assesses its economic effects, and evaluates different legal options from an economic perspective with a view to achieving specific goals. Accordingly, it can address a large variety of topics and pick from a wide range of ideas, analytical frames, and tools. Studies in this area can, for example, investigate economic drivers that have influenced the development of the modern LoS, analyze general economic characteristics of ocean resources, explore the economics of specific ocean related activities governed by the LoS (exploiting the sea floor, fishing, protecting coasts against sea level rise, etc.), and assess important economic effects of selected LoS measures (drawing boundaries, creating marine enclosures, and establishing permit regimes). Economic analyses of the LoS are particularly valuable in linking information regarding facts and norms, for example, by illuminating the economic dimensions of conflicts to lawyers or translating specific regulatory approaches into costs and benefits. In this way, it may contribute to managing oceans more rationally, efficiently, sustainably, and peacefully.

Keywords: *Environmental law and economics, international law and economics, fisheries law and economics, marine enclosures, delineating maritime boundaries, costs of maritime*

conflicts, seabed mining, costs of coastal protection, economic institutions and property rights in the sea

Introduction

Motives for using the sea are diverse. They shift over time, depend on actors' varying preferences, and are contingent on technological developments, political relations, and the availability of ocean resources. Accordingly, the sea's social and economic value has been subject to continuous change. Historically, competing interests over marine spaces and resources have been the main driver for the development of the law of the sea (LoS). Competitive situations and conflicts arise between individuals, groups, or collective actors such as enterprises, states, or international organizations. In a broad sense the LoS addresses conflicts between different types of actors related to the sea. This chapter aims to highlight those areas in which economics can contribute particularly well to better understanding the LoS's origins and effects. It also introduces some of the central themes of the LoS and subjects them to different kinds of economic analyses.

This investigation is based on the following assumptions: First, the LoS is shaped by different factors, including economic ones. Second, the LoS has *inter alia* economic effects which can be made visible through economic analyses. Third, economics provides an eclectic set of analytical devices that can promote a better understanding of certain legal issues as well as the mechanics and effects of the laws governing them. A better understanding may result in proposals to revise and improve the law, e.g. to achieve specific legal goals more efficiently or to increase law's effectiveness. Economic arguments can thus complement political and legal objectives and commitments that lawmakers have to consider. Fourth, conflicts governed by the LoS exist at different levels, i.e. local, national, supranational, and international. These dissimilar conflicts and laws have to be assessed differently, i.e. particularly conflicts between

individuals on one side and conflicts between states on the other. Both types of actors follow very distinct sets of premises, interests, and rationales when they weigh the pros and cons of their actions, e.g. with a view to consenting to or complying with LoS.

This chapter is structured as follows: The first section gives a broad overview of the main factors that have contributed to shaping the LoS and sketch its main structure (II.). In a second step, we will address different ideas regarding the function economics may have in analyzing the LoS (III.1.). We will also look at the actors observed within the economic analysis of the LoS, particularly highlighting the differences between individuals and states (III.2.) Third, the chapter outlines some general economic characteristics of ocean uses and resources (IV.). Fourth, we will then proceed to examine important economic effects of central LoS measures such as drawing boundaries in the sea and creating marine enclosures (V). Fifth, the chapter then explores the economics of specific activities or aspects governed by the LoS, i.e. exploiting minerals (a non-moving resource), fish stocks (a moving resource), and sea-level rise (an environmental and social issue) (VI.). Finally, this chapter closes with an outlook on topics relevant for future studies in the area of the economics of the LOS (VII.).

Introducing the LoS

Laws usually develop in response to conflicts (Berman, Greiner, & Saliba, 2004). They provide generic objectives, principles, and rules that define what different actors ought to do in situations that have given rise to dispute before. Their general purpose is to prevent and resolve such frictions and encourage behavior consistent with agreed norms.

As indicated in the introductory section to this chapter the development of the law of the sea has largely evolved around the competing interests of different actors over marine spaces and resources. These interests and conflicts have changed over the centuries. In ancient times, maritime spaces were valued mainly for geostrategic, security, and trade purposes (other resources were either mostly abundant or simply not accessible). Empires like Athens or Rome

policed or restricted access to certain areas and negotiated agreements with neighboring powers in this regard (Vitzthum & Hafner, 2006, pp. 10-28).

Claiming exclusive control or even specific rights over the sea probably peaked at the dawn of the so-called Spanish Era of colonial times (1500-1648). Portugal and Spain agreed on 7 June 1494 to divide up the world's oceans. A line was drawn 370 leagues west of Cap Verde and the Azores reaching from pole to pole to ban vessels from other seafaring nations from these areas ("Contract of Tordesillas") (van der Linden, 1916). This effort, of course, evoked protest by the English, the Dutch, and the French and sparked an early but long-lasting legal debate about the rights of states over the sea, which is referred to as the "battle of the books" (Treves, 2015, p. 4; Vitzthum & Hafner, 2006, pp. 32-38). The conflict between those who claim exclusive rights (*mare clausum*) and those arguing in favour of non-exclusivity (*mare liberum*) has become—and remains to this day—the root conflict of the law of the sea (O'Connell, 1982, p. 1; Sohn, Juras, Noyes, & Franckx, 2010, pp. 1-12).

As technological progress advanced, opportunity for conflict also increased as ocean spaces and resources became more accessible. Traditional uses increased in volume and became more effective (ships, fishing gear, weapons etc.), and new types of off-shore activities emerged (seabed-mining for oil, gas, and minerals, off-shore cables and pipelines, renewable energy etc.) (Salomon & Markus, 2018).

Another complicating factor is that several land-based activities substantially increase or decrease the economic value of the sea. For example, while coastal tourism has become a large-scale global business which raises the value of coastal and near-shore waters (Gössling, Hall, & Scott, 2018; Simcock, 2018), coastal developments as well as industrial and agricultural run-offs such as nitrate can degrade their environmental status and usability (Oenema, Liu, & Wang, 2018; Schmid, 2018; van Beusekom, 2018; C. Winter, 2018).

At the beginning of the 21st century even the ocean's remotest spaces and smallest resources have become interesting for exploitation and subject to regulation under the LoS. At the time

of writing mineral extraction from deep sea areas as well as access to and use of marine genetic resources from the high seas areas are being internationally regulated (Koschinsky et al., 2018; Lodge, 2015; Markus & Singh, 2016). Notably, in 2015 an agreement has been reached under the auspices of the International Maritime Organization (IMO) that addresses different "marine climate engineering technologies" (Ginzky, 2018; Keller, 2018).

Hance Smith has aptly coined this overall development as the "industrialization of the world ocean" (Smith, 2000) and others have referred to it as the "blue acceleration" (Jouffray, Blasiak, Norström, Österblom, & Nyström, 2020). Today, many ocean ecosystems and resources are threatened by the enormous surge in ocean activities (Maribus, 2010, 2013, 2014, 2015, 2017, 2019). Accordingly, most of these ocean activities have been regulated to protect the marine environment and their economic value (Harrison, 2017).

To better understand which types of conflicts shape and drive the development of the LoS in the early 21st century, they may be grouped into four general categories (Markus, 2018): First, there are allocation conflicts among *users of a single resource* (e.g. fisheries v. fishers). Second, conflicts exist among *users of different resources* (e.g. shipping v. offshore mining). Third, the continuous expansion of maritime activities, as well as their increasing environmental impacts, requires reconciliation between *user and conservation interests* (e.g. shipping, fishing, and offshore oil, gas, and mineral extractions v. conservation of marine biodiversity). Finally, *inter-ecological conflicts* have been occurring ever more frequently (the buildup of offshore renewable energy production v. protection of marine mammals and sea birds). These four types of conflicts have an *inter-personal* as well as an *inter-state* dimension. In the sea, the various human activities, their impacts on the environment, the ecosystems to be protected, as well as the resources, often extend beyond or across national borders. This situation demands international coordination and the balancing of interests.

Many different types of legal instruments have developed to address these different categories of conflicts (e.g. Kieß, 2018). They include rules of liability, command and control regulations,

integrated strategies and planning measures, market-based instruments, and a variety of non-binding instruments. Most ocean related activities are regulated by a combination of these instruments, altogether directing or re-directing individuals' or collectives' behavior towards specific goals. For example, liability regimes have become an important legal tool in the area of combating oil pollution from ships, particularly oil tankers. The group of command and control measures includes a variety of instruments such as requiring *prior authorization*, *restrictions* (e.g. dumping ban for specific materials), *standards (*e.g. regarding SO_X-, CO_2-, or noise emission levels for ships), construction requirements (e.g. for off-shore wind farms, oil platforms, or ships), demanding the use of specific technologies (certain types of fishing gear that aim to avoid by-catch), etc. Marine strategies and plans have become increasingly important over the last decade ("integrated ocean policies"; "marine spatial planning") (see Schlacke, Markus, & Meier, 2011; Schubert, 2018; Scott, 2015). These instruments often aim at coordinating and integrating different sectoral policies such as fishing, shipping, military uses, off-shore infrastructures, and land-based activities such as agriculture, all of them affecting the seas (in terms of time, space, and content). Strategies and plans usually consist of a set of targets and measures that aim to achieve them as well as procedures to assess and value progress. In addition, market-based instruments include, for example, taxes, subsidies, cap and trade systems, environmental auditing, etc. Under the LoS subsidies are important in many fisheries policies as well as in development of renewable offshore energy systems (Markus, 2019). Cap and trade systems also exist in many fisheries laws and are currently being discussed as an instrument to reduce CO_2-emissions in the shipping sector.

All these different legal instruments are included both in national and international law. In federal state systems, some of these measures are made or implemented at the subnational level. In the special case of the European Union (EU), different laws regarding different ocean activities are adopted at EU-level (particularly fisheries) (Churchill & Owen, 2010; Peñas Lado, 2020). National laws provide rights and obligations for the respective countries' authorities and

citizens. For example, on one hand, most countries' national fisheries laws require fishermen to apply for a permit and to report accurately on their fishing activities (where, when, how, and how much?). Authorities, on the other hand, are empowered and required to ensure that fish stocks are not overexploited, important marine ecosystems are not destroyed, and fishing rules are complied with (Markus, 2019). Where states decide to coordinate their behavior and their national governance of maritime activities they usually develop international law. Their most important legal instruments for inter-state-coordination are treaties which are complemented by binding customs and general principles, but which also include other non-binding instruments such as resolutions, guidelines, and codes of conduct (Boyle & Chinkin, 2007, pp. 210 et seq.; Rothwell & Stephens, 2016, pp. 22-25).

Particularly since the early 1970s, states have established a complex system of international treaties that regulate their rights and duties in different maritime spaces (and how to delimit those spaces) regarding specific activities such as fishing, shipping, mining, research, environmental conservation etc (Rothwell & Stephens, 2016; Tanaka, 2015). These different legal instruments require or call upon states to adopt and implement specific measures at the national level. Sometimes states also commit themselves to take joint actions. To this end they often create very different types of international bodies such as, for example, the

- International Seabed Authority (ISA),
- Intergovernmental Oceanographic Commission (IOC),
- International Maritime Organization (IMO),
- Commission on the Limits of Continental Shelf,
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP),
- International Fisheries Organizations,
- Organizations for the protection of regional seas (e.g. the OSPAR Commission),

- The International Tribunal for the Law of the Sea.

Under the auspices of these organizations states pursue different objectives and tasks such as the joint management and distribution of resources, developing and adopting common strategies and measures to protect the marine environment, administering the implementation and development of international treaties, or providing scientific expertise, etc. (Boyes & Elliott, 2014; Harrison, 2011; Singh, 2018).

The central treaty and the starting point for all legal analyses of the LoS is the United Nations Convention on the Law of the Sea (UNCLOS) from 1982. Quoting Tommy T.B. Koh of Singapore, President of the Third United Nations Conference on the Law of the Sea, UNCLOS is often referred to as a "constitution for the oceans". In its preamble, it declares that the contracting member states are "[p]rompted by the desire to settle, in a spirit of mutual understanding and cooperation, all issues relating to the law of the sea […]".

UNCLOS divides the seas into different zones and allocates the states sovereign powers, rights and duties over different parts of the zones. It particularly distinguishes between so-called inland waters, territorial waters, archipelagic waters, contiguous zones, exclusive economic zones (EEZ), and the continental shelf, as well as the high seas and the so-called "Area".

Whereas — in principle — the sovereignty of the coastal states extends to inland, territorial and archipelagic waters, they only have functionally limited sovereign rights for the purpose of exploring, exploiting, conserving, and managing the natural resources in the EEZs and on the continental shelf (Art. 56 and Art. 77 UNCLOS). The high seas waters stretch beyond EEZ waters. Here, the "freedoms of the high seas" generally apply (freedom of shipping, overflight, laying submarine cables and pipelines, installing systems, fishing, scientific research, etc.). The "seabed and ocean floor and subsoil thereof" located beyond the limits of the (extended) continental shelves and under the high seas water column is called the "Area" and has the legal status of a 'common heritage of mankind' and is administered by the International Seabed Authority (Arts. 1 (1) and 136 ff. UNCLOS).

Besides zoning the seas and assigning sovereign powers, UNCLOS also prescribes a general framework of rights and duties regarding the protection of the marine environment (Arts. 192 – 237 UNCLOS), the management of marine living resources (Arts. 61-68, 116-120), marine scientific research (Arts. 238-265), and dispute settlement (Part XV). It also regulates different aspects of navigation (e.g. Arts. 17, 37-45, 52-53). Notably, UNCLOS also created the legal framework for multiple institutions to be involved in the development of the law of the sea, particularly the above mentioned Commission on the Limits of the Continental Shelf, the International Tribunal for the Law of the Sea, and the International Seabed Authority, as well as international fisheries organizations governing fisheries on the high seas (Harrison, 2011, p. 58; Rothwell & Stephens, 2016, pp. 506-533; Singh, 2018; Unterweger, 2015).

Outside of UNCLOS, a large number of treaties have been adopted to complement the basic legal framework laid down in the "constitution for the oceans". In addition, as of September 2020 ITLOS had decided different 29 cases (two of which were advisory opinions) in which it applied and interpreted this system of treaties (see also Oxman, 2015).

Economic perspectives on the LoS

The following subsections addresses how the economics of the LoS fit into the overall research field of the economic analyses of law. Given that the LoS consists of both national and international law, the central methodological challenges to transfer economic concepts and methods to the international level will briefly be highlighted.

Research focus and purposes of economic analyses of the LoS

Economic analyses of law have focused on many different legal fields and served different purposes. Accordingly, analyses have drawn on a variety of theoretical assumptions and methods, and different research schools have developed (for an overview see Towfigh, Petersen, & Englerth, 2015). Some basic theoretical premises and themes, however, frequently reoccur, such as that actors try to act rationally and maximize their preferences in situations where resources are limited, or that laws can increase or decrease efficiency, reduce external

effects, or influence the development of the costs of certain activities that they regulate. Since the 1950s different areas of law have been examined from different economic perspectives—particularly the laws on property, contracts, torts, liability, antitrust, and fisheries (see overview in Bouckaert & Geest, 2000; on fisheries e.g. Le Gallic & Cox, 2006; Nøstbakken, 2008). Recently, economic analyses have paid increasing attention to different public law fields such as energy, environmental, and international law (Cole, 2010; Danielsen, 2016; Faure & Partain, 2019; Goldsmith & Posner, 2005; Guzman, 2008; Livermore & Revesz, 2017; Rao, 2001; Sykes & Guzman, 2017; Trachtman, 2012; van Aaken, 2014).

Over the years several basic economic assumptions have been complemented and sometimes subjected to substantial critique. This critique also reflects in the discourse on the economic analyses of the law. Actors have been found to not act that rationally after all (Basu, 2020; Jolls, Sunstein, & Thaler, 2000), the role of non-market factors in creating wealth has been highlighted (Sen, 2000, 2010), the relevance of institutional mechanisms for managing common resources have been explored (Ostrom, 1990), and many varying arguments have been brought forward as to what purposes economic analyses should serve in the face of fundamental market problems and increasing inequalities (Pistor, 2019).

Economic analyses of the LoS can thus pick from a wide range of ideas, analytical frames, and tools and pursue a large variety of objectives. Quite generally, they may aim to investigate and better understand how the LoS works (positivist approach) or how it should work (normative approach) (R. A. Posner, 2014, Part 1 sec. 2.2.). The first objective aims to better understand economic dimensions of the law, particularly the economic aspects of the conflicts that have called lawmakers to develop and adopt new laws as well as laws' economic effects. The second objective is to use economics to evaluate different legal options from an economic perspective with a view to achieving a specific goal (e.g. deciding which legal option is most efficient, produces the lowest costs, internalizes externalities, changes harmful incentive structures to make laws more effective, etc.).

To this day the economic analyses of LoS have largely concentrated on fisheries laws (Hannesson, 2004; Markus, 2010, 2019). Only very recently have other study areas received more attention such as, for example, the economic analyses of why and how the LoS allocates control and use rights over different marine areas to coastal states (E. A. Posner & Sykes, 2010) or how it governs conflicts regarding wrecks, piracy, MPAs, coral reefs, pollution, or deep seabed mining (Hallwood, 2014; Koschinsky et al., 2018). Obviously, many topics remain yet unexplored and the economics of the LoS as a research field is just emerging.

Analyzing inter-state relations

As explained above, the LoS exists at least at two levels—the national and the international. Federal state systems and entities like the EU may add even more layers. Notably, however, only few legal fields are as determined and influenced by international law as is the LoS. Accordingly, the economics of the LoS has to pay due attention to this governance level.

The economic analyses of international law also borrow from economics the basic idea that—at least to some extent – states act rationally and aim strategically to maximize advantages under conditions of limited resources (Bianchi, 2016, p. 269). Transferring these ideas, however, to the international level raises at least two fundamental analytical concerns.

First, such an analytical move basically analogizes individuals and states by anthropomorphizing states, i.e. they are conceptualized as aggregated and unitary actors that are able to develop specific preferences and make rational choices. In the international arena, however, the complexity of the inner structures, processes, and interests of states by far exceeds this somewhat simplistic rationale of the *homo oeconomicus* (Barrett, 2003; Bodansky, 2010, pp. 108-190; Sprinz & Vaahtoranta, 1994; Wiener, 1999). Negotiation situations in particular are characterized by a complex amalgam of international and national interests, political values, and legal rules. To use Putnam's words, international negotiations are complex 'two level games', at the very least (Putnam, 1988).

Second, the goods and assets traded between states are very different from those traded between individuals (Bianchi, 2016, pp. 269-271). In general, states mostly negotiate power and its components, or they aim to pursue joint interests, e.g. to protect common pool resources such as marine biodiversity or other values of general interest (e.g. human rights Dunoff & Trachtman, 1999, p. 13). In this process states usually have the tendency to shy away from two very different kinds of costs, i.e. "monetary" and often so-called "sovereignty costs". First, they are inclined to avoid monetary costs of designing and implementing new international treaties, especially creating new costly administrative structures both at the national or the international level (Bodansky, 2010, pp. 136-190 ; Markus, 2016). Second, states are also generally unwilling to limit their sovereignty through international agreements in nationally important areas such as energy (off-shore oil and gas, renewable energy), food (fisheries), trade (shipping), and with a view to their geostrategic interests (naval powers, borders). Particularly with a view to marine environmental protection, states often have diverging perceptions of the problems in question as well as differing values regarding nature and economic development which influence their international negotiations (Bodansky, 2010; Markus, 2018).

General economic characteristics of ocean resources

From an economic point of view, the marine environment in its entirety, the individual ecosystem services it provides, and its resources constitute so-called *common pool resources* (Cooper, 1975; Gordon, 1954; E. A. Posner & Sykes, 2010). Common pool resources are defined by two central characteristics (for details see Madison, Frischmann, & Strandburg, 2010). First, common pool resources in nature are subject to little control or authority (or sometimes none at all), which means that excluding individuals from using them is for the most part impossible. Second, their use is characterized by scarcity and rivalry, which means that the use of the resource by one actor reduces or makes more expensive the use by others (externality). For example, fishing activities by some reduce the opportunities and raise the

costs for other fishers to catch fish. Also, the extraction of non-renewable resources such as oil, gas, minerals, sand, and gravel reduces the amount available to other parties and makes further extraction more complicated and expensive. In addition, the marine ecosystem's ecological carrying capacity and its potential to provide ecosystem services may be seen as common pool resources (regarding valuation see, for example, Bartowski 2019, Bartowski & Lienhoop 2019). Utilization and harm of every kind can affect ecosystem services, impairing, for example, marine waters' ability to promote biological diversity or provide clean coastal waters for recreational use. Finally, even marine resources which have yet to be discovered could be regarded as common pool resources. In principle, every newly discovered resource makes the search for other undiscovered resources more expensive (Posner & Sykes, 2010).

The public nature of marine environmental goods and the rivalry between users creates a social dilemma which is widely referred to as the '*tragedy of the commons'* (Gordon, 1954; Hardin, 1968; partially revising Hardin, 1998). From the point of view of an economically acting individual user of marine environmental resources, the situation is as follows: exploitation costs will decrease and profits will increase if competitors restrict their exploitation activities in order to preserve the environment or to promote the efficient distribution of the contested resource. For single competitors, however, short-term, calculable profits have a higher value than long-term non-calculable benefits (O'Donoghue & Rabin, 1999), thus, an economic incentive arises to not contribute to conservation or efficient use, but rather results in exponential increase in pressure to utilize and to pocket higher profits (*free-riding*). Forgoing benefits of resource exploitation would be totally irrational, because a) the individual user would not be able to guarantee the preservation of the resource by himself alone, b) as a single contender, only he or she alone would lose profits, and c) the advantages of forgoing would solely benefit the competitors. This mostly ends in individual strategy decisions which lead to inefficient and destructive results for the community.

The solution to this dilemma can only come through some form of cooperation among involved users which aims at an overall limited and efficient use and distribution of the resources. Such cooperation, however, may be difficult. Against this backdrop, traditional environmental economics has drawn two strategic conclusions: either utilization rights should be allocated under state control, or the common pool should be transformed into private property (see already Hardin, 1968). Both solutions require external control and neither has proven to be consistently successful in practice. However, under certain circumstances, cooperative solutions are possible by means of internalized norms and successful communication (Ostrom, 1990, 2010). Before all others, *Elinor Ostrom* has identified eight 'design principles' in extensive studies that promote independent, largely autonomous cooperation solutions (Ostrom, 2010). The principles include, for example: clear and accepted borders between legitimate users and non-users; sanctions which become increasingly severe when rules are broken repeatedly; precise monitoring of the resources and their users; local avenues for quick resolutions of conflicts; a minimum level of competences to create rules; and a non-hierarchical and polycentric system of decision making.

Regarding many marine issues, cooperation has to be achieved between states. Factors, however, that either discourage or encourage cooperation, also exist at this level. On one side, the tragedy of the commons dilemma also exists between states (at least to some extent). Particularly, international law's mainly decentralized implementation and enforcement can worsen its effects. On the other side, there are different factors that can promote effective international legal coordination and cooperation. For simplicity reasons and illustrative purposes, such factors may be divided into three groups: Those which (1) promote successful negotiations, (2) are of a substantial and material nature, and (3) promote effective implementation (Markus 2018, p. 554-555). In addition, other factors like the existence of reciprocal interests between states, their potential to use force or other sanctions to promote compliance, and possible reputational interests are deemed important in solving international

issues, including those regarding the use and conservation of the seas (Markus 2018, pp. 555-559).

The economic effects of two central LoS measures

The following section looks at two of the most central legal measures incorporated in the LoS: drawing maritime boundaries (1.) and allocating exclusive control through enclosures (2.). It will highlight how and to what extent the LoS has responded to economic aspects of conflicts over the sea and its resources and which economic effects can be attributed to the existing LoS.

Delineating maritime boundaries

Delineating boundaries serves a very specific purpose in the LoS context: it aims to delimit national claims over spaces and resources in the sea. International legal principles and rules on how to draw boundaries in the sea have emerged from countless conflicts over spaces and resources. Their main function is to balance these competing interests. These conflicts have been so important throughout the development of the LoS that a large number of UNCLOS provisions and a large share of international judicial bodies' LoS case law are dedicated to delimitation questions (particularly Arts. 5-16 [baselines, territorial waters], Arts. 46, 47 [EEZ], Art. 74 para. 1, 2, Art. 76 paras. 1-10, Art. 83 para. 1, 2 [continental shelfs], Art. 121 para. 2, 3 [islands] UNCLOS) (regarding case law see Evans, 2015; Oude Elferink, Busch, & Henriksen, 2018, pp. 1-32). Over time, delineating boundaries in the sea has become more and more a technically and legally complex enterprise requiring expert knowledge (Fietta & Cleverly, 2016). As long as there are conflicts over marine resources and spaces, there will also be delimitation and boundary issues.

Today, these boundary conflicts are present particularly in the Arctic Ocean, the South China Sea, and the Mediterranean, as well as generally around the edges of continental shelves which coastal states currently aim to extend (for an overview of other excessive maritime claims see Roach & Smith, 2012). In addition, a lot of boundary issues between neighboring states have

never been settled. Some of these conflicts are at rest for now but history teaches that boundary issues can always resurrect where politics and interests change.

As explained earlier, countries pursue and weigh many political interests within their international relations regarding the sea; their interests are not purely economic (see Gillespie, 2005; on fisheries see Hannesson, 2004). A simple microeconomic analysis can, nevertheless, help to make visible states' interests, preferences, possible choices, and the likely costs in situations which involve maritime boundary conflicts.

The basic assumption here is that states draw boundaries in the sea where they want to indicate to other states the exact area in which they claim certain rights over spaces and resources. Their claims may or may not be disputed by other states. Disputes usually emerge in situations where states are neighboring or facing each other and their claims over the sea overlap. Boundary conflicts can also exist where states are not close to each other but where one state pursues "long-distance-interests" such as, for example, fishing, navigation, or research in areas claimed exclusively by other states in distant areas.

Boundary disputes between states cannot be decided unilaterally. As *Hallwood* has illustratively explained, this leaves countries with several choices (Hallwood, 2014, pp. 63-70). For example, if states A and B argue about a specific boundary, there are four options to address the conflict:

- Country A's preferred boundary is agreed upon.
- Both countries compromise and agree on a different boundary.
- Country B's preferred boundary is agreed upon.
- No agreement is reached and the conflict continues.

With a view to obtaining the benefits resulting from resource exploitation country A would most likely prefer option 1 over 2, option 2 over 3, and option 3 over 4. This is because option 1 would allow country A to exclusively reap the benefits of that relatively large ocean space enclosed by the preferred boundary. Under option 2 it would have to share some of the desired

resources with country B. Option 3 would exclude A to an even larger extent from using the disputed area, but it would still most likely be preferred over the last option, since option 4 could lead to substantial costs. First, where a specific marine area is disputed between different states, the chances are low that conflicting parties will establish sustainable, efficient, and effective resource management systems for exploiting either renewable or non-renewable resources. Costly overexploitation or conflicts between nationals of both countries about dwindling resources are likely to arise. Second, the costs of the conflict themselves can be extremely high, for example, where they lead states to set police or even naval ships in motion to ensure that certain activities can be carried out (e.g., as happened during the famous Cod Wars between Iceland and the UK starting in the late 1950s, or in the conflict between Canada and Spain about the "Estai", a vessel fishing close to Canada's EEZ, or with a view to research vessels drilling for oil and gas in the Mediterranean in areas disputed between Turkey and Greece), or where they may negatively affect relations between government outside of marine policies such as in the areas of trade and investment (regarding the costs of international conflicts see e.g. Coulomb, 2011; see also Stiglitz & Bilmes, 2012).

To better understand the costs of conflicts over maritime boundaries, economists would, for example, try to operationalize and calculate the additional rent to be drawn from exploiting the disputed area as well as the dispute costs (Hallwood, 2014, pp. 66-70). Calculating exploitation rent would inter alia include assessing the revenues from exploitation weighted by the probability of a successful dispute resolution and subtracting the expected dispute costs. These steps can be repeated over different time periods. Summing up the discounted values of the additional rent and the dispute costs for all years included in the calculation provides a clearer picture of the value of the disputed area and states' strategic interests with a view to drawing boundaries.

Creating marine enclosures

The establishment of exclusive control over different areas in the sea has attracted economists' interests for a long time. They have tried to understand whether and to what extent the claiming of exclusive control over spaces or resources follows an economic logic or pattern (Demsetz, 1967). Regarding the LoS, they have asked whether there are economic arguments that support the way the LoS currently allocates use rights in different maritime zones (Hallwood, 2014, pp. 57-64; Hannesson, 2004; Posner & Sykes, 2010).

Economists have used the term enclosure to describe a process in which commonly used resources are subjected to exclusive control, i.e. formerly freely accessible, shared, and wildly used goods are now claimed by relatively few(er) actors. Where such claims gradually strengthen, develop a clear structure, and become increasingly accepted (or are effectively enforced), they turn into something economists would call economic institutions and lawyers would refer to as use or (even) property rights (see Munzer, 1990; Penner, 1997).

To some extent, observing different enclosures in history has revealed that the process of enclosing seems to follow a certain economic rationality and can also have specific economic effects. One basic observation was made by Demsetz in 1967 who investigated and interpreted the hunting economy in North America in the 17th and early 18th centuries (Demsetz, 1967). During this time demand for meat and fur increased and the hunting methods became more effective. While buffalo herds almost went extinct as a result of extensive hunting, beaver colonies survived a similar pressure. Demsetz concluded that this had been due to buffalo herds remaining open to all hunters while beaver hunting areas had been divided up and the allocation order had been (sufficiently) effectively controlled by the native Americans. Demsetz argued that such enclosures can internalize the externalities following from an open access regime. According to him, a shift from open access to exclusive use rights is likely to occur where the costs of exclusion fall below its gains (see Lueck, 1995).

The resemblance of establishing preferential maritime zones for coastal states to other historic enclosures is indeed striking (Hannesson, 2004, p. 23). As has been described above, for

centuries empires and states have tried to claim exclusive control over maritime areas for specific purposes but have not been interested or able to secure them for long. For a very long time the sea was mainly valuable with a view to pursuing security, geostrategic, or trade interests. Other ocean resources were abundant (fish) or simply not accessible (mineral or fossil resources). In the logic of Demsetz, the economic value of claiming exclusive rights over ocean spaces and resources was low, while the cost of claiming them was high. The industrialization of the world's oceans (see above) has changed this situation: Exploitation of many ocean resources has become technically feasible and often extremely effective, and some resources have become scarce and highly valuable. Following Demsetz's line of argument this process has created a situation where the benefits for coastal states to claim exclusive exploitation rights over specific ocean resources exceed the costs of doing so. As a result, states have been inclined to end the open access regime in the oceans and initiate the process of enclosure (see Hannesson, 2004).

This view offers a convincing explanation of the incentive structure underlying the development of one of the most central developments in the modern LoS. Some additional aspects must be highlighted, however, to make the analysis more complete. First, *Hannesson* has correctly observed that enclosures which re-allocate use rights between states are quite different from those re-allocating use rights been individuals, i.e. states are aggregated actors which follow different sets of premises (Hannesson, 2004, p. 27). The international process of enclosure has been particularly influenced by the power structures prevalent in international relations at the time of drafting the modern LoS. Unsurprisingly, those countries which have been most powerful over the relevant decades are the greatest winners of the establishment of the EEZ and the (extended) continental shelves.

Second, inside the newly established enclosures (i.e. within the coastal states' territorial waters, their EEZs, and their continental shelves) the resources are still a common resource among the nationals of a given coastal states. The last five decades have proven that the incentive structure

for enclosing also exists inside coastal states' exclusive areas and that states are still required to legally address the problems inherent in open access regimes towards their nationals (Markus, 2019).

Third, creating marine enclosures can have the positive economic effects generally attributed to them (e.g. Hallwood, 2014; Hannesson, 2004, p. 10), but they can also create new problems. On the positive side, providing exclusive control over ocean areas and resources may incentivize states to establish effective management systems that aim to ensure sustainable and efficient use of the resources in the respective areas. Particularly where resources are renewable and management requires use restrictions, such a system may increase the likelihood that those who participate in management will enjoy its benefits. In addition, where there is competition over scarce resources, a well ordered and accepted system of use rights will, again, help to reduce costly conflicts between competitors over the disputed resources. On the negative side, however, allocating exclusive use rights does not automatically internalize all kinds of negative externalities (Faure & Partain, 2019, p. 42). For example, states or fishermen may take good care of their commercially valuable stocks but neglect the effects of fishing on non-target or commercially less valuable species (or other parts of the marine ecosystem).

The economics of specific ocean activities governed by the LoS

The following sections will highlight some important contributions economic analyses can make to better understanding the economic dimension of the LoS. It will mainly try to explain how economists would value the benefits of claiming and exploiting ocean floor resources under the existing LoS, the economic effects of central fisheries management measures, and the costs of coastal protection actions aimed at responding to climate change-induced sea-level-rise.

Exploiting the ocean floor

In the course of the "industrialization of the world ocean" resources on, in, or below the ocean floors have become accessible. Oil and gas as well as different kinds of sands and minerals are being extracted on a large scale, at a fast pace, and in increasingly deep waters (Patin, 2018; Vogt & Skei, 2018). Today, states and commercial enterprises have set their eyes on minerals located in the deep sea such as polymetallic nodules, ferromanganese crusts, and polymetallic sulphide deposits (for an overview of these minerals see Petersen et al., 2016; Sharma, Khadge, & Jai Sankar, 2013).

This development takes place within the existing and developing legal framework of UNCLOS. As explained above, UNCLOS establishes a system of different maritime zones in which states have different rights and responsibilities. With a specific view to the ocean floor, coastal states claim sole control in their territorial waters (or archipelagic waters as the case may be), and they enjoy exclusive exploitation rights over living and non-living resources on the continental shelf (Art. 77 (1) UNCLOS). In contrast to the rights over the EZZ, rights over the continental shelf do not depend on occupation or proclamation but exist *ipso facto* (Art. 77 (3) UNCLOS). Coastal states may, however, actively claim an extended 'outer continental shelf' in accordance with specific conditions and procedures (Art. 77 (4) – (9) UNCLOS).

Beyond these zones lie the areas referred to as 'areas beyond national jurisdiction'. In these areas, two other regimes apply. The first is the high seas regime established through Part VII of UNCLOS, which essentially covers the high seas water column. As explained above, here states are basically free to enjoy the freedom of the high seas. Different rules apply on the ocean floor lying under high seas water and adjacent to the extended continental shelf, i.e. the 'Area'. Article 136 of UNCLOS prescribes that the Area and its resources constitute a 'common heritage of mankind' where no state may exercise sovereign rights. The responsibility of creating a regime for the exploration and exploitation of resources in the Area falls within the scope of the International Seabed Authority (ISA) (Art. 156 UNCLOS). In accordance with its mandate under Part XI of UNCLOS and the 1994 Implementation Agreement, the ISA has

spent the last two decades working on creating a centralized system of regulation and governance to manage deep seabed mining in the Area (The 'Mining Code') (see Lodge, 2015, pp. 240-241). The ISA is guided *inter alia* by Article 140 which provides that activities in the Area shall be 'carried out for the benefit of mankind as a whole' and that the ISA 'shall provide for the equitable sharing of financial and other economic benefits derived from activities in the Area through any appropriate mechanism, on a non-discriminatory basis' (Art. 140 UNCLOS). At present, the international LoS governing the use of ocean floor resources currently develops around four focal points: states' claims for extended continental shelves, delimitation issues between states with opposite or adjacent coasts, the development of the Mining Code for mineral extraction in the Area, and environmental conservation (regarding environmental conservation see Boetius & Haeckel, 2018; Markus, Huhn, & Bischof, 2015; regarding conflicts with opposite or adjacent coasts see Tanaka, 2017).

Different economic questions arise in view of these developments and conflicts. Generally, states and private enterprises need to assess the economic value of exploiting resources on or in the ocean floors, both close and distant to their shores. Based on such an understanding they may better weigh the pros and cons of near-shore or more distant exploitation activities, claims towards other states, and environmental conservation.

Assessing the economic value of exploiting resources located on or in the sea floor can be done, for example, by comparing its costs and revenues in financial terms. To this end, the perspective of a private investor is adopted. This approach would include a simple investment calculation, i.e. calculating, for example, the possible revenues from selling the exploited resource (e.g. oil or certain minerals) as well as the costs of invested assets (e.g. drilling machines, labor hours). A wider view would include, for example, the costs of cleaning the water polluted by drilling operations or accidents. Such an extended approach is called 'cost-benefit analyses' (for a fundamental example McKean, 1958; for a famous early overview Prest & Turvey, 1965). To get an even broader idea about the types of assets, the different professions, or the liquidity

streams needed for the exploitation operation, one may rely on even more complex instruments from cost accounting and financial management.

The following paragraphs aim to illustrate the steps from a rather narrow to a more extended economic perspective regarding the exploitation of sea floor resources. To this end, we introduce a simple and an extended profitability calculation and then the conceptual tools for steering exploitation operations.

An ordinary investment calculation or a costs benefit analysis would require several basic steps, i.e. operationalizing and quantifying the necessary investments (part of costs), the costs of processing, the income (sales, revenues), and the difference between revenues (R), and costs (C). Practically, this involves ascertaining the type of resource of interest, its qualities, the potential quantities available for extraction, and (world) market prices (today or over a certain period into the future). Often, several of these elements remain uncertain, and thus the assessments entail risks of miscalculation.

The question of whether it is economically worthwhile to invest in the exploitation of ocean floor resources (Cf. Perloff, 2004, pp. 569 et seq) may be formalized by calculating the so-called net present value (NPV) of an exploitation project (e.g. mineral or oil resources), which is the difference of revenues from selling the exploited resource and all costs of exploitation (e.g. drilling and transportation) for any period t, from year 0 to the year at the end of a chosen time horizon, T, summed up over all periods in question. One pertinent problem, however, remains: The difference of revenues and costs in period T, e.g. 20, is not of the same value as it is now, i.e. period 0. So it is necessary to devaluate all net income, i.e. R – C, and this is accomplished by 'discounting', i.e. by dividing it by 1 plus an interest rate 'i', e.g. 0.04 or 4 %, i.e. (1+0.04) for every year of the future periods.

All this in short-hand means:

$$(1) \qquad NPV = R_0 - C_0 + \frac{R_1 - C_1}{(1+i)^1} + \ldots + \frac{R_T - C_T}{(1+i)^T}$$

Additional components of costs and of returns, e.g. costs of cleaning the pollution from drilling and additional returns for especially high valued oil, can easily be integrated into this equation, resulting in the above mentioned cost-benefit analysis (for an early example referring to water-resource projects see McKean, 1958; for a more elaborated approach see Zerbe & Dively, 1994). If exploiting minerals, for example, destroys fishery grounds, one may add the value of the damage to the cost-positions or subtract it from the return for every year in question. Alternatively, if a state deems it important to reduce unemployment through an investment in exploitation activities, one may simply add such a variable and its value to the returns.

While these types of calculation provide some information regarding the profitability of an investment into the exploitation of resources located on or in the ocean floor, a lot of questions for those who are interested in investing remain yet unanswered, such as: What type of machines must be bought and how expensive are they? Which groups of qualified employees have to be engaged and how high will their wages be? How much liquidity (means of payment) will be necessary throughout the project?

Thus, for steering an exploitation project, the project owner (states or private entities) needs a more elaborated concept or even different concepts from the realm of business economics, especially the 'balance sheet' concept and that of the 'cash flow statement'. Such an approach would include an assessment of the sum of all the different material and financial assets, K_i, necessary for drilling and conveying minerals or oil, as well as financing, either by equity, E, the project's own means, or by debt, Y, which results in the following equation:

$$(2) \qquad \sum_1^N K_{i,t} = E_t + Y_t$$

with N assets

i running from 1 to N.

This 'balance equation' provides us with really important information:

- we have a set of N different assets for e.g. extracting minerals from our coastal area and the summed-up value,
- which have been financed by the company established for extracting the minerals itself, E, and in part by debt Y, probably through a bank,
- true for every point of time, t, of our time horizon.

The amount of information regarding the exploitation project should be enhanced, because the operating agency must ensure for each point of time that it is able to meet its own obligations (e.g. payments). Operationalising we read the traditional cash account (van Hilten, Kort, & van Loon, 1993, p. 65 et seq): Net sales plus additional debt must meet the payment obligation from interest to be paid on debt plus investment, taxes and dividends for each point of the lifetime of the project:

(3) $$S_t + \Delta Y_t = r * Y_t + I_t + \mathrm{Tax}_t + D_t$$

with *S* being net sales (R-C),

r rate of interest on debt Y,

I for gross investment,

Tax for corporate tax and

D for dividends paid.

Of course, the complexity of economic tools can be further increased. Another level of complexity would, for example, include building larger economic models for simulating alternative developments, especially unexpected risks. These frameworks address questions about integration of non-controllable events or the power of steering complex processes, even considering constraints that might be given by shortfalls of labor force or natural limits of the coastlines or limits of action prescribed by law (Ruth & Hannon, 2012, p. 4).

Fisheries

The United Nations Food and Agricultural Organisation (FAO) states that since the 1980s global marine fisheries capture has levelled off to around 80 million tonnes annually (FAO, 2016, pp. 10-13). Recent studies, however, estimate true global catches to be significantly higher and they also indicate a slow but steady decline of fish populations (Pauly & Zeller, 2016). Technological progress, the growth of world population, and changing consumption patterns are likely to increase fishing pressures in the mid- and long term (Hegland, 2018). The FAO estimates that approximately 31.4% of global fish stocks are overfished and 58.1% are fully exploited without any room for further growth (FAO, 2016, p. 38). Despite this global trend it must be noted that the degree of overfishing can vary substantially in different regions, fisheries, and countries (for a comparative assessment see e.g. Williams & Staples, 2010).

Laws regulating marine fishing activities can generally be understood as a response to the problem of overfishing. Their most important aim is to ensure that fishing activities do not threaten stocks by overexploitation. Most modern fisheries laws, however, more ambitiously strive to ensure that fishing activities are carried out at sustainable levels. International fisheries law and many national fisheries laws use the Maximum Sustainable Yield level (MSY) as the central point of reference for defining sustainable fishing (see Markus, 2019), i.e., the largest harvest that can be taken from a fish stock year after year while still maintaining the average stock size (for critical assessment see Finley & Oreskes, 2013).

Though MSY seems to be the focal point in fisheries management, it must be noted that it does not reflect the ecosystemic effects of fishing activities on non-target fisheries species (which is particularly problematic in multi-species fisheries and with regard to the conservation of marine mammals) or on the marine environment as such (see generally Kaiser & Groot, 2000). Economists would also argue that fishing at MSY may not meet efficiency criteria, since in most cases it exceeds the *maximum economic yield-level* (MEY), i.e., the level of fishing at which economic profits in a specific fishery are maximised (Dichmont, Pascoe, Kompas, Punt, & Deng, 2010). Accordingly, fishing restrictions which allow fishing at MSY-level may have

to be modified to respond adequately to environmental necessities and efficiency considerations.

Lawmakers all over the world have adopted an array of measures to achieve their respective ideal fishing targets. Measures may include so-called input- or output-restrictions. Input restriction may include the limitation or reduction of the number of fishing vessels (e.g. through a licensing system or buy-back schemes), the regulation of vessel size and engine power, catching periods or areas, and fishing gear (Holden, 1996, p. 196; Kura, Revenga, Hoshino, & Mock, 2005, pp. 90-91). Output-restrictions may include quantitative catch restrictions, i.e., "total allowable catches" (TAC), as well as landing obligations and discard regulations. TACs are usually divided into quotas which are then assigned to fishermen (who may or may not be allowed to trade them).

In theory, these measures taken together should determine the overall catch levels as well as the environmental impacts of fishing activities. In reality, however, the overall amount of catch and the environmental impacts depend on many more factors. For example, they are also influenced by the quality of information available on the state of the stocks, the public expenditure on control and enforcement, and the amount of subsidies provided by the government for increasing or maintaining fishing capacities, etc (Markus, 2009; G. Winter, 2009).

The following sections will illustrate how economic thinking and methods can help to better understand the effects of fisheries laws on the costs of fishing. To this end, we will introduce three small instruments that represent fish stocks, their development, the logic of commercial fishery (particularly with a view to profitability), and governmental measures to manage the amount of catch. Designing such instruments in three consecutive steps also makes clear what kind of information is required to guide fisheries management (state and dynamics of stocks, the fishing capacity of fishermen, prices, etc.). It is worth noting that the models used for advising governments on the development of stocks and fisheries management are substantially

more complex, consisting of large bundles of equations, representing, e.g., age cohorts or different species (Methot & Wetzel, 2013).

We begin with a basic model of a fish stock in a defined area of the sea:

(4) $$st\_f_t = st\_f_{t-1}^{(1+r)} - c_{t-1}$$

st_ft for stock of fish at time *t*;

ct for amount of fish caught at time *t*,

r for rate of growth of the stock of fish.

This simple mathematical expression represents the development of the stock, depending on its natural growth rate per year (*r*), minus the amount of fish caught. If the fish stock, for example, consist of 100 units in the previous year (*t*-1) and the annual growth is 10 % (so that (1+*r*) is 1.1), the stock would amount to 110 units. If we then assume an annual catch of 5 units, the stock will eventually consist of 105 units that given year. At the end of the fishing year 105 units would still be in the water and 5 units would have been landed for further processing or consumption.

National and international fisheries lawmakers aim to limit the amount of fish being caught (c_t). As explained above, they try to establish a catch rate that allows stocks to re-produce around the MSY-levels (or other ideal levels). If this were easy, the problem of overfishing would not exist. The catch factor, c_t, in particular is in practice really difficult and expensive to define (costs of science (Methot & Wetzel, 2013)); furthermore, it is often influenced by fishermen's or governments' economic interests, preferring clear and reliable short-term gains over unclear and more uncertain long-term gains.

Leaving these specific problems aside for a moment, we move on to modify our instrument: The amount of catch (e.g. in tons per year) is converted into the vessels necessary for catching it (e.g. number of vessels) by using a variable '*a*' that shows how much fish is caught during one year by one vessel. This means simply that the amount of catch (c_t) strongly depends on

the capacity of the number of vessels employed, *cap_v*$_t$. Then we introduce the dynamics of the development of the capacity: It is equal to their fishing-capacity the year before, cap_v$_{t-1}$, after adjusting for depreciating vessels and investment in new ones.

(5) $$c_t = a * cap\_v_t = a * (cap\_v_{t-1})^{(1-dr)} + a * inv\_v_{t-1}$$

cap_v for the capacity of fishing in terms of number of vessels

a for transforming the capacity of fishing into the amount of fish to be caught

inv_v the investment in new vessels at time *t*

dr rate of depreciation of the capacity of the vessel

In a third step we illustrate the conditions under which fishermen will invest in the fishery sector. In simple terms, fishermen will invest where they expect to make profit, i.e. where they assume that the returns from selling their catch will exceed the sum of all their costs (catch in year *t*, c_t, minus the sum of all sorts of costs, $\sum_a co_{at}$). As already indicated above, governments can influence fishing activities (and thus c_t) not only through quantitative or technical restrictions but also by changing the cost-revenue structures for fishermen, either increasing or decreasing the profitability of fishing through imposing taxes and providing subsidies. Depending on governments' objectives, altering fishing costs through taxes and subsidies can promote or discourage investments into the fisheries sector, lead to an increase or decrease in fishing capacities (Markus, 2009), and eventually raise or reduce the overall amount of catch (c_t) (Markus, 2010). Thus taxes (tax_t) and subsidies ($subs_t$) are introduced into the third equation. The statement now reads: Investment depends on the difference between revenues and the sum of all costs. Introducing the amount of catch and accounting for various types of costs, co_a, and for taxes and subsidies we get

(6) $$inv\_v_t = b * (r_t - \sum_{a,t} co_{a,t}) = b * (p_{f_t} * c_t - \sum_{a,t} u_{co\,a,t} * c_t - f_{co\,t} - tax_t + subs_t)$$

r for revenues at time t

co for costs of type a at time t

$(r_t - \sum_{a,t} co_{a,t})$ for net income of the fishermen at time t

with 'b' transforming the net income into investment.

On the right hand side of equation (6) we define the revenues as price times amount of catch sold and separate the costs into those depending on unit-costs multiplied by the amount of catch and fixed costs (not being influenced directly by the amount of fish caught), then we can integrate taxes and subsidies.

Coastal protection against sea level rise

Among the many effects of climate change, one of great concern is rising sea levels. The IPCC in its Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) has forecasted in 2019 that by the end of the century, depending on the ambition levels of climate mitigation policies, the global mean sea level will likely rise between 0.4 to 0.8 meters (by 2300 about 0.5 m up to 3.5) (Pörtner, Roberts, Masson-Delmotte, & Zhai, 2019, p. 325). As a result, extreme sea level events such as high tides and storms will become more threatening to coasts, for example, by 'permanent submergence of land (…), more frequent or intense coastal flooding, enhanced coastal erosion, loss and change of coastal ecosystems, salinization of soils, ground and surface water, and impeded drainage' (Pörtner et al., 2019, p. 326). Climate change induced risks of sea level rise already affect and will increasingly affect coastal cities (Hallegatte, Green, Nicholls, & Corfee-Morlot, 2013; Hanson et al., 2011; Sherbinin, Schiller, & Pulsipher, 2007).

Particularly national policy and law makers are now confronted with an array of questions regarding their response to these emerging risks and threats—especially questions concerning which strategies and actions should be pursued to avoid potential damages. Many different economic considerations will be vital in this regard, particularly the costs of coastal protection

as well as protection measures' effects on the economy. The following paragraphs will provide a basic idea of how economists would approach the effects of protecting coastal regions against rising sea levels on regional or national economies.

For illustrative purposes, we will focus here on the question of how the construction sector and the affected economy as a whole must develop for raising and maintaining dikes. One possible approach would be to apply the so-called 'input-output-methodology' (D'Hernoncourt, Cordier, & Hadley, 2011), using what mathematicians call matrix algebra.

Providing security through higher dykes for a specific region could be so large a task that it could substantially affect the entire economy of that region. For example, the construction sector might have to expand. This, in turn, would most likely include attracting additional work force (basically divesting it from other sectors) and deploying additional large machinery (which may be produced within the region or be imported from abroad). To be able to operationalise and quantify such interdependent processes within a (regional) economy requires the application of a concept that could encompass all its sectors, perhaps 20 or 60 different branches, their interdependence (e.g. mutual deliveries), and their specific employment structures (perhaps even differentiated for specifically qualified groups).

Let x_t be the complete amount of production and services of the specific economy at time *t*, *x* now being an array of all sectors of the region, e.g., from agricultural production, to construction, to education.

Part of the production and services provided by each sector is used by the other branches; each of these deliveries is covered by a mathematical square figure *A*, called a matrix. We read equation (7) below: All the production and services of all the branches of the economy, x_t, is either used by other industries, $A_t * x_t$, or used as so-called final demand, y_t. Mathematically:

$$x_t = A * x_t + y_t \tag{7}$$

If we re-arrange, we get

(8) $$x_t = (I - A)^{-1} * y_t$$

Now we read: The final demand of output of each branch, *y*, e.g. security against rising sea-level, requires an output of *x* of the same and additionally of some or all other sectors necessary for the production for this demand. For the Netherlands, for example, it has been calculated that for each € 1 million spent on 'additional security' for higher dykes, the output of the economy – database Netherlands of year 2000 - would have to be expanded by about € 1.9 million (D'Hernoncourt et al., 2011).

Outlook

This chapter has introduced the different functions and perspectives of economics in order to give a clearer picture of the LoS. To this end, it has explained how economic factors have contributed to shaping its development, how these factors influence its functioning and effects, and how economic concepts can help to evaluate different legal options. In this course it became visible how economics links information regarding facts and norms, e.g. how economists use data about natural or social processes to explain to lawyers the economic dimensions of conflicts or how they translate specific norms into costs and benefits. In addition, the chapter emphasized that analyzing various economic aspects of the LoS may require very different types of economic methods and concepts. All of this together makes the economics of the LoS a truly intra- and interdisciplinary effort.

This chapter, however, only scratched the surface of the possible research program to be pursued within the area of the economics of the LoS. The continuing industrialization of the oceans as well as boundary conflicts currently fuel a dynamic development of the LoS and create a large reservoir of research questions. Economic research will be necessary to inform, for example, the ongoing international regulation of deep seabed mining, of the access to and benefit sharing of marine genetic resources in the high seas, and of renewable off-shore energy production, as well as the looming conflicts in the Arctic Ocean, the Mediterranean, or the

South-China Sea. Economics will be particularly necessary to guide the regulatory efforts to protect the marine environment. Projects must identify the overall costs and benefits of greening the different maritime sectors such as fisheries, transport (shipping, pipelines, harbors), mineral extractions, tourism, etc. To this end, investigations could include, for example, the systematic application of the ecosystem services approach to the protection of specific elements of the marine environment or exploring the economic effects of the large variety of regulatory instruments of marine environmental law (Costanza et al., 2014; Faure & Partain, 2019; Milon & Alvarez, 2019). Future investigations will clarify the objective, functions and methods in this regard and hopefully contribute to managing ocean uses more rationally, sustainably, and peacefully.

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