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Michelle Eva Portman

Environmental Planning for Oceans and Coasts

Methods, Tools and Technologies

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I seem to have been only like a boy playing on the seashore, and diverting myself, now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

– Isaac Newton (1642–1726)
physicist-philosopher

Foreword

My son, Matthew, grew up as the son of a coastal and ocean social scientist who was involved intimately in broadly interdisciplinary work regarding the application of social science to environment policy, in particular with coasts and oceans. Matthew was by inclination an arts and humanities person, and shied away from the "sciences", though he had a great feeling for the coastal and ocean environment in which we have both been life-long participants as surfers, sailors, paddlers and fishermen.

A few years ago, Matthew called me and said that he had been reading up on coastal management. He said, "Coastal management is really more about planning than just science, isn't it?" I heartily agreed, and Matthew now has a Master's Degree in City and Regional Planning, with an emphasis on the relationship between water policy and coastal development, and a fine job in that field.

This is the first part of what is important about Michelle Portman's book: it emphasizes the role of planning, as opposed to either science or management, in coastal and ocean affairs. A second important aspect is that it treats the coast and ocean as one, not as separate intellectual or policy domains. This latter part distinguishes it from the vast majority of other works on the subject.

The third aspect of Environmental Planning for Oceans and Coasts is that it emphasizes the difference between science, and policy and management. Science strives to be objective, reliable and to produce valid results. Science is about what was, what is or what might be if humans behave in one way or another. It is never, however, about what should be; that is, science is never normative. Policy and management, on the other hand, are not about science but about governance. Governance is, appropriately, always normative. Although this book treats an interesting (and somewhat extraordinary, given the "normal" list of coastal and ocean issues) set of coastal and ocean policy and management sectors as examples, it does not dwell on the science of those topics, but rather moves quickly and completely to the planning, policy and management context of the topics. This is as it should be in a book about environmental planning, including decision support tools to assist in this planning for coasts and oceans.

Finally, this book presents a perspective on how to deal with change in the biophysical, socioeconomic and public policy aspects of coasts and oceans. It is not a long list of the issues themselves; it is rather a framework within which to approach and deal with issues and the changes that are occurring at faster and faster rates in and around our coasts and oceans.

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Preface

> *The dismal truth is that shores . . . are fast disappearing, and may well do so completely within the life of some of us.*[1]
>
> – Rachel Carson, 1957

Like many people of my generation and many of those born before me, such as Rachel Carson, I entered adulthood acutely aware of the changes taking place in the natural world before my eyes – unwanted changes, in my opinion – changes that worried me. I spent my early childhood in the 1960s in Silicon Valley, California. Before being called “Silicon Valley”, it was the Santa Clara Valley and it still had agricultural fields and fruit orchards, remnants of the “fruit basket” of the U.S. West Coast. But these field and orchards were rapidly becoming housing developments, shopping malls and gas stations. It seemed that orchards turned into parking lots overnight, just like in the Joni Mitchel song: “You never know what you’ve got till it’s gone. . .” I knew what we had then, and I knew it was going. . ..

These changes signified to me far-reaching transitions from the natural world to the developed, which engendered feelings of loss, which in turn brought me to want to dedicate my career to addressing the situation. I hoped that as an environmental planner I could improve conditions under which development takes place, and if not stop it, at least try to mitigate some of its more disastrous effects on the environment. Unfortunately, intermittingly from job to job as a planner, I found myself contributing more to development than to conservation and environmental protection. With this realization, I decided to get a doctoral degree in public policy and use my experience as a planner to help others to better care for the environment. I felt that this was a way to reach out, bring my knowledge and feelings about sustainability and conservation together, and make a difference. I view this book as a stepping stone towards these goals.

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[1] Souder W (2012) On a farther shore, the life and legacy of Rachel Carson. Random House, New York, p 267.

Without specifically planning it, I've never lived far from the sea. Although my family was not particularly beach-going, I spent my summers at sleep-away camps in Oregon and Washington, and in various places in California – always right on the water. I understood the tremendous draw of the ocean and lakes for tourism, recreation and development. As a high school exchange student for a year in Recife, Brazil, I lived in a seafront home (*na beira mar*) on one of the most beautiful beaches in the world: Pierdade-Boa Viagem. My college years took me to the magical beaches of the Sinai Desert and of the Mediterranean Sea. By the time I got to the legendary Cape Cod, where I spent two years as a post-doctoral fellow at the Woods Hole Oceanographic Institution, I had seen such incredible beaches that the cold, windswept shores of Massachusetts were not particularly inviting! But it was there that I learned to appreciate the importance of fishing grounds, industrial ports and ocean sanctuaries, among other uses of oceans and coasts.

While living and working in New England, I realized that the conservation of coastal and marine environments is part and parcel of other paradigms, such as the public trust doctrine, that guarantees the rights of all people to the sea's shores and oceans, just as our rights are guaranteed to the air we breathe and the water we drink. Just as significant as these rights is the obligation of the "powers that be" – in this case, the government – to plan, manage and protect ocean and coastal resources for the public and for posterity. About a decade ago, as a doctoral student of public policy – and at the same time a planner working for the Massachusetts Department of Environmental Protection – I decided that this was a topic to which I would dedicate the next chapter of my career.

While not targeted solely towards planners working in the public sector, this book assumes a praxis-oriented view. For the most part it is organized around the following theme: we have a responsibility to act as stewards of the natural resources entrusted to us as planners, as policy makers and as citizens. Good stewardship requires a responsible attitude and a good understanding of the world around us and of the institutions through which public policies are made and carried out. And more than this, it requires an appreciation of natural processes, a humbling before the forces of nature. Nowhere on Earth – or on the "water planet" as we should perhaps rightly say – are these forces more immediately apparent than in the near-shore coastal environment, at the meeting of land *and* sea.

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This book consists of 12 chapters organized in three parts. The first section (Part I) highlights the basics tenets of environmental planning for oceans and coasts. It covers important concepts from the general field of planning and relates these to oceans and coasts. Problems inherent within these environments are addressed, such as sea level rise, marine pollution, overdevelopment, etc.

A number of methods are regularly used by planners working to improve environmental quality and conditions of oceans and coasts. Part II covers those methodological approaches tailored to oceans and coasts – among others: integrated planning, pollution prevention, marine spatial planning and the ecosystem services approach.

The last section, Part III, focuses more specifically on state-of-the-art tools and technologies employed by planners for marine and coastal protection. These include marine protected areas, marine spatial planning, decision support tools and various forms of communication, including visualization, narration and strategies for stakeholder participation. The last chapter in this section (Chap. 11) deals with coastal adaptation, thus revisiting how the book began with an emphasis on change.

The concluding chapter (Chap. 12) stands alone. It reviews the main points brought up throughout the book and includes some examples. It provides some new information, such as about coastal and marine online databases and classification schemes, but for the most part it summarizes the fundamental concepts and ideas most important to the book.

Before embarking on the use of this book, or its chapters, the reader should be aware of a few organizational points and emphases. Generally, in the spirit of integration (across landscape units, in this case), there is no hard and fast separation between coastal and marine (ocean) topics. Further, the book does not attempt to present an "objective" view of oceans and coastal planning; its message is one of environmental protection and sustainable use. Although examples and case studies I use are from throughout the globe, most are taken from developed, industrial countries. This by no means implies that environmental planning for oceans and coasts is not taking place, or should not take place, in developing countries – more likely it has to do with use of the English language and availability of materials on the Web. Finally, the book's outline mirrors that of a class I teach entitled: Planning and Management of the Coastal and Marine Environment. While not designed throughout as a textbook, I hope this book can be used as one.

To wrap up this (somewhat personal) introduction, I acknowledge the following assistants, who accompanied me on this journey – Jen Holzer and Miri Koolyk. Their expert editing and general assistance in administration and correspondence were invaluable. I also thank Professor Jay Gatrell of Bellarmine University in Louisville, Kentucky. A chance meeting with Jay led to the contract for this book, a huge boost which led to my idea becoming a reality. Others who helped me along the way include Maria Adelaide Ferreira, Michael Orbach, Gesa Geißler, Johann Köppel, Judi Granit, Yael Teff-Seker, Erez Roter, Emri Brickner, Yarden Elhanan, David Terkla, Ran Levy and Gaul Porat.

Finally, if there is anyone, without whose help this book would not have been possible, it is my dear and supportive husband, Etan Rozin, who is always ready to aid and support me in my endeavors be they illustrating, writing, meetings, teaching or singing!

August 2015 Michelle Eva Portman

Contents

Abbreviations

BSH	Federal Maritime and Hydrographic Agency (Germany)
CBD	Convention on Biological Diversity
CMSP	Coastal and marine spatial plans
CS	Continental shelf
CZMP	Coastal Zone Management Plan (India)
DST	Decision support tool(s)
EBM	Ecosystem Based Management
EC	European Commission
ECS	Extended continental shelf
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ES	Ecosystem services
ESA	Ecosystem services assessment
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gases
GIS	Geographic information system(s)
ICZM	Integrated coastal zone management
IMO	International Maritime Organization
IMP	Integrated marine planning
IPCC	Inter-governmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IWM	Integrated watershed management
IWRM	Integrated water resources management
MARPOL	Convention for the Prevention of Pollution from Ships (1973)
MCA	Multi-criteria Assessment
MMO	Marine Management Organisation
MSFD	Marine Strategy Framework Directive (EU)
MPA	Marine protected area

MSP	Marine spatial planning
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration (US)
PP	Pollution Prevention
PTD	Public Trust Doctrine
ROV	Remote operated vehicle
SEA	Strategic Environmental Assessment
SLR	Sea level rise
TBPA	Transboundary protected area
UK	United Kingdom
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States of America
USAID	United States Agency for International Development
WFD	Water Framework Directive (EU)
WWF	World Wildlife Fund

Measures

kg	kilogram(s)
km	kilometer(s)
mm	millimeter(s)
MT	metric ton(s)
nm	nautical mile(s)
ppm	parts per million
Tg	teragram(s)

Part I
Foundations and Issues

Chapter 1
Connections: Environmental Planning, Oceans and Coasts

The sea, once it casts its spell, holds one in its net of wonder forever.

– Jacques Y. Cousteau

Abstract This chapter draws relevant planning concepts into the purview of coastal and ocean policy and management and introduces some of the main environmental issues related to oceans and coasts from a planning perspective. To understand such a perspective, the development of the planning profession is briefly explained along with its connection to environmental management. Different types of planning can be more or less suitable to problem solving in the marine and coastal environment. Changes brought on by the current era of immense human impact and influence highlight the need for planning, to address myriad threats to coastal and marine environments.

Keywords Coastal zone management • Environmental planning • Generic planning • Marine spatial planning • Planning outcomes • Planning process • Reactive and proactive planning

It has often been said that the name of our planet, Earth, is a misnomer. With more than 70 % of its surface covered by water, the name "Water" or "Ocean" would be more fitting. One fact often overlooked is that the amount of land exposed between large bodies of water on our planet is constantly in flux. We know, and are becoming painfully aware of this fact as climate change wreaks havoc on our planet, that the amount of water flowing in our oceans depends on how much water is locked up in frozen ice caps and glaciers.

This leads to the second most important characteristic of our planet: the ever-present *force of change*. The present *rate of change* is, in fact, what differentiates this period from all others throughout history; certainly the history of mankind, but also throughout the known history of our planet. While there is some uncertainty regarding chronologies, major change events are familiar to those who study such phenomena.

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For example, despite what you may have learned in primary school, scientists don't know exactly what earthly phenomenon caused the extinction of the dinosaurs and 65 % of the other living organisms that disappeared with them. Paleontologists have two competing theories: one tells of the collision of a celestial meteorite slamming into Earth causing a dusty upheaval that enshrouded the planet in a thick blanket of clouds, which in turn caused a lethal drop in temperature that engendered the mass extinction. The second theory contends that intensive volcanic eruptions caused a similar dusty cover, which by chance were later followed by the meteorite landing. To sort this out, paleoecologists look for clues about the timing of these events in ancient sediments.

But despite all the uncertainty surrounding them, it is clear that these events happened. What is unclear is their chronology. The most recent theories posit that the planet incurred a double whammy, with the nefarious volcanic eruptions spewing soot into the air followed by the meteoric event *right after*. Records suggest that "right after" was about *200,000 years* afterwards (Kerr 2012); in other words, a period equivalent to the duration of man on Earth. Yet when we talk about the *anthropogenic* climate change occurring today, we usually refer to changes since the industrial age began – give or take a mere 150 years! How can it be that our terms of reference vary so? This is due to the current complex relationship of man to the natural environment, such as that found where sea meets land and is, in essence, the subject of this book.

The two most fundamental environmental issues of our time are indeed climate change and extinctions, with the latter framed more professionally as "biodiversity loss". These two issues are interconnected and complex. Oceans and coasts exemplify such complexity. As the interface between land and sea, the coast is the staging ground for numerous changes – from diurnal tidal fluctuations to what can be catastrophic results of seasonal erosion. Irrespective of sea level rise, increased and intensified storm activity and the loss of biodiversity through the destruction of habitat by coastal development, the coast is ever changing.

The mark of time is forever present on the malleable land and seascape that comprises the coastal zone. But, you may wonder, what is the *coastal zone* and where is it? For environmental planners, this depends to a large extent on the circumstances and planning situation at hand. I expand on the answer to this question in the next chapter, but for now, suffice it to say that the types of environments that comprise areas of concern for planning and management of oceans and coasts have changed in recent decades.

Mostly due to technological advances, human ability to exploit the oceans has improved. We can now extract resources in ways, at depths and at distances from shore that we were unable to in the past (e.g., Arrieta et al. 2010). For example, electronic devices aid commercial fishers in locating concentrations of fish (Roberts 2007) and new, resistant materials allow wind turbines to withstand the harsh conditions that exist in very deep water and far out at sea (Portman et al. 2009).

Change has also transpired in other ways. While in the past the ocean environment far from shore was largely ignored by coastal planners, today it is considered an important area of attention. It is a venue for planning almost to the same extent as

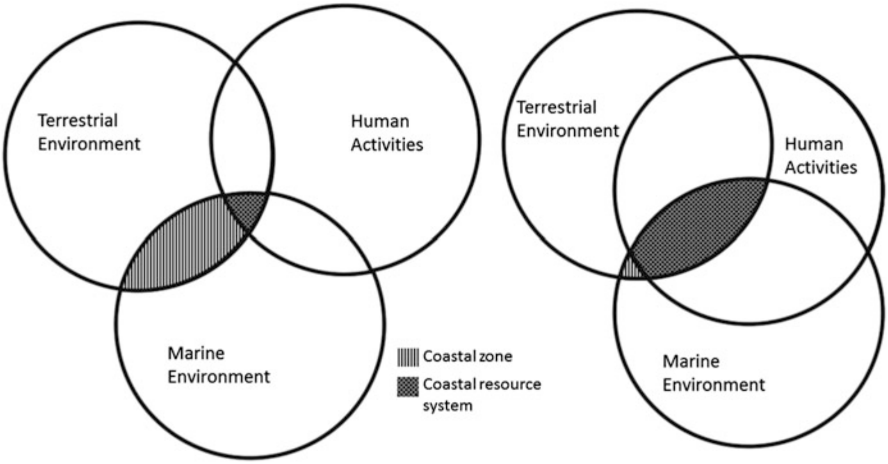

Fig. 1.1 Above (*left*) is Scura et al.'s (1992) conceptualization of the relationship between the coastal zone and coastal resource systems (also used by Cicin-Sain and Knecht 1998). Above (*right*) is a more current interpretation, showing human activities as more prevalent at the interface of terrestrial and marine environments (reprinted with permission from the publisher, Worldfish)

that of the terrestrial coastal area (Fig. 1.1). As for the ocean environment, just as much activity can take place there, and sometimes more, than can on land.

A few common definitions of the coastal zone are presented in Chap. 2 (Box 2.1), but the most straightforward definition is that it is the interface between land and sea. How much of each it includes varies by definition. Therefore, environmental planners should be prepared to learn as much as they can about the two similar and interrelated environments whether they are concerned with the marine environment *or* the terrestrial environment, or, as most likely, both.

1.1 The Planning Connection

The planning profession emerged in the mid-nineteenth century out of a series of calamities – health crises that led to epidemics, social crises that led to riots and strikes and crises that revolved around hazards both anthropogenic and natural, such as fire and floods (Knox 2010). Progressive intellectuals of that time envisioned healthy cities much as environmentalists today envision healthy ecosystems. By many accounts, our oceans and coastal environments are highly threatened and, as such, are "in crisis" (EEA 2006; Halpern et al. 2008; Lester et al. 2010; Lubchenco and Sutley 2010). Therefore, there is no doubt that, as in the past, the planning profession has much to offer as we grapple with managing these environments.

In the early days of the profession, planners working in urban areas sought to improve conditions so as to achieve laudable environmental quality goals even though the sub-field of *environmental planning* per se, did not yet exist. The first urban planners helped introduce air pollution control, water purification, sewage handling, public laundries, public health inspectors and replacement of the gutter with the park as the site of children's play. As population increased along the coast, and since the tourism sector became a major economic development force starting in the post-World War II era (O'Connell 2003), planners have increasingly attended to both undeveloped seashores as well as growing coastal metropolises. In the past decade, marine spatial planning, which brings the main tenets of the planning profession to the marine environment, is developing as a sub-discipline of urban and regional planning.

Coastal communities and regions throughout the world continue to attract population and development at an alarming rate. Currently, more than 44 % of the world's population (more people than inhabited the entire globe in 1950) lives within 150 km of the coast (UN Atlas Project 2014). Two thirds of the world's major cities are located along coasts. As development and population growth continue in most of these areas, so do the pressures on the resource base of oceans and coasts, both natural and human-made.

Sustaining the ecological health and productivity of our coastal and marine environments in the face of the intense global social, economic and environmental changes is one of our most daunting tasks. Fisheries depletion, coastal wetland loss and destruction of critical coastal and marine habitats from coral reefs to ice-sheets are pressing issues. Pressures for offshore oil and gas development compete with the need to protect the recreation and tourism value of the coastal zone. Efforts to establish new marine protected areas are at odds with desired access to these areas by commercial fisheries (Beatley et al. 2002; Hastings and Botsford 2003).

The good news is that we don't have to reinvent the wheel. Even though early planners and architects who sought to preserve natural unbuilt spaces, including those along coasts, often viewed the preservation of open spaces as "civilizing features", limited to representing social refinement and aesthetic beauty (Dooling et al. 2006), aspects that have little to do with the undersea-scape, many of their approaches are still relevant. Although they didn't have to contend with the number of competing goals that exist today, there is still much to learn from past developments and accomplishments in the field.

Planning is essentially a matter of identifying both what needs to be done and how to do it. There are "best-practice" approaches to figure this out, some of which are described below. Planning is basic problem solving or "applying knowledge to action" (Friedmann 1987) and it is critical to managing how we humans interact with our environment (Randolph 2011).

Environmental planners put a premium on guiding human activities while working with the physical elements of the environment as both challenges and opportunities. Coastal and marine planners and managers must also adopt such an approach to the greatest extent possible (Cicin-Sain and Knecht 1998; Ehler and Douvere 2009). All the while, planners must be aware of the special characteristics of the coastal and marine environment in all that they do.

1.2 The Management Connection

Environmental management refers to a set of actions broader than those of environmental planning and over a different time frame. It provides the means for controlling or guiding human-environment interactions in order to protect and enhance human health and welfare and environmental quality; management is a longer-term process than planning and it can include planning within it as a stage or part of the management process.

Approaches to environmental management have evolved in recent years – in response to changing conditions faced by professionals. A well-known tenet of the discipline is that environmental managers address human activities taking place within the environment and not the physical (environmental) processes themselves. However, in recent years the basis of the field has evolved from a desire for living with nature to a responsibility for managing natural systems, because we both *need* and *impact* nature's systems (Randolph 2011).

The extent to which we impact natural systems is encompassed in the term "Anthropocene". This term is informally used as the name of the present geological epoch that started approximately at the beginning of the Industrial Revolution.[1] The term, coined by the ecologist Eugene F. Stoermer and popularized by the Nobel Prize-winning atmospheric chemist, Paul Crutzen, reflects the overwhelming influence of human behavior on the Earth's atmosphere in recent times (Crutzen 2002).

As mentioned, environmental management is a long-term process and therefore applicable to the coastal and ocean environment in the Anthropocene. Planning in this era calls for a broad and long-range perspective to guide activities. As discussed in Chap. 4, one of the advantages to integrated coastal zone management is that it relates to temporal cross-generational concerns. This fosters management for sustainability. Sustainable development is progress and change that aims to meet the needs of today without compromising the ability of future generations to meet their needs (Brundtland 1987). This essential approach has many implications for coastal and marine management.

Environmental management often depends on the use of technological approaches that provide the necessary interdisciplinary perspective, analytical tools and participatory processes to arrive at a plan. Of course, there are different types of planning, from generic styles to situation-tailored approaches. Here, too, we can discern effects of the evolution of the profession. Adaptive approaches have been promoted in recent years, both for planning and management, because they incorporate adjustments over time and recognize the dynamic nature of natural ecosystems. Adaptive management is therefore commonly applied for ocean and

[1] The term has not been adopted as part of the official nomenclature of the geological field of study although a proposal has been put forth to the Geological Society of London to accept it. There is still some controversy over when the epoch actually began. See: Kutschera (2008).

Fig. 1.2 An example of the dynamic, ever-changing, pivotal cycle of fisheries management. Planning is involved, but observation suggests that fisheries' managers first learn by trying and failing with measures that are least costly. (Figure credits: Webster, D. G. foreword by Oran R. Young, *Adaptive Governance*: *The Dynamics of Atlantic Fisheries Management* © 2008 Massachusetts Institute of Technology, by permission of The MIT Press)

coastal resources, such as erosion management, fisheries management (Fig. 1.2) and ocean governance (e.g., Webster 2008; Portman et al. 2013).

1.3 Planning and Management for Coasts and Oceans

Although they have been used for decades in coastal planning, conceptual planning models have only recently found their way into marine planning, management, monitoring and evaluation. This is not surprising, as human interests and concern expand to all corners of the globe and to a myriad of environments from mountain caps to deep-sea trenches. As we advance through the twenty-first century, we will continue to see more and more planning tools, mechanisms, approaches and even terrestrial planning legislation being adapted for application to the sea (Box 1.1).

Box 1.1: What Is Environmental Planning?
Environmental planning applies the process of planning to environmental protection and problem solving. It addresses human-environment interactions at numerous levels, scales and purposes including responses to natural hazards, human and environmental health issues, natural resource use and management, sustainable community design and applications for decision-making based on the functions and processes of natural systems and ecosystem services. (Randolph 2011)

At its most basic, the generic form of environmental planning is a problem-solving strategy for environmental protection and management. It involves setting objectives, gathering and analyzing information and formulating and evaluating alternative policies, projects and/or designs to meet objectives. This comprises the synopsis of planning. These steps generally make up the generic planning process (Fig. 1.3).

Different types of planning tools and approaches may be appropriate for different coastal and marine environments and different goals. Thus, being well-acquainted with the types of planning is helpful. Most are based on the generic stages of planning and are variants of three classic approaches: rational-comprehensive planning, incremental planning, and advocacy planning. Planning processes can be further characterized as reactive, proactive or integrative, as discussed below.

Rational-comprehensive planning was for a long time the predominant planning model (Mitchell 2002). It is based on the use of instrumental rationality for analysis and decision making (Briassoulis 1989). Its central assumption is that there is a right (or wrong) way of problem solving or development. This positivistic view assumes that it is possible to find this best way. It also incorporates the notions that scientific knowledge and modern technologies (belief in progress) can control the

Fig. 1.3 The generic planning process

environment and its processes, that common public interest is clear and that change is usually engineered from the top (Fainstein and Fainstein 1996).

Incremental planning is the most widely noted alternative to rational-comprehensive planning (see Mitchell 2002). It is based on “bounded” instrumental (functional) rationality, which considers the planner or planning institution as an actor who simplifies the complex world by finding a *satisfactory* solution, rather than the *best* solution. In this model, planning is carried out in a decentralized manner and the focus is on what can be implemented. There is no clear determination of goals and objectives, only a few options are considered and evaluated and the problem is often redefined at regular intervals (Fainstein and Fainstein 1996; Mitchell 2002).

Advocacy planning refers to a process with a predetermined agenda, such as biodiversity conservation or fairness and equity. It is akin to participatory planning, which emphasizes involving the entire community in developing a plan. In the coastal and marine context, these would most likely be quite diverse stakeholders. Advocacy planning contrasts starkly with the rational planning process described above, in which there is little or no role designated for the people affected by planning (Briassoulis 1989). Other types of planning are listed and referenced in Table 1.1.

Planning necessitates advocacy on the part of underrepresented groups (such as the poor) and supporting values that cannot be expressed easily through the market (such as nature). This latter point justifies the relevance of advocacy planning for oceans and coasts. Because the health of marine ecosystems is by and large in jeopardy today (Roberts 2007; Lubchenco and Sutley 2010), advocacy planning applied to oceans and coasts should be wisely (and widely!) used.

A challenge for ocean planning is that the private concerns represented are often exclusively those with particular resource extraction interests, such as mining or oil and gas exploitation, even though the ocean is a public trust resource. The ocean is thought of as far away and distant from most of the public; after all, humans are terrestrial beings. Whenever possible, environmental planning should incorporate advocacy planning, be sensitive to it and support combined (i.e., integrated) goals of special interests together with the enhancement of ecosystem health for the benefit of future generations and the general public at large.

Although not among the main planning models, other approaches to planning are particularly apposite to the planning of coastal and marine environments. Contingency planning is highly relevant due to coastline exposure to hazards such as tsunamis, extreme storm events, severe flooding and erosion. Adaptive planning (like adaptive management) has been emphasized frequently in the conservation planning literature for marine resources, usually related to adaptive governance (see Weinstein et al. 2007; Webster 2008). In the marine spatial planning context, it is adopted to enable the use of an ecosystem-based management (EBM) approach (Ehler and Douvere 2009). With its emphasis on iterative evaluation, adaptive planning is also useful in a conservation context (Margoluis et al. 2009). The rapid degradation of ocean ecosystems dictates the urgent necessity for spatial conservation planning and management measures that can be modified later with

Table 1.1 Summary of the conceptual planning models most relevant for environmental planning of the oceans and coasts

Planning approach	Main tenets	Seminal source
Rational-comprehensive	Science-technology based; planner is technician; dominant model	Banfield (1959)
Incremental	Used for crisis management; highly political; problems handled individually	Lindblom (1965)
Advocacy	Planner cannot be neutral; planning congruent with client values/goals; relates to conflict	Davidoff (1965)
Contingency	Risk assessment based; used for natural and man-made hazards; alternative course of action to address adverse consequences	Christiansen (1985)
Adaptive	Reliance on modelling; anticipatory, predicts future events; recognizes dynamic character of ecosystem	Kato and Ahern (2008)
Participatory	Focus on process, not outcomes; often bottom-up	Arnstein (1969)

the acquisition of new information (Lester et al. 2010). The principle of adaption enables managers to be flexible, recognizing that plans will be modified as more information becomes available and planners learn more about ecosystems and gain more experience with new conditions.

Originally, the participatory planning approach was developed as a response to the shortcomings of rational-comprehensive planning for dealing with diverse stakeholder perspectives and conflicting values. The emphasis on the planning *process* as opposed to planning *outcomes* sets this approach apart from others.

An influential paper by Arnstein (1969) presents a typology that categorizes actions in a process by the power these actions provide to participants. The most important lesson for planners may be the cynical view engendered by Arnstein's ladder analogy. It illustrates that some types of so-called "participation" render citizens partners in a process that leave them, in effect, powerless (i.e., "non-participation" in Fig. 1.4).

Unfortunately, nonparticipation is still observed in the planning profession, especially in environmental planning, which is particularly value-laden (Gunton and Day 2003). Due to the public nature of some coastal resources and most marine resources (as embodied in the public trust doctrine described in the next chapter) as well as the high incidence of conflict in coastal and near-shore marine areas, planners need to be especially conscious about ensuring public participation.

It has become increasingly apparent since Arnstein's time that although participatory processes may lengthen planning actions in the short term, they are likely to save time in the long term; this has been widely discussed for coastal management (e.g., Portman et al. 2012) as well as for planning in the marine environment (e.g., Ehler and Douvere 2009; Portman 2009).

One of the advantages of the participatory approach is that it can help avoid reactive measures in planning. Turning actions into proactive measures as opposed to reactive ones through good planning should be a goal of planning practitioners.

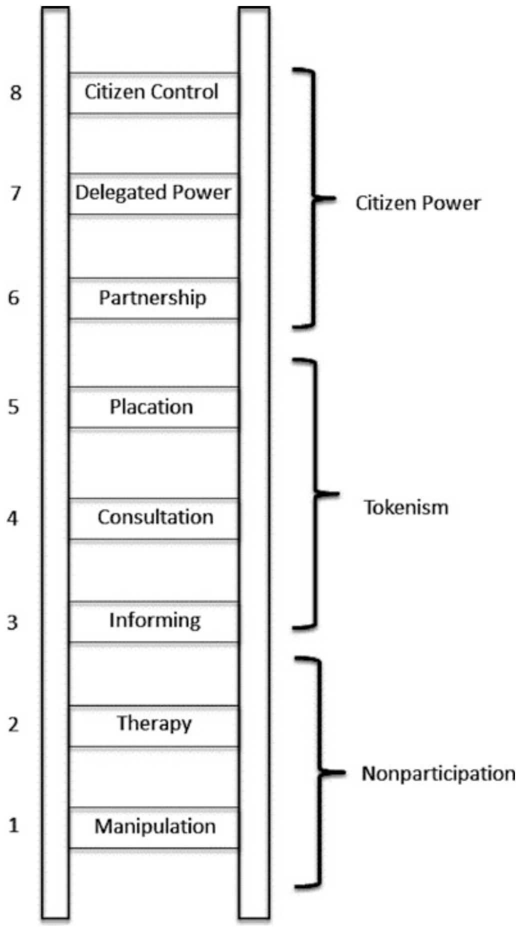

Fig. 1.4 Arnstein (1969) characterizes citizen participation on a continuum using a ladder analogy. (Source: Arnstein (1969). Reprinted by permission of the publisher: Taylor & Francis Ltd. http://www.tandfonline.com)

Reactive planning responds to ongoing crises or problems. By contrast, proactive planning is preemptive. Any of the different planning approaches in Table 1.1 can emphasize reactive, proactive and/or integrative management measures.

Reactive planning measures try to correct prior environmental damages, like the cleaning up of the British Petroleum drill site blowout in the Gulf of Mexico that began in April 2010. *Proactive* measures are taken explicitly to enhance or protect environmental quality before it has been degraded. This includes the prohibition of energy infrastructure in sensitive areas, such as the Wadden Sea Park in the North Sea, or restrictions on development in areas destined to be affected by sea level rise.

Highly relevant for oceans and coasts, integrative planning crosses numerous boundaries including physical, institutional, disciplinary and more. All environmental planning should be *integrative*, particularly for the coasts and oceans. Because integration is so important for planning of the coasts and oceans and because there is significant confusion as to what it entails, I dedicate Chap. 4 of this book to the subject of integrated management of oceans and coasts.

1.4 People, Oceans and Coasts

A familiar adage asks: if a tree falls in a forest and there is no one to hear the fall, does it make a sound? Analogously, environmental planning is essential only in those areas impacted by human activities or where humans are impacted. But this is exactly the point about the Anthropocene – human impacts are now ubiquitous; the pressure exerted by humans at the interface between land and sea is particularly great and should be a topic of great concern to environmental planners.

Rising numbers of coastal inhabitants is a pressure in itself. Coastal regions are among the most attractive places to live, both economically and aesthetically. Resources of the coastal zone provide numerous job opportunities and many people rely on the seashore for recreation. Population density is a measure of stress placed on coastal areas; when more people are using a limited resource, the carrying capacity of a region can easily be exceeded.

Although debatable, it is widely assumed that environmental degradation grows in proportion to population size (Malakoff 2011) if per capita consumption and technology are held constant – in reality, a hugely optimistic assumption. The environmental consequences of increasing human population size are dynamic and nonlinear. There are many linkages between human activity and environmental degradation, but at the risk of oversimplification, the contributing factors can be grouped as human population size (P), the per capita rate of consumption of energy and materials (A) and the technologies that support that rate of consumption (T) (Harte 2010).

The equation used to express this idea is:

$$\begin{aligned}\text{Environmental }\mathbf{I}\text{mpact} &= (\mathbf{P}\text{opulation size}) \times (\text{Per capita }\mathbf{A}\text{ffluence level}) \\ &\quad \times (\mathbf{T}\text{echnology level}) \\ \mathrm{I} &= \mathrm{P} \times \mathrm{A} \times \mathrm{T}\end{aligned}$$

The "IPAT equation", as it is known, was first coined by Paul Ehrlich and John Holdren; the former, a prominent eco-demographer and author of the 1968 book *The Population Bomb*; the latter, President Obama's Director of the White House Office of Science and Technology Policy and Co-Chair of the US Council of Advisors on Science and Technology. It is a valuable reminder of factors that play a role in determining environmental impacts, such as carrying capacity and resilience,[2] which are also important concepts for coastal and marine planning associated with human-related impacts and stressors.

More than one third of the world's population lives in coastal areas and on small islands. Together these areas make up just over 4 % of the Earth's total land area.

[2] Although the term can also refer to ecological resilience, USAID defines "resilience to recurrent crises" as the ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth.

Coastal tourism is one of the fastest growing sectors of global tourism; it provides employment for many people and generates local income. For example, reef-based tourism generates over $1.2 billion annually in the Florida Keys alone.

Of the Earth's coastal population, 71 % live within 50 km of estuaries and in settlements concentrated near mangroves and coral reefs in tropical regions. These marine and coastal habitats have been severely degraded, mainly through anthropogenic impacts (UNEP 2006). The effects of ecosystem degradation and the effects of coastal development on ecological structure and processes can be monumental.

The way in which people and other coastal biota share space and resources is becoming the great challenge of the twenty-first century (Weinstein et al. 2007). Conflict mitigation, consensus building, trade-offs, sacrifice and compromise will become the norm for sustainable coastal and marine management. Its success will depend on mankind's ability to adopt a transdisciplinary,[3] integrative approach to both ecological and commercial management of coastal resources, and one that is proportional to human dominance in the landscape.

Along European coasts, for example, population densities are higher and continue to grow faster than those inland. In 2006, population densities of the coastal regions (NUTS3)[4] of EU member countries were on average 10 % higher than inland. In some countries this figure was more than 50 % (EEA 2006). As mentioned, almost half of the EU's population lives less than 50 km from the sea. EU member states reported in 2008 that only 8 % of their coasts have what is considered a "favorable conservation status", with most of these on the land side of the coast (called "upland"). Seventy per cent of coastal habitats are in an unfavorable condition, and the status of 22 % is unknown (see European Environment Agency 2010).

All these issues have to do with planning. Balancing carrying capacity, enhancing habitat protection to maintain biodiversity and developing policies and plans based on sustainable practices are all intrinsic parts of environmental planning. According to Randolph (2011), the field has experienced a "silent revolution". Five elements of emerging approaches in the field of environmental land use planning for the twenty-first century are:

1. Science-based sustainability analysis.
2. Adaptive management or scientific learning.
3. Collaborative planning, design and decision making or "social learning".
4. Seeking common solutions to multiple objectives.
5. Linking local action to both local needs and global concerns.

[3] The term "transdisciplinary" connotes the transcending of two or more disciplines to form a new, more holistic approach. It is distinguishable from the common terms multidisciplinary and interdisciplinary which refer respectively to the contrasting of disciplines in an additive manner and the combining of two or more disciplines to a new level of integration.

[4] European coastal region units as defined in EEA (2006).

These new perspectives hold true for environmental planning applied to oceans and coasts and are discussed throughout this book.

1.5 The Role of the Planner

The role of the planner is often to bring disparate agents together; those from the market sector, from civil society and from government. As mentioned, agents involved in planning may be public entities at various levels of government with varied constituencies. They may be private organizations with particular concerns and/or professionals of various backgrounds and expertise. Planners may also work with stakeholders from user or advocacy groups. These stakeholders may have clear sets of salient or hidden agendas or they may be private, single individuals with concerns for their own welfare or for that of the environment.

Planners can serve as facilitators of public involvement or as champions of citizen empowerment. Environmental planners often act as technical experts, providing data and information that serve as a basis for decision making. Those environmental planners working in the coastal and marine realm may find themselves performing regulatory duties, such as compliance and enforcement, impact statement review or managing staff who perform these tasks. They may work as politicians or political advisors, promoting a particular agenda. Because planning is future oriented, planners may work as visionaries, helping coastal communities discover and articulate their visions of the future and explore the means to achieve them.

1.6 Special Concerns for Oceans and Coasts

There is no doubt that oceans and coasts are in trouble these days. Overfishing has occurred in most seas on the globe. Sea levels are rising, thus accelerating processes of coastal change and threatening to drown island nations. Ocean acidification, caused by ever-increasing levels of CO_2 in the atmosphere, is impairing the ability of organisms dependent on the process of calcification to form shells or skeletons. Ocean water warming, also due to high levels of $CO_{2,}$ is forcing species migration and supporting the proliferation of invasive organisms in areas far beyond their original habitats. Ubiquitous, insensitive coastal development is destroying habitat, changing sediment flows and the effects of currents and causing instability of formations that have been sedentary for thousands of years. What can be done?

While planners cannot solve all of these problems, perhaps even very few of them, it is the environmental planner's duty to be well-informed, realistic and inclusive. Proactive, reactive and integrated planning using one or more of the approaches listed above (see Table 1.1) can help him or her accomplish the tasks necessary for addressing the current environmental conditions of oceans and coasts, problematic as they may be.

For years, the planning profession has focused on terrestrial issues almost exclusively. Environmentalists, too, have neglected the ocean environment in comparison to land. A major study published a decade ago reported on research that surveyed thousands of papers ($n = 5974$) published in leading biological conservation journals. Fewer than 11 % covered topics related to marine conservation; this was in contrast to approximately 61 % addressing terrestrial conservation. Further, only 5 % of articles reviewed in leading marine ecology journals ($n = 6618$) addressed conservation issues (Levin and Kochin 2004).

To initiate a transition to a new horizon in planning such that more attention is focused on oceans and coasts, environmental planners need to be clear about what distinguishes these environments from terrestrial ones. What characterizes coastal and marine environments and what are the most pressing conservation issues for these unique places?

In an article addressing information needs for marine protected areas, Agardy (2000) lists the differences between marine and terrestrial systems and concludes that "the random applications of terrestrial models to the marine environment may not succeed in protecting resources and [their] underlying ecology." But we must try. On the one hand, oceans and coasts and their resources are held in public trust by public/governmental agencies for public benefit and, therefore, we all have a stake in their exploitation and protection. On the other hand, humans are first and foremost terrestrial beings; only a fraction of the public may ever intimately experience the undersea world firsthand. I discuss these issues and their repercussions in greater depth in the next chapter of this book.

1.7 Summary

This chapter has set the stage for this book by introducing some important concepts of environmental planning and by articulating links between the field of planning and characteristics of the marine and coastal environments. Because the marine environment has been neglected by planners in past decades and because anthropogenic influences have brought about a myriad of changes that frequently threaten the continued functioning of oceans and coasts, marine and coastal conservation is an important theme of which planning professionals should be well aware.

More so than for other types of planning, environmental planning is influenced by a range of human values and perspectives. Environmental planning is unique in that it applies the process of planning to environmental protection and problem solving while addressing human environment interactions at numerous levels and scales. Environmental protection has much relevance today for oceans and coasts. Equally important, the basis of environmental management has evolved from a desire for living with nature to taking on responsibility for it. Such changes in attitudes and approaches pose new challenges for coastal and ocean resource professionals and stakeholders.

As we progress through the new millennium, characteristics of global change will no doubt become a recurring theme for professional planners, particularly demanding the attention of environmental professionals. At the interface where land meets sea, the full panorama of endless change continues as it has for millennia, but the rate of change and the role of man now exist in disturbing flux. If you are an environmental planner or have an interest in the field, read on – the subsequent pages of this book will likely be of immeasurable value.

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Chapter 2
Definitions and Fundamental Concepts

Men do not think they know a thing till they have grasped the "why" of it...

– Aristotle's Physica, Book II

Abstract In the form of four W's: Why? Where? When? and Who?, this chapter describes some of the institutional issues related to ocean and coastal planning. It covers why special or unique approaches are needed, what areas (locations) are included in the coastal zone and make up the different maritime zones. A brief history of how coastal and ocean planning and management has developed is presented, and lastly, the chapter gives examples of international, national and sub-federal entities involved in planning for oceans and coasts. With these emphases, the chapter provides a foundation for further study of environmental planning for oceans and coasts.

Keywords Arbitrary boundaries • Intertidal zones • Maritime zones • Private tidelands • Sovereign jurisdiction • Subtidal • Supratidal • UNCLOS

Rachel Carson, author of the best-selling book *Silent Spring* (1962) and considered by some to be the founder of the modern environmental movement, wrote extensively about the sea and the shore. Before delving into the perils of pesticide use, which made her world-famous and forever changed environmental regulation, she wrote three bestsellers: *Under the Sea-Wind* (1941),[1] *The Sea Around Us* (1951), and *The Edge of the Sea* (1955).

In a seminal article published in the *Atlantic Monthly* in 1937, she wrote:

> The ocean is a place of paradoxes. It is the home of the great white shark, two-thousand-pound killer of the seas, and the hundred foot blue whale, the largest animal that ever lived. It is also the home of living things so small that your two hands might scoop up as many of them as there are stars in the Milky Way. And it is because of the flowering astronomical

[1] It was actually the reissued version of this book, published in 1952 after the popularity of her next book was confirmed, that achieved best-seller status.

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numbers of the diminutive plants, known as diatoms, that the surface waters of the ocean are in reality boundless pastures.

Carson's writing reflected overall truths that were new ideas – basically, that all of life is a continuum and interconnected – but most of what she wrote in this passage was wrong. A very large pair of hands could probably scoop up only enough seawater to hold 100 million diatoms – a tiny fraction of the billions of stars that make up the Milky Way. Her ensuing description of diatoms was also incorrect. How could it be that such mistakes were glossed over in such a highly visible non-fiction article? How could Carson have been so off-the-mark and yet still considered an expert on the sea?

Her statements reflect the limited knowledge of her era, but in many respects, knowledge about the sea is still limited today (see Chap. 3). Most people know very little about the seas, even those involved in decision making about ocean environments and resources. Carson herself had little contact with her prime media, other than a thorough familiarity with what existed at the edge of the tide outside the seaside cottage where she lived. Upon writing her second book about the sea, she had spent what amounted to a few minutes standing at the bottom of a skiff's ladder in little over 2 m of water off the coast of Florida wearing a diving helmet (Souder 2012). Another reason that such a statement passed as truth is because it embodied another broad point reflecting common thought *at the time*: that the sea and its resources are endless – as endless as the stars.

2.1 Why? Special Challenges

Today we know that the sea's resources are unequivocally finite. Not only that, but that they exist in a delicate balance with most other aspects of the planet – climate, land, freshwater and more – and that they are in trouble (Roberts 2007; Halpern et al. 2008; Lubchenco and Sutley 2010). For this reason, it is the purview of the environmental planner working on marine and coastal environments to have in mind first and foremost the preservation and protection of these delicate balances. Doing so or not doing so will have implications far beyond the specific coastal and/or marine environment being worked on. Also, it is imperative for the environmental planner to be aware of the particular characteristics of the marine and coastal environment and that he or she understands their particular challenges.

Agardy (2000) succinctly compares characteristics of the marine environment to those of the terrestrial environment. In doing so, she helpfully raises awareness of the unique challenges of the sea; the comparison can also be helpful to planners transitioning to work on oceans and coasts from more conventional terrestrial environs. Marine systems have nebulous boundaries, large spatial scales and fine temporal scales. Consideration of the three-dimensional living space of organisms is essential, as is consideration of relatively unstructured food webs and nonlinear system dynamics. Oceans have been less studied than land. Relative to marine systems, terrestrial systems usually have clear boundaries, small and temporally coarse spatial scales, relatively two-dimensional living space, structured food webs and linear system dynamics (Agardy 2000).

What do these characteristics mean for the marine environment? What do they mean for the coastal environment? The latter may be even more difficult to decipher. A natural tendency of books about marine planning, coastal planning or environmental planning in general is to treat each ecosystem type or seascape/landscape unit separately. In many ways, this contradicts principles of integration that are fundamental to the planning approaches of integrated coastal zone management and integrated marine planning, described in Chap. 4 of this book. Therefore, I try to avoid hard and fast distinctions between coastal and ocean environments.

2.2 Where? Location, Location, Location

Most of the Earth (70.8 %, or 362 million km^2) is covered by oceans and major seas. Marine systems are highly dynamic and tightly connected through a network of surface and deep-water currents. The properties of the water cause stratified layers, tides and currents. Upwellings break this stratification by mixing layers and creating vertical and lateral heterogeneity within the ocean biome. Total global coastlines exceed 1.6 million kilometers in length and coastal ecosystems are found in 123 countries around the world.

Before describing man-made, or what can be considered “socially-constructed”, marine and coastal boundaries, I briefly describe coastal and seascape units. Elements of the interface between land and sea include the waterline, shoreline or coastline, and beaches. The shore refers minimally to the narrow strip of land in immediate contact with the sea, including the area between high and low water lines, aptly termed the intertidal zone. True marine areas are generally considered to be those that are subtidal or always seaward of the tides. Supra-littoral areas make up the terrestrial portion of the coastal zone or “uplands”. Despite these rather clear definitions, for management and planning purposes the coastal zone is, in fact, a vague term with many interpretations (Box 2.1).

The elements of the coastal zone should be well understood by planners because there are processes related to each that are important to consider when anticipating impacts of development. The incremental effects of global climate change also affect these areas. For example, sediment transport is an important process along the coast, dependent on long-shore and near-shore waves and tides; it relates to processes of erosion and accretion. Effects of sea level rise will be exacerbated by any type of construction that changes the natural shoreline. Physical geographers and geologists who specialize in structure formations and geomorphological processes in marine environments and in the coastal zone use these nuances of terminology to describe their areas of interest. Further explanations about these terms can be found in Chap. 3 of this book.

Box 2.1: Various Definitions of the Coastal Zone

The coastal zone has many definitions and all of them are social constructs. In other words, coastal boundaries depend on humans and man-created institutions, i.e., laws, regulations, jurisdictions and such. Various definitions are provided here.

The coastal ocean is a shallow (<200 m) area, covering approximately 7 % (26×10^6 km^2) of the surface of the global ocean, where land, ocean and atmosphere interact; in oceanography, this region is termed the Epipelagic Zone (*The Encyclopedia of the Earth*. http://www.eoearth.org/view/article/151298/).

The coastal zone includes offshore waters, the coastline, and the adjacent shores (Sorensen 1997).

A "coastal zone" consists of the coastal waters and the adjacent shorelands, as well as islands, transitional and intertidal areas, salt marshes, wetlands, and beaches (16 U.S.C. § 1453. Definitions, US Coastal Zone Management Act).

The coastal zone is any part of the land that is influenced by some marine condition, such as tides, winds, biota or salinity. The coast is global in its distribution but not in its width. In some places the coastal zone might be a few hundred meters wide, whereas in others it might be more than 200 km wide (Davis and Fitzgerald 2004).

The coastal zone is the environment resulting from the coexistence of two margins, namely, the terrestrial edge of the continent and coastal water as the littoral section of shelf seas. Its terrestrial portion is defined by an area extending 10 km landwards from the coastline. Where relevant, assessment of the basic coastal zone is enhanced by comparisons among the immediate coastal strip (up to 1 km), the coastal hinterland (the zone between 1 and 10 km line) and the non-coastal national territory, called inland (EEA 2006).

The coastal zone is a narrow band of terrestrial area dominated by the ocean influences of tides and marine aerosols; it defines a marine area where light penetrates throughout (UNEP 2006).

Boundaries of the coastal zone should correspond with the boundaries of the resources addressed in a coastal management plan. Coastal zones can be affected significantly by human and other activities that occur at a great distance from the coast itself. Where influences are generated further inland, a definition of the coastal zone should encompass the entire watershed or river basin that drains into coastal waters (Beatley et al. 2002).

In the oceans, physical boundaries are often determined by geophysical properties such as sediment thickness or depth. General delineations consist of the upland, continental shelf, continental slope and deep sea (Fig. 2.1). Areas past the jurisdictional boundaries of any one state are considered the high seas (Fig. 2.2). Although not belonging to any one jurisdictional entity and considered to be in the international domain, this delineation is clearly a social construct – meaning that it is based more on people's decisions and institutions than conditions of the natural world. In any case, the high seas are by and large public domain and shared international resources; here, the term "freedom of the seas", which has been in use since the age of imperialism, takes precedent.

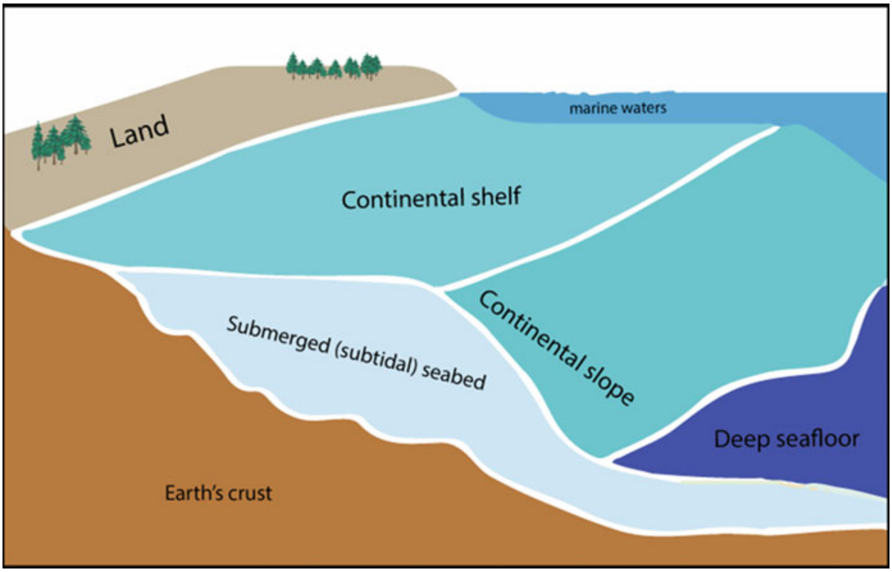

Fig. 2.1 A simplified look at the different areas of coasts and seas

Jurisdiction over an area is often related to who manages it. Once a jurisdictional authority is known or determined, planning begins with delineating the managerial boundaries to correspond with either the physical and ecological units of the coasts or oceans (Clark 1996) or to address a specific problem such as flooding or marine pollution (Brenner et al. 2006; Balaguer et al. 2008; Hering and Ingold 2012).

There are many cases where rather than encompassing physical or even administrative units, jurisdictional boundaries have been set arbitrarily. "Arbitrary", in this case, refers to spatial demarcation that does not reflect the physical, and especially the natural, elements of the environment, but is based instead on artifacts. For example, the distance a cannonball could fly was used to set the extent of littoral state jurisdiction in the U.S. during colonial times (Sohn et al. 2010). Such boundaries may impede meaningful conservation and integration efforts (Clark 1996; Cicin-Sain and Knecht 1998). In almost all cases, coastal and marine planners' work will be subject to combinations of physical and jurisdictional boundaries. Examples of such combinations can be found in just about every demarcation of marine and coastal boundaries.

Most maritime zones are determined according to the United Nations Convention of the Law of the Sea (UNCLOS). Sovereign rights of a coastal nation decrease as one moves further from the shore. The baseline from which most boundaries or maritime zones (Fig. 2.2) are delineated is usually dependent on the shape of the coast, and the actual waterline is determined relative to both high and low tides. The most physically-dependent element of these offshore boundaries is perhaps the continental shelf (Box 2.2).

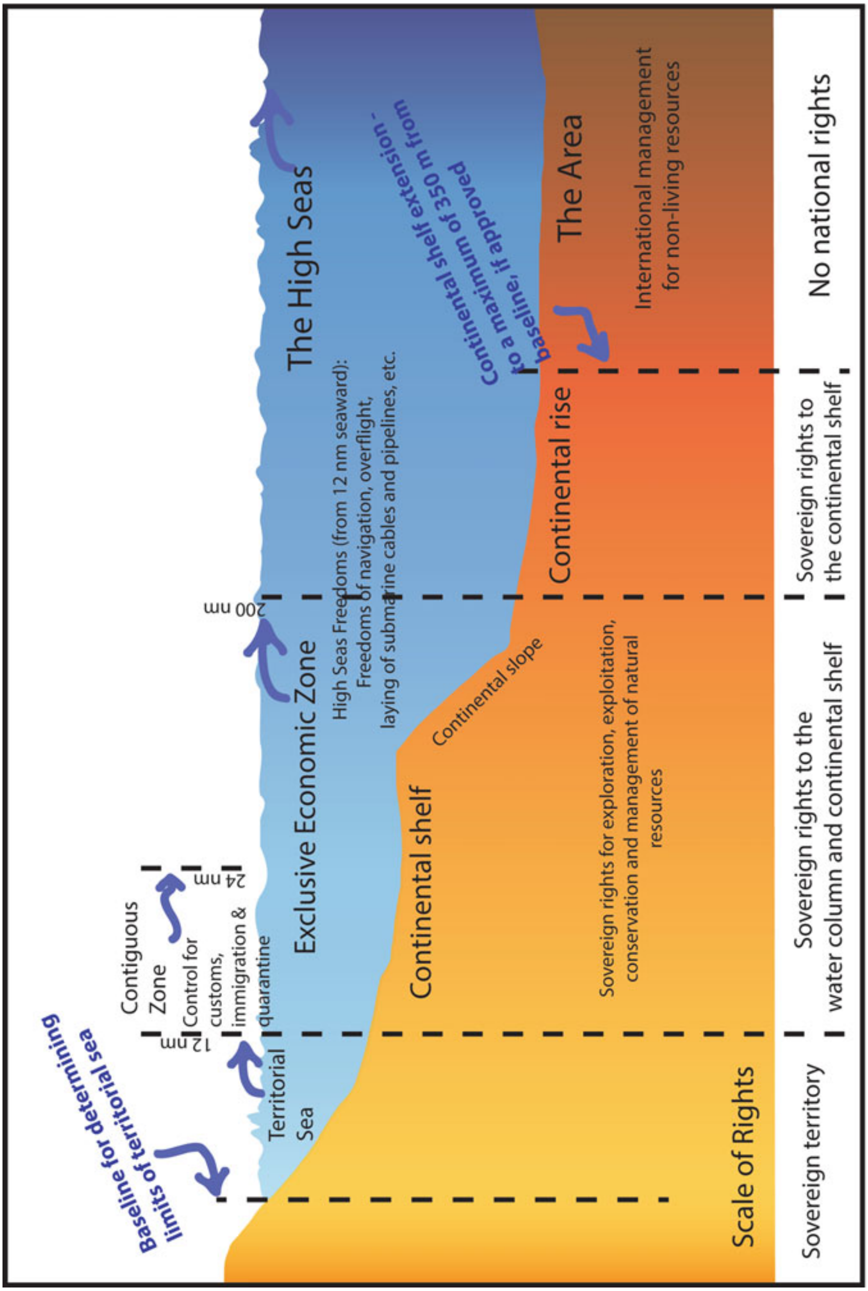

Fig. 2.2 Maritime zones under the UN Convention of the Law of the Seas (UNCLOS) of 1982 (Note: 1 nautical mile (nm) = 1852 m)

Box 2.2: Important Marine Jurisdiction Definitions (according to UNCLOS)

Internal waters are all waters landward of a coastal state's baselines. A coastal state has complete sovereignty over these waters.

The **territorial sea** extends from a coastal state's baselines to 12 nm and includes airspace. A coastal state has sovereignty over its territorial sea though foreign vessels have a right to innocent passage.

The **contiguous zone** extends from the outer limit of the territorial sea to 24 nm. A coastal state can exercise control to prevent infringement of its customs, fiscal, immigration or sanitary laws and can set regulations within its territory or territorial sea.

The **exclusive economic zone** extends from the outer limit of the territorial sea to 200 nautical miles (nm). A coastal state has sovereign rights over the natural resources of the water column and the seabed as well as jurisdiction over certain matters like marine scientific research and the protection and preservation of the marine environment. Foreign vessels may exercise their freedom of navigation in this zone.

The **high seas** are waters beyond the national jurisdiction of any state.

The **area** is seabed beyond national jurisdiction, the nonliving resources of which are administered by the International Seabed Authority, a body established by the Convention. All states party to the Convention are members of the Authority.

An interesting local example of boundary determination is the Massachusetts Waterways Regulation Program. This regulatory program administers the Massachusetts Public Waterfront Act of 1866, one of the oldest pieces of legislation pertaining to coastal development (hereafter "Chapter 91" because it is implemented through Massachusetts General Laws Chapter 91). The act's main goals are preservation of water-dependent uses of coastal properties and of public use rights in tidelands. Water-dependent uses are activities for which proximity to the water is either essential or of great advantage (Portman 2006).

In private tidelands (Fig. 2.3), which are those of the intertidal zone between low and high tide, land ownership in fee title is distinct from "use ownership". In areas that are owned privately, the public maintains some usage rights, particularly for "fishing, fowling and navigating". The two ownership domains are referred to as *jus privatum* and *jus publicum*. In the intertidal area within Chapter 91 jurisdiction, the state confers *jus privatum* to private owners that is subservient to the *jus publicum* (Archer et al. 1994).

A finer demarcation of marine and coastal areas, based on an "ecosystems" approach, can be found within the context of the Millennium Ecosystem Assessment of 2005 (MEA). This demarcation distinguishes between terrestrial ecosystems (e.g., sand dune systems), areas where freshwater and saltwater mix, near shore coastal areas and open ocean marine areas. In a synthesis report, based

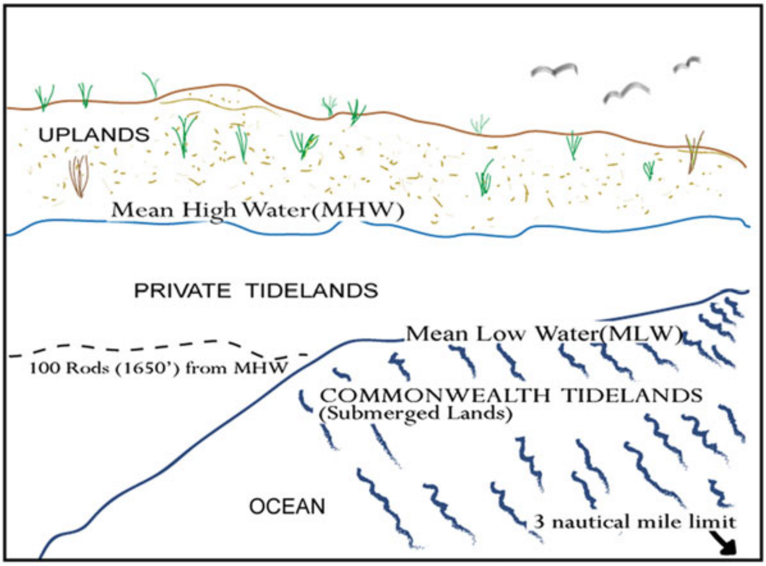

Fig. 2.3 Jurisdictional boundaries according to Chapter 91 of the Massachusetts General Laws. As for most US states, sub-federal Massachusetts state jurisdiction extends 3 nm seaward from the mean low water mark

on the findings of the MEA, the ocean and coastal realm is divided into "marine fisheries systems" and "inshore coastal systems and coastal communities". Marine systems are defined as waters from 50 m depth to the high seas. The latter term refers to systems that extend from waters shallower than 50 m depth to the coastline and inland from there to a maximum of 100 km distance or 50 m elevation, whichever is closer to the sea (UNEP 2006) (Box 2.3).

Box 2.3: The Importance of Marine Boundaries: Iceland

After WWII, while the Soviet Union, the US and Europe dealt with matters of the Cold War, Iceland dealt with an extraordinary defense matter: that of preserving its fish stock. Iceland's fish stocks were of utmost importance. The country had been dependent on fishing since its settlement (around 960 AD), first for subsistence, and later for commercial fishing. Following skirmishes that lasted nearly four centuries, Iceland's territorial waters – the area from which it could exclude foreign fishing vessels – were set as extending three nautical miles from land in 1896. As commercial fishing picked up again after WWII, fish stocks throughout the Atlantic plummeted and most countries increased their territorial limits. In 1952, Iceland extended its territorial sea limit to 4 nm. Then, in 1958, Iceland declared a 12 nm limit, which Britain protested by sending in naval boats to protect British trawlers fishing in Icelandic waters. These were the first acts of the Cod Wars that flared on

(continued)

Box 2.3 (continued)
and off for the next 30 years. Iceland continued to expand its claims as fish stocks continued to dwindle. To do so, Iceland employed its coast guard to cut the cables of any foreign trawlers that were caught poaching. Matters came to a head in 1976, when Iceland declared a 200 nm limit around its shores, at which point Britain broke off diplomatic relations and ordered British Navy boats to ram Icelandic coast guard boats, which occurred on several occasions. The situation was only resolved in 1985, when international law confirmed Iceland's position by granting the 200 nm limit to all countries involved in the dispute.

Logically, different demarcations also depend on who is making the distinctions and why (see Sect. 2.4). For example, the European Environment Agency defines the marine part of a coastal zone as the zone extending 10 km offshore (i.e., as in Natura 2000 coverage analysis) or a variable zone of sea shelf, depending on the issue analyzed (EEA 2006), e.g., navigation routes, territorial waters, fisheries, coastal dynamics, etc.

No matter which geographical or ecological boundaries are adopted, as one goes farther out to sea, less regulation and fewer boundaries exist. Yet high seas areas – the deep marine areas – are important and vast. The deep ocean, defined in a report of The Economics of Ecosystems and Biodiversity (TEEB)[2] initiative as beyond the continental shelf where water depths vary from 200 to 11,000 m, constitutes the world's largest biome. Deep oceans cover more than 87 % of the ocean (Beaudoin and Pendleton 2012). Though sparsely documented, these areas are thought to contain huge reservoirs of biomass and the largest number of undiscovered species. Studies suggest that conservation of deep-sea biodiversity is essential for sustainable functioning of the entire ocean and, therefore, as development capabilities extend farther out to sea, more attention needs to be directed by environmental planners to these areas.

2.3 When? Historical Developments

Coastal management, and later, marine planning, have taken similar and interconnected routes of development. Experts describe coastal area management as having been stimulated by two basic needs: (a) the need to develop a response to erosion and subsequent environmental degradation, including natural disasters, and (b) the pursuit of economic development, particularly infrastructure such as seaports and recreational facilities (Vallega 1999). In recent years, concerns for

[2] TEEB is a global initiative supported by UNEP, focused on drawing attention to the economic benefits of biodiversity.

environmental protection and sustainable development of the oceans have brought about the advent of marine planning and management.

In 1991, Stella Vallejo articulated an international perspective of the evolution of the concepts of coastal area management (CAM) and ocean management in her book *Development of Integrated Sea Use Planning*. It included a chronology from 1966 of the increasing number of initiatives in CAM and a review of one of the first pieces of legislation on the topic – the 1972 US Coastal Zone Management Act. Known as the CZM Act, this legislation empowers the US littoral states to implement coastal area management programs. Vallejo pointed out early on that in view of the conceptual basis of CAM, its practical applications present particular challenges. Among these are that "the marine dimension has conceptually emerged as having two distinct components: the coastal area and the ocean area. In practice, planning and management efforts accentuate this dichotomy." (Vallejo 1991). Unfortunately, this dichotomy continues today.

Probably the two most important developments since the early 1990s, when Vallejo articulated these concerns, have been the advent of *integrated* coastal zone management and the recent burgeoning popularity of marine spatial planning. It seems that ICZM, in some ways, failed to be *integrative* enough to extend to the management of far-from-shore marine areas (Klinger 2004; Portman et al. 2012). In the past decade, marine spatial planning, often with an emphasis on integrating the terrestrial coast with the near-shore marine environment, has moved in to fill the gap.

Both coastal and maritime policies have long been a part of nationally-expressed interests and the subject of many international agreements. The UNCED conference of 1992 in Rio de Janeiro, and the 1993 World Coastal Conference in Noordwijk, The Netherlands, provided kick-off points for concern about coastal zone planning and management. Related conventions and legislation of the mid-1990s set the pace for European coastal development and protection, as they did for much of the developing world.

The European Commission initiated a three-year *Demonstration Program for Integrated Coastal Zone Management* in 1996 that included sites in different member countries. Experiences drawn from this program were used to develop a European strategy for coastal development, which eventually resulted in the European Council Recommendation of May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe (European Parliament 2002). Today, most countries have initiated regional or national efforts towards ICZM (Portman et al. 2012).

Marine spatial planning (MSP) got a much later start. Ehler and Douvere's *Marine Spatial Planning*: *A step-by-step approach toward ecosystem-based management*, published in 2009 by UNESCO's Intergovernmental Oceanographic Commission, is one of the first major texts on how to conduct MSP. The handbook describes MSP as a process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to "achieve ecological, economic, and social objectives, usually specified through a political process" (Ehler and Douvere 2009).

The expansion of offshore activities due to improvements in extraction technologies and the push for greater exploitation of the sea as land resources dwindle has led to interest in MSP as a tool for sea use management. For example, the proactive siting of wind farms was reported as a major factor driving marine spatial plans at the US sub-federal level, such as the Massachusetts Ocean Management Plan of 2009 and the Rhode Island Ocean Special Area Management Plan adopted in 2010 (Eastern Research Group 2010). Also in Germany (Fig. 2.4), offshore wind farm siting has been a factor driving MSP in the German EEZ (Portman et al. 2009). Others have attributed the advent of MSP to the need to meet international and national commitments to biodiversity conservation (Douvere et al. 2007). Several European countries, on their own initiative or driven by European legislation and policy, have taken global leadership in implementing MSP over the last decade (see Chap. 6).

2.4 Who? Institutions and Legal Considerations

Planning, especially in the public domain, is a diverse and interdisciplinary field that continues to evolve as society changes, as democracy matures and as methods of knowledge and understanding improve. If we accept the tenet that planners cannot manage the environment, but rather human activities within it, then we realize that studying the field means understanding human constructs. Human constructs are, by and large, human institutions. In the context of this chapter, I use the term "institutions" in its broadest sense: to refer to human conventions (i.e., laws and regulations), as well as agents and organizations. With the knowledge of public sector institutions available in most modern democratic societies, we can build typologies of these agents for planning and management in particular environments.

Public conventions and institutions are just as essential for the planning of coasts and oceans as they are for terrestrial planning. On land, private institutions often have the upper hand due to the predominance of private land ownership. Due to the public nature of oceans and coasts, public institutions wield more influence than they do in the terrestrial environment. However, that having been said, private influences are now increasing in the marine and coastal environment (Portman 2009).

Although a diverse range of tools and mechanisms exists for planning and management of coastal and marine environments, a few general design principles are worthy of mention. These are foundational drivers that shape regulation and regulatory entities in nations the world over, so planners working in coastal and marine environments should understand these principles and their origins.

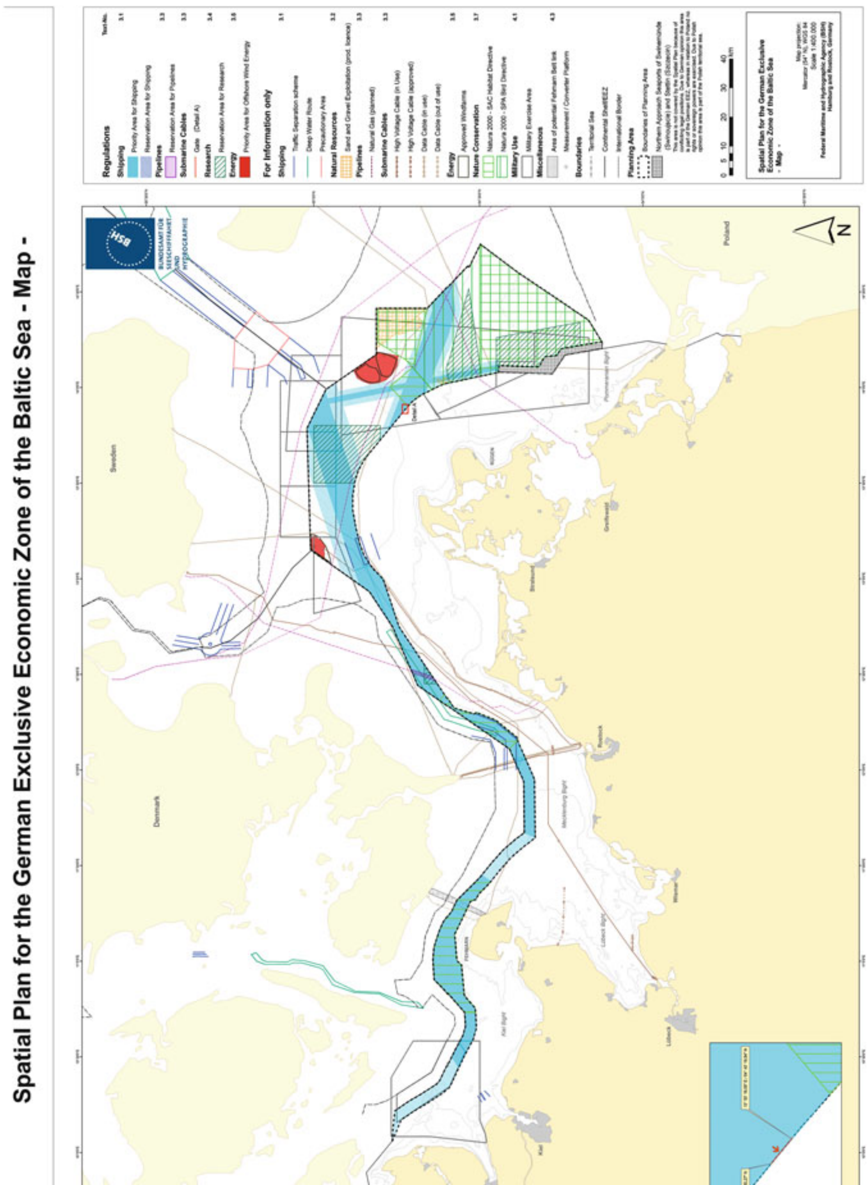

Fig. 2.4 An example of a marine spatial plan for the Baltic Sea, Germany (Reprinted with permission of the Bundesamt für Seeschiffahrt und Hydrographie 2014)

2.4.1 Regulatory Principles

Most ocean and coastal policies draw their authority from the public trust doctrine (PTD). This doctrine was first administered through Roman Civil Law and later promulgated by English Common Law. It holds that the air, the sea and the shore belong not to any one person, but to the public at large. The PTD has developed into one of the most important doctrines in public property law (Box 2.4).

Like other aspects of planning and management discussed in this chapter, the PTD has evolved considerably – from being implemented by monarchs to being implemented by federal or sub-federal states. For centuries, England protected its tidelands and waters in the king's name for all English subjects. In the American colonies, for example, the Colonial Ordinances of 1641–1647 codified the PTD based on the British monarchy's example. As states joined the union following American independence, they acquired jurisdictions similar to those of the original 13 British colonies that had already acquired all sovereign rights from the British Crown for management of tidelands and submerged coastal areas. Today, most US coastal states have jurisdiction seaward to 3 nm, which is distinct from federal jurisdiction (Archer et al. 1994). In England, the near-shore area is still officially owned by the monarchy's Crown Estate (Portman 2009).

Box 2.4: The Public Trust Doctrine

"By the law of nature these things are common to all mankind – the air, running water, the sea, and consequently the shores of the sea. No one, therefore, is forbidden to approach the seashore."

– Principles of Justinian (Liber 2, Tract 1, Section 1), Roman Civil Law Digest, circa 500 A.D.

Major principles of the PTD direct marine and coastal planning: firstly, the public has fundamental rights and interests in the natural resources of the sea and the shore; and secondly, the state, as trustee of the public interest, has a duty to preserve and enhance these resources and to protect the public's right to use them (Turnipseed et al. 2009). This means that it is the state's duty to protect access to coastlines and to submerged marine areas *for the public*. Navigational servitude for purposes of commerce and fishing is guaranteed as a public right in most nations that have a system of common law.

All over the world, laws and regulatory programs are administered by a myriad of agencies that have important roles in planning and management of the coastal and the marine environments. To describe all of these agencies – from local, to regional, to global – is beyond the scope of this book. However, some examples are worth noting. The following descriptions are organized according to scales of administration from international/global to those administering local or state programs at the subnational (sub-federal) level.

2.4.2 International Bodies

Most international regulatory bodies have limited enforcement power and are based on mutual agreements between nation-states. For example, the UN Convention on the Law of the Sea (UNCLOS) has created a number of institutions to settle conflicts: the International Seabed Authority (Article 156 of UNCLOS) and the International Tribunal of the Law of the Sea (Article 186 of UNCLOS) are two of them. However, nation-states must submit to this authority by signing and ratifying the UNCLOS.

Many international institutions are not regulatory in nature. Rather, they create and execute programs. Some international bodies are characterized by use-sector specialization and thus they serve particular constituencies (e.g., fishermen, ship builders or fiber-optic cable operators). Others may be limited geographically (e.g., to states in a region). Both of these types, sectoral and geographic, operate by cooperating with lower-level governance agencies (e.g., nation-states) and coordinating with other international institutions.

The UN has sponsored many international bodies. For example, the UN Regional Seas Programmes are administered under the auspices of the United Nations Environment Programme (UNEP). Each program comprises a non-regulatory agency that operates at the regional level, bringing together a number of countries that share a sea. The UN also sponsors advisory agencies such as the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), established in 1967 by several UN agencies. Many of these agencies are specialized – they have particular roles such as advising regarding fisheries, regulating commerce or pollution prevention. For example, the International Maritime Organization serves as the UN agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships (see Chap. 5).

The European Union (EU), representing the economic and political union of 28 member states located primarily in Europe, has advanced entities and programs targeting oceans and coasts, operated respectively through a system of supranational, independent institutions and intergovernmental decisions negotiated by its member states. The EU's highest decision-making institution consists of three bodies: the Commission, the Parliament and the Council of Ministries (often referred to as the "Council"). Many EU regulations and directives,[3] executed by directorate-generals, impact activities carried out at sea or on the coasts (see Tables 2.1 and 2.2). The EU also issues "Communications" which articulate visions but do not have the authority of regulations or directives. Communications are important in that they signal to interested parties and stakeholders that legislation is being considered or is under development.

[3] A directive is a legislative act of the European Union, which requires member states to achieve a particular result without dictating the means of achieving that result. It can be distinguished from EU regulations, which are self-executing and do not require further implementing measures.

Table 2.1 Legislative actions of the EU that impact marine planning and management

Action	Acronym	Type	Responsible directorate[a]
Integrated Maritime Policy	IMP	Regulation	MARE
Common Fisheries Policy	CFP	Regulation	MARE
Marine Strategy Framework Directive	MSFD	Directive	ENV
Natura 2000	N2000	Director	ENV

[a]See Table 2.2 for full name

Table 2.2 Directorates of the EU with some connection to marine and coastal planning and management

	Directorate	Acronym	Selected mandates related to marine/coastal management
Most relevant directorates	Maritime Affairs and Fisheries	MARE	Environmental protection
			Financing fisheries sector
			Maritime policies
			Maritime safety
			Resource management
	Environment	ENV	Climate change
			Coastal management
			European Environment Agency (coast, tourism, transport, energy)
			Water protection
			Marine strategy
			Nature and biodiversity
General directorates influencing marine/coastal management	Research and Innovation	RTD JRC	Biotechnology
			Energy
			Environment/sustainability
			Industrial technologies
			Scientific support for fisheries
			Sustainable maritime transport
	Regional Policy	REGIO	Baltic Sea/Adriatic/Atlantic/Azores
			Coastal zones
			Shipbuilding
			Tourism
			Transport
	Foreign Policy Instruments Service	EEAS	EU in the UN (oceans and Law of the Sea)
			Euro-Mediterranean partnership
			External relations (environmental protection, non-EU countries, commercial aid)
	Competition	COMP	Aid to fisheries sector
			Fishing industry (economic support)
			Maritime transport (freedom, competition, aid transport, aid shipbuilding)

The EU issued its communications on coastal management at the turn of the millennium (European Commission 2000). The Recommendation Concerning the Implementation of Integrated Coastal Zone Management in Europe (2002/413/EC), adopted by the European Parliament and European Council of Ministers, followed in May 2002. This recommendation was momentous as it marked the formalization of eight principles of Integrated Coastal Zone Management (ICZM) that were to be implemented in the member countries of the EU through national strategies for management of the coast (see a list of these principles in Chap. 3).

The EU bases its marine policy on four main pillars: the Marine Strategy Framework Directive (MSFD), the Common Fisheries Policy, the Integrated Maritime Policy (IMP) and Natura 2000. Although these four pillars articulate the EU agenda for planning, management and conservation of its marine areas, various other directives (e.g., the Water Framework Directive, focused mostly on inland waters) also impact the sea and coastal areas.

Complementing these four pillars, the new Maritime Spatial Planning Directive, "Establishing a framework for maritime spatial planning" (2014/89/EU), will require EU member states to develop a spatial, place-based approach to take a long-term look and to improve coordination of activities taking place in marine areas. This latest directive will help implement management and maritime governance policies established in the IMP including, as its environmental pillar, the MSFD (2008/56/EC). The directive clarifies the EU's commitment to implementing an ecosystem-based approach whilst aiming for "blue-growth", i.e., economic development of ocean and coastal resources.

2.4.3 National Entities

Most countries of the world have promulgated laws and regulatory programs aimed at coastal zone management at the nation-state level for some time. The US example, the Coastal Zone Management Act, in place since 1972, has already been mentioned as one of the first national-level laws addressing coastal planning. In the past decade, new institutions (i.e., agencies and regulation) have developed rapidly for planning and management of the seas.

In the US, although policy makers have considered devising national ocean policy for many years (Stokstad 2009), only in 2010 did President Obama issue Executive Order 13547 for Stewardship of the Ocean, Our Coasts, and the Great Lakes. This Executive Order founded the US National Ocean Council to coordinate the work of the multiple federal agencies already involved in marine conservation and marine planning. It also established advisory committees for the development of regional coastal and marine spatial plans (CMSP) (White House Office of the Press Secretary 2010).

Similarly, in the UK, The Marine and Coastal Access Act of 2009 was mandated to ensure clean, healthy, safe, productive and biologically diverse oceans and seas by putting in place better systems for delivering sustainable development of the marine and coastal environment. This Act has set up a framework for management and proactive planning. One of its most innovative features is the creation of a "super" overarching management agency, the UK's Marine Management Organisation (MMO). This approach is distinctly different from most other countries, where governments have created either inter-sectoral committees or appointed a lead agency from those already in existence to oversee the nascent regional marine spatial planning processes.

Beyond the establishment of the MMO, there are two main parts to the system set up by the new Act – the marine policy statement and marine plans. Once these exist, decisions with respect to proposed developments must comply with them. The marine policy statement guides and directs decisions at the national level and sets objectives for sustainable development. The marine plans constitute a source of information to be referenced by stakeholders when considering where and how they might carry out activities. Marine plans are designed to interpret and present national policies based on the marine policy statement and to apply area-specific policy where appropriate.

2.4.4 Sub-federal Agencies

On the subnational and even on the local level, programs once concerned with the terrestrial coastal zone are being extended further and further out to sea. Germany's federal Spatial Planning Act (Raumordnungs-gesetz), enacted in 1965, was amended in 2004 to mandate offshore spatial planning. Germany's planning establishment has moved forward by addressing both the country's territorial sea and its EEZ (with the siting of offshore wind farms having been the impetus). The provincial *Länder* governments have taken an active role in planning for territorial waters, whereas the Federal Maritime and Hydrographic Agency (the BSH) has taken the lead for MSP in the EEZ.

Successful subnational regional coastal and marine programs are being extended to more states and provinces and they are being replicated from place to place. Many countries follow the US example in which a national law, such as the Coastal Zone Management Act, gives a great amount of authority and discretion to the subnational states.

Another interesting example is India – an enormous country with a huge coastline. In 1991, India adopted a system (similar to that of the US) with its Coastal Regulation Zone (CRZ) Notification law. This law is administered under India's Environmental Protection Act of 1986. The CRZ Notification requires the state Coastal Zone Management Authorities to prepare Coastal Zone Management Plans (CZMPs) in consultation with stakeholders, experts, academic institutions or other organizations. Since 1991, the CRZ Notification law has been amended about two dozen times with different guidance and requirements being imposed over the years. Although the CZMPs are required for regions or states, they ultimately require approval of the Indian Ministry of the Environment and Forests (Portman et al. 2012).

Although many countries have adopted hierarchical planning and management policies for their coastal areas as planning is conducted in areas further out to sea, this model may be less appropriate. The reason is that in these areas, subnational jurisdictions wield less influence. This, together with the newness of planning efforts directed at areas further out to sea, could be an opportunity for greater integration between subnational entities.

2.4.5 Other Groups: Private and Nonprofit

Advocates for proper environmental management among stakeholders interested in particular ocean and coastal activities may be hard to identify at first, but these groups are increasingly vocal and visible. Examples are fishermen who have lost their livelihoods due to overfishing or environmental NGOs interested in moratoriums on whaling. Furthermore, if the ecosystem-based management[4] approach (described in Chap. 6) is adopted for MSP, then advocacy will be needed to attend to "interests of nature" that are not always represented by stakeholder groups.

In the mid-nineteenth century, when the roots of the environmental movement took hold, private philanthropists were instrumental in setting the conservation agenda. Natural areas were understood to have an inherent worth by "preservationists" such as John Muir, a forefather of the modern conservation movement. Such areas were worthy of financial support for management (and in some cases for purchase) to maintain them in their natural state and protect them from development. Today, organizations such as The Nature Conservancy, the Bahamas National Trust and the Dorset Wildlife Trust do just that on a global, national and local scale respectively and they are expanding their work along coasts to include submerged marine areas (Table 2.3).

Regardless of public trust, private ownership or participatory planning processes, in most democratic societies numerous advocacy groups influence coastal and marine planning. Private individuals can make an impact through monitoring, collecting and reporting data on the marine and coastal environment, and through sharing traditional environmental knowledge (Newmaster et al. 2011).

[4] This approach is defined as an integrated approach to management that considers the entire ecosystem, including humans and their needs, and particularly ecosystem services within them (Mengerink et al. 2009).

Table 2.3 Some marine protection tools used by land trusts with their related opportunities, challenges and limitations

Tools	Opportunities	Challenges/limitations
Protected area co-management	Taps varied expertise	Coordination may be complex
	Involves multiple jurisdictions/ authorities	Administrative costs
	Cost-sharing	Possible conflicting objectives
	Facilitates cross-boundary approaches	
	Possibilities for greater public participation	
Acquisition	Greater control for conservation	Expense
	Permanency	Possible in limited areas
		Navigational servitude protection
		Demarcation challenges
		Limited to stationary resources
Strategic planning	Systematic	Long time frame required
	Replicable for networks	Good data needed
	Opportunities for public participation	Demarcation challenges
Zoning	Enables various uses	Good data needed
	Enables various protection levels	High implementation costs
		Statutory authority necessary

Adapted from Portman (2009)

2.5 Summary

In the form of four W's: Why? Where? When? and Who?, this chapter has described some of the institutional conventions related to ocean and coastal environments, why they are needed and who implements them. There are many more issues related to institutions for environmental planning of oceans and coasts. The topics discussed in subsequent chapters will build and expand on this information.

Nevertheless, being acquainted with rudimentary concepts, doctrines and conventions that apply to oceans and coasts at various scales of governance is important. Although large portions of the public seem unaware and unconcerned about what goes on at sea, this is likely to change in the near future. The public trust doctrine still holds, rendering the sea a resource for all – belonging simultaneously to all and to none – and leading to calls for "freedom of the seas" (Van Dyke et al. 1993). Yet freedom does not translate to chaos; planners must determine how human activities can best be allocated while considering relevant values and needs of the populations they serve.

The rest of the chapters in this book are concerned more specifically with tools and mechanisms for planning and management of oceans and coasts. Many of these tools and mechanisms are only functional if the fundamental institutional constructs discussed within are heeded. As alluded to herein, some constructs are dependent on (physical) conditions of the ocean and coastal environment, while others are less so. The next chapter focuses on some physical aspects of coastal and marine environments that set the foundations for delineating constructs used in the planning and management of oceans and coasts.

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Chapter 3
Policy, Law and Mapping: Foundations of Mankind's Relationship to the Sea

When I come to the sea, the great bulk of the land at my back falls away. It is the measurable and the known; before me is all unfathomed magnitude and mystery. If there is magic on this planet, it lies beneath that azure surface.

– Jennifer Ackerman, Notes from the Shore

Abstract Various physical elements of ocean environments, those driven by geologic and climatic forces, have implications for oceans policy and law and therefore for planning. Living resource systems interact with these physical elements to form the ecological systems that require the attention of environmental planners. After providing a basic knowledge about how hydrographers describe the physical formations of the sea, the development of national and international regulatory regimes in view of these descriptions is discussed. At its close, this chapter addresses how laws and policies incorporate ecosystem-based management and the precautionary principle in ocean resource management, as well as how these are addressed by international policy.

Keywords Continental slope • Extended continental shelf • Freedom of the seas • Lead-lines • Multi-beam echo sounder • Tragedy of the commons • UNCLOS

For centuries, seafarers, philosophers and jurists from many nations and persuasions pondered the relationship of man to the sea. Historically, those who sailed the sea ruled it, which accounts for the great influence of Admiralty Rules[1] on what occurs in oceans and along coasts, even today. Establishing modes of behavior in the sea has always been a complex affair, with many influences and changes over time.

In 1609, Hugo Grotius, an influential Dutch jurist, wrote one of the most important doctrines regarding the seas and oceans – *Mare Liberum*, meaning

[1] Admiralty law deals largely with relationships between private entities operating maritime vessels and is distinct from the United Nations Law of the Sea (UNCLOS) discussed at greater length in the previous chapter.

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"freedom of the seas". His treatise is considered by many to be the backbone of our modern laws of the sea, although the right of unobstructed navigation was commonplace long before him. The notion of freedom of the seas would dominate ocean policy and regulation until the mid-twentieth century; it continues to be applied to much of the high seas and wields influence in all ocean waters, even though application of the concept is evolving just as the ocean environment itself changes.

This chapter covers some of the geophysical processes that influence law and policy relevant for planning and management of oceans and coasts. These processes are geological, meteorological, hydrological, seismic and more. At times, they are poorly understood; they involve great uncertainty and are difficult to consider comprehensively. Planners and managers of ocean and coastal environments are faced with the challenge of integrating policy and the best available science for decision making. Policy makers often lack information and knowledge about the natural world. By the same token, natural scientists often fail to make information accessible to decision makers and laymen (including the public at large). Yet such accessibility could provide the basis for political will to support science-based environmental policy, which is highly desirable for planning.

3.1 Our Understanding of the Sea

As emphasized in the previous chapters, the ocean is an extraordinarily dynamic environment, much more so than the land. Seasonal and annual variations exist, as on shore, along with cyclical variations and gradual trends in species occurrence, community composition, ecosystem productivity, etc. The ocean changes daily, seasonally and historically, over both evolutionary and geological time (Bolster 2012).

Most of the ocean is yet unexplored. We know more about Mars than we do about the ocean depths and the myriad types of marine organisms and life forms found within them. The main reason, among many, for this lack of knowledge is the expense and difficulty involved in accessing the sea for marine science research. Historically, access has been exceedingly difficult. So much so, in fact, that global mapmakers simply had to do without illustrating parts of the oceans and coasts (Fig. 3.1). Thankfully, technologies for collecting data and mapping have improved immensely over the past few decades.

Ironically, environmental changes are making ocean exploration both more important and more feasible. For example, melting of ice in the Arctic polar cap during the summer months has made it possible to collect good mapping data in areas that were completely inaccessible all year round only 15–20 years ago. Incentives for exploration are great; it is estimated that the Arctic holds 13 % of the world's undiscovered oil, 30 % of its undiscovered gas and 20 % of its undiscovered liquid natural gas (USGS 2008).

Some basic facts warrant review as a foundation for addressing the potential contributions of planners to the fluctuating marine and coastal environments that

Fig. 3.1 A 1906 map showing the Arctic as "Unknown Regions" (copyright expired)

cover so much of the globe. Before considering the rapidly changing living sea, it is helpful to review the sea's basic non-living characteristics. These have to do with geology and geomorphology.[2] I begin with a review of the forces pertaining to the macrophysical state of the globe affecting the oceans and the coasts. Since coastal environments are already much more familiar to planners, the emphasis throughout much of this chapter is on the offshore marine environment.

[2] Geology is the study of the physical properties and history of the Earth and the substances of which it is composed. By contrast, geomorphology is a subset of geology that refers to the study of the characteristics, origin and development of landforms, with special emphasis on the dynamics of the formations of the planet's outer crust.

3.2 A Geological Perspective

On land, planners refer to "zones". This term implies "zoning", which is a type of land use categorization used in many industrialized countries (Courtney and Wiggin 2002; Portman 2007). Such zones are social constructs, dependent on human institutions such as land tenure and ownership. In the sea, zones are denoted by institutional and/or physical attributes. Institutional zones are the seemingly arbitrary limits of the territorial sea, the exclusive economic zone (EEZ), the contiguous zone, high seas, etc., as described in the previous chapter. Even though these are social constructs, they almost always relate in some way to the geology and geomorphology of the sea.

While the "coastal zone" is generally understood as the meeting place of land and seascape units, most land-use planners know very little about seascape units. Seascape units are dominated by obvious geological features (i.e., land, sea, beach, etc.), but also by less obvious submerged landforms, seabed types and coastal processes. Ultimately, solar energy, responsible for winds, combined with gravitational forces, provides the energy that drives nearly all coastal processes.

Among the most important features of seascape units of concern to environmental planners are the continental margins. These are areas of intense seismic activity; they are also rich in solid, liquid and gaseous minerals and therefore of high economic value. For millions of years, the four elements needed for oil and gas formation have come together at these margins: time, a closed cavity (space), organic matter settled in the cavity and pressure.

Along the margin is the continental slope, a huge sediment wedge within which most of the minerals are found. The continental crust and the ocean crust of the Earth together make up the Earth's lithosphere, meeting at the base of this wedge. The two crusts "float" in the asthenosphere (Fig. 3.2). The continental crust is of relatively low density and it is geologically old. Its thickness varies from 35 to 50 km. By contrast, the oceanic crust is thin (only 5–12 km), of higher density and is geologically young. Being thicker and less dense, the continental crust "floats" higher than the oceanic crust (Davis and Fitzgerald 2004).

International policy makers and jurists have considered the economic importance of these various geologically distinct areas. The economic values of geological features were instrumental in determining the extent of the EEZ in international law (i.e., UNCLOS). The continental shelf (CS) contained within the continental margins in some regions of the globe (for example along the eastern seaboard of the US) is by and large bounded by the EEZ. One reason for this is that the shelf's seabed has immense importance for purposes of resource exploitation. The second reason relates to the salient geological attributes of continental margins: the CS is a natural prolongation of the terrestrial areas of continents and therefore has a justifiable connection to the nearby coastal nation-state. The result: although these areas are perhaps "marginal", they can still be claimed as part of a country's territory for certain activities.

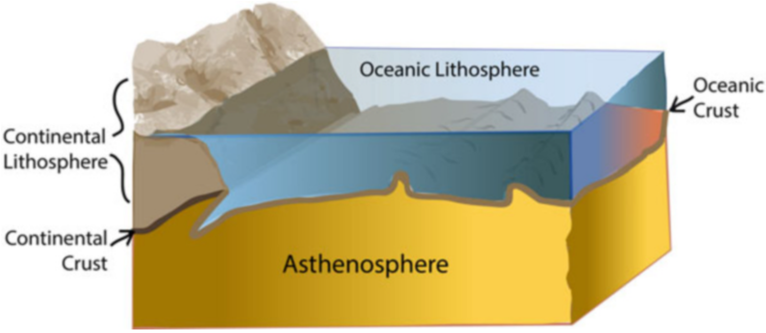

Fig. 3.2 The two crusts of the lithosphere – oceanic and continental – float on the asthenosphere

Since 1982, parties to the UNCLOS have had the opportunity to submit requests to establish their jurisdiction for seabed exploitation beyond the EEZ and beyond the CS if they can prove a natural prolongation. A detailed explanation of the rules for determining such a "natural prolongation" (according to UNCLOS) are beyond the scope of this chapter,[3] but a basic understanding of physiographic elements of the sea provide a rudimentary background.

Just as the oceanic and continental crusts have been floating for billions of years, tectonic plates within the lithosphere have been shifting and colliding. The plate edges are areas of convergence and divergence that have resulted in oceanic ridges and trenches respectively. Areas of shelf-slope-rise and, most importantly, the foot of the slope (between the slope and the rise) with areas of accompanying sediment (pelagic sediment, sediment wedge, terrigenous[4] sediment, etc.) are used for determining extended continental slope (ECS) areas according to UNCLOS. In the ECS, nation-states can potentially establish jurisdictional rights with respect to resource extraction and exploitation (see Sect. 3.4 below and Box 3.1).

Box 3.1: Important Geological Features

These definitions epitomize the influence of science on policy, and vice versa; they combine perspectives of natural and social science (public policy, law, philosophy, etc.):

Archipelagos: Groups of closely interrelated islands, including parts of islands, interconnecting waters and other natural features which form an intrinsic geographical, economic and political entity (Articles 46 and 47 of UNCLOS define what can be considered an "Archipelagic State").

(continued)

[3] Good sources for further explanation are Churchill and Lowe (1999) and Sohn et al. (2010).

[4] Originated on land.

Box 3.1 (continued)

Atolls: Ring-shaped coral reefs or strings of closely spaced, small coral islands enclosing shallow lagoons. Commonly formed over sinking volcanoes, atolls usually have no landmass.

Continental margins: The submerged areas of natural prolongation of the land area under the ocean consisting of the shelf, slope and rise.

Continental shelf (juridical): The continental margin without the territorial sea area. For juridical purposes, this area must be continuous.

Hydrothermal Vents: Also called "black smokers", these extinct volcanoes supply plumes of hot chemical and mineral gases for organisms that live by chemosynthesis. Ephemeral by nature, they appear and disappear as a result of changes in the supply of subterranean magma.

Manganese nodules: Polymetallic rock aggregations found on the sea bottom formed of concentric layers of iron and manganese hydroxides around a core. Nodules vary, but most are about the size of potatoes. They are the results of very slow geological processes and are formed over millions of years.

Sea mounts: Isolated submarine mountains that rise to an elevation of 1,000 m or more above the ocean floor. They are distributed throughout the world's oceans. It is estimated that there may be tens of thousands of seamounts in the Pacific Ocean alone.

Submarine ridges: Part of the continental margins, but not natural components thereof, with only a morphological connection with the land mass.

Submarine elevations: Part of the continental margin and its natural components that have both morphological and geological connections with the land mass.

For definitions of other undersea features (e.g., plateaux, caps, banks, spurs, etc.), a good source is: Steele JH and Thorpe SA, Eds. (2010). *The Coastal Ocean*: *A derivative of the Encyclopedia of Ocean Sciences*, Academic Press, Elsevier

The shore is where energy transferred through the oceans is expended on land and where sediments eroded from land are transferred to the oceans. At such a meeting place, geomorphological forces have great influence, making shorelines highly dynamic and greatly varied. For example, sandy shores consisting of unconsolidated river-transported material will contrast sharply with coastal cliffs or bluffs, berms and scarps. More than 90 % of the sediment reaching the oceans is transported by rivers; without this transport most beaches would not exist. Fluvial and sediment discharges from streams interact with waves and tides to produce many other unique coastal landforms including deltas, barrier spits and estuaries (Davis and Fitzgerald 2004).

A description of all the coastal processes and formations related to land and seascapes is beyond the scope of this chapter, but there are a few processes that stand out and deserve mention. Notable areas are coastal river deltas, lagoons and bays, all of which can form parts of estuaries. Waves and tides constantly move sediment, both parallel and perpendicular to the shore. But along estuaries, sediment builds up, often in tidal marshes. Once grasses and other plants take root, they trap more sediment and stabilize the coast.

Estuaries are characterized by the continual blending of salt water from the sea and fresh water delivered by rivers from the land, thus rendering the ratio of salt water to fresh water in constant flux. In addition to serving as natural flood controls, estuaries filter pollution, trap nutrients and provide rich fishing grounds and habitat for fish reproduction (see Chap. 7 on ecosystem services). Unfortunately, many important functions of estuaries are threatened today due to pollution, development, overfishing and more.

3.3 A Meteorological Perspective

Climate is driven by physics that largely strives to balance forces of energy (heat). The Earth's energy ultimately comes from the sun and this energy drives nearly all coastal processes. Fundamental imbalances in heat/energy dispersal over the globe are related to the position of the different parts of the geoid (the Earth) in relation to the sun. Diurnal, seasonal, annual and long-term changes over millions of years are physical responses that work towards balancing ever-fluctuating imbalances. Many of these are cyclical.

Oceans have a significant role in the hydrological cycle and, to a great extent, they regulate climate. Air over oceans cools and heats much more slowly than air over land; this imbalance drives winds.[5] Easterly and westerly winds drive local and regional ocean surface circulation (Fig. 3.3). Thermoclines and haloclines also influence winds above water and the currents in water. A thermocline is a layer of seawater in which the temperature gradient is distinct from that of layers of colder waters below and warmer waters above. Halocline gradients are defined by salinity levels. Both of these types of layering lead to variations in living resources within the water column. Both winds and currents are related to the global "conveyor belt" of ocean circulation (Fig. 3.4).

Any discussion of the climate cycle with respect to oceans and coasts would be incomplete without mention of climate change effects. The steady increase of CO_2 since the beginning of the industrial age has led to intensification of the greenhouse effect, which is causing great changes to oceans and coasts. Since climate change

[5] Heat-holding properties of ocean water are such that it takes a long time for water to heat up or cool down. The land, on the other hand, is opaque and cools and heats much faster. Ocean and land temperatures influence the air over them. Hot air expands causing it to move towards cooler air. This movement drives wind patterns. Unless there are overriding weather conditions (such as a storm), a sea breeze occurs from the ocean to land during the day and in the night the opposite likely occurs.

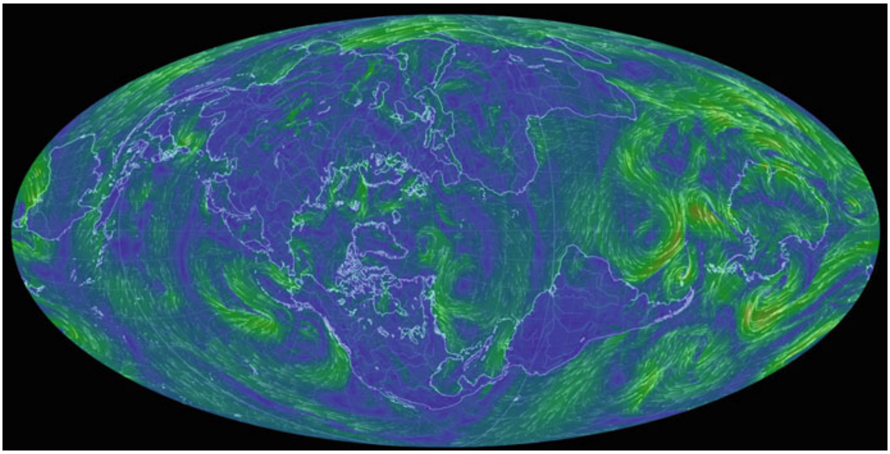

Fig. 3.3 Global wind movement at the ocean surface (Reprinted with permission of earth.nullschool.net)

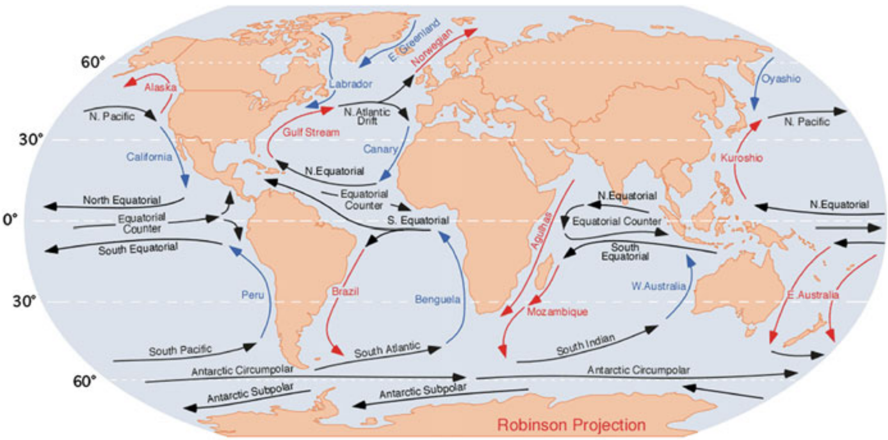

Fig. 3.4 Global ocean "conveyor belt" flows. The *red* and *blue arrows* are warm and cold currents respectively. (Source: http://www.physicalgeography.net/fundamentals/images/oceancurrents.gif. Reprinted with permission of Scott Jones)

and its effects are dealt with in many sources, this chapter only briefly covers the topic.

It is important to remember that the greenhouse effect, which leads to warming, is an inherent part of the Earth's climate. Without this effect, the average global temperature would be a lot colder – by some estimates, around −20 °C. But today, the unusually high level of CO_2 and other greenhouse gases are leading to melting ice, ocean acidification and relatively rapid changes in the temperature distribution patterns in the oceans (IPCC 2013).[6] The great influx of freshwater from melting ice influences haloclines and, therefore, seawater circulation patterns and flows. This could lead to tipping points that change or "turn-off" the conveyor-type movements of large-scale ocean currents, with highly significant consequences.

Another result of the kind of climate-related global change expected in the coming years is, of course, sea level rise (SLR), resulting not only from more flowing water becoming available in the seas, but also from higher water temperatures, which cause "expansion", or swelling, of the seas.

On the whole, climate change may have the greatest and most obvious effect at the sea-land interface along the coasts. Higher sea level, coupled with global and regional climate instability that leads to higher frequency and greater intensity of storms, is causing widespread erosion and coastal hazards, such as flooding, and thus impacting many coastal communities.

3.4 Living Resources

In addition to the exploitation of mineral resources, the protection of fish stocks by coastal states from foreign fishing was among the drivers for the establishment of the EEZ through international law decades ago. Outer boundaries of the EEZ extend to 200 nm from shore because these areas are considered most productive for fisheries – containing 95 % of fisheries resources (Freestone 2009). Today, coastal states are responsible for managing fisheries stocks and protecting other resources within the EEZ in an optimal manner, according to UNCLOS (Article 62).

In reality, ocean fish have little respect for boundaries set by human conventions. Many ocean fish are highly migratory, with two important examples being tuna and sharks. International law categorizes ocean fish according to stock types: local, transboundary (across EEZ of states), straddling (those crossing both EEZs and high sea areas), highly migratory, discrete high seas stocks, anadromous stocks, catadromous stocks and sedentary species (e.g., certain types of shellfish). Anadromous fish are those that are spawned (hatched) in fresh water, then spend most of their life at sea and return to lay eggs in fresh water. Catadromous fish are spawned at sea, spend most of their lives in freshwater and then return again to sea to spawn the next generation. Fish are generally managed as stocks (emphasizing their value as commodities) and not as species, yet the particular attributes of species must be understood and acknowledged for stock management.

[6] The Fifth IPCC Assessment (Summary for Policy Makers) reports: "Since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (p 4).

Marine ecological timescales differ from marine geological timescales and both vary from those on land. The primary producers at the base of the marine food chain are phytoplankton, microscopic plants that live only for a few days. The primary producers on land, by contrast, include perennial grasses and trees with life spans measurable in decades or centuries.

Marine systems are more responsive than terrestrial ones to modest conditional changes. Rising or falling atmospheric temperatures can influence ocean waters in a specific locale, affecting the distribution of phytoplankton, zooplankton (microscopic animals) and ichthyoplankton (larval fish and eggs), which can lead to shifts in those fish communities exploited by humans (Bolster 2012).

To understand the way humans have affected marine ecosystems over time, determining some sort of baseline is essential. This is a huge challenge. Prominent marine fisheries scientists have related fisheries management to the "shifting baseline syndrome". Changing baseline conditions impact resource users' and managers' ability and willingness to curb overfishing. Each generation has difficulty accepting the conditions that prevailed prior to their own existence. Each generation perceives what it experiences as normal and assumes that subsequent declines were aberrant (Pauly 1995).

In addition, we are inclined to adopt a somewhat false dichotomy that changes in marine systems are caused either by human factors (such as overfishing, pollution or habitat destruction) or by natural environmental effects. In reality, anthropogenic impacts occur in the context of environmental effects, and vice versa (Bolster 2012). Environmental planners working in coastal and marine environments should acquire at least a cursory understanding of geological, climatic and ecological processes, all of which affect the sea's resources. This is particularly true of biological resources, which are perhaps the most yielding and sensitive of these, and have exhibited the greatest amount of change due to the greatest variety of factors over the past half century.

3.5 Improved Mapping for Understanding the Sea

The ability to move about the ocean, whether for navigation or for the exploitation of resources or space, is dependent on knowledge of the marine and coastal environment. Such knowledge, in turn, depends on mapping and imaging. The delimitation of boundaries through mapping is useful for determining the limits of individual property, just as it is useful for delimiting sovereign rights at the nation-state level. Boundaries are basic tools for planners.

It is essential for planners and managers to know where the different jurisdictional regimes are applied and where they can be applied. For example, freedom of navigation in the high seas is guaranteed by international law and the right to "innocent passage" and "transit passage" between areas of high seas, territorial sea and EEZ areas should be maintained. How do we delimit these areas? What do we need to know?

Ocean travel has always been dependent on two parameters: location and depth. For centuries, man depended on celestial navigation. To navigate, the angle of the sun, the moon, planets and stars above the horizon were measured at a precise time using a sextant. The motion of these celestial bodies was predicted and then observed and recorded in tables. Fixes on any two bodies provided a unique location (although probably inaccurate by today's standards). With the advent of reliable chronometers (time-telling machines) beginning in the sixteenth or seventeenth century, this type of navigation became commonplace.

Depth measurements were consistently made using a lead line dropped into the sea at intervals. Until circa 1945, with the exception of a few innovations (such as the replacing of rope with piano cord to avoid stretching), lead lines were used for about 4,000 years (Fig. 3.5). During much of this period, the passage of knots on a rope was recorded to gauge vessel speed. Depth was measured in fathoms (approximately 1.83 m or 6 ft) – the distance between a large man's outstretched arms. These techniques and terms have influenced generations. Wind speeds are still denoted in knots and the term "unfathomable", a kind of "unbelievably deep", is now synonymous with the term "inconceivable" (Box 3.2).

Box 3.2: A Brief History of Seafloor Mapping

One of the first bathymetric surveys conducted across a huge swath of sea was made under the direction of Lieutenant Matthew Fontaine Maury, Head of the US Navy's Hydrographic Office. He produced the first deep bathymetric map of the North Atlantic, using only lead line measurements from ships. The project took many years to complete (1842–1870). Maury was nicknamed "Pathfinder of the Seas", "Father of Modern Oceanography and Naval Meteorology" and later, "Scientist of the Seas", due to the publication of his extensive works, especially *The Physical Geography of the Sea* (1855), the first extensive and comprehensive book on oceanography to be published.

Lieutenant Charles D. Sigsbee, commander of the US research vessel, the *Blake*, produced the first truly operational piano wire sounding machine and thus mapped the Gulf of Mexico (1874–1875). Foreseeing a period when three-dimensional imagery of the seafloor would become a common tool for scientific and engineering interpretation, researchers constructed the first three-dimensional image of an oceanic basin from these soundings.

In the 1920s, Alexander Behm, a German inventor and discoverer, performed the first bathymetric measurements using a single-beam echo sounder, then termed a "precision depth recorder". However, it took until the mid-1940s for the echo sounder to replace lead lining on a large scale.

As mentioned, much progress has been made since the 1940s with respect to hydrographic[7] survey methods. By the eve of World War II, the majority of US

[7] Hydrography is the science of ocean and coastal mapping for navigational purposes; hydrographic maps are designed specifically for ocean wayfinding.

Fig. 3.5 A boat model retrieved from the tomb of Meket-re who was buried at Thebes in about 2000 BC. The man at the head of the boat casts a lead line to measure depth (Reprinted with permission of A. Molon)

Coast and Geodetic Survey ships were outfitted with echo sounders (fathometers). These instruments measured ocean depth according to the time it took for a sound beam sent from the instrument (usually on the bottom of the ship) to return to it. Accuracy was not great because the echo returned from the point of least depth in the swath of seabed within range of the beam.

In the 1990s, multi-beam equipment was developed. Multi-beam echo sounding systems (also called multi-beam echo sonars) obtain depth measurements over a swath of bottom perpendicular to the head of the survey ship, as well as directly below the ship (as in single-beam sounding systems) (Fig. 3.6). Such sounding arrays, coupled with accurate navigation, allow for the generation of very accurate seafloor maps (Fig. 3.7). There is virtually no depth limit for measuring using echo sounding, since today remote-operated vehicles (ROVs) can be equipped with sounders.

In the late 1990s, differential GPS systems became available, increasing locational accuracy. These instruments provide accuracy of ±10 m. Since then, the use of satellites in a process called "satellite altimetry" has resulted in measurements of even greater accuracy, up to ±5 cm, with technologies constantly improving.[8]

Often, hydrographic maps used today combine older lead line measurements with newer single- or multi-beam echo soundings, since the latter involve great

[8] For more information on the history of ocean exploration and its innovations see http://oceanexplorer.noaa.gov/history/exploration.html

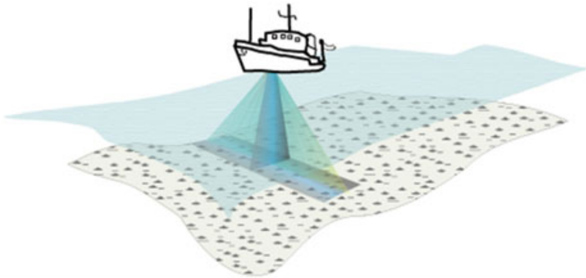

Fig. 3.6 Multi-beam echo sounder at work

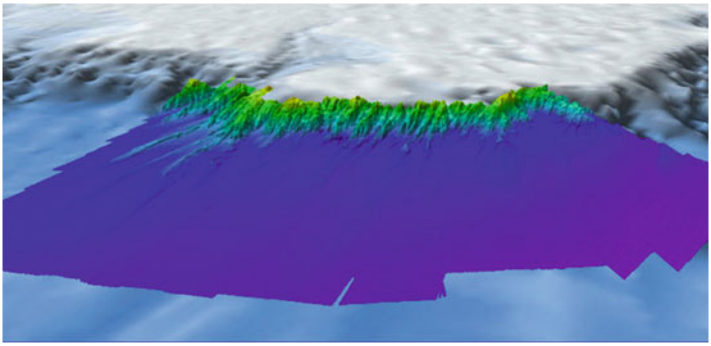

Fig. 3.7 The Beringian Continental Margin in the Bering Sea. The *brightly-colored area* shows bathymetry data collected by multi-beam sonar. (Reproduced with permission of Larry Mayer, Center for Coastal and Ocean Mapping, University of New Hampshire. Data collected and processed by James Gardner, Center for Coastal and Ocean Mapping, University of New Hampshire)

expense and are therefore hard to come by. The preparation of hydrographic maps is the responsibility of the coastal state. The accuracy and availability of these maps are of the utmost importance. As one can imagine, their quality can have important implications for all ocean uses as well as for trade relations, national security and marine science. They are fundamental tools for planners and managers of oceans and coasts.

3.6 A Legal Perspective

Just as land law and regulations provide a base from which to begin land use planning in any context, ocean law and policy is important for environmental planning pertaining to the sea. International maritime laws have evolved over the last 300 years to represent a compromise between two main principles (Fig. 3.8): freedom of the seas for navigation, and resource management (mostly with respect to fisheries) for the allocation of both exploitation rights and conservation duties.

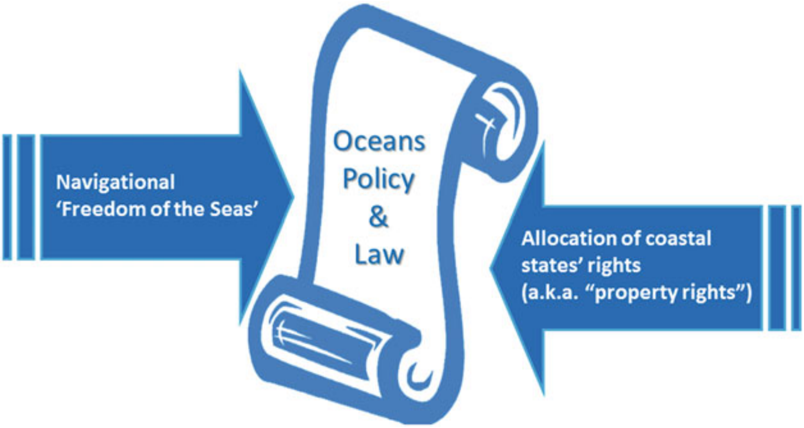

Fig. 3.8 The two opposing forces driving the development of oceans policy and law

The latter, like the division of land into private property, is considered by many a way to avoid the well-known Tragedy of the Commons as described by Garret Hardin (see Hardin 1968).

Following the close of WWII, US President Harry Truman articulated his country's interest in exercising jurisdiction over the natural resources of the seabed, purportedly for their conservation and prudent utilization (see Truman 1945). Other countries followed suit and became interested in demarcating areas according to boundaries, irrespective of the existence of natural prolongations of the continental shelf. This was particularly important for South American countries on the western side of the continent, such as Peru, with a very narrow continental shelf. They were interested in exclusive rights to rich fish stocks sustained by the nutrient-rich Humboldt Current. Exclusive whaling rights were also of interest to them.

There is no doubt that over the last decades, jurisdictional authority of the coastal states is moving seaward. But beyond the self-interested desire of coastal states (or other entities) to establish sovereign rights in areas farther from the shoreline and at greater depths, these efforts also reflect improved technological ability to exploit the sea, better data about what is in the sea and development of international institutional capacity that makes decision making concerning sovereignty and mediation between countries possible. The latter is invariably dependent on improved communication and the understanding that countries must work together for greater global governance to achieve both equitable exploitation of the common heritage of mankind and to protect the ocean and coastal environment. (For information on various legal regimes, see Chap. 2 and Fig. 3.2). (For more on the rights and duties of nation-states that are party to UNCLOS, see Churchill and Lowe (1999) or Sohn et al. (2010)).

As explained in Chap. 2, coastal states have sovereignty over their internal waters and over their territorial seas. However, within their adjacent EEZs, they have sovereign rights[9] to conduct certain activities. In their continental shelf areas, they have rights to *exploit* resources of the continental shelf. These resources vary greatly and can include geothermal energy resources, minerals or even sedentary species, such as benthic-dwelling shellfish.

However, states do not *own* the continental shelf or the water column of the EEZ, and, besides rights, they have important obligations. The idea of allocating sovereign rights to resources of the water column in the EEZ has existed since the 1970s, always accompanied by the duty of conservation. Rights to resources in the continental shelf and the possibility of delimiting the ECS area is a relatively new concept and one that is still evolving, especially in view of the current environmental threats to ocean environments.

3.7 An Environmental Perspective

Despite many laws and agreements, anthropogenic activities are affecting oceans and coasts far more than we have the capacity to control. The major body of international law, UNCLOS, began developing before the majority of environmental legislation took hold in the 1990s. Therefore, much of the influential environmental legislation pertaining to coasts and oceans is occurring on the national and local level and not on the international level that predates it. This results in flexibility such that regulations on the coastal nation-state level are developed in light of current environmental needs. At the same time, the International Tribunal of the Law of the Sea (ITLOS), in charge of interpreting UNCLOS, is doing so in view of newer environmental perspectives, impacting and impacted by such local-level legislation.

This is not to say that environmental concerns were not part of international law and marine and coastal regulation before many national environmental laws were enacted. For over four decades, environmental protection has been an important focus of international coastal and ocean policy, driven by the many transboundary and global threats to the marine environment. These result from pervasive anthropogenic activities; for example, overfishing and marine pollution from ships. As detailed in Chap. 5 of this book, international policy and regulations focus on ship pollution, including spills of hazardous and noxious substances, nuclear waste, ship-emitted sewage and litter, air pollution and the release of ballast water that introduces invasive species into the near-shore waters in ports.

Most environmental planners will be working on ocean and coastal planning at the local or regional level. What will be their role? If we consider two prevalent

[9] The term “sovereignty” is distinct from “sovereign rights”. Sovereignty means that a coastal state has independent authority to govern itself and freedom from external (in this case, foreign) control. Sovereign rights refers to the authority to use (and govern) actions pertaining to some, but not all, resources.

approaches to environmental planning: one that puts special emphasis on environmental quality in planning and the second that describes environmental planning as the application of planning processes to environmental problems (Randolph 2011), the field has much to contribute.

A number of positive developments have occurred in the scientific community that planners can tap into. Ecosystem-based management (EBM) and the precautionary principle have been adopted as guidelines by many ocean and coastal policy makers. EBM is an *integrated* management approach that requires consideration of the entire ecosystem, including humans, to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. The precautionary principle, which gained wide acceptance throughout the 1990s, provided a new approach to environmental decision making. It has four central components: taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of alternatives to possibly harmful actions; and increasing public participation in decision making (Kriebel et al. 2001).

Despite consensus about the importance of the EBM approach (e.g., Ehler and Douvere 2009), challenges remain for incorporating it into the decision-making stages of the planning process. Critics of the approach claim that it is perceived as too complicated, as having prohibitive information requirements and that it is generally ill-defined (Lotze 2004; Tallis et al. 2010).

Early on, ideas were adopted in regional agreements related to the sea that today would be considered precautionary principles. Examples include principles of the 1982 Convention for the Conservation of the Antarctic Marine Living Resources (Croxall and Trathan 2004). More recently, the precautionary principle has been recognized as an important consideration for marine planning, especially with respect to fisheries management (Boersma et al. 2004).

In general, there is a disconnect between conservation, environmental protection and marine planning fields (see Portman et al. 2013). Continued efforts must be made to close these gaps. Now that marine spatial planning is taking hold, especially in Europe (European Parliament 2014), the time is right to bring planning to the fore in order to address the many environmental problems of ocean and coastal environments.

3.8 Summary

This chapter has covered aspects of concern to environmental planners working on oceans and coasts. Various physical elements of ocean environments, those driven by geologic and climatic forces, have implications for oceans policy and management and therefore have been discussed herein. Living resource systems interact with physical aspects of climate and geology to form the ecological systems that require planners' attention. Geology, climate and living resources all have implications for planning.

How we "know" the sea, will be the basis for any policy, law or regulation we intend to impose. For this reason, it is essential that environmental planners understand some of the physical processes that are at work in the sea, especially in areas less accessible and that change over various scales of time, both according to geological time scales – over thousands of years – and over time scales of a mere few decades, due to climate shifts. Furthermore, planners need to understand how we articulate these physical conditions in ways that make sense for policy makers and for planning. All these topics are more complex with regard to oceans than they are regarding land.

This chapter has also addressed how laws and policies incorporate different perspectives into the management of ocean and coastal resources. International ocean policy frameworks and legal systems increasingly provide mechanisms for environmental protection. The evolving nature of these frameworks provides ample opportunity for environmental planners to weigh in. Environmental planning for oceans and coasts is a relatively new field; it should be poised to apply the process of planning to environmental protection and problem-solving for these environments.

Although this chapter has focused mostly on the offshore marine environment, areas of interest to planners may be closer to shore, where landside processes have more influence. Suffice it to say that both marine and landside processes need to be considered simultaneously in an integrated manner. Therefore, the next chapter (entitled Principles of Integration) deals almost exclusively with the various facets of integration.

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Part II
Methodological Approaches

Chapter 4
Principles of Integration for Oceans and Coasts

É um passo é uma ponte *É um sapo é uma rã* *É um resto de mato* *Na luz da manhã.* *São as águas de março* *Fechando o verão* *É a promessa de vida* *No teu coração…*	*It is a footstep, it is a bridge* *It is a toad, it is a frog* *It is the remaining forest* *under the morning light* *These are the rains of March,* *closing the summer.* *It is the promise of life* *in your heart…*

— Antônio Carlos Jobim

Abstract Integrated approaches are essential for planning and management of marine and coastal environments for many reasons. This chapter highlights the integrated approaches most relevant for planning of coastal and marine environments – integrated coastal zone management, integrated marine planning, integrated water resources management and integrated watershed management – and discusses some of the main challenges to integration. Among the most salient of these challenges is the translation of the principles of integrated planning and management to on-the-ground actions that make sense for planners and managers.

Keywords Integrated coastal zone management • Marine planning • Sectoral use • Watershed management • Water resources management

Four years after the European Commission adopted a recommendation for the implementation of Integrated Coastal Zone Management for its member countries (European Parliament 2002), it hired a private consulting firm to evaluate progress on implementing the recommendation (Council Recommendation 2002/413/EC) among the then-24 EU member countries with ocean coastlines. The firm's evaluation found that many countries fell short of expectations. Overall, the evaluation concluded that there is much to be done to improve integrated coastal zone management (ICZM) along European

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coasts (Rupprecht Consult 2006). Most telling among the consultants' findings was that there exists confusion among planners and managers about what integration involves and how to implement it.[1]

Given these findings and other evaluations of the level of integration achieved over the years for ocean policy (e.g., Stokstad 2009), it is helpful to revisit concepts and approaches relevant to integration: how they developed, why they are important and what constitutes common obstacles to their implementation. There is, in fact, a large body of research on maritime spatial planning and coastal zone management that is, of late, concerned with integration. A related approach, integrated watershed management (IWM), has much to do with coastal zone management and marine planning, although academic and professional work linking IWM to ICZM and to integrated marine planning is limited.

The concept of integration with regard to spatial dimensions means that integration should occur between landscape units; this is perhaps of the most interest to planners and the most obvious type of integration. However, there are other dimensions to the approach (as explained below). These dimensions and their related concepts are discussed further throughout this chapter.

In the planning context, it is perhaps easiest to conceptualize the physical (spatial) aspect of integration. It means considering the effects of land-based activities on the coastal and marine environment, and vice versa. For example, inland activities within coastal watersheds influence the coastal environment and therefore also the marine environment. Arguably, the most commonly understood dimension of coastal watersheds relates to the physical environment, connoting the spatial layout of uses. Before addressing integrated approaches applied to each of the environmental realms (coasts, oceans and watersheds), I discuss the importance of integration and its evolution as a norm in the environmental field.

4.1 What Is Integration?

To "integrate" means to unify, to put distinct parts together into a whole (Merriam-Webster 2003). Early on, Underdal (1980) described an integrated approach in a marine and coastal policy context as one in which constituent elements work in parallel or hierarchically and are brought together and made subject to a single, unifying concept. Blatter and Ingram (2000) take this definition further by applying integration both to the framework for regulating and managing different environ-

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[1] The Rupprecht Consult report (2006) also identified a lack of qualified personnel (i.e., planners and managers) conversant on all levels with ICZM in most of the countries reviewed. Other literature on the subject reports that, among other problems, the principles of ICZM are often perceived as loosely structured and idealistic (Chaniotis and Stead 2007; McKenna et al. 2008; Ballinger et al. 2010).

mental resources and for the amalgamation of fragmented centers of institutional power. The key motivations for this are better control of interdependent relationships among environmental media (i.e., water, air, soil, etc.) and greater regulatory efficiency and effectiveness. As regulation targets a myriad of resource interdependencies, the roles of various agencies that have jurisdiction over those resources can be consolidated and the administrative burden reduced (Stokstad 2009; Turnipseed et al. 2009).

Integration is a fundamental principle for a variety of management regimes and therefore highly relevant to environmental policy and planning. For natural resource management, integration connotes the crossing of boundaries; these can apply to the confines of professional interest (i.e., fields or disciplines), to physical (i.e., of ecosystem or landscape unit) limits, or to institutional (i.e., administrative or jurisdictional) boundaries. But each of these types of integration is interconnected. For example, the coordinated treatment of different landscape units represents the crossing of physical boundaries. This constitutes spatial integration, although it is often only achieved through institutional integration among different sectors of government.

Having various user groups, stakeholders or professionals work together, promotes integration. As an example, professional boundaries are crossed when policy makers call for integrated assessment. Although highly context dependent, an integrated assessment assembles, and makes coherent, information from a broader set of domains than would otherwise be researched from a single discipline (see Parson 1995).

Institutional boundaries are crossed by multilevel interactions between organizational entities, but these can also occur between different authorities at the same level as well. Among governance institutions responsible for integration, there may be sectoral agencies that have mandates to promote the interests of particular user groups or other stakeholders, or informal groups and forums. Informal organizational entities can sometimes act to achieve integration among sectors and user groups very effectively.

Intergenerational concerns, which call for temporal types of integration, are becoming more common as awareness rises about the future of our planet, including such approaches as sustainable use and ecosystem services. Both of these approaches reflect concern for future generations.

An often neglected type of integration relating both to governance and to physical/temporal attributes is the integration of science and policy (see Fig. 4.1). This type of integration is brought about by formal and informal institutions or groups of people. To integrate science and policy, the boundaries of traditional fields of inquiry are crossed, such as those dividing the realms of natural science and social science.

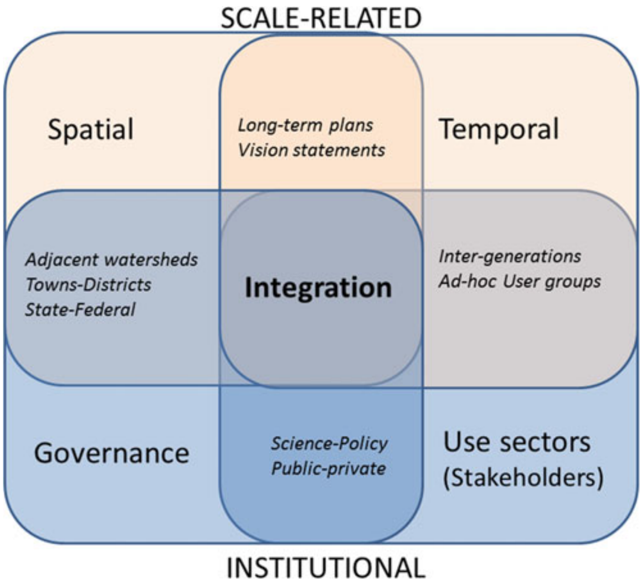

Fig. 4.1 The four common dimensions of integration: spatial, temporal, governance and use sectors (stakeholders)

4.2 The History of Integration

Over the past three decades, a number of seminal environmental declarations have called for integration. One of the earliest articulations of integrated environmental and resource management is found in the report of the Brundtland Commission, published in 1987. This report described, as the chief institutional challenge of the 1990s, the integration of ecological dimensions of policy with those of economics, trade, energy, agriculture and industry. It called for all these dimensions to be dealt with using concurrent agendas, and especially by national and international institutions (Brundtland 1987).

Another important reference to integration is in Agenda 21, the blueprint of action to be taken by organizations of the United Nations (UN), national governments, agencies and NGOs for sustainable development and for addressing global climate change. The text of Agenda 21, adopted in 1992 at the UN's summit in Rio de Janeiro, critiques "[p]revailing systems for decision making in many countries [that] tend to separate economic, social and environmental factors at the policy, planning and management levels" (UN Department of Economic and Social Affairs 1992). Further, the implementation plan of the parties to the 2002 World Summit on Sustainable Development has 81 references to "at all [governance] levels" in a mere 50 pages (Cash et al. 2006). Such recurrence signifies an acknowledgement that

Table 4.1 Common types of integration for resource management and environmental policy. Types are organized as paradigms and by the various mediums they address

	Term	Application	Seminal sources
Medium	Waste planning	Waste planning	Developing Integrated Waste Management Training Manual (UNEP 2009)
	Pollution	Pollution control	EU Directive on Integrated Pollution Prevention and Control of 1996
	Water	Watershed planning	Water Framework Directive (EU 2000)
	Coastal resources	Urban planning	US Coastal Zone Management Act of 1972
	Energy	Infrastructure	Comprehensive Electricity Competition Plan of the US Department of Energy (1998)
	Transportation	Infrastructure	White Paper on EU Transportation Policy (2001)
Paradigm	Resource planning	Energy systems	World Energy Assessment: Energy and the Challenge of Sustainability (UNDP 2000)
	Assessment	Climate change	Integrative Assessment of Mitigation, Impacts and Adaptation to Climate Change (Nakicenovic et al. 1994)
	Policy development	Sustainable development	Our Common Future (Brundtland Commission 1987)
	Environmental policy	Global governance	Agenda 21 (UN Conference on Environment and Development 1992)
	Tourism	Regional planning	Sustainable Coastal Tourism (UNEP 2009)

many problems have causes and solutions spanning multiple administrative levels that can be addressed by better integration.

Many international plans, programs and legislation, especially at the EU level, promote integration in sectors such as water, transportation and energy. Before the adoption of its Water Framework Directive (2000/60/EC), EU water policy was fragmented in its objectives and operations. The Water Framework Directive (discussed further in Sect. 4.5) mandates integration by expanding the scope of water protection to all waters, including surface and groundwater.

With regard to other fields, the White Paper on European Transport Policy set goals for integration of: different modes of transport; external costs of modes and systems; and different levels of transport from international to regional, national and local (European Commission 2001). European countries, such as Denmark and Germany, have integrated national (state) energy markets and they have adopted integrated energy planning that seeks a least-cost combination of supply and end-use efficiency measures (D'Sa 2005). These and other examples of integration (see Table 4.1) set the stage for a discussion of the types of integration that have developed over the past several decades and have influenced the management of marine and coastal environments.

Beyond integrated coastal zone management, integrated marine planning and integrated watershed management, described in this chapter, other management approaches commonly applied to the land-sea interface include ecosystem-based management and integrated tourism planning. Marine ecosystem-based management integrates multiple-use sectors, emphasizing the inclusion of human activities as an integral part of ecosystems (see Mengerink et al. 2009). Integrated coastal tourism planning addresses the conflicts between regional economic benefits, the social environment (i.e., the contextual social and cultural identity and values of place), and impacts on the physical environment resulting from urban sprawl, increased urbanization, pressure on sensitive areas, waste production and the fragmentation of habitats resulting from tourism development (see UNEP 2009).

4.3 Integration for Coastal Planning

Integrated approaches to coastal conservation and development first materialized in the 1970s. Urban planners and landscape architects led some of the initial research on the topic (Belknap 1980; Felleman 1982). One of the earliest references to integration in the Coastal Zone Management Journal (published since 1973) is a paper dealing with the lack of integration in municipal policy for managing the New York City waterfront (see Moss 1979). Since then, a significant amount of empirical research, academic literature and professional publications have described the benefits of integrated coastal zone management (ICZM). Among the most important of these benefits is reduced conflict in the long term and a much better chance for sustainable development (Portman et al. 2012).

Integrated coastal zone management came into common parlance with Chapter 17 of Agenda 21 in 1992, the Jakarta Mandate on Marine and Coastal Biodiversity under the Convention on Biological Diversity (CBD), and the UN Food and Agriculture Organization's (FAO) Code of Conduct for Responsible Fisheries (FAO 1995). Article 10 of the UN FAO's code is entirely devoted to ICZM (see Cicin-Sain and Knecht 1998). Despite these clear beginnings, definitions of ICZM have developed over time and they now vary depending on specific objectives and contexts (Box 4.1).

In general terms, ICZM is a process by which rational decisions are made concerning the conservation and sustainable use of coastal and ocean resources and space. It is a process designed to overcome the fragmentation inherent in single sector management, between different levels of government and at the land-water interface.

Some definitions of ICZM are broad and general. They refer not only to what is integrated spatially and at a governance level, but also to the management and planning process itself. In other words, they define the objectives of integration and the many instruments needed to meet these objectives. Practitioners, and to some extent, the public, should be aware of some key terms in order to have a better understanding of coastal zone management, its elements, what distinguishes it from other types of management and how integration can be applied.

Box 4.1: What Is ICZM?

Exact definitions of ICZM vary, as they are dependent on specific objectives and contexts. The terms "ICZM" and "integrated coastal management" (ICM) are often used interchangeably. Some definitions from various sources follow:

ICM is a continuous and dynamic process by which decisions are made for the sustainable use, development and protection of coastal and marine areas and resources (Cicin-Sain and Knecht 1998).

ICZM is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones (European Commission 2000b).

ICZM is a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts. Protocol on ICZM in the Mediterranean (UNEP/MAP 2008).

ICZM is an adaptive, multi-sectoral governance approach, which strives to balance development, use and protection of coastal environments. It is based on principles such as holistic and ecosystem-based approach, good governance, inter- and intra-generational solidarity, safeguarding the distinctiveness of coasts, precautionary and preventive principles (UNEP 2009).

A major contribution of the EU recommendation for the implementation of ICZM (2002/413/EC) was the formalization of eight principles of ICZM that should be implemented in the countries of the EU through national strategies for management of the coast (Box 4.2). In the US, ICZM has been implemented for some time through the US Coastal Zone Management Act, in place since 1972. The Act bestows responsibilities upon individual sub-federal states for the incorporation of federal coastal zone management principles in state and local plans for the coast. Analysis of these and other experiences suggest that ICZM in different contexts has met with varying levels of success. In any case, it is clear that much work remains to be done in order to improve coastal environments since the advent of ICZM (Klinger 2004; Ballinger et al. 2010; Portman et al. 2012).

Box 4.2: A Brief Description of the Eight ICZM Principles Adopted by the EU

Principle of ICZM[a]	Description
A broad "holistic" perspective (geographic and thematic)	ICZM should be based on "approaches that look at the bigger picture" across administrative boundaries, landscape units (marine, coastal and terrestrial) and sectoral interests (conservation, tourism, fisheries, transport, etc.)
A long-term perspective	Decisions should promote sustainable use of resources beyond present political and economic needs
Adaptive management	ICZM should be dynamic and continually evolving with implementation flexible enough to adjust to new (social, economic and environmental) conditions and to incorporate new knowledge
Reflect local conditions	Understanding the characteristics and driving forces of local natural processes and social and economic needs of local coastal communities is essential; there is no "one size fits all" solution
Work with natural processes	Coastal environments are dynamic and change at temporal and spatial scales due to natural and human-induced processes. Understanding this dynamism and the limits it imposes on "fixed" human use is key
Participatory planning	Public participation and stakeholder involvement is essential. Engagement of stakeholders should occur at all decision-making stages with stakeholder views incorporated through a transparent and balanced process
Support and involvement of administrative bodies	Integration between administrative levels and sectors with jurisdiction over the coast is needed. Organizational structure reform or creation of multi-sectoral institutions might be required
Combined mechanisms	ICZM usually depends on the application of a mix of mechanisms, e.g., planning, management, funding, knowledge, technology and the involvement of stakeholder groups

[a]For case studies pertaining to the implementation of these principles, see: The OURCOAST project of the European Commission (http://ec.europa.eu/ourcoast/index.cfm?menuID=18#)

Attempts at implementing ICZM have been followed by evaluations of its effectiveness. Mitchell (1982) undertook an early comparative study when the formal concept of comprehensive, integrated conservation and development of coastal margins was barely a decade old. He described and analyzed the national US Coastal Zone Management Program as the basis for a comparative analysis of fledgling coastal management efforts in other nations. In addition to comparing the systems of ICZM in the United States to those of Western Europe, he compared between developed and developing countries. Mitchell found that while the national programs were not always highly integrated, they at least consistently underscored a public commitment to the use of science in management decisions, which is also a type of integration (see Fig. 4.1). The programs also helped replace ad hoc crisis responses with proactively planned strategies and provided mechanisms for resolving conflicts among competing users (Mitchell 1982).

The widely used text on coastal zone management by Cicin-Sain and Knecht (1998) provides a summary of narrative case studies of integrated coastal management practices implemented by 22 different nations. The study compared developed and developing country cases based on a number of variables, including the socio economic context, political system, demographic characteristics and development level (characterized roughly as developed, middle developing and developing). Although each nation pursued a unique path to ICZM, researchers found that the problems countries faced exhibited similar patterns. Most nations experienced conflicts among uses, among users and among agencies administering coastal and marine programs, indicating a need for further integration. Another important finding was that a similar suite of tools and approaches aimed at integration could be identified in many of the nations included in the study.

A more recently conducted study came to similar conclusions. Portman et al. (2012) analyzed tools used in eight (developing and developed) countries for coastal management. In addition to looking at current ICZM programs and plans, this study focused specifically on integration and developed a typology of types of integration. A link was drawn between certain tools used and types of integration achieved. Policy makers can use the findings of this study to adopt mechanisms that are most suited to the type of integration needed, or lacking, for the particular situation.

Both Cicin-Sain and Knecht (1998) and Portman et al. (2012) found that even though most plans and programs pertaining to coastal areas call for the establishment of ICZM practices, there are many challenges to success. The lack of integration is still a stumbling block for successful sustainable management of the coast, along with other factors, such as lack of knowledge and/or expertise, resistance to change, and weak support for local ICZM efforts at higher levels of government (Rupprecht Consult 2006; Portman et al. 2012).

4.4 Integration for Marine Planning

Although integrated management has been applied to the coastal zone in many places for some time, its application to the seas is relatively new and corresponds with increased conflict as human activities intensify at greater depths and at greater distances from shore. One of the challenges for integrated ocean management is the question of where responsibility for its implementation lies. As discussed in earlier chapters, jurisdictions in the sea are ambiguous compared to those on land. On the one hand, this could facilitate integration, as boundaries are already porous.

Conversely, it may be unclear which agencies or institutions must lead the way towards integration.

This dichotomy has led to questions about whether integration should be mandated at a local, regional or international level. What institutions or policy doctrines could possibly ensure the use of integrated management and planning approaches in the ocean realm? Some policy experts have tried to address these questions. For example, Tanaka (2004) makes the case for integrated management based on international legal doctrines such as the Common Heritage of Mankind, embodied under the 1982 UN Convention of the Law of the Sea (UNCLOS).

Tanaka (2004) and others advocate integrated marine policy as an ecology-oriented approach because, theoretically, integration involves the simultaneous consideration of different ecosystem types, such as marine and coastal or deep seas and continental shelf areas, which go beyond human constructs (i.e., jurisdictional limits). Due to some of the major differences between landscapes and seascapes, such as those previously discussed (i.e., large versus small spatial scales, fine versus coarse temporal scales, three-dimensional versus two-dimensional living space, etc. (Agardy 2000)), human constructs in marine environments should be less important. Perhaps because of these ambiguities, sea boundaries are often more controversial than those on land (such as the dispute over sovereignty of ocean areas in the South China Seas currently making headlines). These conditions make efforts at integrated marine planning extremely important and quite challenging.

The greatest progress on structured ocean planning and management has occurred close to shore, where marine spatial planning (MSP) processes are becoming common (Collie et al. 2013). Similar to ICZM, marine spatial planning, or maritime spatial planning as it is called in Europe, strives to manage the resources of the sea and the near-shore environment by integrating across varying landscape types (Ehler and Douvere 2009). One of the greatest challenges in doing so has been the lack of information about the marine environment. However, as technology has improved for exploiting the sea, it has also improved for collecting data on the marine environment. These two processes have made integrative marine planning both essential and possible (see Chap. 6).

Institutional progress towards integrated ocean management has lagged behind that of coastal management. Kiel (1977) called for integrated US ocean policy in an article published in the journal *Marine Policy* during its first year of publication. A similar charge came from Arild Underdal (1980), a marine policy expert with the Institute of Political Science in Oslo, Norway, in an article entitled "Integrated Marine Policy: What? Why? How?" Four decades later, many countries are only now becoming more integrated in their planning and management approaches through recently initiated MSP efforts.

Despite these good intentions, decades of multiple agency involvement in marine management and jurisdictional overlap complicate integration and are hard to change. We see that well into the new millennium, US laws and policies aimed at regulating the exploitation of marine resources at the federal level continue to be organized around uses in a sectoral manner (Fig. 4.2). Although US subnational states control their waters out to three miles, many uses within them

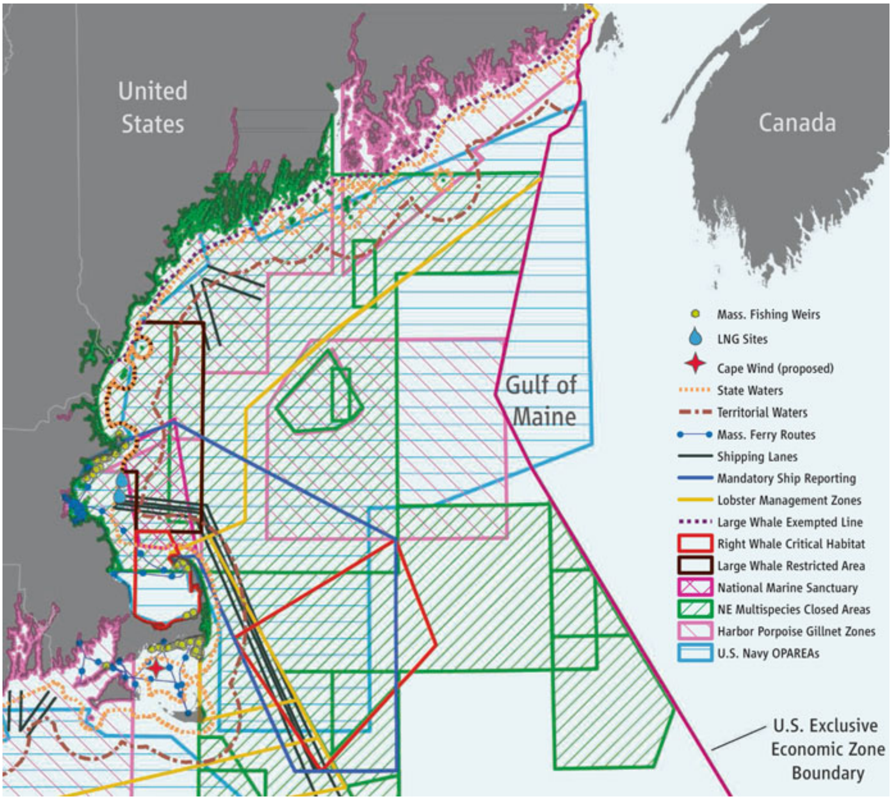

Fig. 4.2 Various jurisdictional lines off the coast of Massachusetts, USA (Source: Turnipseed et al. 2009. Reprinted with permission of copyright holder C. Good)

still require federal authorization. Beyond the three-mile limit, some 20 federal agencies have responsibilities for more than 140 laws that apply to federal ocean waters and the Great Lakes (Stokstad 2009).

Notably, efforts at achieving greater integration through marine planning have been advanced mostly at the sub-federal level in the United States. State-level MSP initiatives generally range from the most basic localized, single-issue planning initiatives to more comprehensive, multi-use, ecosystem-wide efforts addressing areas beyond state waters. State-level initiatives in Rhode Island and Washington State, for example, have set planning boundaries to cover state jurisdictions (three miles from shore). Despite a lack of federal support, Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut, together formed the Northeastern Regional Planning Body (Northeast RPB) as envisioned by the US National Ocean Policy. The Northeast RPB constituted and established itself, meets regularly and has developed a regional ocean plan. The Mid-Atlantic and Southeast Atlantic have also formed RPBs. These RPBs are expected to produce regional MSPs for review and approval by the National Ocean Council (Olsen et al. 2014).

In US marine areas, international environmental protection measures (those crossing jurisdictional lines between countries, like the Natura 2000 Program) are limited and few. Hence, it remains to be seen whether integration across jurisdictional lines that support ecosystem-based management can be achieved in US waters through state-level or regional MSP.

In Europe too, past measures to control pressures and impacts on the marine environment developed over the years by sector, resulting in a patchwork of policies, legislation, programs and action plans at national, regional, European and international levels, with little coordination between them. A 2005 European Communication identifies sectoral management measures as a significant institutional barrier to the improved protection of Europe's marine environment (European Commission 2005). Since this communication was issued, European efforts at integration through marine planning and other environmental directives addressing the coastal, terrestrial and marine environments have made more progress than those of the US, at least at a larger cross-boundary scale.

Integrated marine management efforts in Europe reflect the discussion and controversy regarding new uses of the sea and the need to meet commitments to protect the marine environment. Following earlier communications about the marine environment, the European Commission published its guidelines for integrated marine policy in June 2008. A subsequent 2010 Communication on the subject of marine planning eventually led to Directive 2014/89/EU establishing a framework for maritime spatial planning, discussed further in Chap. 6. This directive, seen as essential to the development of Europe's "Blue Economy", is particularly interesting due to requirement for member countries to conduct integrated marine planning (IMP).

Despite the need to address the intensification of human activities at increasingly greater distances from shore, integrated MSP has not yet been applied to the high seas. Policy analysts have considered how MSP could theoretically be applied to the high seas and have proposed aiming for integration from the get-go. Tanaka (2004) suggests that there are two opposing management forces in the sea: a zonal force that segregates uses and an integrated force that brings them together for management purposes. For the latter, sets of ecosystem components, functions and processes are emphasized instead of jurisdictional boundaries.

Differences in MSP boundary demarcation highlight the need to examine how the delimitation of boundaries supports or impedes integration. This need is based on the questions and concerns of experts in natural resource management (e.g., Molle 2009), among them marine policy experts and conservationists (e.g., Turnipseed et al. 2009). MSP, as an integration tool, is particularly interesting because it is relatively new, addresses the management of the largely public resources of the sea and provides ample opportunities to incorporate approaches such as ICZM and integrated water resources management. Of particular interest are MSP processes that balance development with conservation at varying spatial scales and with differences in scope (Portman 2011).

4.5 Shoreward: Integrated Water Management

Spatial and temporal integration mean that planning and management efforts related to global ocean health and regional or local well-being incorporate the planning and management of terrestrial water resources. The river basin (watershed) is a landscape unit for which it is relatively easy to conceptualize integration. What is meant by horizontal and vertical integration, relevant generally for integrative planning (Portman 2011), is easily illustrated for a river that flows into the sea (Fig. 4.3). It is clear that activities on land within the coastal watershed have countless effects on the marine environment; this calls for the application of watershed management approaches, foremost of which is integrated water resources management (IWRM), along with ICZM and MSP, to achieve greater integrated planning for ocean and coastal environments.

As a case in point, Kelly et al. (2011) posit that ocean acidification can be curbed by focusing more attention on local and regional scale actions within terrestrial watersheds. They argue that in view of the many challenges facing international efforts to mitigate greenhouse gas emissions, smaller scale actions gain in importance. State or

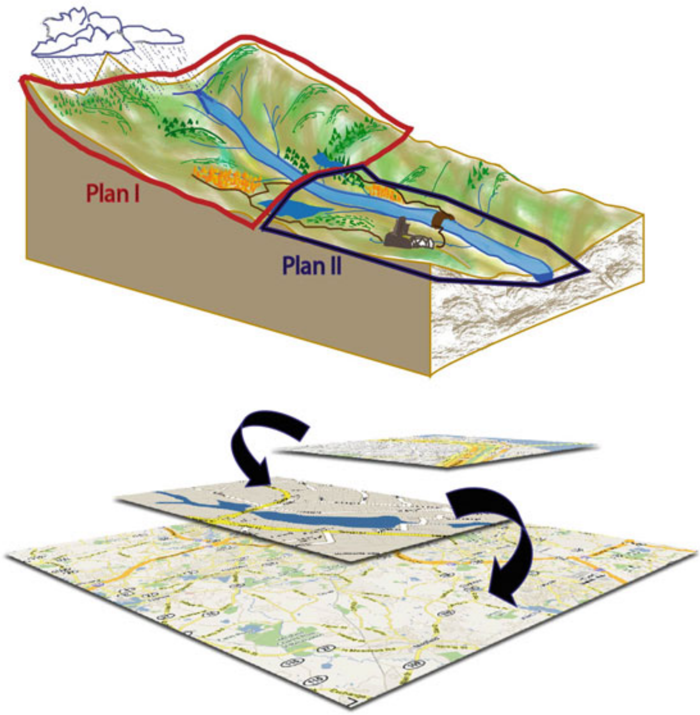

Fig. 4.3 *Top*, spatial (horizontal) integration between adjacent jurisdictions from upriver (Plan I) to downstream (Plan II); *bottom*, hierarchical (vertical) integration between jurisdictions (e.g., local, district, regional) shown by maps of different scale and scope

district regulations, or even local ordinances, applying to stormwater surges (e.g., holding tanks), coastal and riparian buffers (e.g., areas of vegetation near land-water intersections), and improved onsite water treatment facilities are effective measures that address watershed run-off and associated pollutants that have numerous impacts on coastal and marine environments.

IWRM, together with a similar approach called integrated watershed management (IWM), and marine and coastal planning, are interrelated. Watershed planning has the advantage of the watershed (or the "river basin") being the natural geomorphological unit for water-caused erosion (Tefera and Stroosnijder 2007). Indeed, there is significant consensus today that the river basin is an appropriate unit for water and natural resources management efforts. Since the interface between land and sea is greatly influenced by coastal watersheds, its relevance to planning of the coastal environment and the near-shore marine environment is clear.

In a well-known text on the topic, IWM is described as comprising a comprehensive, multi-resource management planning process in which all stakeholders within a watershed jointly negotiate how they will define their interests, set priorities, evaluate alternatives and implement and monitor outcomes (Heathcote 1998). While it makes the most sense to look at the coastal watershed in terms of inland waters' impact on the coastal and marine environment, it is important to note that there are frequently impacts working in the opposite direction – of the sea towards land. Ocean waters may impact land by seasonal flooding or inundation. There are dangerous hazard-causing influxes of water towards land, such as tsunamis and, of late, hazards from sea level rise (see Chap. 11).

The EU's Water Framework Directive (WFD) operationalizes IWRM principles, covering a number of different steps for achieving good water status by 2015 (chemical status for all waters, ecological status for surface waters and quantitative status thresholds for groundwaters). An important milestone set by the WFD is the delineation and characterization of water bodies within River Basin Districts, which approximate watersheds. Other milestones of the WFD are the establishment of registries of protected areas within each district; the development of river basin management plans; the establishment of monitoring networks based on the results of characterization and risk assessment; incorporation of the "polluter pays" principle; and the design of measures for achieving WFD environmental objectives (e.g., prevention or control of pollution) (European Commission 2000a).

The ongoing implementation of the EU's WFD can be viewed as a reorganization phase in the process of change in institutional arrangements and ecosystems (Hammer et al. 2011). As for many types of integration, entrenched institutional behaviors are often among the most formidable obstacles to the development and implementation of best-practice resource management programs (Hering and Ingold 2012).

The EU's WFD is no exception. For example, the WFD promotes the involvement of local actors in the provision of information in ways that can help integrate management and planning for water resource protection at multiple levels. However, in a review of implementation of the WFD in Sweden, Hammer et al. (2011) found the combination of local knowledge from water resource users (local actors) with water management science to be fraught with ethical, methodological and conceptual difficulties. Documented discussions among scientists, policy makers and stakeholders in regards to implementation of the WFD underline the need to develop a conceptual framework for a science-policy interface (another dimension of integration) related to water (see Quevauviller 2010).

For water resources management and planning, as for coastal and oceans planning, setting up a cooperative management and planning structure that goes beyond the familiar triangle of legislative committees, regulatory agencies and special interest groups (e.g., industrial and environmental) is challenging. Sometimes IWM plans and programs are overambitious and end up becoming highly technical interpretations of policy with the desire to do too much at one time (Schreiner and Hassan 2011; Hering and Ingold 2012). In any case, as with ICZM and IMP, some of the greatest challenges to IWM center on overcoming institutional barriers and using innovative and evolving tools of governance.

4.6 Summary

Whilst integrated approaches take many forms, they contain common elements, most of which have been covered in this chapter. Typically, these approaches recognize the need for coordinated management, involve a wide range of stakeholders and work in accordance with an agreed set of environmental and social objectives.

Almost all efforts made to bring about integration in marine and coastal resource planning and management will aim at crossing boundaries at various governance and spatial/temporal dimensions. These include coordinating contributions of science and policy, interfacing among various levels of government and between governments, and addressing physical attributes of various land and seascape units. The needs of various resource users, the general public, future generations and even the needs of functioning ecosystems should be considered.

Integration is essential for planning and management of marine and coastal environments for many reasons. One of the greatest challenges to the approaches discussed in this chapter – ICZM, IMP and integrated water planning and management (IWRM and IWM) – is the translation of the principles of integrated planning and management to on-the-ground actions that make sense for planners and managers. Students and researchers can learn from understanding the successes and failures of programs and plans that strive for integration in the planning field, in policy and beyond.

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Chapter 5
Pollution Prevention for Oceans and Coasts

Water and air, the two essential fluids on which all life depends, have become global garbage cans.

– Jacques-Yves Cousteau

Abstract This chapter discusses some of the major pollution prevention measures for ocean and coastal environments. Catastrophic events, particularly offshore oil spills, have influenced environmental protection of both oceans and coasts in many ways. Ocean pollution results both from such major events and from routine activities, both on land and at sea. Two types of marine pollution are discussed at length as examples: oil pollution from ships and litter. Programs and regulations aimed at prevention addressing these and other sources of pollution are continually developing – but the challenges are great. Marine pollution is both persistent and widespread and, as such, poses many challenges for planners.

Keywords Command and control • Ecosystem based management • Oil spills • Polluter pays • Precautionary principle • Qualitative descriptors • Regional seas

Guidance for collective action in democratic societies rests on public policies, and planning feeds into and from such policies. Therefore, most planning program curriculums include study and practice in public policy (Weimer and Vining 2011). Among many other topics, public policies address public hazards such as pollution and overexploitation of natural resources. For the environmental planner working on ocean and coastal environments, among the most relevant public policies are those pertaining to the avoidance of, and response to, pollution-causing activities.

There are many types of pollution prevention (PP) mechanisms, with more being developed all the time. One of the challenges in the marine environment is the rate at which pollution threats expand and move from place to place. This is related to the nature of the marine environment, as discussed throughout this book, but also to the sources of the pollution emitted and to enforcement difficulties. Whether marine pollution is the result of an accident, a one-off occurrence or a constant process, reducing and managing its effects is extremely challenging.

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Substances polluting the marine environment are many and varied. They include eutrophication-causing nutrients (such as nitrates and sulfates), plastics (including microplastics), dioxins, polychlorinated biphenyls (PCBs) and numerous other chemical compounds. Although they can be significantly diluted in the ocean water column, many of these substances tend to accumulate in marine organisms, in the benthos and ocean substrate. Pollutants come from numerous activities (such as ocean dumping and spills), from the atmosphere and from water flowing into the ocean as runoff from land. Some polluting substances are transported over hundreds of kilometers by rivers before they enter the seas.

This chapter focuses on pollution problems of the oceans and dedicated solutions. It is well known that attempts to "manage" pollution, like attempts to manage the environment, are difficult, if not impossible. In most cases, rather than managing the pollution itself, planners must manage the pollution-causing activities. Since the role of planners is often a proactive one, they can play a significant role in determining how successful PP mechanisms are.

The next section gives a historical overview of the need for PP in the marine environment. I follow this by a somewhat theoretical discussion of approaches to PP. Because national and local policies, laws and regulation vary from place to place, I describe conventions and treaties existing on an international, national or regional level. Environmental planners should be well aware of such legal mechanisms and policies because they influence planning in many ways.

5.1 A Short History of Influential Events

Pollution prevention policies (both for land and for oceans) were initially promulgated in response to environmental disasters. It is no secret that humans have a hard time acknowledging phenomena that occur as a gradual process over time. This explains the difficulty in making headway in climate change mitigation; climate change is a process whose effects have accumulated at a steady and constant pace over the past decades. The same is true for many types of marine pollution. Until something really catastrophic occurs, little progress is made.

Oil spills are noteworthy among the disasters that engendered subsequent pollution prevention measures (Box 5.1). One of the first, the 1969 Union Oil Blowout, occurred approximately 10 km off the California Coast (near the city of Santa Barbara). Three million gallons of crude oil spewed from the ocean floor, resulting in 57 km of tarred beaches and thousands of seabird, dolphin and seal fatalities. The deleterious accident led to a ban on further production of oil and gas off of the coast of California. It also led to the founding of Get Oil Out (GOO), an advocacy group that works to protect the state's marine environment from oil development and exploitation (http://www.getoilout.org).

Box 5.1: The World's First Catastrophic Oil Spill

In 1967, the Torrey Canyon spill was a wake-up call, as the world's most serious oil spill. It involved an estimated 32 million gallons of crude oil being released into the ocean, causing an oil slick covering 700 km^2 of ocean area. A Liberian-registered tanker chartered by British Petroleum spilled the oil when it struck a rock off of the southwest coast of England. Eighty kilometers of French coastline and 190 km of English coast were contaminated. Around 15,000 seabirds were killed, along with huge numbers of marine organisms. Following the spill, additional damage was caused by the heavy use of so-called detergents to break up the slick.

Source: Southward and Southward (1978)

Since 1969, GOO has been protecting the Santa Barbara Channel[1] and coastline from environmental, economic and aesthetic encroachments by petroleum development. The group advocates for observance of official safety standards and supports offshore lease buy-back programs. While some may decry such environmental NGOs as extreme and over-reactive, they are essential for the balancing of environmental protection with economic development. In fact, within hours of my writing these words (on May 19, 2015), a new oil pipeline break spilled an estimated 105,000 gallons of crude oil several kilometers west of Santa Barbara, California; evidence that such organizations have an important role to play. The broken pipeline, designed to carry about 150,000 barrels of oil and built in 1991, is the only one operating in the waters off Santa Barbara County lacking a shutoff valve that could have averted such a catastrophe. Due to such failures in oversight and compliance, marine life and beachgoers along the shores of California have again had to bear the brunt of our addiction to oil.

Another huge oil-related accident occurred in 1989 when a large tanker, the Exxon Valdez, ran aground in Alaska's Prince William Sound, spilling 42 million liters of Alaskan North Slope crude oil, thus contaminating approximately 2,000 km of pristine shoreline (Peterson et al. 2003). Tens of thousands of seabirds and other marine life were lost. As a result, the use of single-hull tankers were outlawed for transporting oil in North America and Europe – a classic preventive measure. Unfortunately, existing tankers, including the Exxon Valdez itself, ended up being moved to other areas of the world for use in regions with less stringent environmental regulation, such as the Middle East and Asia.

Another disaster occurred 250 km from the Spanish coasts of Galacia in 2002. After being barred entrance to harbors in France, Spain and Portugal, the ruptured

[1] Due to the abundance of oil in the thick sedimentary rock layers beneath it, the Santa Barbara Channel has drawn attention from the petroleum industry for over a hundred years. The world's first offshore oil drilling took place from piers at the Summerland Oil Field in 1896, just 10 km from the 1969 spill site (Wilder 1998).

oil tanker *Prestige* leaked approximately 125 tons of oil a day into the sea over the course of six days. On the seventh day, it broke apart, releasing another 20 million gallons of oil into the sea. This contaminated thousands of kilometers of European beaches, killed marine organisms and, of course, impacted ecologically important habitats. The Galacia fishing industry, so essential to the regional economy, was suspended for six months. The accident led to the slogan: “Never Again” (Nunca Más). Unfortunately, memories fade over time and oil spills, blowouts, transport accidents and polluting activities have continued.

The most recent of the world’s major spills has been the Deepwater Horizon oil rig blowout. From April 20, 2010, over 500 million liters of oil spewed into the Gulf of Mexico over the course of 87 days. The spill’s initial explosion killed 11 company workers (Box 5.2). As discussed in other parts of this book, this spill – named “the BP Spill” after the responsible party, British Petroleum – influenced planning and management of the marine environment on a large scale in that it indirectly lead to the passage of Executive Order 13547 for Stewardship of the Ocean, Our Coasts, and the Great Lakes (see Chap. 6).

Box 5.2: The BP Spill’s Effects Today

At the writing of this chapter, five years have passed since the BP Spill wreaked havoc on environmental conditions in the Gulf of Mexico. Warren Cornwall, a *Science* writer, describes images of some of the spill’s disastrous immediate effects:

> . . .pelicans staring out through a coating of brown goo, a dolphin surfacing in an oil slick, the carcass of an oil-bathed turtle. In the end, 675 kilometers of Louisiana marsh were oiled.

Since the BP Spill, many studies and ongoing monitoring have taken place in the Gulf of Mexico. The concerns are not only ecological. Billions of dollars in environmental fines and the livelihoods of thousands of Gulf Coast families depend on these findings. Among the more salient impacts discovered so far in one of the most hard-hit areas – Barataria Bay, Louisiana – have been:

- the increase of oil-eating bacteria
- the disappearance of acrobat ants (*Crematogater polisa*) from the oiled sites
- fewer nests built by seaside sparrows (*Ammodramus martimus*) with fewer chicks
- the increase in erosion where oil killed plant roots
- negative health impacts to bottlenose dolphins (*tursiops truncates*) compared to Florida dolphins not affected by the spill

(continued)

Box 5.2 (continued)

- genetic evidence of exposure to toxic chemicals on Gulf killifish (*Fundulus grandis*).

Long-term effects are largely unclear, as are effects on a regional scale. In some cases, surprising resilience has been observed, such as among brown pelican populations. Abiotic effects are more obvious than biotic ones. Marsh erosion was a significant threat to the bay even before the spill, but since, channels have been dug which have exposed more of it to erosion and killed off vegetation by altering water flow, thus exacerbating erosion even further.

These results and more will have repercussions in corporate boardrooms and among local and regional business folk, and will impact how spills are responded to in the future.

Source: Cornwall (2015)

To summarize, various spills the world over have led to significant regional and international efforts to curb not only oil pollution, but pollution from other toxins as well. Among the most prominent example of these efforts is the International Maritime Organization's (IMO's) issuance of comprehensive marine pollution prevention rules through the conventions discussed below, such as MARPOL and the 1972 London Protocol on the Dumping of Wastes (see below).

5.2 Pollution Prevention and International Governance

Pollution prevention in the marine and coastal environment is challenging, given the need to make decisions under uncertainty. As mentioned, challenges stem from the complexity of marine ecosystems and limited data about and understanding of the interconnectivity of their components across scales (Jones 2001; Cash et al. 2006), especially across large marine ecosystems.

An entire branch of environmental policy analysis looks at the process of policy diffusion, which examines conditions that favor (or hinder) the spread of policy innovations across scales, usually related to levels of governance. The "diffusion" framework examines the interplay between transnational and international forces, national factors and the characteristics of policy innovations. Policy analysts using this framework indicate that policies have a tendency to converge, i.e., to become similar as new regulations diffuse "out". Common diffusion mechanisms are hierarchical imposition, coercive policy transfer and domination (Tews 2007). Bernstein and Cashore (2012) refer to "areas of influence" leading to diffusion. We see all these phenomena embodied in directives, treaties and conventions, such as those instituted by both the World Bank and the EU (Tews 2007).

Two significant policy approaches that have "diffused" globally, address, among other issues, pollution prevention. Ecosystem-based management (EBM), discussed throughout this book, is an approach that embodies pollution prevention mechanisms; I expand on it in the chapter on marine spatial planning (Chap. 6). More exclusively dealing with pollution prevention, is the precautionary principle. This overarching principle is realized through treaties and conventions that recommend (or require) standards to be met by party countries.

The precautionary principle (and EBM) have been enshrined in European legislation and thus exert influence over member countries. The 1991 Maastricht Treaty on European Union incorporated the precautionary principle as both a legal obligation and a required objective for environmental policy (Article130r). This commitment was further amended by the 2001 Treaty of Nice, as follows: "[European] community policy shall be based on the precautionary principle and on the principle[s] that preventative action should be taken, that environmental damage should as a priority be rectified at [its] source . . .." Europe's more recent Marine Strategy Framework Directive (MSFD) refers directly to this commitment (Preamble, paragraphs 27 and 44). According to the MSFD, countries are also guided towards use of the precautionary principles by the requirement that they define and measure "Good Environmental Status (GES)" (De Santo 2010).

Eleven qualitative descriptors have been defined by the MSFD with the overall goal of achieving what is considered GES by 2020 (Ferreira et al. 2011). The descriptors are: biological diversity; non-indigenous species introduction; populations of exploited fish and shellfish; marine food webs; human-induced eutrophication; seafloor integrity; alteration of hydrographical conditions; concentrations of contaminants; contaminants in fish and other seafood; marine litter; and introduction of energy (e.g., noise). Each descriptor represents an issue that must be tracked.

For example, in order to track human-induced Qualitative Descriptor 5: eutrophication,[2] EU countries must monitor physical and chemical (abiotic) features together with biological (biotic) features. The former includes monitoring inputs of fertilizer and other nitrogen and phosphorous-rich substances (from agriculture, atmospheric deposition, inputs of organic matter – e.g., sewers, mariculture, riverine inputs – and from various other uses). Biotic features are monitored through changes in production and in spatial coverage of bottom flora and fauna (Ferreira et al. 2011).

As another example, Descriptor 8 seeks to ensure that "Concentrations of contaminants are at levels not giving rise to pollution effects". This requires a combined approach of monitoring ambient chemical contaminant levels and the monitoring of biomarkers (Lyons et al. 2010). Contaminant levels refer to

[2] Eutrophication refers to the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to water quality. Undesirable effects resulting from anthropogenic enrichment by nutrients include, for example, a reduction of oxygen levels needed to sustain marine organisms, including fish.

Table 5.1 Some examples of indicators that can be adopted for measuring Quality Descriptors 5 (human-induced eutrophication) and 8 (pollution effects) of the EU's Good Environmental Status

Impact/effect	Indicator	Type of feature	Used by...[a]
Eutrophication	Chlorophyll a	Biological	US EPA
	Macroalgae	Biological	OSPAR
	Phytoplankton indicator species	Biological	OSPAR
	Water clarity/turbidity	Physical-chemical	US EPA
Pollution effects	Impact of tributyltin (TBT) on gastropod molluscs	Biological	NOAA
	Fish Disease Index	Biological	HELCOM
	Polycyclic aromatic hydrocarbons (PAHs)	Chemical monitoring	US EPA

[a]Examples; not an all-inclusive list

chemicals present in the water column and sediments. Biomarkers are "molecular fingerprints", identified by testing the tissues of living organisms.

Besides the EU, many other organizations (at various levels of government) are working to define indicators, characterize their impacts and set standards (see Table 5.1). In some cases, the work of these organizations has resulted in recommendations calling for the best environmental practices (BET) tailored to particular activities, such as for mariculture (OSPAR 1994). Such recommendations are highly useful for planners.

5.3 Implementing Marine Pollution Prevention

Regulation for pollution prevention usually combines guidance and regulatory standards to address overall (ambient) seawater quality, end-of-pipe emission thresholds and dilution requirements. As on land, ocean pollution can be categorized as coming from point sources and non-point sources. A specific, stationary source would fall into the former category. This could be, for example, an outfall pipe, where the byproducts of sewage wastewater treatment are emitted at a significant distance from shore.

Non-point source types of pollution include diffuse emissions from ships, for example, vessel sewage vacated at sea or pollutants emitted by the combustion of fuel. Standards usually address physical and chemical properties of ocean water as well as biological descriptors (as for the GES). Such standards are important not only for ecological reasons. They often determine the ability of humans to use ocean resources; for example, whether an area is safe for recreation (i.e., swimming and boating) and whether seawater is fit for desalination.

Regulatory mechanisms commonly involve the issuance of permits. A permit may impose operational conditions based on an assessment of impacts expected from proposed offshore or upland near-shore construction and/or operations (ongoing activities). Such conditions will aim to reduce pollution and ensure environmental quality (i.e., lower impact). Sometimes pollution prevention regulation takes the form of a “permit to pollute”. In such cases, any dumping or emitting of waste into the sea should be allowed only if the outcome of such action meets precautionary standards.

As for general environmental protection, conditions may be imposed on an operator, development proponent or on the user of marine resources through “command and control”. For this type of regulation, the regulator commands the polluting entity to meet standards in a specific way. This contrasts with the imposition of a general standard that must be met over an area or in a particular media – an “ambient” standard such as that imposed for seawater. A middle-of-the-road regulatory option would consist of imposing one of several best available technologies (BATs), or a BET (mentioned above), to meet an ambient standard.

5.4 Two Non-point Source Marine Pollutants

The sources of pollution, the types, and the ways that they are addressed at the international, national or local level are so numerous that they cannot all be addressed here. Marine pollution is a subject worthy of its own book and, of course, there are such books (see, for example, Weiss 2014). However, it is important to understand in a general way what can be done to promote marine PP and who is doing it. The problem of marine litter and the release of oil and oil-related toxins from ships are discussed in the rest of this chapter as examples. These are two non-point sources, among many, that have significantly impacted the seas, and their influence is growing as activities in the marine and coastal environment increase.

International regulatory measures related to oil spills from ships are largely the result of the history described in Sect. 5.1 (Box 5.1 and Box 5.2). Some of us may have been impacted by oil spills, depending on where we live, work or vacation. Marine litter is a topic that affects us all, whether or not we sail, cruise, plan port facilities or own a yacht. Anyone who has been on a beach has undoubtedly encountered marine litter. Compared to oil pollution from ships, marine litter is barely regulated. As such, it is one of the most pressing problems for environmental planners and managers, perhaps one which has the most to benefit from adequate attention.

5.4.1 Oil and Other Pollutants from Ships: The IMO and MARPOL

As the most efficient means of transportation for about 90 % of global trade, international shipping has huge impacts on the marine environment. The

International Maritime Organization (IMO), originally established in 1948, is the standard-setting authority for the safety, security and environmental performance of international shipping (Chircop 2015). The IMO's main role is to create a level playing field to prevent ship operators from addressing their financial issues by compromising on safety, security and environmental performance.

The IMO administers the 1973 Convention for the Prevention of Pollution from Ships (MARPOL), which entered into force in 1983.[3] MARPOL regulates ship construction and equipment, but its main purpose is to prevent the pollution of the marine environment by minimizing operational and accidental discharges of oil and other harmful substances. MARPOL was amended in 1978 and therefore generally referred to as MARPOL73/78; the convention has had many amendments (with the last one adopted in 2005) and it includes six technical Annexes. Among other regulatory actions, the Annexes designate geographical areas within which strict controls on operational discharges have been established (see Sect. 5.5 below).

Following the Torrey Canyon episode of 1969 (see Box 5.1), the UN gave coastal states special powers to take self-help measures beyond the limits of their territorial sea to respond to polluting events. This developed into a number of international conventions administered by the IMO beyond MARPOL. One is the 1969 Civil Liability Convention, which established that a ship owner is strictly liable for oil pollution damage without any need to prove his or her negligence or fault.[4] It follows the "polluter pays" approach, in which the party responsible for a polluting action is automatically responsible for damage to the environment. Beyond arranging for the provision of clean-up funds, the convention supports PP indirectly by deterring ship owners from operating under conditions that are likely to result in spills.

The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Protocol) is another important IMO-administered convention related to PP. It is perhaps hard to imagine today, but in the past, the dumping of various waste materials into the oceans – from the remnants of municipal solid waste incineration (ash) to radioactive waste – was commonly practiced by industrialized nations.

Also administered by the IMO are two other important conventions – on the Control of Harmful Anti-fouling Systems on Ships of 2001 and on the Control and Management of Ships' Ballast Water and Sediments of 2004. The main aim of the former is to prohibit the use of the organotin compound tributylin (TBT) paint as an anti-fouling agent on the outer hulls of ships (Box 5.3). The latter is an important pollution prevention measure because ships' ballast waters, drawn in one place and released in another, are a major vector for the spread of marine invasive species.

[3] Before a convention comes into force – that is, before it becomes binding upon governments which have ratified it – convention terms must be formally accepted by individual governments.

[4] Exceptions to this rule would be in special circumstances such as war and insurrection.

Box 5.3: The Pollution Consequences of Anti-fouling Paint
By limiting resistance in water, a clean, smooth hull allows a ship to travel faster. If not treated, the rugosity of a ship's hull will increase over time by the growth of fouling organisms, such as barnacles, algae or molluscs. In the 1960s, the chemical industry developed tributylin (TBT), an organotin compound that could be painted onto a ship's hull. By the 1970s, TBT was widely used.

It was soon found that organotin compounds persist in the water and in sediments and kill many types of non-targeted sea life. Among some of the effects of TBT:

- shell deformations in oysters
- sex changes (imposex) in whelks
- immune response, neurotoxic and genetic affects in other marine species

In the 1970s and 1980s, high concentrations of TBT in shellfish on the coast of France caused the collapse of commercial shellfisheries there. This prompted many countries to enforce some restrictions on the use of TBT in anti-fouling paints.

In 1988, the problem was brought to the attention of the Marine Environment Protection Committee of the IMO. A decade later, the IMO adopted a resolution to develop an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling biocides used on ships. In October 2001, the IMO adopted the International Convention on the Control of Harmful Anti-fouling Systems on Ships, aimed at prohibiting the use of harmful organotins in anti-fouling paints and establishing a mechanism to prevent the potential future use of other harmful substances. The Convention went into force in 2008.

Source: Sanitillo et al. (2000)

5.4.2 *Marine Litter*

Marine debris and litter (hereafter "marine litter") is particularly hard to address through regulatory standards because it has so many forms and sources. Its persistence results from a lack of coordinated global and regional strategies and from deficiencies in the implementation of existing programs, regulations and standards at all levels – international, regional and national (UNEP 2009). While there are existing regional protocols and national laws regulating the dumping of trash at sea and on shore, the global nature of marine litter, the inability to confine it within territorial boundaries and the complexity of identifying its sources have made effective laws difficult to draft, and even harder to enforce.

Marine litter is “any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment” (Galgani et al. 2010). It reaches the oceans through deliberate disposal or unintentional discharge, either at sea or from land by way of rivers, drainage systems and wind (UNEP/MAP 2012).

Sea-based sources of marine litter include ship travel (merchant, public transport, naval and research vessels) and fishing activities (from vessels, angling and fish farming), offshore resource extraction (mining and energy products), legal and illegal dumping at sea, and natural disasters that affect offshore structures and vessels. The major land-based sources of marine litter include waste from dumpsites located on the coast or banks of rivers, from rivers and floodwaters, industrial outfalls, discharge from stormwater drains, untreated municipal sewage, littering of beaches and coastal recreation areas, ship-breaking yards and storm-related events (UNEP 2009) (Fig. 5.1).

Damage to people, property and livelihoods caused by marine litter can be grouped into several categories. These include damage to fisheries and fishing boats and gear, damage to cooling-water intakes, blockage of water flow in power stations and desalination plants, contamination of beaches, commercial ports and marinas and contamination of coastal grazing land, which causes injury to livestock. Vessel propeller fouling, blocked engine intake pipes and damaged drive shafts have also been attributed to marine litter. Marine litter-related damage to people includes safety risks at sea, accidents involving SCUBA divers and snorkelers who encounter submerged debris, as well as damage to people’s health (i.e., physical injuries, disease) from litter on beaches and in bathing water, including from medical waste.

A significant amount of marine litter is plastic debris (Fig. 5.2). Overall, plastics have become increasingly dominant in the consumer marketplace since their commercial development in the 1930s and 1940s. Global plastic resin production reached 288 million metric tons (MT) in 2012; a 620 % increase since 1975 (PlasticEurope 2013). Large plastic masses can injure marine organisms by entanglement and ingestion. Further, many plastics are chemically harmful – either because they are themselves potentially toxic or because they absorb other pollutants (Rochman et al. 2013). Less is known about the effects of small, microscopic-sized plastics that find their way into ocean waters. Attention is now turning to the impact of microplastics from such primary sources as feedstock in the plastics industry and from the breakdown of large plastic items (UNEP/MAP 2012).

The three primary conventions most relevant to marine litter are the International Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78), particularly Annex V (which prohibits at-sea disposal of plastics and garbage from ships), the London Protocol and the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (the “Basel Convention”). The disposal of plastics at sea has been banned since 1988, yet despite 134 nations agreeing to eliminate plastics disposal at sea, oceanic sampling suggests that the problem has persisted or worsened since the ban began. In the North Pacific, for example, the concentration of microplastic debris has

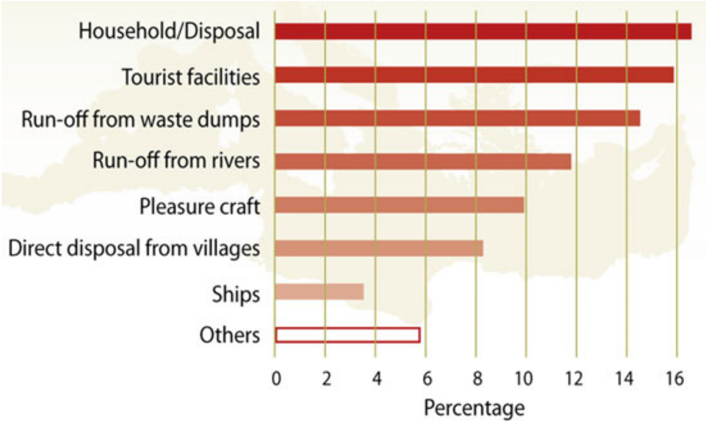

Fig. 5.1 Sources of marine litter in the Mediterranean Sea (Reproduced by permission of source: GRID-Arendal)

Fig. 5.2 Plastic bags and other plastic materials, discarded at sea, float on the surface of the ocean. Sea turtles, and other marine fauna, mistake floating plastic bags for jellyfish and die as a result of swallowing them (Copyright holder Gary Bell/OceanwideImages.com. Reproduced by permission of oceanwideimages.com)

increased by two orders of magnitude (Rochman et al. 2013). The problem is so acute that there are now several "gyres", which are the conglomeration of large amounts of litter, held together by ocean currents (Fig. 5.3).

Beyond international regulations, plans are needed on regional and national levels to address the problem of marine litter. A review of several Regional Seas

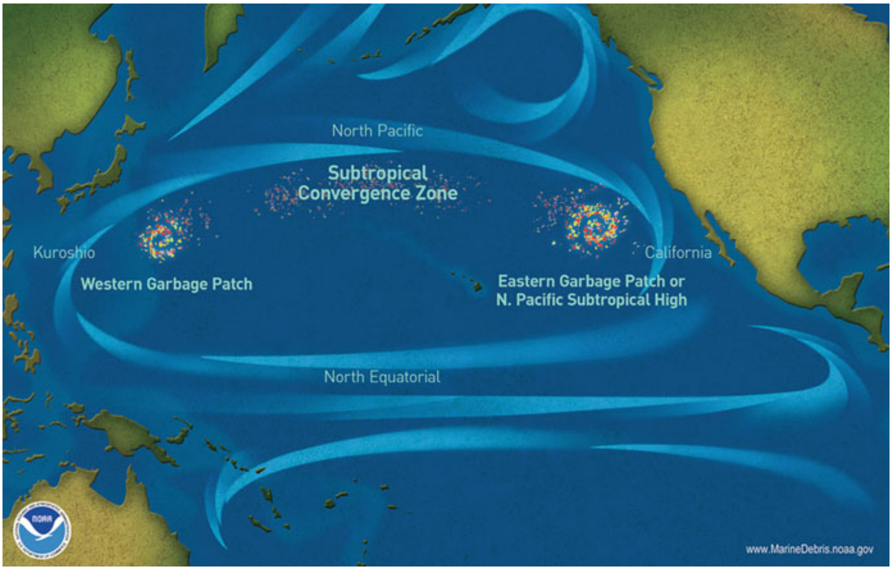

Fig. 5.3 Gyres of marine litter gather due to oceanographic features such as the North Pacific Subtropical High and the Subtropical Convergence Zone in the Pacific Ocean. No one can say for sure how large these areas are, especially since they move and change, sometimes daily (Reproduced with permission of http://marinedebris.noaa.gov/info/patch.html)

Programs[5] tackling marine litter (see UNEP 2009) identifies the following needs: legal instruments and administrative arrangements addressing both land and sea-based sources of waste, information, education and public awareness programs about marine litter, the enlisting of civil society (e.g., the private sector, environmental NGOs, etc.) to tackle the problem, monitoring of marine litter quantities and its distribution, litter removal operations and research activities on a broad range of litter-related issues.

Recent research highlights the need to consider both land and sea activities in tackling the problem of marine litter. It is known that about 80 % of the plastic found in the ocean originates on land. By linking worldwide data on solid waste, population density and economic status, Jambeck et al. (2015) have estimated the mass of land-based plastic waste destined to enter the ocean by 2025. The authors calculate that 275 million MT of plastic waste was generated in 192 coastal countries in 2010, of which 4.8–12.7 million MT entered the ocean.

Experts suggest that solutions to marine litter require the adoption of waste reduction and "downstream" waste management strategies such as expanded recovery systems and extended producer responsibility (Wise et al. 2013) – activities that

[5] This is a UNEP supported program that brings neighboring countries together by region to devise and implement specific actions to protect their shared marine environment. More than 143 countries participate in 13 Regional Seas Programs.

need to take place on land. Such suggestions are perfect opportunities for the implementation of principles of integration (discussed in Chap. 4).

5.5 Place-Based Efforts at Pollution Prevention

A way to achieve a balance between activities that pollute and environmental protection, a balance that has numerous implications for planners, is to add a spatial dimension to policy. This can be done by the designation of areas that are particularly sensitive to pollution. The IMO provides two such place-based mechanisms: Special Areas (SAs) and Particularly Sensitive Sea Areas (PSSAs).

SAs are allocated a higher level of protection with respect to MARPOL 73/78 than other areas of the sea. The designation of an SA is based on its oceanographic and ecological conditions and its level of sea traffic. Examples of SAs are the Red Sea and the Oman area of the Arabian Sea (for a full list, see the IMO website). PSSAs are identified by the IMO for their ecological, socioeconomic or scientific attributes where such attributes are recognized as being vulnerable to damage by international shipping activities. When an area is approved as an SA or PSSA (which depends on how it is declared and why), specific measures can be used to control the maritime activities in that area, such as specific routing measures, strict application of MARPOL discharge and equipment requirements for ships (e.g., the installation of special surveillance and tracking devices).

So far, few PSSAs have been established and many more are needed (Table 5.2), especially in particular areas of the world where ecological resources and environmental conditions have received less attention. Shipping industry organizations wield more influence over decision making by the IMO (responsible for designation and implementation of the SAs and PSSAs) than do environmental constituencies (Chircop 2015), which may be a factor hindering their wider use.

SAs and PSSAs are areas designated for higher standards of PP at the *international* level; however, such areas exist also at the regional and national levels of government. Place-based approaches can also be effective at the local level (e.g., Kelly et al. 2011), although they may require more coordination, cooperation and integration to widen their impact. In any case, such spatial regulatory tools are not exempt from the same problems and challenges of other regulatory programs. Their effectiveness often hinges on the implementing agency's ability to enforce restrictions and prohibitions; always challenging at a broad scale in the ocean environment.

Table 5.2 List of PSSAs adopted by the International Maritime Organization

Name	Country	Year adopted
The Great Barrier Reef	Australia	1990
The Sabana-Camagüey Archipelago	Cuba	1997
Malpelo Island	Columbia	2002
Wadden Sea	Denmark, Germany, The Netherlands	
Area around the Florida Keys	United States	
Paracas National Reserve	Peru	2003
Western European Waters	Europe	2004
Extension of the Great Barrier Reef	Australia, Papua New Guinea	2005
Canary Islands	Spain	2005
The Galapagos Archipelago	Ecuador	2005
The Baltic Sea area	Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden	2005
The Papahānaumokuākea Marine National Monument	United States	2007
The Strait of Bonifacio	France, Italy	2011
The Saba Bank (Northeastern Caribbean area)	Kingdom of the Netherlands	2012

5.6 Summary

A planner's work is inextricably linked to public policy – principled action imposed by governing institutions to protect the public and public interest. Many public policies, as discussed in this chapter, aim to reduce pollution in ocean and coastal environments, making them a cornerstone of environmental planning for oceans and coasts.

As on land, pollution prevention policies focus on reducing inputs to the oceans, or avoiding them altogether, so as to minimize impacts on, or risks to, marine biodiversity, marine ecosystems, human health and legitimate uses of the sea. But despite all good intentions, as long as we depend on the oceans for economic activity and resource extraction, there will be toxins and other anthropogenic substances in the sea, either from accidental events (such as oil spills) or through routine operation (such as vessel maintenance). Numerous regulatory programs, many of them adopted within the past two decades, address marine pollution prevention and thus aim to keep such substances to a minimum.

For example, the EU's MSFD requires member states to implement an EBM approach and the precautionary principle. One way they do this is by putting the necessary measures in place to achieve or maintain "Good Environmental Status" in the marine environment by 2020. Further, the MSFD aims to improve overall coherence and integration of existing EU policies and legislation including, where appropriate, the ongoing work of the Regional Seas Program partnerships (as relevant to European Seas), mentioned in the penultimate section of this chapter.

As with all approaches to environmental planning (and as described in the previous chapter), integration is key – meaning that PP efforts should occur spatially (between landscape units: terrestrial, coastal and marine), temporally (over time) and at all levels of governance (international, regional, national and local). In the interest of being inclusive and broad, this chapter has dealt mostly with international level PP activities and has addressed only two examples of major sources of marine pollution – oil spills and marine litter – but there are many others.

Despite indications that energy production may be moving away from offshore oil and gas and towards more renewable sources (Portman et al. 2009), some oil spills (like that which occurred on May 2015, off of the coast of Santa Barbara, California) come from the transport of oil. Another point highlighted herein is that solutions to marine pollution (especially litter and pollution caused by near-shore activities) must be addressed in the terrestrial environment. Since great amounts of marine pollution originate on land, terrestrial planners and environmental planners working on oceans and coasts need to be equally engaged.

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Chapter 6
Marine Spatial Planning

...marine spatial plans are heterogeneous – there are essential ingredients, but no single recipe for success.

– Collie et al. 2013

Abstract Much literature has been published in the past decade on marine spatial planning (MSP), a fact which speaks to its evolution as an accepted means for managing activities within maritime boundaries. This chapter defines MSP, gives a brief history of its development, articulates some of its major challenges and reviews literature on the topic – in particular, tools for incorporating an ecosystem approach in the planning process. Three MSP case studies are presented from the US, Portugal and Germany. It is clear from these examples that MSP is a necessary approach that is increasingly engaging planning professionals and is, to a large extent, still evolving.

Keywords Compatibility determination • Ecosystem approach • Ecosystem-based management • Ocean zoning • Public and stakeholder participation • Spatial planning • Strategic environmental assessment

Ehler and Douvere's *Marine Spatial Planning: A step-by-step approach toward ecosystem-based management*, published in 2009 by UNESCO's Intergovernmental Oceanographic Commission and its Man and the Biosphere Program, is one of the first major guides to marine spatial planning (MSP). Many other "how to" texts have followed, addressing similar, related processes, including integrated maritime planning (Dickinson et al. 2010), ecosystem-based management for ocean planning (Mengerink et al. 2009) and marine zoning (Agardy 2010).

In some contexts, MSP has been described as planning that is "analogous to" land use planning in terrestrial settings (Turnipseed et al. 2009b). Some authors contend that zoning can be done in the oceans as readily as it can be done on land. But can it? And even if it can be done, does that mean it should be? Are ocean zoning and MSP one and the same? These are all good questions addressed in this chapter.

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For many years, land use planning methods and strategies were not considered appropriate for the sea and therefore, as of today, place-based "sea use" planning has not occurred in the ocean waters of most nations and states. However, this does not imply that all planners need to do to remedy the situation is to implement terrestrial planning measures in marine environments. As mentioned throughout this book, there are significant differences between marine and terrestrial environments, as well as between those and the coastal strip, where sea meets land, and areas that are farther out to sea.

Ehler and Douvere's (2009) handbook, perhaps the most influential document on MSP to date, opens with the following paragraph:

> MSP offers countries an operational framework to maintain the value of their marine biodiversity while at the same time allowing sustainable use of the economic potential of their oceans. Essentially, MSP is an approach that can make key components of ecosystem-based management of marine areas a reality.

Yet, can we, in fact, rely on MSP to do all of this? The best answer to this question is: it depends. Despite the tendency by some marine policy experts to tout MSP as the road to marine ecosystem health and protection for the well-being of all, many fundamental challenges remain. Perhaps the fact that marine planning has *not yet* been implemented for sea areas around the world means that planners have a chance to do a better job than they've done on land to achieve goals of sustainability and long-term ecosystem health, and to truly achieve ecosystem-based management.

From among the many questions upon which the outcomes of MSP depend are challenging issues for environmental planners, such as:

– How can we guarantee that MSP will be ecosystem-based?
– How can MSP ensure sustainable use?
– Will MSP always include public participation? Should it?

The rest of this chapter defines MSP, gives a brief history of its development and articulates a few of its major challenges, particularly those surrounding ecosystem-based marine planning. The penultimate section describes exemplary MSP efforts as case studies of various scales, from the subnational to the international. The chapter also briefly mentions how decision support tools, ICZM and zoning can be incorporated or addressed to improve MSP.

6.1 MSP Defined

In the past decade, there has been a virtual explosion of academic articles on the topic of MSP. The results of a simple search for the term "marine spatial planning" in the journal *Marine Policy* shows no publications on the subject in the year 2004, one publication in 2006 (Doherty and Butler 2006) and 22 articles on MSP in the year 2013 alone. But what exactly is MSP and what is the set of actions that, taken together, make up a marine spatial planning process or initiative?

A common description of MSP defines it as a process that aims to rationally organize the use of marine space and the interactions among its uses. However, varying definitions abound (Box 6.1). Generally, MSP seeks to balance competing demands for development, the need to protect the marine environment and the achievement of social and economic objectives.

Even though the history of comprehensive and formalized MSP is relatively short (as discussed in the next section), many believe it has the potential to greatly improve management, reduce the loss of ecosystem services, help address or avoid conflict and create economies of scale and efficiencies for enforcement and management (Ehler and Douvere 2009). Therefore, understanding the evolution and best practices of MSP is crucial for planners working on oceans and coasts.

Box 6.1: Some Definitions of Marine Spatial Planning (MSP)

MSP is a comprehensive, ecosystem-based process through which compatible human uses are objectively and transparently allocated, both spatially and temporally, to appropriate ocean areas to sustain critical ecological, economic, and cultural services for future generations. As an adaptive process, MSP requires the participation and input of stakeholders throughout a plan's development, implementation, monitoring, and evaluation (Eastern Research Group Inc 2010).

MSP is a framework which provides a means for improving decision making, as it relates to the use of marine resources and space. . .All MSP exercises are spatial (place-based) management processes no matter at what scale and in what social context or biome they are being practiced. MSP is also temporal, utilizing forecasting methods and fully taking into account seasonal dimensions (Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF 2012).

MSP is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process (Ehler and Douvere 2009).

MSP is a strategic, proactive means of regulating, managing and protecting the marine environment, which identifies existing and potential future demands on ocean resources, both human and non-human, and attempts to balance these demands, and their effects, in a sustainable manner by designating preferred uses in specific geographic areas (Mengerink et al. 2009).

Maritime spatial planning is about planning when and where human activities take place at sea – to ensure that they are as efficient and sustainable as possible. It involves stakeholders in a transparent way in the planning of maritime activities (European Commission 2014).

Marine spatial planning, maritime spatial planning, coastal and marine spatial planning, integrated ocean management, and systematic conservation and marine use planning all denote similar decision-making approaches that use scientific and geospatial information to address conflicts and organize human activities in the ocean, while maintaining ecosystem health, function, and services (Coleman et al. 2011).

6.2 A Brief History

Some marine policy experts consider the origins of MSP to be rooted in zoning, applied over 30 years ago as a management approach for nature conservation within the Great Barrier Reef Marine Park (Ehler and Douvere 2009). However, the general idea of zoning does not necessarily imply nature conservation or protection of the marine environment (Courtney and Wiggin 2002). Further, the “zoning” analogy can be misguided; firstly, because zoning is only one possible outcome of a marine spatial planning process, and secondly, considering the origins of terrestrial zoning.

While it is true that zoning has been applied to biosphere reserves, parklands, fisheries (Bohnsack 1996) and to terrestrial biosphere reserve planning (Kenchington and Agardy 1990), historically, zoning is a tool of town planning (Fischel 2004).[1] In a publication focused on the use of ocean zoning, Courtney and Wiggin (2002) point out that terrestrial zoning aims to regulate uses of private property. By and large, the ocean and its treasures are public goods, so that taking zoning from its land use applications directly to the sea may require significant adjustment.

Nevertheless, whether resulting in zoning schemes or not, there are so many ongoing MSP initiatives that not all of them could possibly be described in this chapter. Some of them are local (sub-federal state) initiatives, such as those of the German *lander* Mecklenburg-Vorpommern and the US Commonwealth of Massachusetts (see below). Many are national efforts either to plan the territorial sea or a country’s exclusive economic zone (EEZ). Others are regional efforts, such as the Baltic Sea Action Plan, which requires multiple governments to work together. Legislation that has catalyzed MSP efforts includes: the EU’s Marine Strategy Framework Directive of 2008, the UK’s Marine and Coastal Access Act of 2009, President Obama’s Executive Order 13547 (US) and, most recently, EU Directive 2014/89/EU establishing a framework for MSP.

6.3 Step-by-Step MSP

In general, MSP, like most generic planning processes, aims to answer four fundamental questions: Where are we today? Where do we want to be? How do we get there? And what have we accomplished so far?

To answer these four questions, we need to understand existing baseline conditions. This usually involves significant data collection efforts. Once we have baseline information, we can form some idea of where we want to be in relation

[1] The original purpose of zoning was to protect homeowners in residential areas from devaluation by undesirable industrial and apartment uses. Zoning came into wide use around the years 1910–1920 (Fischel 2004).

to what exists. A management plan or implementation plan advises on how to get from where we are today to where we want to be; in other words, how to create the desired conditions. Finally, we want to conduct monitoring and evaluation, which is also part of the planning process, to give us an idea of how successful we have been. Such a view of planning, whether terrestrial or marine, has much in common with approaches from other professional fields that follow similar paths. One example is policy analysis, defined as a process that yields advice (Weimer and Vining 2011). For MSP, advice comes in the form of a plan.

Ehler and Douvere's (2009) *Step-by-Step Guide to MSP* describes the following ten steps:

1. Identify need and establish authority for planning in the marine environment
2. Obtain financial support for the marine planning process
3. Organize the process through pre-planning
4. Organize stakeholder participation
5. Define and analyze existing conditions
6. Define and analyze future conditions
7. Prepare and approve the spatial management plan
8. Implement and enforce the spatial management plan
9. Monitor and evaluate plan performance
10. Adapt the marine spatial management process

Most of these steps are straightforward, but some are complex and require further explanation. Organizing the process involves forming a team and developing a workplan, defining principles, goals and objectives and defining the spatial and temporal boundaries of the plan. The latter "sub-step" refers to how long it may take to complete the plan and also refers to the planning horizon (i.e., the time period for which the actions proposed are expected to be valid). Defining and analyzing future conditions involves mapping future demands for ocean space, some of which are known absolutely, while others may be estimated or forecasted. The weighing of alternative scenarios can also be part of analyzing future conditions.

Two important points should be made in reference to these steps. First, moving step by step in the process will most likely not be linear. Feedback loops should be built into an iterative process. As always, when the public, private entities and numerous stakeholders are involved, planners leading the process will likely modify it as work progresses. New information often becomes available, rendering assumptions about existing conditions and forecasts obsolete or inaccurate. Second, not every MSP process will follow these steps. Many MSP processes have occurred (and will occur in the future) which approach the process differently, using some steps but not all, or using variations of the steps (Collie et al. 2013).

All planning processes – terrestrial, marine and coastal – could benefit from following such a step-by-step process. One advantage of approaching MSP using all of these ten steps is that they are comprehensive. This is particularly important in the marine environment, where aspects of planning that may be taken for granted in the terrestrial environment require special attention. One such aspect is information gathering (on existing conditions or for the purposes of forecasting); information about the marine environment is often lacking or very hard to come by (see Chap. 3).

Another particularly challenging aspect of MSP is initiating and maintaining public and stakeholder participation (Step 4). On the one hand, most resources of the sea are public goods, belonging to all (see Chap. 1). In many near-shore, submerged areas, the public trust doctrine[2] has been adopted and some experts on marine policy contend that it should be adopted for even more areas (Turnipseed et al. 2009a). Yet much of the public is unaware of what goes on in the marine environment and remains apathetic regarding its future (Potts et al. 2011; Smith and Brennan 2012).

6.4 Ecosystem-Based Management and MSP

Many MSP efforts adopt ecosystem-based management (EBM) or the "ecosystem approach" as the basis for moving forward. This is both helpful and challenging. EBM seeks to protect and enhance the marine environment by balancing ecological, economic and social goals and objectives towards sustainable development. This means that it has the potential to improve the quality of marine and coastal environments. Yet, in a practical sense, this is unclear and in many cases confusing, especially for planners.

In 2005, COMPASS[3] published a statement on EBM:

> Ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. [Its] goal is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.

There is nothing particularly marine-oriented about EBM. Since MSP is a relatively new type of planning and since most marine ecosystems are threatened, an EBM approach is called for. In fact, most MSP initiatives adopt EBM and make it a focus of the plans produced, or at least a major principle (Mengerink et al. 2009; Collie et al. 2013; European Parliament 2014; Olsen et al. 2014). The UNESCO guide (Ehler and Douvere 2009) directs MSP towards the EBM approach and emphasizes that both MSP and EBM are mutually beneficial place-based measures.

Among the common tools for achieving EBM are ecosystem services assessments and marine protected areas (discussed in detail in Chaps. 7 and

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[2] See Chap. 1 for an explanation of this term.

[3] COMPASS: a team of science-based communication professionals; see http://www.compassonline.org and McLeod et al. 2005.

8 respectively). Another helpful tool is environmental impact assessment (EIA), including strategic environmental assessment (SEA). EIA is the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals, prior to the making of major decisions and commitments. SEA is much broader than EIA. The latter is usually applied to detailed site-specific planning. For plans and programs of the EU, SEA is a legally enforced assessment procedure required by Directive 2001/42/EC, known as the SEA Directive. An underlying goal of the proposed MSP process should be to seek and identify opportunities to use these tools (and others) to incorporate EBM, and thus to enhance ecosystem health and well-being.

Marine protected areas (MPAs) have served as demonstration sites for testing the integration of ocean space uses with ecosystem needs in mind and, as such, they are important tools for advancing EBM. Ban et al. (2012) and others have suggested that the planning processes for MPA networks and for MSP differ only in scale and scope. Regardless of similarities between protected area network planning and MSP, the contribution of MPAs within marine plans to EBM is undoubtedly significant.

Protected areas of various types (for example, no-take reserves or those that allow conditional extraction of resources) often serve as the foundation for the development of spatially explicit zones designed to safeguard what is most ecologically important, vulnerable (sensitive) or biologically diverse. Where MSP entails developing a "blueprint" for instituting various use zones, MPAs can contribute by specifically indicating areas of increased conservation and protection (e.g., for marine wildlife or for environmental quality). Clearly, however, MSP is not a substitute for MPAs, but rather a broad framework that can use and systematically extend or amend protected area management to go far beyond what even well-planned and well-managed MPAs can achieve by themselves.

Many decision support tools are available to help planners incorporate principles of EBM in MSP processes (Coleman et al. 2011). Some of these tools are explained and accessible, many as downloadable software applications via the Ecosystem-Based Management Tools Network (http://www.ebmtoolsdatabase.org/). This is a loose international consortium of tool developers, users, NGOs, government agencies and research institutes that administers a repository of tools suitable to aid in decision making about the planning and management of marine and coastal environments.

Decision support tools for EBM are available in two primary formats: either as stand-alone models or as individual components in integrated packages (or "toolkits"). Some of these are discussed in Chap. 10. The important point is that EBM is an accepted approach to MSP, which focuses on environmental quality and protection, and it is often the planners' job to infuse best practices related to EBM throughout the planning process.

6.5 Case Studies

MSP has been used at various scales, in various forms, through various processes and to achieve various ends; perhaps most importantly, it has been used to achieve broad socioeconomic and environmental goals (Box 6.2). The diversity of ways in which MSP has been put into practice creates challenges for deriving lessons learned. Nonetheless, there are features common to successful MSP and by reviewing past and ongoing MSP efforts, we gain insights into its constraints, impediments and supports.

Box 6.2: Common Elements of MSP

- Participation of stakeholders in various stages of the planning process, including development, implementation, monitoring, adaptive management, etc.
- Contains spatially explicit objectives
- Incorporates EBM
- Has objectives mandated by government legislation or international conventions, or identified as part of a planning process
- Collaboration between neighboring and regional countries
- Addresses one or more of the three pillars of sustainability: environmental/ecological, economic and social/cultural
- Plans are comprehensive and relate to the land-sea interface as well as to the marine area
- Plans are multidisciplinary and integrative; they address multiple marine and coastal resources and use sectors

The following section provides a short synopsis of marine planning efforts in the US (with a special focus of the Massachusetts Ocean Management Plan), Portugal and Germany. The German example addresses the country's national plan, as well as its involvement working with a number of countries to develop a common spatial vision. A good source of further information on marine spatial plans from around the world can be found at UNESCO's Marine Spatial Planning Initiative site: http://www.unesco-ioc-marinesp.be/.

6.5.1 The United States

In July of 2010, President Obama issued Executive Order 13547 (hereafter Order 13457) for Stewardship of the Ocean, Our Coasts, and the Great Lakes. Issued while the US government struggled to respond to the worst offshore oil spill in US history thus far – British Petroleum's Deepwater Horizon well blowout in the Gulf of Mexico (further described in Chap. 5). This accident, which led to the release of nearly five million barrels of oil into the ocean water column, caused the US government to review policies related to environmental safety and other measures commonly employed by companies permitted to exploit vast subsea resources. What happened during and in the months following the blowout (which lasted from April to September 2010) also highlighted the need for greater coordination between state and federal governments and for improved contingency plans.

Order 13457 established the first ever US National Ocean Policy, which in turn created the US National Ocean Council (NOC), consisting of 27 federal agencies, departments and offices. It also subdivided the US oceans and Great Lakes areas into nine regions. Each of these can form a Regional Planning Body (RPB) on a voluntary basis to develop a coastal and marine spatial plan for its respective region (Olsen et al. 2014).

The NOC published an Implementation Plan in 2013, which gives guidance to the administration and partner institutions on how the Ocean Policy should be implemented (Anon 2013; National Ocean Council 2013), and how to include marine planning. However, since its inception, this idea has become highly politicized,[4] to the point that the US Congress has refused to fund any MSP-related activities. Federal support for integrated national ocean policy has fallen short of what was anticipated in 2010 (Olsen et al. 2014).

Despite wavering federal support, several US sub-federal states – Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut – together formed the Northeastern Regional Planning Body, as envisioned by the US National Ocean Policy; it constituted and established itself, meets regularly and is currently developing a regional ocean plan. The Mid-Atlantic and Southeast Atlantic have also formed RPBs. These RPBs are expected to produce regional MSPs in 2015 for review and approval by the NOC (Olsen et al. 2014).

MSP efforts in the US are most advanced at the sub-federal (state) level and have, from the start (in the mid-2000s), been largely driven by interests in developing marine renewable energy facilities (Eastern Research Group Inc. 2010). It is advantageous for such facilities to be located relatively close to shore, near centers of energy consumption, so most facilities are proposed in state territorial waters. Such was the case in Massachusetts, the site of great controversy over construction of America's first large-scale offshore wind farm on Nantucket Shoal off Cape Cod (Kimmell and Stalenhoef 2011).

To address this controversy, the Governor of the Commonwealth of Massachusetts signed the state's Oceans Act on May 28, 2008, requiring the Secretary of Energy and Environmental Affairs (EEA) to develop a comprehensive ocean management plan, with a draft plan by June 30, 2009, and a final plan by the close of 2009. To advise the process, a 17-member commission was constituted,

[4] Many members of the US House of Representatives see marine planning as an unnecessary layer of government, hampering the development of business activities at sea. Also, industrial (oil, fishermen, etc.) lobby groups (e.g., the National Ocean Policy Coalition, see http://oceanpolicy.com) have advocated against MSP.

USES/RESOURCES	COMPATABILITY MATRIX		Renewable Energy			Mining	Navigation			Commercial Fishing			
			Wind	Tidal	Wave	Sand & Gravel	Shipping	Anchoring	Ferry outlets	Trawling	Gilnets	Hook/ lines	Shellfish
U S E S / R E S O U R C E S	Renewable Energy	Wind								P	P		
		Tidal								P	P		
		Wave				T				P	P		
	Mining	Sand & Gravel			T		T						
	Navigation	Shipping				T							
		Anchoring											
		Ferry outlets											
	Commercial Fishing	Trawling	P	P	P								
		Gilnets	P	P	P								
		Hook/lines											
		Shellfish											

Key			
	Compatible	T	Temporal considerations make determination
	Functionally incompatible	P	Relevant planinng policy will make determination
	Conditionally incompatible		

Fig. 6.1 An example of a partial compatibility determination like that used for the Massachusetts Ocean Management Plan (UMass Boston Planning Frameworks Team and Partnership 2009. From a publicly available report)

which included state legislators, agency heads, and representatives from fishing and environmental organizations, coastal regional planning agencies, as well as from the offshore energy industry. EEA also received assistance from a council of nine scientists with expertise in marine sciences and data management.

Perhaps most impressive about this MSP process was: (a) its adherence to a schedule of expedited plan development (approximately one year); (b) a heavy emphasis on public participation; and (c) the effective use of innovative tools and methods, such as a compatibility determination matrix (Fig. 6.1). Unfortunately, despite original intentions, the commercial fishing lobby was strong enough to extract itself from subjection to plan guidance and therefore the fishing sector is not regulated by the plan. Besides fishing, the Massachusetts' Ocean Plan indicates site preferences and performance standards for all sectoral marine uses, including renewable energy facilities, aquaculture, sand mining (for beach nourishment), undersea cables, pipelines and more (Fig. 6.2). Also, the plan has a five-year mandatory update requirement. In January 2015, EEA published the first formal amendment of the 2009 Ocean Plan.

6.5.2 *Portugal*

Portugal's sea area has special significance, both historically, due to Portuguese connections to the sea, and due to its size. Its EEZ, including the maritime areas of the mainland and of the archipelagos of Madeira and the Azores, encompasses over 1,727,400 km^2. This compares with the country's relatively small continental area of approximately 327,670 km^2 (Ferreira et al. 2014).

The area covered by the EEZ is the third largest in size in Europe after France and the UK, and the largest if one considers only the maritime area of continental

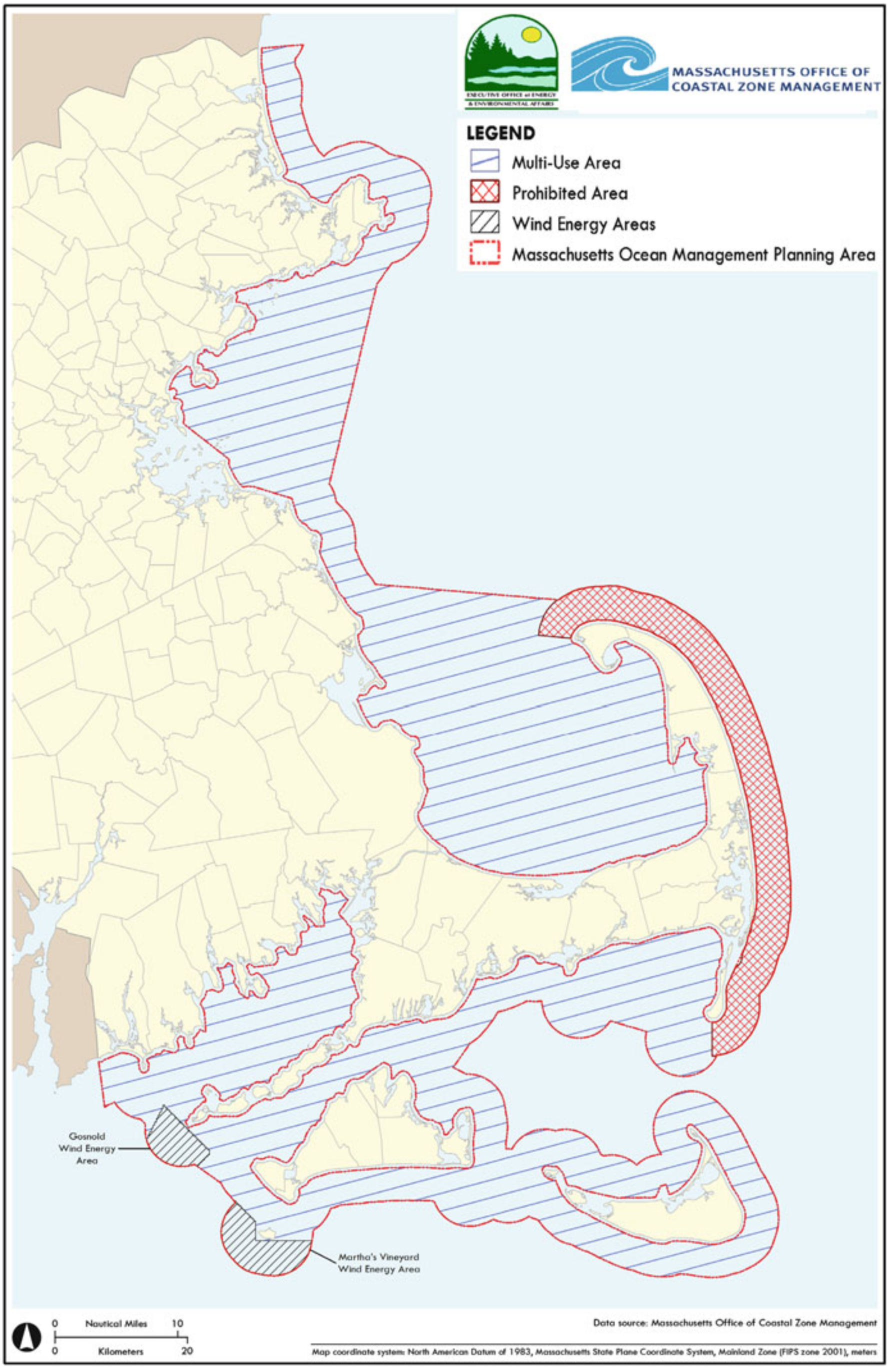

Fig. 6.2 Management areas designated in the 2015 update of the Massachusetts Ocean Management Plan (From a publicly available report, Commonwealth of Massachusetts 2015, p 132)

Europe, excluding overseas territories. In May 2009, Portugal submitted a claim to the UN Commission on the Limits of the Continental Shelf to extend its jurisdiction over an additional 2.15 million km^2 of the adjacent continental shelf. If approved, this claim would result in Portuguese jurisdiction covering a marine area greater than 3.8 million km^2 (Portuguese Government 2009).

Portugal initiated a national marine plan according to the nation's first National Ocean Strategy 2006–2016 (NOS2006-2016), which wisely recognized the need to exploit maritime space while valuing marine habitats and biodiversity. The NOS2006-2016 was the outcome of Ministers' Resolution No. 163/2006 (Estrutura de Missão para os Assuntos do Mar, or EMAM). EMAM also articulated the national government's intention for the NOS to be achieved through two instruments: the National Strategy for Integrated Management of Coastal Zones (ENGIZC) and a plan of the maritime area. The ENGIZC was approved in 2009. The Portuguese marine spatial plan, called the Plano de Ordenamento do Espaço Marítimo (POEM), was developed between 2008 and 2010, followed by a three-month public consultation period.

Important drivers of the POEM were natural and cultural amenities protection, development of marine renewable energy, interest in reforming fisheries management and port development. Its overall goals were economic development, nature preservation and the advancement of Portugal as an important maritime country (VLex Portugal 2006). POEM development was led by a multidisciplinary team consisting of representatives from various government ministries and agencies, particularly the Portuguese Water Institute, and four external consultants, including university representatives (Calado et al. 2010).

POEM addressed the maritime area of mainland Portugal without the significant areas around the offshore islands. It involved a baseline study and analysis followed by scenario development, which led to a preliminary plan proposal in 2010 (Vasconcelos 2009; Borges 2010). The plan attempted to balance development and environmental protection, to achieve coherence between land and marine planning strategies, and to employ legally binding zoning. By some accounts, the plan was unsuccessful. A 2012 government ruling considered POEM's final version "an unprecedented study. . .critical for the future planning and management" of the national maritime space, but did not give POEM the status of a maritime spatial planning and management instrument (Frazão Santos et al. 2014).

During its development, the two most significant challenges for the POEM effort were access to good-quality data and the lack of an effective public discussion and input to the plan (Calado et al. 2010). The POEM team developed a website as a platform to encourage stakeholder input and efficient communication between the POEM planning team and the public, but Calado et al. (2010) describe the mandatory public discussion as "tokenistic". The public comment process took place over a short period of one year, despite the complexity of the plan (Borges 2010). Moreover, gathering information from marine sectors, agencies and research entities was difficult because of barriers to coordination, including varied data formats, the need to counter vested interests and barriers to sharing (Calado et al. 2010) (Fig. 6.3).

Fig. 6.3 Map showing the existing (*top*) and potential (*bottom*) "situations" for the EEZ area off the Portuguese continent used for POEM development (Source: Direção-Geral de Politica do Mar 2012)

In February 2014, a revised National Ocean Strategy was published (NOS2013-2020), adopting the EU's Blue Growth Development model. In April 2014, a national law establishing the foundation for marine spatial planning and management of the national maritime space (the MSPM Law) was published. A decree proposal detailing aspects of the MSPM Law is, at the time of this writing, pending approval. The proposal stipulates that after its approval, Portugal has six months to develop a maritime spatial plan (*O Plano Situação* or Situation Plan) for its entire maritime space, and that as long as such a plan is not available, the POEM will be referenced (Ferreira et al. 2015).

The Portuguese case shows that MSP can take place in fits and starts. It is very dependent on the authority it is allotted through government channels. Over time, both the area to be addressed through an MSP process and the base laws giving authority for Portugal's MSP have changed.

6.5.3 Germany

Germany developed a plan focused on the economic opportunities of the German EEZ, with special attention to the management of the conflicting demands of new technologies, tourism and nature protection. The planning process draws its authority from the Federal Spatial Planning Act of 1997 and its 2004 amendments (*Raumordnungsgesetz* or ROG), which together establish the need for spatial planning of the North and Baltic Seas' EEZs.

Both federal plans for the North Sea (covering approximately 28,600 km^2) and for the Baltic Sea (covering approximately 4,500 km^2) went into effect in 2009. Germany uses three types of zones for the implementation of its marine plans. These include "priority areas", where one use (e.g., shipping, pipelines, etc.) is granted priority over all other spatially significant uses, and "reservation areas", where one use is given special consideration in a comparative evaluation with other spatially significant planning tasks, measures and projects. "Marine protected areas" may be prescribed, applying strict measures to reduce impacts (e.g., pollution) on the marine environment.

As an example, priority areas have been designated for shipping and wind energy development, while other uses are prohibited in such areas unless they are compatible with these priorities. The designation of areas for ship transit lanes takes account of international shipping laws. Reservation areas have been designated for shipping, pipeline and research uses that are considered particularly important compared to other competing uses.

A major driver for German MSP, as in the US, has been the development of marine renewable energy, particularly offshore wind farms (Portman et al. 2009). The planning and construction of offshore wind turbines have continued, even if at a slower pace than originally expected. A related use that has triggered marine planning efforts has been the need for transmission grid development to connect offshore wind turbine arrays to the onshore grid. To facilitate this grid development, a resolution was passed in 2011 to establish an offshore grid plan (Offshore-Netzplan) for each of the EEZs of the North and Baltic Seas. Such plans were approved in 2012 and 2013 respectively.

The process of Offshore-Netzplans development has been criticized on the grounds that it should have been part of the original MSP process, especially since the same public agency (the Budesamt für Seeschifffahrt und Hydrographie) was responsible for both processes and should have foreseen the transmission needs. With the subsequent development of the separate offshore grid plans, the assessment of alternatives and of indirect and cumulative effects of offshore wind development did not take place (Lüdeke et al. 2012).

Over the next few years, amendments to the marine plans of 2009 can be expected; the first proposals are already in development. Besides changes requested by stakeholders, several international regulations that were not in place before must be addressed in the forthcoming amendments. As for Portugal, standards set by EU Directive 2014/89/EC establishing a framework for MSP for member countries will

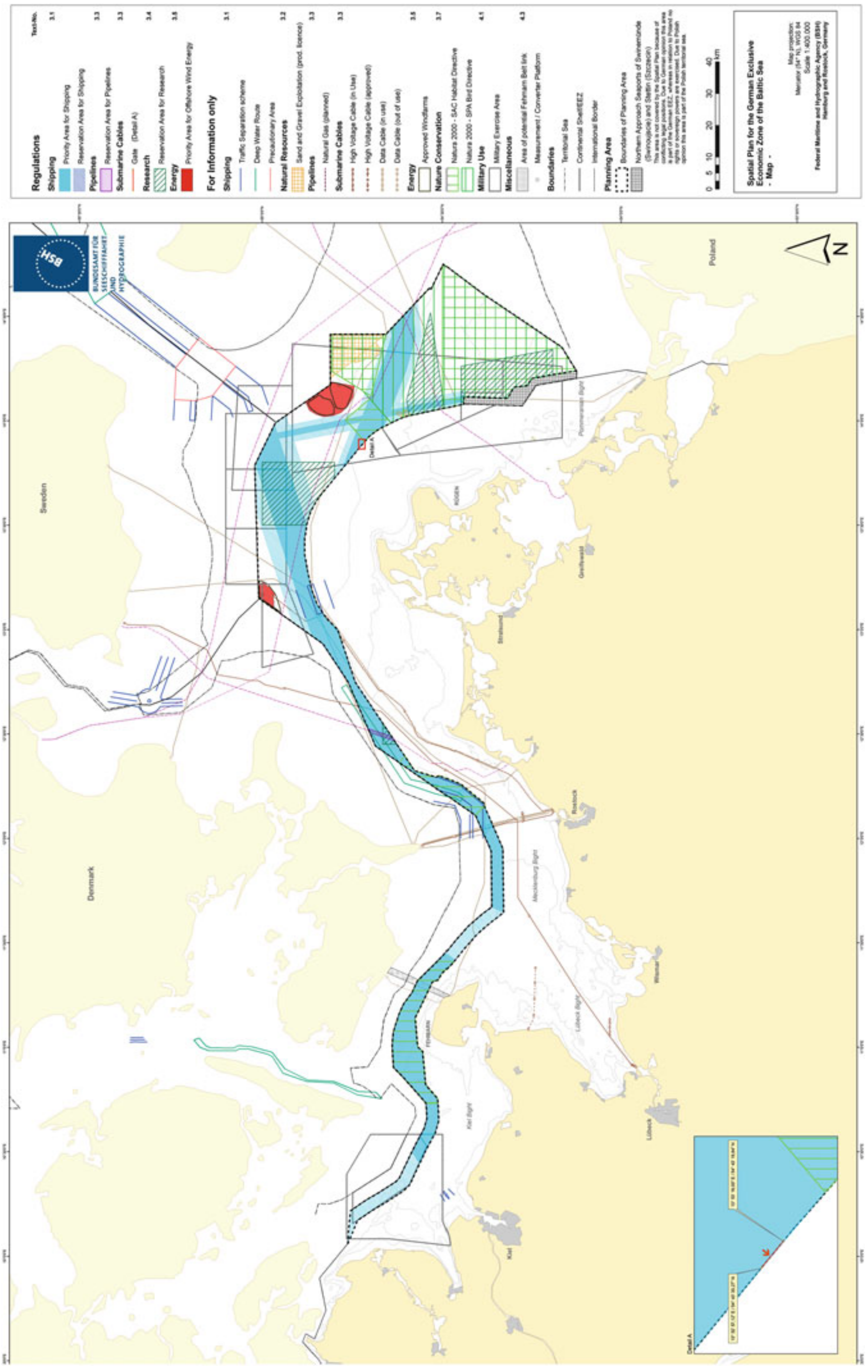

Fig. 6.4 The Baltic Sea Marine Plan of Germany. *Red* areas are those prioritized for offshore wind, *blue* shows priority shipping lanes and the hatching designated areas set aside for research (Reprinted with permission of the Bundesamt für Seeschiffahrt und Hydrographie 2014)

be considered in the new German marine plans. Furthermore, the Marine Strategy Framework Directive (2008/56/EC) requires certain measures in the field of marine environmental policy to be adopted by the close of 2015.

While Germany's EEZ areas are relatively small, especially in the Baltic Sea (Fig. 6.4), MSP processes in the country began early relative to other countries. This has given Germany a chance to get organized towards cross-boundary MSP. It is clear that international cooperation is of the utmost importance for the achievement of MSP goals and objectives.

In its Baltic Sea EEZ, Germany is bound by rules of the Helsinki Commission for the Protection of the Marine Environment of the Baltic Sea (HELCOM). The HELCOM Baltic Sea Action Plan (BSAP) was adopted by all the coastal states (including Germany) in 2007. It aims to restore the good ecological status of the Baltic marine environment by 2021. The BSAP strongly links Baltic marine environmental concerns to important socioeconomic fields, such as agriculture and fisheries, and it promotes cross-sectoral tools including MSP (Backer et al. 2010). Its biodiversity conservation segment goes as far as committing the HELCOM countries to develop a transboundary process of intergovernmental MSP. As such, it is an exemplar for the EBM approach in MSP (Douvere and Ehler 2008), albeit one that has yet to be fully implemented.

Further, the German example is unique in that the country's national government approached MSP by establishing a strong legal basis for it through the ROG. In addition to supporting other aspects of MSP, the ROG outlined a system for the articulation of objectives within the plans themselves.

6.6 Summary

A variety of terms refer to what has commonly come to be called "marine spatial planning": coastal and marine spatial planning, integrated ocean management, marine use planning and integrated marine planning. Different efforts are distinguished from one another by their emphases – sometimes on EBM, sometimes on the importance of space allocation and sometimes on the political process that forms the basis for what is ultimately achieved by planning.

A common definition of MSP (Ehler and Douvere 2009) highlights the public aspect of the planning process. According to this definition, MSP aims to achieve objectives set through a political process, usually distinct from that of the planning itself. Mengerink et al. (2009) define MSP as a "proactive means of regulating, managing and protecting the marine environment in a sustainable manner". This definition emphasizes the health and well-being of the marine environment. The authors of this definition prescribe EBM as the foundation for MSP. EBM is almost always incorporated into MSP processes, so it is hard to envision how MSP would be different if it were not EBM-based.

Some experts (e.g., Ehler and Douvere 2009; De Santo 2011) describe the origins of MSP as dating back to the use of zoning schemes for large marine protected areas, starting with Australia's Great Barrier Marine Park about 30 years ago. Yet land zoning, so fundamental to land use planning, is different than zoning the sea, as discussed. Regardless of its similarity or distinction from land use planning, MSP is a necessary approach, and one that more and more countries are adopting, each in their own way.

MSP is not a substitute for integrated coastal zone management (ICZM) or integrated *marine and coastal* area management, but, rather, builds on these important approaches. MSP is not an end in itself, nor is it a specific policy. It is a critical and timely mechanism for managing uses of the sea and considering possible conflicts before they arise, and it should be a way to achieve an improved marine environment through ecosystem-based management.

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Chapter 7
Ecosystem Services for Oceans and Coasts

Wilderness is not a luxury, but a necessity of the human spirit.

– Edward Abbey

Abstract This chapter introduces the ecosystem services (ES) approach as it pertains to marine and coastal environments. It starts with a description of the approach's development, relates the approach to coastal and marine environments and ends on a somewhat critical note. Despite a great amount of attention to the ES approach in conservation literature and its pivotal position in the field of ecology, it struggles to achieve universal and transdisciplinary appeal. This chapter discusses some of the challenges of using ES in planning decisions and of building consensus around ES, and explores the application of this approach across different land and seascape units. ES assessment still requires much research and practical work; finding ways to incorporate ES values into the work of planners in the marine and coastal environment is perhaps as important as it is challenging.

Keywords Cultural services • Ecosystem services assessment • Production functions • Provisional services • Regulating services • Service-providing units

The term "ecosystem services" (ES) has become common parlance in the environmental field. The ES approach, which refers frequently to the assessment of ecosystem services (ESA), aids in valuing ecosystems so that planners, resource managers and the public can identify both salient and hidden benefits of the environment and make decisions involving trade-offs among benefits. Sometimes benefit values are described monetarily and can be used to develop ecosystem service markets. ESA provides a way to anticipate the effects of impending changes on the environment and, as such, has become a prominent tool applied for spatial planning and land use management (Box 7.1).

Although most work based on the ES approach has focused on assessing terrestrial services, some is beginning to address marine environments as well. Coastal resources have long been excellent candidates for application of the ES

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approach because benefits of great variety can be found along seashores, from simple recreational benefits to more indirect benefits, such as flood and erosion control.

Box 7.1: What Are Ecosystems and Ecosystem Services?
An *ecosystem* is defined as a dynamic complex of plant, animal, and microorganism communities (biotic) and the non-living (abiotic) environment interacting as a functional unit. Ecosystem services are the benefits that people obtain from ecosystems. There are many different methods for assessing these services, i.e., "ecosystem services assessment". Some ecosystem services assessments (ESAs) make a conscious decision to focus on the biotic elements of the environment when surveying and analyzing ecosystem services, whereas others are more general.

7.1 Types of Ecosystem Services

There are four types of ecosystem services. The first type consists of provisional services, which are the easiest to conceptualize. These are the products that nature provides for direct consumption. In the marine environment, there are many examples of provisional services: products of mariculture (Fig. 7.1), fresh water produced through desalination and storage space for the dumping of wastes and wild fish stocks, to name a few. The second type of ES encompasses regulatory services. These provide humans with indirect services such as flood control, climate stabilization and carbon binding, which help counteract global warming by absorbing CO_2.

Cultural services are the third type of ES. They usually consist of non-material benefits. They can be mystical, religious, historical or aesthetic values that we derive from the environment. Along the coast, this could be the value of looking out over the open sea, or conversely, of viewing breathtaking coastal scenery from the sea. The last type, supporting services, are the most difficult to conceptualize; in fact, current debates among experts in the field of ESA, question whether they make up a singular category.

Whether a category unto themselves or not, supporting services make all the other services possible. They include such benefits as nutrient cycling, soil formation and photosynthesis. In terrestrial environments, the pollination services provided by bees are a tangible example of this type of service. In a marine environment, kelp beds that serve as nests for pup-bearing seal cows in cold Arctic waters are a good example (Fig. 7.1). Another example is the growth of phytoplankton. These are photosynthesizing microscopic organisms that inhabit the upper sunlit layer of almost all oceans, and are primary producers of biomass. In short, supporting services don't directly produce products for human consumption or use, but they do provide services, such as food, for other organisms, and,

Fig. 7.1 Examples of two types of ecosystem services: (**a**) Supporting services: coastal kelp beds in Reykjavik, Iceland, and (**b**) Provisional services: mariculture pens in Berufjördur Bay, Iceland (Photos by M. Portman)

Table 7.1 Marine ecosystem service types and examples

Landscape unit	Service category	Service	Example	Location
Coastal	Provisioning	Construction	Sands	Upland
	Regulating	Coastal protection	Mangrove forest	Intertidal
	Cultural	Recreation	Bathing area	Intertidal
	Supporting	Seal habitat	Kelp beds	Intertidal
Marine	Provisioning	Food	Pelagic fisheries	Continental shelf
	Regulating	CO_2 reduction	Carbon fixation	Open ocean
	Cultural	Recreation	Scuba diving	Near shore
	Supporting	Primary production	Phytoplankton	Contiguous zone

ultimately, they supply resources that humans do use, such as whales for whale-watching (tourism), seal blubber or fuel (Table 7.1).

In addition to providing a framework for valuing the benefits of natural systems, the ES approach conveys the extent of threats to ecosystems. Scientists and environmental activists alike have promoted the ES approach with the goal of crafting socially acceptable and effective policy to address ecological threats. Various professionals, such as sociologists, anthropologists, geographers and public policy analysts, have acknowledged ES as a "language" for environmental protection. Many see ES as the last great hope for making biodiversity and environmental conservation a priority for planning and resource management (Daily et al. 2009).

This chapter reviews the historical development of the ES approach, focusing on its relevance to environmental planning for oceans and coasts at different stages of its development. It describes the present state of the art of the ES approach and the impediments to its adoption in mainstream planning praxis. There are a number of challenges that hinder the accessibility of the approach to a wide audience, one that has the potential to include professionals and laymen working within the coastal and ocean planning milieu.

7.2 General Historical Background of ES

References to valuing the benefits of natural ecosystems can be found in early publications from various fields (e.g., King 1966; Ryther 1969). Within the field of ecology, the value of products, functions and structures of ecosystems has been recognized practically since the field materialized. As early as 1948, Rachel Carson[1] alluded to these services when writing about wildlife conservation: "For all the people, the preservation of wildlife and of wildlife habitat means also the preservation of the basic resources of the Earth, which men, as well as animals, must have in order to live. Wildlife, water, forests, grasslands — all are parts of

[1] Rachel Carson (1907–1964) is considered by some to be the founder of the modern environmental movement (see Chap. 2).

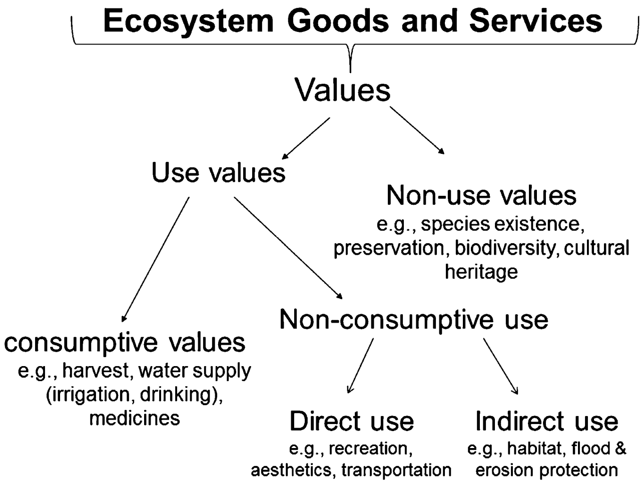

Fig. 7.2 Simplified schematic of use value types (Adapted from NRC 2005)

man's essential environment" (Carson 1948). Today, the ES approach aims to attribute a value (graded or ordinal) to these essential elements.

The ES approach rose to prominence starting in the early 1980s by offering a structured, detailed view of value types that had previously been based mainly on two categories: "use" and "non-use" (Fig. 7.2). The ES approach appeals to policy makers' (and the general public's) desire to put a "price tag" on nature. Philosophically (and from a policy perspective), one could argue that this desire has utilitarian roots in the valuation of products and processes as expressed in the ideas of Jeremy Bentham and John Stuart Mill (Rawls 2005).

In the 1990s, following the publication of seminal articles, particularly *Nature's Services* (Daily 1997) and a cover story in *Nature* (Costanza et al. 1997), ecosystem services became hot news. Stories were featured shortly thereafter in *Newsweek* and in the *New York Times,* on radio talk shows and even in a segment on television's *Nightline* (Salzman 1998). Both neoliberal economics (of the 1990s) and the maturation of the field of conservation planning[2] contributed to this high-profile media coverage.

Following these early developments, groundbreaking work was conducted, including extensive work on particular services, such as crop pollination (e.g., Kremen et al. 2004), water flow and hydropower production (e.g., Guo et al. 2000) and recreation (e.g., Naidoo and Admowicz 2005). A groundbreaking advance on the institutional and social change front came about from the emergence

[2] As the field of conservation planning has matured, the premise that specific regions, areas and landscape types are valued more than others has become widely accepted. This has led to the development of geographic-dependent, place-based, spatial prioritization techniques that make use of biodiversity conservation principles and contribute to work on restoration ecology, complementarity and resilience, as discussed in Chaps. 8 and 10.

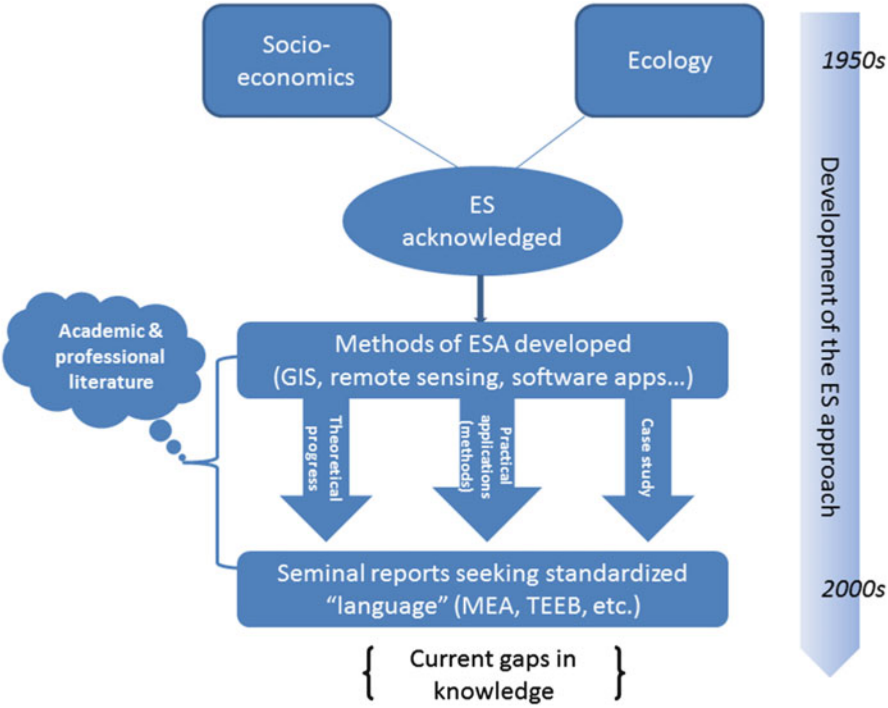

Fig. 7.3 The development of the ES approach in professional and academic literature (Adapted from Portman 2013)

of small-scale systems of payments for ecosystem services in various locales throughout the world (FAO 2004; Achterman and Mauger 2010).

Parallel to some of these advances, a number of seminal reports catapulted the ES approach to prominence in the academic and policy-making communities. The most influential report has been the Millennium Ecosystem Assessment (MEA), carried out during the years 2002–2005 under the auspices of the UN. This general report was followed in 2006 by a synthesis report focused on marine and coastal ecosystems. Entitled *Marine and Coastal Ecosystems and Human Well-being*, the purpose of this report was to supplement the general MEA, whose marine chapter focused largely on the condition and trends of fisheries resources, and neglected other important marine activities such as tourism, mining, shipping, etc. (UNEP 2006) (Fig. 7.3).

Another initiative that has made substantial contributions to the ES approach is the work of The Economics of Ecosystem and Biodiversity (TEEB) group. Supported by the UN (like the MEA), TEEB is a global initiative, focused on drawing attention to the economic benefits of biodiversity. TEEB's first influential document was an interim report on the economic significance of the global loss of biological diversity (TEEB 2008). This work led to progress, such as a standardized classification scheme for ES valuation (mentioned below) being discussed in the context of the System of Environmental-Economic Accounting of the UN Statistical Division (Haines-Young and Potschin 2010).

These institutionalized global efforts have been accompanied by the establishment of the UN Intergovernmental Platform on Biodiversity and Ecosystem Services, in 2010, and the increase in national-scale ES assessments, like those in Great Britain (UK National Ecosystem Assessment 2011) and Japan (Satoyama Satoumi Assessment 2010). The EU has called on its member states to map and assess the state of ecosystems and ecosystem services in their national territory (Action 5 of the EU Biodiversity Strategy to 2020).[3] A new toolkit provides a typology to aid in the assessment and mapping of ecosystems (European Commission 2013). This document proposes the use of the Common International Classification of Ecosystem Services (CICES), developed for environmental accounting purposes – an important step towards a common "language" of ES for practical and professional use.

One of the advantages (if successful) of a system that "measures" value, whether monetarily or otherwise, is widespread understanding. Professional planners can express value in ways that make sense to policy makers who wish to satisfy (and serve) their constituencies. However, despite significant advances in methods of ES valuation, policy leaders have been slow to incorporate the ES approach into decision making (Chan et al. 2006; Daily et al. 2009). The approach faces many challenges to its incorporation into existing regulatory institutions and planning (Ruhl 2010; van der Horst 2011; Portman 2013). This has numerous implications for planning in marine and coastal environments, which pose special opportunities and challenges for the incorporation of the ES approach.

Despite the challenges, in a recent review, Lester et al. (2010) describe ES as a critical research area for advancing a transition to ecosystem-based management (EBM), a widely accepted principle of marine planning (see Chap. 6). The goal of EBM is to maintain ecosystems in a healthy, productive and resilient condition so that they can provide the *services* humans want and need (McLeod et al. 2005), and thus it fits well with the ES approach.

7.3 ES for the Marine and Coastal Environment

Early on, Costanza et al. (1997) estimated the worth of ES to be, on average, about $33 trillion a year (at that time). Subsequent work estimated the contribution of ocean services at $21 trillion, with 60 % of this coming from coastal and shelf systems and the other 40 % from the open ocean (Costanza 1999). Despite estimates

[3] Action 5 of the Biodiversity Strategy requires member states to map and assess the state of ecosystems and their services in their national territory by 2014, and to promote the integration of those values into accounting and reporting systems at national levels and at the EU level by 2020 (European Commission 2013).

valuing marine ES as greater than those of terrestrial-based ES, studies on marine ES have lagged behind those focusing on terrestrial services (Cognetti and Maltagliati 2010). This parallels the lag in attention to marine biodiversity compared to terrestrial biodiversity both in practical terms (Norse and Crowder 2005) and in the literature (Roach 2003).

Despite the attention drawn by Costanza's work and the desire to include marine and coastal ES in assessments, attention to valuing these ES was a late addition to the MEA of 2005, and they have been subject to a situation of "catch up" and "fit in" ever since. There are clearly many ways in which the oceans and their ecosystems contribute to societal well-being, even if consensus on how to assess these services evades us. What follows is a short description of ES of the coasts and oceans, organized using the widely-adopted categories of provisional, regulating, cultural and supporting services.

7.3.1 Provisional Services

Most of the fish we eat come from oceans, although the quantity of fish consumed from terrestrial aquacultural enterprises (inland fish ponds) is rising steadily. In 2011, 154 million tons of fish were removed from the world's oceans – 4 % more than in 2010 – and about 85 % of this amount was destined for direct human consumption (FAO 2012). Much of the remainder is slated for livestock feed and even fertilizer – not a wise use of the oceans' resources, but a common one.

The oceans are also the means through which much of the world's production is exported and imported. For example, 90 % (in volume) of the EU's freight exchanges with the rest of the world are seaborne and more than 90 % of global trade is conducted via sea transport (UNCTAD 2012). In contrast to terrestrial infrastructures, which have a market price through road and rail building, seaborne transportation costs do not directly reflect the value of the natural infrastructure derived from the oceans' airspace and water column.

The oceans provide other direct material goods essential to global, regional and national economies and well-being: oil and natural gas, minerals, pharmaceuticals, tides and offshore winds for marine renewable energy sources, to name just a few. Offshore wind energy (Fig. 7.4), for example, is expected to constitute 26 % of the installed wind energy capacity in the EU by 2020 (European Commission 2009).

7.3.2 Regulating Services

The oceans play a role in regulating ecological, physical and chemical processes upon which life and human well-being depend. They regulate atmospheric gases and climate; they are essential for water, nutrient and waste recycling. Together

Fig. 7.4 An offshore wind turbine prototype in Bremen, Germany with a 5 MW nacelle of the type installed in the North Sea (Photo by M. Portman)

with the life forms they support, oceans process dangerous pollutants produced on land, albeit not all pollutants, and not entirely.

The oceans regulate global climate by storing heat and absorbing gases that contribute to global warming, as explained below (and in Chap. 3). The ocean waters' ability to store heat enables a milder climate on the Atlantic coast of Europe than on the Atlantic coast of North America. (The Gulf Stream runs southward along the European coast, but does not come close enough to the Atlantic coast of North America to influence climate there.)

Obviously, even the vast oceans are limited in their ability to regulate climate and to purify water. In many places, the amount of pollutants reaching the ocean overwhelms the ocean's capacity to absorb them (see Chap. 5). Many coastal areas are now considered "dead zones" due to an overload of nutrients that promote phytoplankton blooms that quickly exhaust oxygen in the water, thus causing marine life, dependent on oxygen, to die (Diaz and Rosenberg 2008).

A good example of a coastal regulating service is that provided by marine and coastal flora – such as mangrove forests or kelp beds – in the form of coastal protection. Mangroves that grow in the intertidal zone prevent coastal erosion. These can sometimes be considered supporting services because they ensure that nearby beaches remain intact for recreation.

7.3.3 *Cultural Services*

Oceans are venues for recreation; they host a variety of tourist, leisure and sport activities. These activities are dependent not only on the physical space of the ocean (e.g., for boating, surfing, diving and swimming), but also on the marine life found within (e.g., for whale-watching and recreational fishing) and they often provide the foundation of local or regional economies. For example, in the south of Portugal, 18 % of the workforce is employed in restaurants and hotels that service millions of tourists visiting the beaches of Algarve (CSIL Centre for Industrial Studies 2008). On Cape Cod in the US, where ships once sailed in the mid-1800s for whale hunting, they now ferry tourists to sea on whale-watching excursions.

Coastal tourism employs more than two million people in the EU, making it the largest maritime economic industry. The cruise ship segment of the European economy is expected to grow strongly in the coming years (European Commission and DG Mare 2012). Unfortunately, the value of the oceans and coasts derived from cultural ES is still extra-market in many cases, particularly for value related to psychological and social benefits, such as those derived from historical and aesthetic elements of the environment.

7.3.4 *Supporting Services*

Supporting services underpin the existence of almost all the other types of services. For example, near-shore ecosystems provide habitats corresponding to the various life stages of organisms, thus supporting reproduction and growth of various fish species. Another service is photosynthesis, the biochemical process through which marine phytoplankton (together with terrestrial sources) produce much of the oxygen we breathe, while removing CO_2 from the atmosphere. The oceans also play an essential role in both nutrient (e.g., carbon, phosphorous, nitrogen) and water cycles. They store more than 95 % of the planet's water and are the source of 90 % of the evaporation necessary for the functioning of the water cycle.

The web of marine and coastal ES, typified by the four categories, hints at the complexity involved in assessing them. The more conceptually distant a service is from direct human use and the more abstract it is, the more difficult it is to assess. In addition, there are complexities related to the scale and extent of the ecosystem being assessed. Abstract services are often less place-based and therefore their measurement or quantification is extremely challenging.

Table 7.1 characterizes some services of the coasts and oceans for illustration purposes. Although it shows a differentiation between coastal ES and marine ES, in practice, the marine and coastal environment should be analyzed as a continuous unit or gradient (see Chap. 4), if at all possible.

7.4 Crossing the Terrestrial-Marine Divide

Of the few notable studies on *marine* ES, most are specific to a single ecosystem type or activities (e.g., focusing on coral reefs, fisheries, marine reserves, etc.). For example, among recent studies of the last decade, Mumby et al. (2007) test the use of ES as a "conservation measure" in designing a network of marine reserves in the Bahamas Archipelago. Similarly, Olsson et al. (2008) and Granek et al. (2009) elaborate on ecosystem-based conservation strategies that protect ES of the Australian Great Barrier Reef and Puget Sound, Washington (US) respectively. These works attest to the rising "flood" (no pun intended!) of academic literature on marine ecosystem services.

Both the relative lag in attention to marine ES and the specificity of foci within ES assessment approaches have hindered the incorporation of marine and terrestrial ES into single, unified assessments that cross terrestrial-coastal-marine landscape units (Portman 2013). One paper that addresses a gradient of landscape units is Barbier et al. (2010). The authors report that important estuarine and coastal ecosystem services (ECEs), such as cross-ecosystem nutrient transfer at coral reefs and erosion control in marshes, are wrought with complexity and have yet to be valued reliably.

Spatial and temporal aspects of the ecological functions underlying cross-landscape unit services are significant. The connectivity between ECE habitats has implications for assessing the ecological functions underlying services such as coastal protection, control of erosion and habitat-fishery linkages (Barbier et al. 2010). Furthermore, coastal ecosystems at the interface between marine and terrestrial ecosystems provide an array of services to many different groups in ways that engender intensified conflict. As such, decision making about which group, or groups, should determine each benefit value can be contentious.

Box 7.2: Different Types of Carbon Capture as Ecosystem Services
Important climate regulation services are found naturally on land and in the oceans. These services are essential for mitigating the effects of climate change.

Black carbon (particulate matter) and brown carbon (organic aerosols), emitted by the incomplete combustion of fossil fuels and biomass respectively, are the two most important light-absorbing substances in the atmosphere. They contribute, like CO_2 emissions, to the greenhouse effect that

(continued)

Box 7.2 (continued)
drives climate change. Both black and brown carbon absorb light and therefore trap light reflected towards space – for example, from snow and ice.

Black and brown carbon can be removed from the atmosphere by photosynthesis and stored in plants and soils. Such "sinks" are a vital part of the global carbon cycle and they are found within the oceans. Terrestrial processes, activities, or mechanisms for removing carbon lead to green carbon sinks.

The carbon removed from the atmosphere through ocean processes is termed blue carbon. Worldwide blue carbon represents more than 55 % of the carbon that would otherwise contribute to global climate change. The carbon captured by living organisms is stored in seabed sediment, mangroves, salt marshes, seagrasses, plankton and more. Thus, ocean ecosystems provide important climate regulation services; however, the best ways to measure and assess these important contributions have yet to be devised.

One daunting aspect of marine and coastal ESA is the sheer scale of such services, especially those considered regulating services and supporting services. For example, the ocean's marine vegetation makes up a fraction of the planet's biomass (much less than terrestrial vegetation), yet it stores a comparable amount of carbon per year. Estuaries and open ocean carbon sinks capture and store between 235 and 450 teragrams (Tg) of carbon every year.[4] By preventing the further loss and degradation of these ecosystems and catalyzing their recovery, we can contribute to offsetting 3–7 % of current fossil fuel emissions in two decades (Box 7.2). Scale will be a significant issue when assessing these services. Most of the existing ES markets have been developed for a local or regional scale (Achterman and Mauger 2010; Ruhl 2010) yet assessments are often conducted on a national scale, at coarse resolution. Reconciling between such assessments and their practical application has been challenging.

7.5 Decision Making Based on Coastal and Marine ESA

So what does the ES approach offer environmental planners working on coastal and marine environments? In most cases, other than for market development (i.e., credit assignment), the ES approach has been used for the identification of tradeoffs in the face of proposed development. Similar to other types of assessment (for example, "with-without analysis", commonly used for environmental impact assessment (Randolph 2011)), ESA identifies expected loss in value from

[4] This is up to half of the emissions from the entire global transport sector, estimated at around 1,000 Tg of carbon per year.

anticipated environmental change. Such change could be anticipated from myriad activities (Box 7.3); from localized development to large-scale change, such as global warming or ocean acidification.

Box 7.3: Sea Otter "Services": An Example

Kelp forest ecosystems around the world provide food and shelter for fish, shellfish and other marine organisms. They also protect coastlines from damaging wave action. Sea otters are a keystone species, necessary for maintaining the health and function of the kelp forests. The role of sea otters, in this respect, is well-documented around the island of Kodiak, Alaska. There, as in other places along the North American west coast, otters limit herbivorous sea urchins and, in turn, enhance the abundance and distribution of kelp and other fleshy macroalgae in coastal inshore ecosystems. The urchins chew the anchors that keep the kelp in place, causing the kelp to die and float away. This sets off a chain reaction that depletes the food and oxygen supply in the water, causing the numbers of many marine organisms to decline. As otter populations fluctuate, researchers have observed corresponding shifts between kelp-dominated and urchin-dominated conditions. Abrupt changeovers occur, influenced by follow-on effects in the general ecosystem related to three mechanisms: the creation of biogenic habitat (created by living organisms), primary production (food) enhancement and the influence of coastal kelp beds in keeping wave action in check.

Source: Ripple et al. (2014).

One spatially explicit modeling tool – Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) – developed by the Natural Capital Project, addresses this type of decision making. The InVEST software application shows how different future scenarios will affect hydrological services (e.g., water quality and peak stormwater runoff), soil conservation, carbon sequestration, biodiversity conservation and the value of several marketed commodities (e.g., agricultural crop products, timber harvest and fisheries' yields). Once production functions have been determined for each of the ES identified in different areas (Fig. 7.5), InVEST computes relative values for each, and trade-offs are identified to aid decision making.

Models are generally service specific, evidence of the need for plenty of good science to conduct ESAs. Many of the projects implemented so far by researchers using InVEST address the marine and near-shore environment such that models for the development of service-specific production functions for coastal protection, coastal vulnerability, marine aquaculture, marine water quality and offshore wind energy are available (see http://www.naturalcapitalproject.org/models/models.html).

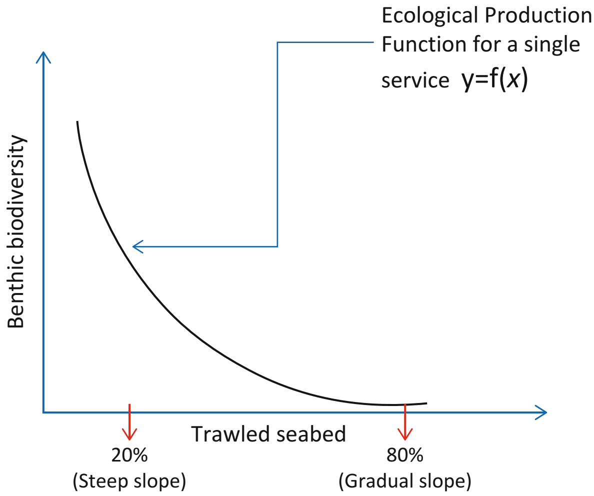

Fig. 7.5 An example production function. Since trawling is associated with poor benthic biodiversity and since steep bathymetry (slope) hinders trawling, we can estimate *y* in terms of *x*

The InVEST software is a spatially explicit, advanced GIS tool (Fig. 7.6), but planners can also devise their own low-tech versions of ES trade-off analyses. For example, Needles et al. (2015) created a simple management action/services matrix as a first step towards identifying trade-offs to facilitate decision making. Researchers found that management actions that restored or enhanced natural vegetation (e.g., salt marsh and mangroves) and certain shellfish (particularly oysters and oyster reef habitat) benefited from multiple services. In contrast, management actions, such as desalination, salt pond creation, sand mining and container shipping, had large net negative effects on several of the other services considered in the matrix.

7.6 Evolving Concepts and Controversy: A Critical Note

Although the ES approach has generated much interest, research and hope, it is not without its dissenters. The approach draws criticism on theoretical and empirical grounds, ranging from ethical concerns regarding the commodification of nature and claims that ES assessments reflect a neoliberal fetishism (Kosoy and Corbera 2010; Luck et al. 2012), to serious concerns about the approach's impracticality and biases (Portman 2013; Adams 2014). Many global ES assessments are skewed towards the natural science disciplines. Social science content is often limited, and heavily dominated by economics (e.g., Adams 2014) a science that involves much uncertainty and is often based on theoretically expected behavior.

Further, good economic data is hard to come by and expensive. Even when it seems like economic data would be easy to obtain, there are challenges. For example, commercial fisheries landings data include information on the volume and ex-vessel value of catches. Such data is readily available from the US National Oceanic and Atmospheric Administration (NOAA). However, the data are recorded

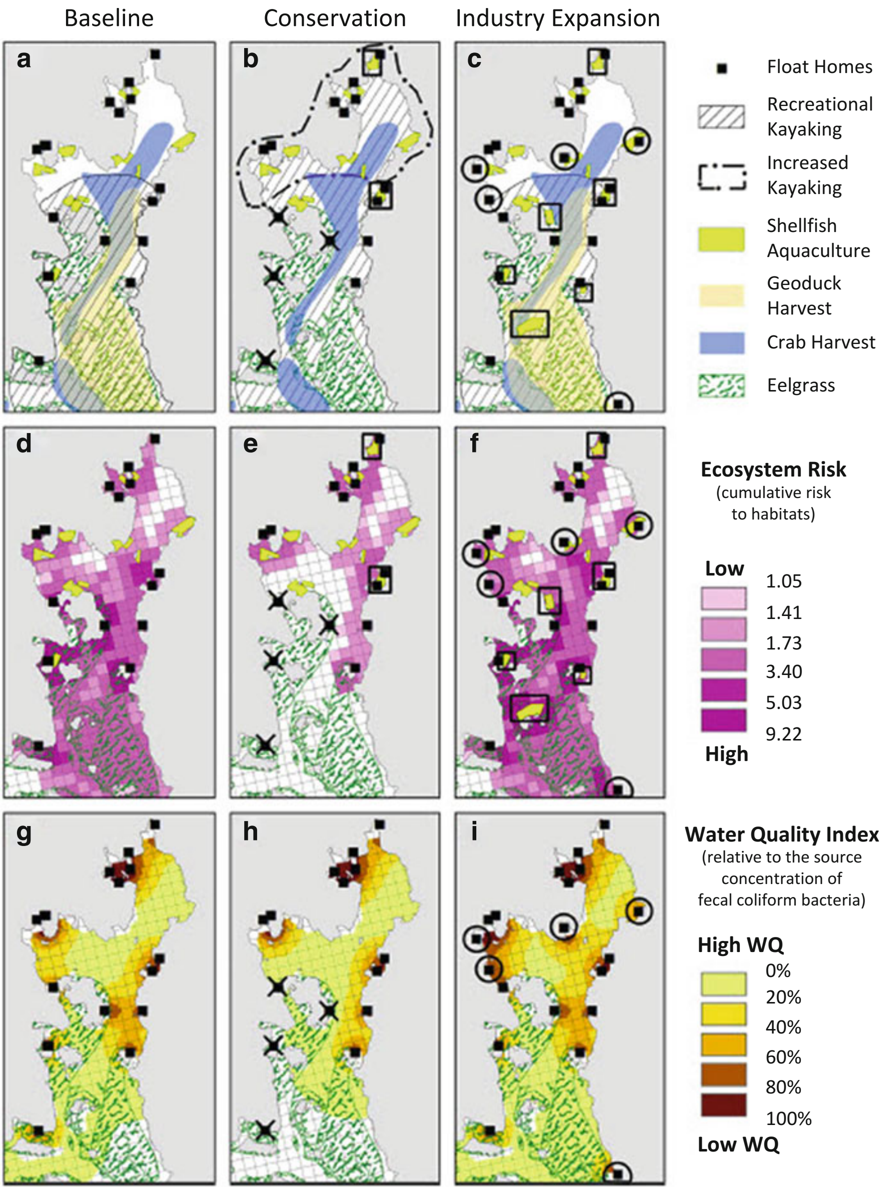

Fig. 7.6 InVEST outputs for a case study at Lemmen Inlet, British Columbia. The scenarios were: Baseline (no changes to current uses or zones); Conservation (zoning rules restrict float homes and aquaculture near eelgrass); and Industry Expansion (new float home leases and oyster tenures are added, and wild geoduck harvest is allowed) (Source: Guerry et al. 2012. Reprinted with permission from Taylor & Francis)

at relatively coarse and ecologically inappropriate spatial scales, for reasons that range from concerns for confidentiality of fishing locations, to constraints on agency data quality and management.

When ES analysis progresses to mapping, problems of scale arise. The US National Ocean Economics Program (http://noep.mbari.org) for example, compiles data from the US Bureau of Labor Statistics into a database that allows users to search for annual contributions of ocean or coastal-based activities (e.g., tourism, recreation, fisheries and transportation) to the economy at county and state scales. These estimates have flaws, including the underestimation of fisheries employment and the accrual of value to land-based counties rather than to the ocean sources from which these services derived (Lester et al. 2010). Such problems hinder the use of the ES approach in places where resources are relatively plentiful for data collection and management and where research institutions are established and well-equipped. Problems on these fronts are vast in developing countries or in parts of the world where regional cooperation for study is essential but severely impeded.

Other challenges to the use of the ES approach have to do with the lack of consensus on what should be assessed as a service. The MEA was the first to classify "ecosystem services" into four categories: provisioning, regulating, cultural and supporting. The use of these four categories has been found confusing, especially due to difficulties identifying "support" services. Wallace (2007) argues that the four classifications are inadequate because they mix ends with means; the "end" is the service provided and the means are the supporting services and, as such, not services in and of themselves. Although ecosystem services depend on ecosystem functions, the two are not synonymous (Granek et al. 2009). It is likely that authors of the MEA anticipated this problem. Some parts of their report leave out "supporting services" (for example, in Table 7.1 of the MEA (2005)).

Some suggest that such conceptual problems can be circumvented by the use of "service providing units" (SPUs). So far applied only to the terrestrial environment, the SPU concept refers to the quantification of biological components of a given ecosystem that ultimately support human activities (Cognetti and Maltagliati 2010). But what about abiotic components of the ecosystem that support human activities? The recent Proposal for a Common International Classification of Ecosystem Goods and Services (mentioned in Sect. 7.2) proposes distinguishing the material and energetic outputs from ecosystems as "goods" and the non-material outputs as "services" (Haines-Young and Potschin 2010).

Since ESAs often make use of values on a continuum that are relative to one another, it is important that ES across landscapes be comparable. Comparability of landscapes is not a challenge unique to the ES approach (e.g., Beger et al. 2010); however, solving it becomes essential for using the approach in planning praxis. Creating comparable indices for ES across disparate landscape types is especially important for mapping terrestrial-coastal-marine continuums to conduct assessments.

Cognetti and Maltagliati (2010) highlight the differences between marine and terrestrial environments and call for unique ESA models for each. For land environments, they envisage a matrix of a human-altered landscape interspersed with fragments of original biodiversity; conversely, for the marine model, the matrix is represented by the original biodiversity with fragmented areas of human activities. “Original biodiversity” areas are, for example, those with “original” habitat left adjacent to cultivated land that provide supporting services for honeybees. Whether or not one accepts this differentiation between models, it is clear that more work is needed, especially with regard to the marine environment.

As described in other parts of this book (e.g., Chap. 2), marine ecosystem components are more transient (fluid) than terrestrial ones. Most marine areas are held in public trust or at least comprise areas of public domain that lack the constraints and opportunities that private property holds for ES protection and management. Marine data collection is complex, expensive and often not readily available. For terrestrial ESA, remote sensing, GIS and image analysis provide parameters for valuing services, such as Leaf Area Index or Normalized Difference Vegetation Index (Nunes et al. 2011); for the marine environment, great sophistication is often needed. Most textured images generated from satellite photos or flyovers that give good indications of terrestrial vegetation and land uses deliver pictures of a monolithic water sheet when applied to the oceans.

Attention to ecosystem services does not automatically lead to nature protection and conservation of biodiversity (Adams 2014). In this regard, challenges arise in the relationship between ecological processes and the delivery of ecosystem services, a relationship which is often poorly understood. For example, in Maryland (US), stream channels were re-engineered to provide particular services from streams (e.g., stormwater management for flood protection), which caused the loss of healthy riparian trees in favor of uncharacteristic terrestrial and wetland species (Palmer et al. 2014). Other problems include missing (or fluctuating) markets for services such that value depends on when an assessment is done, skewed decisions about ES that invariably reflect the owners’ or power holders’ valuation of the resources, and difficulties balancing both synergies and competition among services simultaneously. Furthermore, it is important to remember that the ES approach is not in itself a conservation measure (Adams 2014).

An influential article that addresses some of the challenges highlighted here reviews the environmental regulatory programs in the US, such as the Oil Pollution Act, the National Environment Policy Act, the Clean Water Act and the Endangered Species Act, in view of their ability to address ES. Some of these laws require those responsible for damage to ES to provide compensation, both physical and monetary, for benefits lost (Levrel et al. 2012). Although the authors address reactionary mechanisms, and not proactive decision-making institutions with bearing on planning, it is a welcome addition to the literature. This type of research has wide implications that apply to areas much broader than the marine policy milieu alone.

Clearly, the ES approach is still evolving. The utility of the concept for oceans and coasts depends, in part, on our ability to understand the links between landscape structure, movement of organisms and materials through the seascape and the subsequent provision of multiple ecosystem services (Mitchell et al. 2013). Much of our knowledge about aspects of ecosystem services of marine and coastal environments remains rudimentary and therefore the effective management of varied landscapes to provide and protect ES is curtailed (Kremen 2005; Tscharntke et al. 2005; Daily et al. 2009; Nicholson et al. 2009). However, most experts do agree that the identification and quantification of ES are valuable for environmental planning, and win-win outcomes are possible (Adams 2014).

7.7 Summary

This chapter introduces the ES approach as it pertains to marine and coastal environments. It began with a description of the approach's development, related the approach to coastal and marine environments, and ended on a somewhat critical note. Despite growing attention to the ES approach in conservation literature and its pivotal position in the field of ecology, wide adoption of the approach faces many challenges. Particularly challenging is the incorporation of ES valuation in planning decisions, building consensus about priorities among the different services, and valuing ES across land and seascape units such that different kinds of services are comparable and trade-offs can be weighed and made.

The evolution of ESA has engendered a broadening of the definition of ES and assessment tools to account for as many services and landscape types as possible. It is hoped that this will facilitate the fulfillment of the approach's potential for conservation and for its application to coastal and marine environments. While there is general consensus that marine and coastal ecosystem-based management must incorporate ESA in decision making, successful examples are still in relatively short supply.

ES and ESA for oceans and coasts is an area for which much research and practical work is still needed. It is also an area where crossing the policy-science divide is of the utmost importance, as evidenced by the previous section's critique. Although research and scientific literature on ESA abounds, planning professionals have yet to fully incorporate the approach for improved environmental decision making.

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Part III
Tools and Technologies

Chapter 8
Marine (and Coastal) Protected Areas

A nature reserve preserves its original state which everywhere else has to our regret been sacrificed to necessity. Everything, including what is useless and even what is noxious, can grow and proliferate there as it pleases.

– Sigmund Freud

Abstract This chapter covers some of the most important issues relevant to planners in regard to establishing, maintaining and managing marine protected areas (MPAs). Despite debates about MPA design and management and differing perspectives on how they should be defined, it is generally agreed that they are one of the more effective tools for marine habitat and biodiversity conservation. This chapter emphasizes important ideas regarding the establishment of such areas, including the designation of networks of protected areas and transboundary protected areas. These are two approaches, among others, that will aid planners in protecting oceans and coasts.

Keywords No-take zones • Novel ecosystems • Place-based conservation • Restoration ecology • Spatial prioritization • Transboundary marine protected areas

One doesn't usually think of Sigmund Freud as a conservationist, but his insightful comment about nature reserves' "original state" is true. The best way to protect nature, accepted among environmentalists and development proponents alike, is by restricting human activities within designated areas – "putting these areas aside", so to say. However, what is considered a nature reserve is highly variable; the often-used term "protected area" can mean many things to many people, especially in the sea and along coasts. In the ocean, there are likely greater impediments to blocking off areas and imposing restrictions than on land. Thus, the implementation of place-based marine protection (i.e., the establishment of marine reserves) often falters.

The need to protect marine and coastal environments has spurred recent interest in the designation of new marine protected areas (MPAs) (Box 8.1). As mentioned throughout this book, most near-shore areas, both coastal and marine, face

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increasingly severe problems of deteriorating environmental quality, loss of critical habitats, diminishing levels of fish and shellfish populations, reduced biodiversity and increased risk from natural hazards. Scientists have determined that, globally, 60 % of ecosystem services are significantly degraded and that no marine ecosystem remains unaffected by humans (UNEP 2006; Halpern et al. 2008). Therefore, one of the necessary allocations of space in the marine environment should be for the establishment of MPAs.

Past research confirms the significant contribution of MPAs for rebuilding fish stocks, protecting marine biodiversity and preserving habitats (Halpern 2003; Claudet et al. 2008). As such, MPAs have become the cornerstone of many ongoing marine conservation initiatives. In some cases, they are even the focus of marine spatial planning initiatives. Important ideas about the establishment of MPAs involve the designation of networks of reserves (Abdulla et al. 2008) and transboundary marine protected areas (Louzao et al. 2012). This chapter covers some of these ideas while focusing on issues relevant to planners in regard to establishing, maintaining and managing MPAs.

Box 8.1: The Promise of Sydney

In November 2014, the International Union for Conservation of Nature (IUCN) concluded its once-a-decade World Parks Congress. The 8-day congress, which took place in Sydney, Australia, attracted approximately 6,000 participants from more than 170 countries. Among the more than 70 new conservation commitments that were announced by the countries in attendance, of note was the emphasis on commitments to protect the marine environment. This included the call to protect 10 % of the world's ocean area by 2020, as a way to achieve the new conservation goals set out by the Congress, in a document dubbed The Promise of Sydney. Among the pledges were some relating specifically to the marine environment:

- Bangladesh promised to create the country's first marine protected area.
- Gabon announced it would create new marine protected areas covering 23 % of its territorial waters.
- Madagascar announced plans to triple its marine protected areas.

Source: http://scim.ag/WorldParks

8.1 Conservation Paradigm Shifts and Protected Areas

The idea of allocating areas devoid of human activity and development to protect nature, natural resources and ecological processes that occur within, has been considered a logical step since the birth of the conservation movement in the mid-nineteenth century. Around that time, two movements held disparate views as to the foundation of concern for the natural world. These paradigms are still relevant to the underpinnings of the environmental movement.

Founded largely on the beliefs of John Muir and his contemporaries, the preservationist movement was based on the idea that nature has inherent worth which provides mankind with spiritual benefits. The conservationist movement, promoted by leaders such as Gifford Pinchot, head of the US Forest Service, advocated that nature and its resources exist mainly for practical purposes; that is, to serve human needs. These contrasting ideas had myriad implications as to the purposes of protected areas and how they should be managed. More recent conservation paradigm shifts both reflect changes in the relationship between people and nature and influence how protected areas are planned and managed.

Modern conservation thinking has developed in four main rapidly shifting phases (Mace 2014). The first began prior to the 1960s, when broad "nature for itself" thinking prevailed. This paradigm prioritizes wilderness and intact natural habitats void of people or with significant restrictions on human activities and with an ostensible focus on species conservation through carefully managed protected areas. This thinking continued throughout the 1960s and remains a dominant ideology for many people today. In the 1970s and 1980s, rapid population increase and awareness of habitat destruction and environmental impact resulting from increased human activity led to what Mace (2014) terms the "nature despite people" paradigm. Here the focus was on the anthropogenic impacts to species and habitats and on strategies that would reverse or reduce these effects, with less emphasis on protected areas.

Once it became clear that human pressures and impacts were ubiquitous and persistent while the best endeavors of conservation were faltering, conservation thinking shifted towards the irreplaceable goods and services provided by nature (the "ecosystem services" paradigm described in Chap. 7). This coincided with great interest in neoliberal economic policies and the valuation of services largely ignored by conventional markets. The paradigm moved away from concern for singular species towards ecosystems as a whole, emphasizing an integrated approach referred to as "nature for people". The last phase inextricably links people and nature, emphasizing the importance of cultural structures and institutions for developing sustainable and resilient interactions between human societies and the natural environment, and it operates at a range of scales from global to local (Mace 2014).

These different framings influence conservation science, tools and strategies. For example, The Nature Conservancy[1] recently moved away from a focus on preservation by establishing protected areas towards exploiting opportunities for conservation outcomes for businesses to invest in for their own benefit. These would be ostensibly win-win situations for business entities. Not surprisingly, this has led to some strongly held and divergent viewpoints coming to the fore (Soule 2014).

[1] A prominent global environmental NGO headquartered in North America.

The four shifts described have occurred over a relatively short period (roughly 1960 to present day) with much overlap between them. Current science and practice incorporate all four framings, sometimes in mutually supportive implementation. An example is the identification of opportunities for efficient outcomes, achieved using sophisticated conservation planning tools for the design of protected areas that incorporate both high biodiversity and optimization of ecosystem services (Cimon-Morin et al. 2013).

Despite the emphasis on place-based conservation throughout these four shifts, it has long been clear that the establishment of MPAs, when compared to terrestrial protected areas, has been neglected. Global ocean coverage remains low, at only 3.4 %, whereas terrestrial coverage hovers around 15 % (UNEP-WCMC 2014). One reason for this lag is that when the first large swaths of area were set aside for national parks and nature reserves in the mid-nineteenth century, it was inconceivable that anything, let alone man's actions, could threaten the well-being of the creatures and conditions found at sea.

Coverage of terrestrial and inland water protected areas was about 15.4 % by 2014 (Fig. 8.1). If we compare this percentage to marine areas under some level of national jurisdiction,[2] only 8.4 % of the oceans are protected (UNEP-WCMC 2014). Areas protected are generally limited amounts of near-shore waters (see Chap. 2). Therefore, much more effort to establish MPAs is needed.

Overall, an MPA should encompass significant variety, including both areas designated to replenish fish stocks (e.g., Stellwagen Bank US), and to provide ecotourism opportunities (e.g., Great Barrier Reef Marine Park, Australia), as well as to protect unseen (submerged) seascapes with wilderness values and qualities. Some MPAs are already identified as "wilderness",[3] both by those responsible for their stewardship and by others interested in making the public more aware of their exceptional natural and cultural resources. A good reason to seek such wilderness status is to garner support for marine conservation in general and to raise awareness of its inherent value (Barr and Kliskey 2014).

[2] According to the UNEP-WCMC (2014), this constitutes areas encompassed within 200 nm of the shoreline that can potentially be declared by a coastal state as the exclusive economic zone (EEZ). However, as explained in Chap. 2 of this book, national jurisdiction is limited to the areas within territorial waters where national sovereignty prevails.

[3] Among the most important benefits of wilderness are: preserving "wildness" and "naturalness", scenic beauty, providing opportunities for solitude, spiritual growth, education, science, recreation, economic benefits, subsistence and preserving biodiversity and healthy ecosystems.

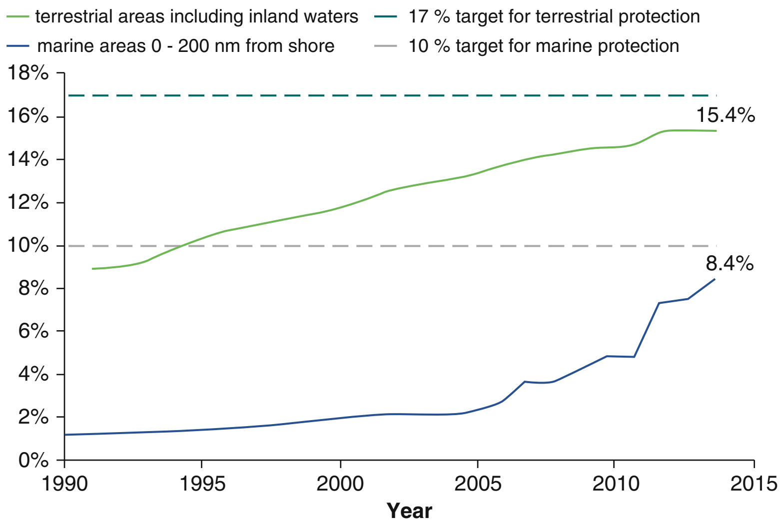

Fig. 8.1 Growth in nationally and internationally designated terrestrial (15.4 %) and marine (8.4 %) protected areas 1990–2014 (Source: Juffe-Bignoli et al. 2014. Reprinted with permission of the United Nations Environment Programme – World Conservation Monitoring Centre)

8.2 What Constitutes an MPA?

Broadly defined, MPAs number in the thousands worldwide. The IUCN defines MPAs as ocean sites where legal or regulatory mechanisms limit or restrict human activities to protect natural, historic or cultural resources (Box 8.2). One of the challenges to understanding how much of the oceans *should* be protected is that it is unclear how much is already protected. Because there is such a broad range of what can be called a "marine protected area", numbers are vague. Furthermore, as on land, many areas are paper parks, meaning they are "protected" in name only (Guidetti et al. 2008).

Box 8.2: Marine Protected Areas Defined

A widely-accepted definition used for MPA is based on the IUCN's guidelines for protected areas, published in 2008: "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). The guidelines also categorize protected areas meeting this definition according to six management types and four governance types. In 2012, the IUCN published supplementary guidelines that provided additional advice on using the IUCN guidance for MPA planning and management (Day et al. 2012).

MPAs should safeguard natural ecosystems in danger of disappearing, including areas most vital to habitat and species survival. This can be accomplished in part, by ensuring that endangered species, endemic flora and fauna and sites with high scientific and ecological value are undisturbed. Biodiversity within protected areas should be well-represented, protected and sustainable; in other words, able to persist over time (Moilanen et al. 2009).

According to the most accepted definition and categorization of MPAs (Day et al. 2012; Box 8.2), some level of human activity may be allowed within an MPA. This begs the question: what constitutes an MPA? Is it an area of full protection or one of reduced human disturbance? Is it completely a marine area or could it contain both marine and terrestrial (e.g., upland and supra-littoral)[4] areas?

Some so-called *marine* protected areas may be mostly terrestrial (coastal) land area (see Portman et al. 2012). Well-known online databases, such as those maintained by MedPan, Protected Planet and MPA Global, that have been used in studies of MPAs (Wood 2007; Abdulla et al. 2008; Guarderas et al. 2008), list many protected areas as "marine" even though they are composed partly or even mostly of supra-littoral lands (e.g., islands). In some cases, the terrestrial portion of the MPA may be even greater than the marine portion (see Portman et al. 2012). Countries themselves often decide on what an MPA is, and reports on the existence of reserves is then picked up by international surveys (Abdulla et al. 2008).[5]

To some extent, an inclusive definition is desirable, since terrestrial (upland), intertidal and other diverse ecosystem types (such as offshore islands) contribute to the function of marine ecological processes. But that shouldn't mean that areas farther out to sea are less worthy of protection. Not only do the *types* of marine environments protected, but also levels of protection within MPAs, vary on a continuum – from complete exclusion of human activities to conditional allowance of all human activities.

Whether fully protected (i.e., completely no-entry/no-take), or allowing some human activity in different parts through some system of zoning, MPAs play a central role in marine conservation (Lubchenco et al. 2003). They lead to improved marine environments, healthy ecosystems, intact ecological processes and functions within them, and they provide spillover effects (Fig. 8.2). "Spillover" refers to improvements in biodiversity beyond the boundaries of protection (Claudet et al. 2011). However, there are still threats to MPA effectiveness (Box 8.3), and some believe that their contribution to marine conservation is overstated (Allison et al. 1998).

[4] Uplands are areas that are rarely, if ever, underwater, while the supra-littoral area is land above the spring high tide line that is regularly splashed, but not submerged, by ocean water. Seawater penetrates these elevated areas during storms with high tides.

[5] For example, in the Mediterranean Sea, Abdulla et al. (2008) recognize a total of 94 MPAs, while a recent publication of the IUCN (Riche 2011) describes 750 Specially Protected Areas in the Mediterranean, of which "two-thirds are marine protected areas covering approximately 97,000 km^2 or roughly 4 % of the marine environment".

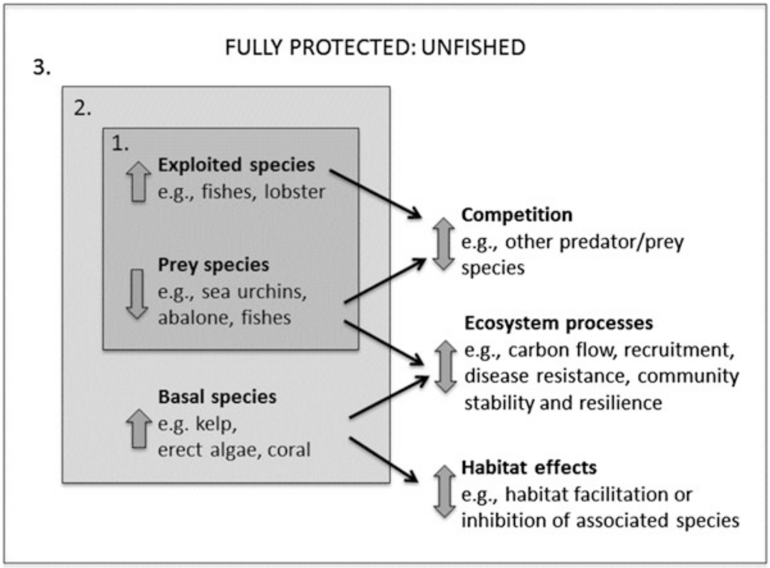

Fig. 8.2 Indirect effects of marine protection can be driven by different interaction types: Prey-predator interactions (1); Trophic cascades (2); or other population-, community- and ecosystem-level indirect effects (3). (Source: Claudet et al. 2011. Reprinted with permission of Cambridge University Press)

Much more research is needed on the effectiveness of MPAs, as well as on examination of what goes on within them vis-á-vis management plans and intended protection goals (Abdulla et al. 2008). That said, recent efforts have made progress in this regard (Edgar et al. 2014). Planning for effectiveness is perhaps of greatest interest to environmental planners and indicates where they can contribute the most.

8.3 MPAs Work

Despite debates about MPA design and management, and differing perspectives on the value of MPAs and how they should be defined, it is generally agreed that they are one of the more effective tools for marine habitat and biodiversity conservation (Claudet et al. 2011; Goñi et al. 2011). Past studies have found that MPAs generally increase the biomass, density and diversity of species within their borders and in their surrounding areas (Francour 1994; Halpern 2003; Claudet et al. 2011; Sala et al. 2012).

Applied research has identified conditions under which countries are amenable to marine conservation actions, which include the designation of MPAs, as well as what types of planning and management work best where. Geographic location and spatial attributes of MPAs have been studied, particularly in regard to their conservation effectiveness (Halpern 2003; Coll et al. 2012; Sala et al. 2012). Such studies have yet to be linked closely to policy for the planning and management of MPAs (as exists for terrestrial protected areas, e.g., Seiferling et al. 2012), although some have focused on the contribution of compliance and enforcement (e.g., Guidetti et al. 2008).

A recent high-profile, worldwide study of 87 MPAs, published in *Nature*, narrowed factors of MPA success to five key features (Edgar et al. 2014). These include: no-take (of biotic resources, usually fish), well-enforced regulations, reserve age and size and its relative isolation (e.g., by deep water or sand). The study found that MPAs with these key features had twice as many large fish species per transect, five times more large fish biomass and fourteen times more shark biomass than in fished areas. On the downside, however, most (59 %) of the 87 MPAs studied, displayed only one or two of these key features. Those with these few key features alone were not ecologically distinguishable from unprotected (fished) sites.

Socioeconomic benefits generated by MPAs remain difficult to predict and are a subject of debate. Among the more salient benefits is the increased revenue from tourism (Badalamenti et al. 2000). Another benefit may be long-term increased fish biomass due to spillover effects on the outskirts of MPAs. Some socioeconomic goals within MPAs are thought to compromise biodiversity conservation goals (Klein et al. 2008), whether these stem from a desire to exploit MPAs for tourism or as a result of fishing closures and restrictions. Either way, it is of the utmost importance for environmental planners to consider benefits and costs of MPAs to communities for purposes of effectiveness, as well as fairness and equity (Klein et al. 2008; Ban et al. 2009; Pollnac et al. 2010).

8.4 The Planning and Design of MPAs

What are some of the tools planners can use to design and manage MPAs?

Science-based planning of MPAs leads planners to numerous proven frameworks for action, some of which are widely used. Systematic conservation planning is one such well-established framework that is largely science-based but can also incorporate stakeholder needs. Systematic conservation planning aims to optimally locate, select, prioritize and design conservation areas in which biodiversity and other important conservation values are represented and protected so that they can persist over time.

Many spatial prioritization tools are available for systematic conservation planning of MPAs. These can be used to determine zoning (i.e., the allocation of use or protection levels within an MPA), and can also be used to determine where it makes the most sense to establish MPAs at larger scales, such as in the territorial coastal waters of a country or an EEZ (e.g., Mazor et al. 2014).

Once an MPA has been sited and approved, comprehensive management plans can define objectives within the MPA and help execute the necessary accompanying restrictions (regulations). In management plans, planners apply spatially specific use directives through regulatory techniques such as complete and/or seasonal closures, equipment constraints, permits and economic incentives/disincentives, to achieve protection aims of varying levels, and to accommodate certain human uses (Laffoley 1995; Day 2002). The use of zones facilitates understanding and compliance by those who have a stake in management of the area and are ongoing users of its resources.

To help with the design and management of MPAs, decision support methods (some implemented through the use of software applications such as Marxan, Zonation, C-Plan, ResNet and DEFINITE; see Chap. 10) are available. There are many examples of the use of these methods for developing MPA management plans (Villa et al. 2002; Leathwick 2006; Portman 2007; Klein et al. 2008; Ban et al. 2009; Mazor et al. 2014). These methods solve spatial prioritization problems which are parameterized and formulated using data that are as comprehensive as possible and reflect the requirements for persistence of biodiversity features.

MPA zoning should be established according to overall management goals (Claudet and Pelletier 2004). Just like for land uses, the "sea uses" allowed in the various zones should be combined with: (a) the establishment of conspicuous MPA borders (with or without access fees) to reduce impacts of incidental intrusions; (b) dissemination of information about what uses are permitted, and in which areas; and (c) participatory involvement of local communities who contribute to protection and management (Claudet et al. 2011).

Box 8.3: A New Plan for a Great MPA

In 1975, Australia created the 344,000 km^2 Great Barrier Reef Marine Park off the state of Queensland, making it one of the first and largest marine protected areas in the world. A marine park authority was also created then to manage the park, along with one of the first ocean zoning plans. Conservation effects were enhanced in 1981 when the reef was designated a World Heritage Site. Yet conditions of the reef have deteriorated. The reef's coral cover shrank by half between 1985 and 2012 due to cyclones, predation by crown-of-thorns starfish and bleaching – loss of the coral's photosynthetic organisms when the water gets too warm. Without intervention, many believe that the Great Barrier Reef may lose its biodiversity and ecological integrity. A controversial plan, the Reef 2050 Long-Term Sustainability Plan, is now under consideration by the Australian government and is aimed at protecting the reef's value while allowing "sustainable development and use".

Source: Normile and Dayton (2014)

Complicating the planning and management of MPAs is the fact that many habitats and ecosystems are in transition and not enough is known about changes taking place within them, such as from climate change and unrecorded exploitation.

Furthermore, it is assumed that the protection of an area will ensure the continued existence of high-value elements of the environment, i.e., biotic and abiotic resources and living communities contained within or nearby. Yet frequently, reserves are established in or around damaged and highly impacted areas (Portman et al. 2012), sometimes because these are the areas available to serve as protected areas.

Sometimes preservation actions are performed to revive an endemic or historic ecosystem. Such goals are related to the emerging sub-field of restoration ecology. Restoration goals may be the rehabilitation of functional aspects of an ecosystem, replacement of one ecological community by another or restoration of both function and structure of an historic ecological state (Fiedler and Groom 2006).

In addition to dilemmas about how to restore ecosystems to their former functionality, questions arise about how to adapt to, plan for and manage *unfamiliar* environments; those that, due to so many changes, have never been seen before. Although controversial, there is a scientific paradigm developing around the idea of "novel ecosystems". The approach shifts conservation management concerns from maintaining existing or historical ecosystems towards qualitative considerations of how ecosystems function to provide species' habitats and ecosystem services (Bridgewater and Yung 2013). Proponents of this paradigm point to situations in which management for persistence of novel ecosystems makes more sense than trying to restore past conditions.

Although the conservation of nature should be considered the fundamental objective of MPAs, neglecting their related social, cultural and economic impacts has often impeded their success. A lack of local consensus about the existence of MPAs and their value has resulted in apathy or disregard for MPA designation and regulation, if not outright hostility (Badalamenti et al. 2000).

Planning and managing MPAs should be conducted using multidisciplinary approaches. While the field of conservation biology has, in some instances, considered the identification or planning of MPAs as ad hoc or opportunistic compared to science-based systematic planning (Klein et al. 2008; Ban et al. 2009), many conservation planners now embrace local community initiatives as a means of establishing protected areas. They recognize the value of community connections to ultimate MPA success (Dalton 2005; Pollnac et al. 2010) and try to infuse these with science-based methods.

Another issue that must be addressed is the lack of information available for systematic, efficient and effective planning of MPAs. As mentioned throughout this book, less is known about marine environments than about terrestrial ones. Open access databases and technological developments for improved monitoring, research and surveillance of less accessible and underexplored areas need to be tapped (Katsanevakis et al. 2015), as well as general planning knowledge and methods (see Portman et al. 2013). Incorporating local conservation efforts and transboundary collaboration can also enhance the planning of MPAs and result in improved data sources (Katsanevakis et al. 2015).

8.5 Transboundary MPAs

As is well known, ecosystems do not follow clear, socially constructed anthropogenic borders, especially in the marine environment (Agardy 2000; Grilo 2010; Guerreiro et al. 2010). As of 2000, it was estimated that transboundary protected areas (TBPAs) – those that cross international jurisdictional boundaries of nation-states (both terrestrial and marine) – represent 10 % of the world's network of protected areas (Argawal 2000). Because the marine environment is so fluid and its boundaries are porous, significant effort (including funding) is needed to ensure success of protected areas; for this reason, establishing MPAs across borders should be considered wherever possible.

Most international efforts at protecting *environmental* quality of oceans and coasts are embodied in laws or policies that do not necessarily include the spatially explicit designation of areas. The exception is typically regarding protected areas. The IMO has established two categories of place-based controls where environmental protection is enhanced (see Sect. 5.5 on Special Areas and Particularly Sensitive Sea Areas). For conservation purposes, transboundary MPAs have been established due to the well-recognized need for protecting large areas for conservation to be effective (Halpern 2003; Edgar et al. 2014), together with the understanding that such endeavors, despite risks, also have potential to improve international relations (Mackelworth 2012).

The relatively large number of terrestrial TBPAs means that there is no need to "reinvent the wheel", yet some adaptation is needed to glean knowledge relevant for marine cases. Since 1997, the IUCN has promoted "Parks for Peace" (or Peace Parks) as tools to enhance regional cooperation for biodiversity conservation, conflict prevention, resolution and reconciliation and sustainable development (Sandwith et al. 2001). Some of the proposed Peace Parks are marine parks. Figure 8.3 shows a transboundary MPA, proposed at the time of the signing of the peace accord between Jordan and Israel in the mid-1990s.

Several studies map the causes for success or failure of TBPAs (Table 8.1). Barquet et al. (2014) conducted a quantitative meta-analysis of TBPAs established during the years 1949–2001 by 328 countries, including many with a history of militarized disputes between them, dating back to the nineteenth century. Most of these cases were terrestrial. Mackelworth (2012) reviewed nine cases of marine parks established in the 1990s and 2000s from various areas of the world that suffered intense conflicts in the past. He found that combining conservation with the promotion of peaceful relations provides added value for cooperation; like most conservation initiatives, the long-term sustainability of TBPA projects is based on transparency, the availability of appropriate funding and governmental will.

The assessment of an $11 million transboundary conservation project sponsored by the World Bank to protect the ecological integrity of the Mesoamerican Barrier Reef System offshore of Belize, Guatemala, Honduras and Mexico, highlights both the opportunity and challenge of marine transboundary MPAs.

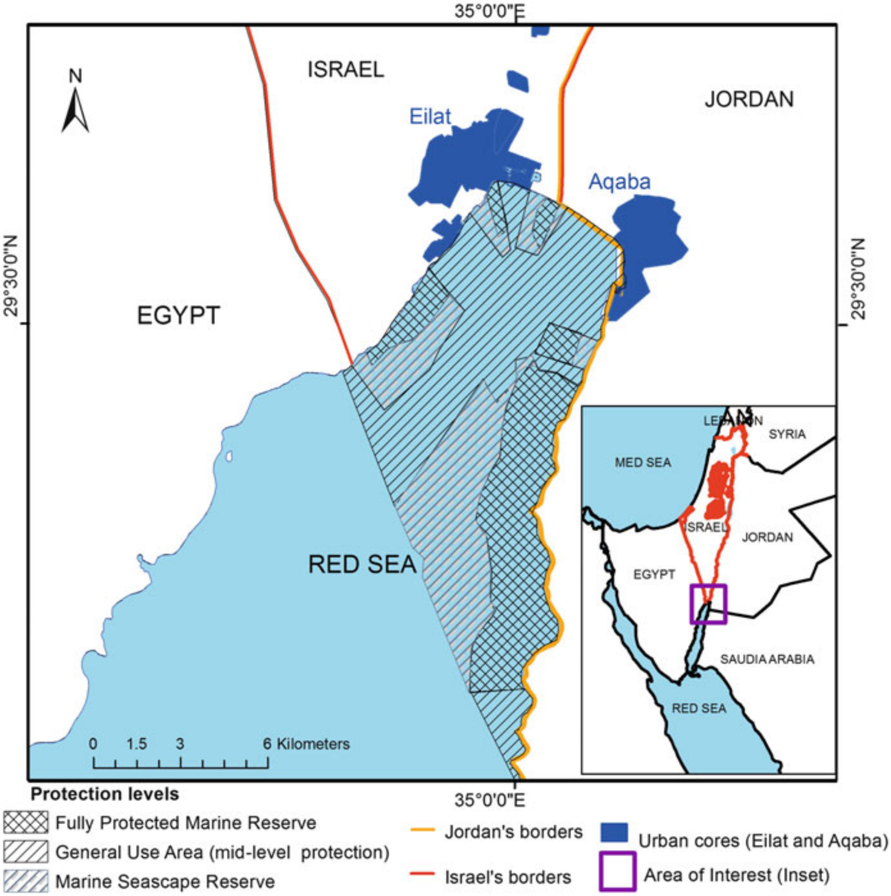

Fig. 8.3 Example of a zoning scheme for the Red Sea Marine Peace Park, a transboundary protected area, developed using a spatial multi-criteria analysis method

The assessment report concluded that by allowing the funding of nationally identified priorities under a regional approach, the project design ignored the very same incremental value the regional approach was supposed to provide. The regional approach may be easily interpreted as a substitute or a disincentive for national investments. The report also confirmed the importance of stakeholder participation for the success of the project (World Bank 2007).

Other areas of research focusing on cross-border marine conservation efforts are in fisheries management (Vetemaa et al. 2001) and long-term ecological research networks. Such studies lead to effective transboundary monitoring and contribute to marine conservation, even when they fall short of actually establishing protected areas (Bouyer et al. 2007; Portman and Teff-Seker 2016).

Table 8.1 Factors influencing TBPA outcomes (based on referenced sources in text)

	Factors	Rationale/detail
Financial	Economic profitability	Creating financial profitability (especially from ecotourism) engenders support among stakeholders and enhances political will.
	Funding/financial sustainability	Stable and continuous funding by third parties and governments helps ensure successful and sustainable projects.
Process	Number of participants	The more actors that are involved, the more likely differences between them may become problematic (jurisdictional, legislative, conflicting goals and objectives).
	Third-party involvement	Third-party facilitators (e.g., states, NGOs, etc.) maintain financial viability, objectivity and focus (but if perceived as asymmetric, they raise suspicion of having a “hidden agenda”).
	Long-term planning	A long-term perspective is needed to achieve significant results.
	Transparency/public awareness	Sharing information with the public and raising public awareness of the ecological matters and efforts promoted by the TBPA engenders public support.
	Equality/balance between parties	When division of funds, labor, power or responsibility among participating states is seen as imbalanced, support decreases.
	Stakeholder and community engagement	Public participation taking place during or before the initial planning phase has proven to be beneficial to the longevity and success of TBPAs.
	Strong promoting party	Whether governmental or non-governmental, participant or third party, a strong promoting entity helps advance TBPAs and keeps them relevant over time.
	Initiatives become part of national efforts	TBPAs that are part of another national effort (political, financial, social or other), and not merely focused on conservation, have better chances for long-term success.
Goals and objectives	Environmental status	Although conservation and nature protection are a central part of all TBPA initiatives, focusing only on these issues does not “hold” a project.
	Government motivation and commitment	Government motivation and commitment are necessary for the project to be financially and practically viable and for it to benefit from policies and regulation.
	Stakeholder interests (and level of interest)	The support of government and non-governmental stakeholders rests on whether they view the project as beneficial to their interests – financial, political, environmental, etc.

(continued)

Table 8.1 (continued)

	Factors	Rationale/detail
	Urgency	A sense of environmental urgency (e.g., acknowledgement of a threshold or "point of no return") contributes to the motivation of states and other stakeholders to cooperate.
Implementation	Monitoring and evaluation	Monitoring the progress of TBPAs helps keep them sustainable over time as emerging problems are identified and addressed.
	Security and border control	In areas of recent conflict, parties (including stakeholders) must feel that security considerations are addressed.
	Legislation	Cross-border conservation and cooperation must be supported by the laws and regulations of the participating parties. Similar rules and regulations among states improve chances for success.
	Identifying and promoting common values and visions	Common values are a platform on which to build cooperation. Values can include environmental, but also social, financial and even religious or pan-national values and shared visions.
	Learning from previous operations	Incorporating lessons learned from previous comparable attempts at establishment, planning and management of the TBPA.

8.6 Summary

MPAs are one of the many tools that planners use to further marine and coastal conservation. As mentioned, there are different types of MPAs, designed for various purposes, with varying levels of protection within them and aimed at protecting diverse marine and coastal environments – from completely submerged areas to sub-littoral, intertidal zones, or even uplands where marine-related ecological processes occur.

To address the many challenges involved in designing MPAs and MPA networks, planners can make use of spatial prioritization techniques. Such planning proposes an optimal spatial configuration for MPA management and zoning schemes, as well as layouts that support the achievement of desired conservation targets, under a myriad of constraints and with known or estimated costs.

Also important are considerations of the socioeconomic effects of MPAs. Protected areas will often benefit some stakeholder groups over others. Such situations must be acknowledged and addressed. Equally important is the involvement of local populations and user groups in the establishment of MPAs and in their ongoing management, including in compliance and enforcement of any use conditions imposed. Research has consistently shown that the involvement of nearby residents, resource users and stakeholders is an important factor in MPA success.

As mentioned, marine and coastal ecosystem and ecological processes do not recognize human boundaries, are constantly in flux and are best addressed at large scales. Therefore, MPAs should cross areas of national jurisdiction if possible. To do so, international collaborations are necessary, and joint management should be considered.

MPAs are critical to ensuring healthy marine ecosystems, improving the chances of ecosystem-based management and balancing marine resource uses and development within the ocean environment. While a full discussion of MPAs is beyond the scope of this chapter, there is a plethora of literature exclusively dedicated to MPAs and many excellent sources for further information, many of them referenced here.

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Chapter 9
Communicating About Oceans and Coasts

De vents d'Espagne en pluies d'Equateur
Voyage, voyage, vole dans les hauteurs
Au-dessus des capitales, des idées fatales
Regarde l'océan.….

– "Voyage, Voyage" by Desireless

Abstract This chapter discusses communication tools that can be used by planners working on oceans and coasts. Such tools can make it easier for stakeholders to examine their own medium and long-term futures, and to envision what is often virtually inaccessible. As such, they can help planners cross the science-policy divide. Myriad ways of presenting information are discussed in the context of environmental planning for oceans and coasts. The tools described are targeted for use with two main audiences – the public and policy makers.

Keywords Cartographic visualization • Environmental communication • Narrative • Ocean literacy • Satellite imagery • Remote sensing • User cases

Previous chapters in this book have emphasized a plentitude of challenges that planners working on marine and coastal environments must address. Communicating knowledge, information and insights related to these challenges will be paramount as we march on through the *Anthropocene*, when human activities are incessantly changing the state of our world. We must also be cognizant that we are in the midst of an ongoing "information revolution", part of the so-called Information Age. This influences how environmental planners work. Best practices of communication of all types, from rhetoric to visualizations, are important tools for disseminating information, particularly for planning and management of oceans and coasts. After all, like the sea and coastal environment itself, modes of communication are changing rapidly.

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Communicating about oceans and coasts is a subset of environmental communication,[1] a relatively new discipline and one that is gaining interest, especially as new tools such as crowdsourcing and social media monopolize channels of everyday interactions. The discipline of environmental communication studies the many ways and the forums in which stakeholders, as individuals or as groups, raise concerns and attempt to influence the important decisions that affect our planet (Cox 2013).

Environmental communication emerged when there was already good public address scholarship coming from fields such as sociology, urban planning, political science and environmental studies. It emerged as a separate field; first of all, because researching all aspects of communication on environmental issues – i.e., those doing the communicating, their positions, historical-political affiliations and means of communication – is necessary to fully understand the scope, scale and content of socio-environmental problems. The second reason derives from a moral imperative. In the face of the major environmental crises of our time, communication influences public opinion and can promote sustainable behaviors (Sheppard 2012).

For planners working on coastal and marine environments, an important goal is the dissemination of technical information. Significant advances made in detection and observation technologies, including remote sensing and image analysis, continue to add new knowledge about marine environments, which in turn improves modelling capabilities, which makes good data available for decision making. Communicating this data to the public, stakeholders and decision makers is especially important for planners interested in improving decision making.

This chapter discusses communication tools that can be used by planners working on ocean and coasts. Environmental planners obtain information about the physical world and use it to improve foresight. Good practice requires planners to make it easier for stakeholders to examine their own medium and long-term futures, to envision what is often virtually inaccessible or what doesn't *yet* exist. They also need to convey information for science-based decision making. Tools described in this chapter are targeted for use with two main audiences – the public and policy makers.

9.1 Communicating About Data

Crossing the science-policy divide is a huge part of environmental planning for oceans and coasts, as explained previously in Chap. 4 on integration. Doing science involves communicating data to the public and to professionals, whether other

[1] Article 2 of the National Communication Association's charter for the Environmental Communication Commission states that its purpose is "to promote scholarship, research, dialogue, teaching, consulting, service and awareness in the area of environmental communication" (1998, para. 2).

scientists, other planners or politicians (see Valiela 2009). As expected, data collection methods have made great strides in recent decades. Remote sensing, for example, has changed immensely. Light Detection and Ranging (LiDAR) technology can be used to create highly accurate digital elevation models (DEM) of the coastal zone, and in some areas real-time oceanic conditions are continuously recorded through the use of autonomous sensory arrays. Furthermore, these data, observed and collected in the field, are frequently made accessible to myriad users through open, online internet access.

One example is data about mean sea level along coasts. Established in 1933, the Permanent Service for Mean Sea Level is responsible for the collection, publication, analysis and interpretation of sea level data from the global network of tide gauges. The network is based in Liverpool at the National Oceanography Centre, a component of the UK Natural Environment Research Council. An interactive data interface maintained by the service shows measurement series taken at tide gauges stationed throughout the globe over different periods of time, some beginning more than 100 years ago (see http://www.psmsl.org/data/obtaining/map.html).

Even more impressive is the accuracy with which certain data can be processed and modeled. Physical oceanographers have used models to make highly accurate predictions of variables such as sea surface height. A map of variability in sea surface height measured from a satellite (i.e., remote sensing) shows quite good correspondence with a map produced by simulated models (Fig. 9.1). The difference in height is measured in centimeters, even though the data apply to global scales of many kilometers (Valiela 2009). Such a map combines advances in scientific capabilities (i.e., observation and modeling) and visual communication (spatial imaging).

Advances in the use of geographic information systems (GIS) together with progress in other communication technologies have put recipients of information, particularly laypeople, under pressure from an "information explosion"; that is to say, "rich in data and poor in information". Therefore, it is crucial to consider methods of display and dissemination carefully. Methods should make the information available and interpretable to a variety of audiences and should be suitable to the planning and management tasks at hand.

9.2 Communicating with the Public

A decade ago, the Pew Oceans Commission published a report entitled *America's Living Oceans*: *Charting a Course for Sea Change*. The report called for "a new era of ocean literacy that links people to the marine environment" (Pew Oceans Commission 2003).[2] The Commission, charged with proposing new approaches

[2] This report was followed by the US Commission on Oceans Policy report (2004) that similarly states: "To successfully address complex ocean- and coastal-related issues, balance the use and conservation of marine resources and realize future benefits of the ocean, an interested, engaged public is essential".

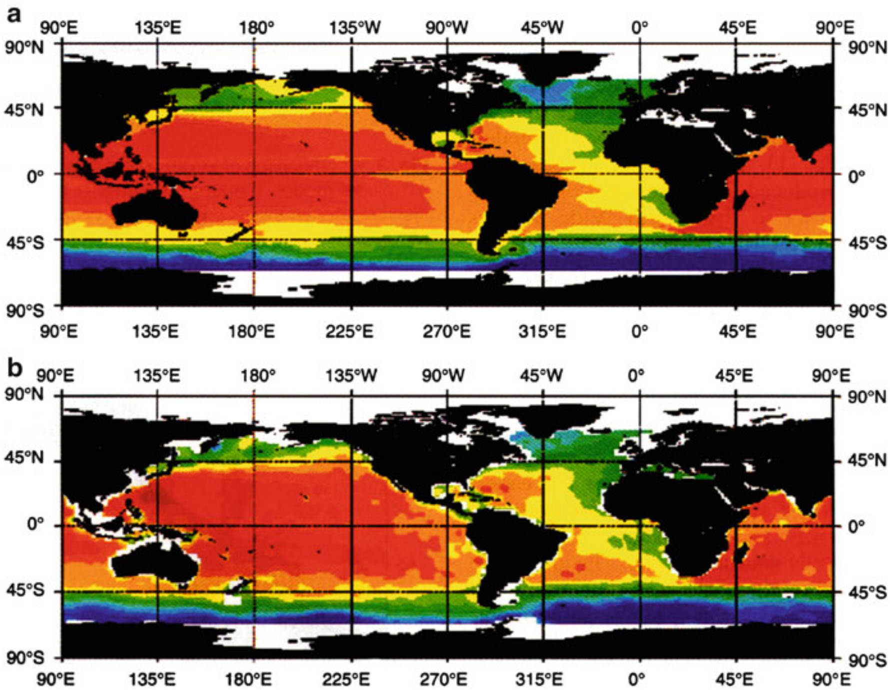


Fig. 9.1 Visualizations of 1993–1994 average sea surface height from a model (*top*) and from TOPEX/POSEIDON altimetry measurements (*bottom*). Improvements in satellite imagery have reduced the root square mean difference between these two representations to a mere 16.8 cm (Semtner 1995) (Reprinted with permission from John Wiley and Sons)

and actions to counter the deteriorating conditions in US ocean waters, concluded that there is a "need to provide the public with understandable information about the structure and functioning of coastal and marine ecosystems, how ecosystems affect daily lives, and how we affect ecosystems."

More recently, the European Community's Blue Growth program report *Scenarios and Drivers for Sustainable Growth from the Oceans, Seas and Coasts* (European Commission and DG Mare 2012)[3] has consistently included public engagement as an integral part of all possible scenarios analyzed. The language used in this report emphasizes the importance of "public opinion", "public acceptance" and "public conviction" in all possible scenarios, positing that progress can only be obtained through understanding (and influencing) public opinion, which depends on good channels of communication.

Most members of the public are either directly or indirectly involved in activities and behaviors that place ocean and coastal areas at risk. Therefore, it is indeed

[3] This report builds on earlier policy initiatives that recognize the contribution of marine and coastal resources in realizing the Europe 2020 strategy towards sustainable growth.

important to assess the scope and depth of policy-relevant knowledge among the public, and to learn where people tend to acquire their information about oceans and coasts.

In one of the first studies of its kind, Steel et al. (2005) used the term "ocean literacy" to describe levels of public knowledge and informedness concerning oceans. Using data gathered from a national random sample of over 1,200 citizens, two hypotheses – trans-situational and situation-specific – were examined as explanations of ocean literacy. The latter hypothesis evaluates socioeconomic status (SES) as an explanation for levels of knowledge, while the former evaluates personal experiences and contexts that might overcome SES characteristics. Interestingly, the authors reported that the source of respondents' information made a difference. They found that newspapers and the internet were associated with greater citizen knowledge on ocean issues, while dependence on television and radio as the main channels of communication were associated with lower levels of "ocean literacy" (Steel et al. 2005). This interesting finding suggests that more research focused on the types of media used by planners is needed.

Other than conventional sources of information (i.e., newspapers, radio, internet), the public learns about ocean and coasts, and environmental issues in general, from personal experience. First-hand experiences involve recreational activities such as boating, scuba diving or snorkeling, as well as visiting museum displays or watching movies. Yet, for much of the general public, visits to the marine environment are complicated and may not be within reach logistically or economically (too distant or financially prohibitive). Marine-related knowledge gained through personal experience may be less agenda influenced than information gained through scientist-to-scientist or scientist-to-policy-maker communication. For all audiences, narrative structures (i.e., storytelling) used together with visualization techniques is one of the best tools for communicating about oceans and coasts. Both aspects are discussed later in this chapter.

In addition to problems of physically accessing the marine environment, the basic task of identifying the relevant stakeholders and convincing them to take part in a public process may be challenging. Engaging hard-to-reach sectors of the public in planning initiatives can be challenging, due to various barriers ranging from physical (e.g., difficulty in attending public hearings), to technical (e.g., language difficulties among immigrants or difficulty using the internet among the elderly). The coastal area is well known as a location of conflict between user groups (Portman et al. 2012). Getting conflicting user groups to come together can be impractical, or impossible.

The good news is that many tools exist for planners that facilitate public involvement in marine and coastal planning and management. For example, research-based guidance exists to scope for impacts of offshore development (see Portman 2009) in the planning of marine protected areas (see Dalton 2005) and for using public participatory GIS (known as PPGIS or PGIS) to solicit socioeconomic data (see St. Martin and Hall-Arber 2008). Activities that revolve around data generation (from the public), data presentation or actual decision making, benefit greatly from best practices in environment communication.

9.3 Communicating with Policy Makers

Planners often serve as go-betweens in the policy-making process, as agents who bridge the gap between the public's wishes, science and policy. This can be a difficult process complicated by the distinctive nature of the career goals of practitioners, scientists and decision makers. Planning practitioners are often aiming to implement the goals of their clients; scientists are busy researching topics that are "hot", current and fundable; whereas decision makers are frequently at the mercy of elected officials and their appointees. In the latter case, goals are short term – i.e., something needs to get done during the incumbent's term – and for academic scientists, time is needed to conduct experiments, write about them and ensure continued funding.

The planner's role may be to ensure the public's participation in a planning process and to see to it that the public's vision is reflected in the activities of decision making. Reading Arnstein's seminal paper (Arnstein 1969), which describes a typology of public participation depicted as eight rungs on a ladder, ranging from manipulation (nonparticipation) to complete citizen control (citizen power), is a good way to start learning about the range of outcomes from a public participation process (described in Chap. 1). However, here I focus on bridging the science-policy gap. As much as possible, planning and management of oceans and coasts should be science-based. Therefore, planners need to learn how to convey the right technical information to both the public and policy makers and, as such, go beyond communication aimed purely at civic engagement.

Common tools used by planners are those that construct the future and include projections and forecasts derived from baseline (scientific) data. A projection is the result of entering hypothetical assumptions into a mechanistic, quantitative procedure. A forecast represents a best guess about the future, achieved by incorporating judgment about the most likely future behaviors and other assumptions. Part of the judgment required for a forecast includes decision making about the quality of input data and the type of analytical model needed to provide the most realistic results.

Standard methods for constructing projections, such as the cohort-component method used for population growth studies, or trip generation models used for transportation planning, are appropriate accounting systems which rely on hypothetical assumptions. The most common of these tell us that if rates of behavior continue, the outcome is foreseen (Myers and Kitsuse 2000). For planners working with policy makers, such tools can be integrated with tools that are more community/stakeholder-oriented such as visioning, scenario development and storytelling (Myers and Kitsuse 2000; Chakraborty 2010; van Hulst 2012). For presentation to policy makers, planners will need to evaluate the forecasted future for its level of desirability and potential alterability (Box 9.1).

Box 9.1: Common Environmental Communication Terms (Adapted from Cox 2013)

Aarhus Convention of 1998	Adopted in Aarhus, Denmark, this is an environmental agreement of the UN Economic Commission for Europe addressing access to information, public participation in decision making, and access to justice in environmental matters (similar to legal “standing”).
Agenda setting	An action, usually involving the media, aimed at affecting the public’s perception of the salience or importance of issues.
Frame	This refers to the cognitive maps or patterns of interpretation that people use to understand reality or to develop a narrative.
Narrative	Organization of phenomena through stories to aid in understanding; a story or account of events as understood by the storyteller.
Rhetorical perspective	Purposeful and consequential efforts to influence society’s attitudes and behavior through the effective use of communication.
Rhetorical genre	Specialized literary uses of language that can be categorized as a particular form or type.

A number of European research programs – such as COREPOINT (Carlisle et al. 2008) and GESAMP (GESAMP 1996) – have specifically targeted the issue of bridging the gap between science and policy making for planning and management of coastal environments. The COREPOINT program used an “expert couplet” model design for nine sites in Northwest Europe. The expert couplets are long-term partnerships promoting joint activities between COREPOINT researchers and local authorities. For each site, information collected about the physical nature of the shoreline, land and seafloor substrate, topography/bathymetry, the nature of hydrological dynamism, erosion versus accretion, socioeconomic data about nearby populations and terrestrial, littoral and marine ecology, served as a scientific background. The role of planners, in these cases, consisted of bringing researchers, policy makers and decision makers together to make use of available information.

Planners will choose tools appropriate to the type of planning with which they are involved, as this will determine the interaction they will have with policy makers. For example, advocacy planners (see Chap. 1) may be involved in drawing attention to the need for policy change through the use of a focusing event. This is a form of agenda setting that serves as a catalyst to get the attention of environmental policy makers. Agenda setting is the collection of activities that policy entrepreneurs engage in to direct the attention of public officials towards a particular problem.

Rapid Assessment Visual Expedition is an example of an agenda setting activity that employs visual communication. In 2010, the International League of Conservation Photographers and the Chesapeake Bay Foundation combined forces, using this method to draw attention to the environmental issues surrounding the Chesapeake Bay watershed. In a short period of time, advocates for the Bay enlisted the pro bono services of expert photographers to generate images that were used to prompt policy makers to acknowledge the importance of the controversial Chesapeake Bay Clean Water and Ecosystem Restoration Act (Schwarz 2013).

9.4 Tools

The main tools discussed in this section are narration and visualization. Often the two go together. The idea that a picture is worth a thousand words only goes so far – once the thousand words have been expressed! – while the *combined* use of narration and visual images is often unforgettable.

Perhaps you remember a scene from the 2006 documentary movie about climate change: *An Inconvenient Truth*, featuring former US Vice President Al Gore. In this movie, the effects of water creeping across, and eventually covering, much of the state of Florida as a result of sea level rise is shocking. Whether or not these images portray a future reality or a worst-case scenario that may never come to pass, the dramatic effect is palpable. There is much to be learned by planners from researchers working on visualization of climate change, much of which involves analyzing maps and simulating scenes of coastal and marine areas.

Professor Stephen Sheppard of the University of British Columbia, a landscape architect, has led interesting research on the use of visual imagery to increase peoples' awareness of climate change. He advocates applying high professional standards to convey the science of climate change. Uncertainties must be acknowledged and professional credibility maintained in this particularly sensitive and heated topic whose causes inculpate the foundations of our society. Such efforts need to address the "3 Ds" of visualizing the future: disclosure, drama and defensibility (Sheppard 2012). Many scenarios simulated by Sheppard are images of vulnerable coastal areas, such as images of seaside communities after predicted storm surges (Fig. 9.2).

9.4.1 Narration

Our world is awash in information and much can be lost if we fail to process it. Narrative helps us process information. Research shows that narrative structure enhances brain activity (Hasson et al. 2008). For mobilizing public opinion about oceans and coasts, conveying impressions can be very effective. Personal narratives that identify real individuals with real places (Box 9.2) have been shown to affect people to the point where they are mobilized to act on subjects such as flooding, sea level rise, increased storm activity, coral bleaching and impacts of invasive species (Shaw et al. 2009).

An example of a universal narrative template is And, But, Therefore (ABT). It works by conveying tension followed by resolution. For example, on the topic of marine conservation, we can streamline facts into this premise: man has improved his ability to exploit the marine environment in recent years AND this has coincided with the need to seek alternatives to crowded terrestrial areas, BUT intensified human activity in the marine environment has resulted in degradation of marine habitats. THEREFORE, a more sustainable approach to marine development is necessary.

Fig. 9.2 Visualization of climate change effects along coasts (South Delta, British Columbia) (Adapted from Sheppard 2012. Reproduced with permission of Stephen R. J. Sheppard)

Box 9.2: Sgeulachdan na Mara/Sea Stories: Narration and Visualization

An interesting project that combines narration, mapping and artistic visualization is an interactive internet site entitled Sgeulachdan na Mara – Sea Stories (http://www.mappingthesea.net/barra/). This project grew out of collaborative research undertaken by social ecologists Ruth Brennan and Iain MacKinnon with artist Stephen Hurrel. The site explores the intimate relationship between people and place, and seeks to make visible (and audible) the rich cultural knowledge that exists in the seas around Barra, Scotland. The dynamic map reflects intergenerational knowledge, particularly the fishermen's unique ways of knowing the sea and the intangible cultural heritage of the marine environment. As described by the creators of the site, it developed as a way of bringing to life what is "often invisible to most people."

(continued)

Box 9.2 (continued)

Sgeulachdan na Mara – Sea Stories: *Barra*. © *Hurrel and Brennan*

Reproduced by permission of Stephen Hurrel and Ruth Brennan, affiliated respectively with Hurrel Visual Arts and the Scottish Association for Marine Science.

A case in point is that of scientist-turned-filmmaker, Randy Olson, who was recruited to give a makeover to the plenary panel discussion for the 2013 meeting of the Coastal and Estuarine Research Foundation (CERF). The title of the plenary discussion was changed from the rather mundane "Responding to Sea Level Rise" to "Sea Level Rise: New, Certain, and Everywhere". Olson crafted three stories around the three keywords of the subtitle using the ABT template, which ended up being the focus of a very successful CERF meeting (Olson 2013).

Planners may also find that rhetorical perspective and certain rhetorical genres are useful. Although rhetoric traditionally has been viewed as an instrumental or pragmatic activity (i.e., persuading others), it also helps to shape (or constitute) our perception of the world. In order for planners to educate, to persuade, and to mobilize the public and policy makers to decision making, they may employ different rhetorical styles, from argumentation to emotional appeal. Rhetorical genres, distinct forms or types of speech or writing, may also be used. These might be sublime in style, like Jacques Cousteau's writing, which evokes feelings of spiritual exultation about the ocean world, or they might be apocalyptic in style. The latter genre, warning of impending and severe ecological disaster, has been used by Rachel Carson in *Silent Spring* and Paul Ehrlich in the *Population Bomb* (Cox 2013).

9.4.2 Visualization

Communication about the natural world, including ocean and coastal environments, often relies on the visual senses. The practice of "visualization" involves making and manipulating images that convey novel phenomena and ideas. These could be 3D or 4D[4] maps, graphical presentation of data or real and manipulated scenes such as photo images showing fabricated or constructed reality (virtual reality).

Visualization has increased in importance as a form of communication as the idea that "seeing is knowing" continues to become increasingly entrenched in Western society. Scientific research has confirmed that the visual sense is by far the most dominant component of human sensory perception (Lange 2011). Therefore, planners should be aware of some fundamental principles of visualization, as well as some innovative techniques.

The often-heard expression "the whole Gestalt" comes from Gestalt psychology, founded by German theorists in the early twentieth century. Gestalt psychology focuses on how people interpret the world. Psychologists noted that sequences of perceptual events, such as rows of flashing lights, create the illusion of motion even when there is none. Motion pictures use this principle. Based on these discoveries, Gestalt philosophers and psychologists developed a set of principles to explain perceptual organization, often referred to as the "laws of perceptual organization" or "Gestalt rules" (Sigman et al. 2001).

Gestalt methods have been used for scientific observation, such as in geology (Amoreaux and Gibson 2013), for the field of cartography (Schmidt and Delazari 2013) and even for natural scene analysis (Sigman et al. 2001). While a detailed description of the use of the principles in environmental planning is beyond the scope of this chapter, Box 9.3 explains them briefly. Land or sea use patterns are understood better through known means of perception and these can be Gestalt-based.

Considering coastal and marine environments in their totality is important. For instance, bathymetric-topographic maps may provide experts with a reasonable picture of what is happening underwater or along the terrestrial coastline, but cutting-edge mapping techniques (such as those described further on in this section) together with land and seascape virtual simulation can make accessible many aspects of oceans and coasts to the public at large and to policy makers.

Marine environments engender special visual communication challenges. Visualization techniques, such as maps, graphics and virtual reality, are particularly important as marine environments farther from shore are impacted by development.

[4] The fourth dimension refers to that of time (temporal), showing changes over time.

Box 9.3: Gestalt Principles of Visual Perception

Gestalt psychology, developed by German thinkers in the 1920s, tries to understand our ability to acquire and maintain meaningful perceptions in a seemingly chaotic world. In the field of imagery, it applies to principles of perception. *Gestalt* (German for "shape" or "form") theories describe how people tend to organize visual elements into groups or unified wholes.

Similarity	Objects look similar to one another. People often perceive them as a group or pattern.
Continuation	Continuation occurs when the eye is compelled to move past one object and continue to another object.
Closure	Closure occurs when an object is incomplete or a space is not completely enclosed. If enough of the shape is apparent, the whole is perceived by filling in the missing information.
Proximity	When elements are placed close together, they tend to be perceived as a group.
Figure and Ground	The eye differentiates an object from its surrounding area. A form, silhouette or shape is naturally perceived as a figure (object), while the surrounding area is perceived as ground (background).
Source: http://graphicdesign.spokanefalls.edu/tutorials/process/gestaltprinciples/gestaltprinc.htm	

These locations, often far from human inhabitants, are environments unfamiliar to the general public and to policy makers. They are hard, if not impossible, to access. Great time and expense is involved in accessing them. Dramatic changes are taking place in oceans due to climate change, which require both 3D (depth) and 4D (time) representation capabilities. While there has been some work on visualizing climate change, both through simulation maps and scenes along terrestrial coastlines (see Shaw et al. 2009), communicating climate change effects in the deep sea lags behind.

Often, data collected from marine observation projects and outcomes of modeling are too abstract to intuitively be used to represent marine characteristics. Researchers working on marine data visualization (and there are such specialists!) contend that processing this data into useful information should be one of the main interests of the marine field (He et al. 2010). Barriers to visualization of marine characteristics are often greater than they are for terrestrial environments because oceanographic processes almost always occur in a 3D space and involve boundary uncertainty, spatio-temporal significance, and are highly dynamic.

9.4.2.1 Mapping

A 1966 article in *The Cartographer* proposed the term "graphicacy" to complement the existing terms "literacy", "articulacy", and "numeracy", already used in the field. Graphicacy is defined as the ability to communicate effectively and understand those relationships that cannot be expressed solely with text, spoken words or mathematical notation, through the use of visual aids, particularly maps (Balchin and Coleman 1966). More significant than the term itself is the concept behind it: words or mathematics, suitable for comprehension of some phenomena, are highly inadequate for others. This understanding led to contributions of graphicacy to the more recent field of cartographic visualization (Hallisey 2005), which studies the application of visualization principles to map making.

Cartography textbooks of the mid-1950s through the 1980s emphasized improving mapping design. This revolved around improving ways to depict hachures and other symbols (today referred to by the GIS term "symbology") to more effectively communicate with the map user. These concerns have much to do with viewer (user) perception and how such "visuals" work (with foundations going back even to Gestalt), and they are by no means trivial. However today, GIS-based geo-visualization is more concerned with multidimensional geospatial representation; far beyond the straightforward graphic depiction of features.

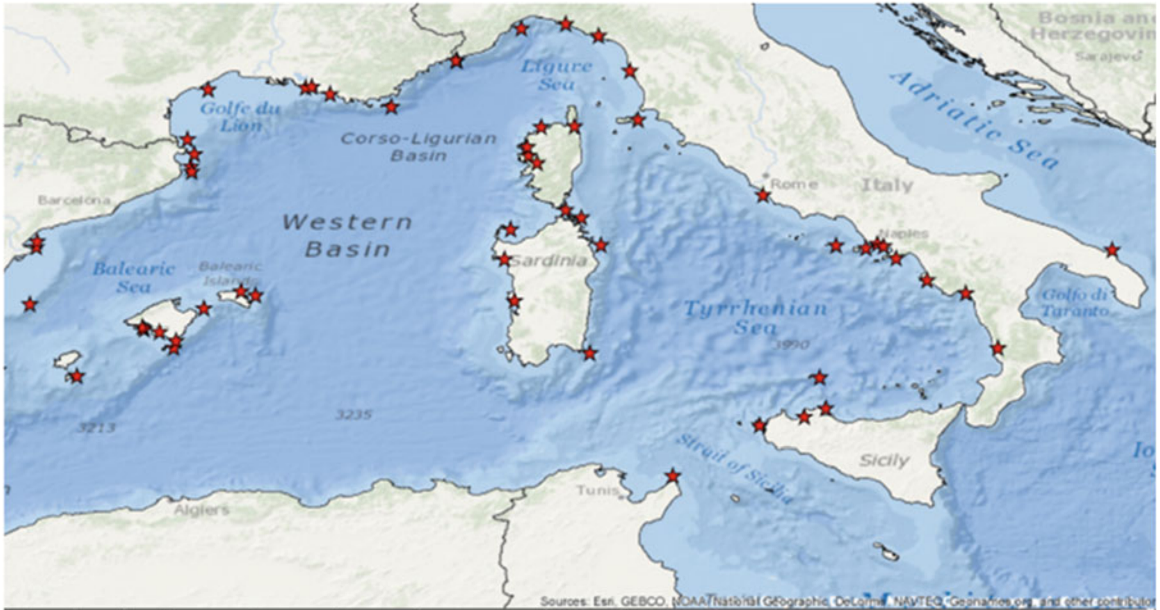
Through GIS, features can be effectively linked to dynamic data sets (Fig. 9.3), thus facilitating both presentation and spatial data analysis. This coincides with the recognition that aspatial analytical techniques alone are inadequate to study data for planning; the effective display of maps is necessary for full understanding.

Recognition of the power of visualization in conjunction with advances in GIS has led to advanced cartographic visualization applications. Such tools incorporate techniques for decision support (see Chap. 10) and are frequently used for marine conservation planning and marine spatial planning. For the most part, spatial visualization research has focused on two methods: spatial and spatiotemporal visualization.

9.4.2.2 How to Present Non-spatial Data

Aspatial (non-spatial) information needed for planning is most commonly presented in tables or figures. Early in the history of scientific literature, subject matter came primarily from descriptions of observations and deductions, or citations of earlier authorities, going back to Aristotle. Eventually, numbers were collected to quantify observations, and since numbers burdened the prose, to be more compelling and concise, scientists began to separate out numbers from text (Valiela 2009).

Cut-and-dry representations of information in graphs and tables is part of visualization, as are photographs, videos and even virtual reality. Graphs, tables, figures and 2D maps are forms of expression that depict novel, and sometimes quite



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	2	Point	2	Al Hoceima	Morocco	2004	2	Alboran Sea
	3	Point	3	Alonissos-Vories Sporades	Greece	1992	2	Agean Sea
	4	Point	4	Archipel de la Galite	Tunisia	1980	4	Levantine
	5	Point	5	Archipelago di La Maddalena	Italy	1994	2	Western Mediterranean
	6	Point	6	Archipelago Toscano	Italy	1989	2	Western Mediterranean
	7	Point	7	Archipielago de Cabrera	Spain	1991	2	Western Mediterranean
	8	Point	8	Area Amantea	Italy	2004	Uns	Western Mediterranean
	9	Point	9	Isole Tremiti	Italy	2004	Uns	Adriatic

Fig. 9.3 A geo-visualization of the distribution of the marine protected areas (*stars*) in the Mediterranean Sea using an ESRI (www.esri.com) world oceans base map

complex, phenomena. Planners should try to combine these forms as much as possible using advanced GIS techniques and tools when appropriate.

Our eyes and minds evaluate graphical cues with different degrees of accuracy. Empirical research has led to the development of guidelines about which graphical cues are the most effective. For example, seminal research by Cleveland (1985) found the following cues to indicate levels of accuracy (listed from most to least): position along an axis, length, angle or slope, area, volume and lastly, color or shade. Therefore, decoding of graphs by viewers will be most accurate if planners use cues that are ranked as highly as possible. Planners should therefore avoid using graphics in which viewers must make judgments based on areas, volumes, color and shade (for more tips and information, see Valiela 2009).

9.4.2.3 What to Present

In addition to dilemmas about *how* to present data, planners face questions about *what* to present when communicating with the public and policy makers about oceans and coasts. Despite earlier statements lamenting the shortcomings in visualization of all four dimensions of ocean data, there are many tools and techniques available. Planners, like potential participants in a planning process, must contend with an information explosion.

New remote sensing technologies provide a steady stream of coastal and marine data that can be used by planners and managers. Data from several long-standing sensor arrays, such as weather stations, seismic monitoring networks and a host of satellite sensor programs, is supplemented by data from numerous smaller-scale networks that incorporate both fixed and mobile sensors. This growing volume of data is highly dimensional and heterogeneous with complex spatial and temporal regimes and multiple variables.

Ocean observing systems (OOS) provide sources of data that are relevant to planners. For example, the Gulf of Maine OOS (GoMOOS) has one of the longest continuous data records of complex, high-dimensional data being generated by sensing arrays. The GoMOOS array includes spatially distributed data buoys that collect and report meteorological and oceanographic variables hourly from multiple depths (http://gyre.umeoce.maine.edu/ or www.gomoos.org). Surface and near surface measurements include wind speed and direction, atmospheric pressure, visibility, solar insolation, surface waves, temperature, salinity and near surface currents measurements. Subsurface measurements include water column current profiles, temperature, salinity, ocean color, multi-wavelength light attenuation, light scattering, chlorophyll fluorescence and dissolved oxygen measurements.

Such data can be presented by planners and used by modelers. He et al. (2010) distinguish between object models, which represent discrete phenomena (usually scalar and vector data), and field models, which represent continuous data sets. The former is used to represent coastline, ocean use areas, fishing grounds and static, place-based infrastructure – the substance of maps that can be easily adapted by the advanced visualization tools described below. Field models are used to represent layers at different depths (such as temperature, salinity, density and acoustic layers), eddies, currents, water masses and measures of wave, chlorophyll rates, etc. Dynamic models can depict four-dimensional data in maps, graphs or other types of visualization schemes.

Unfortunately, even advanced spatial visualization techniques have not effectively dealt with the importance of the third (depth) dimension, essential for visualizing the ocean environment. In many instances, 4D is dealt with before 3D (as in Fig. 9.2). Even 3D maps and depictions are often viewed two-dimensionally. Stereoscopic glasses are needed to view maps and scenes in a virtual reality theater in true 3D, although new screen types are under development that will render the use of special glasses obsolete.

9.4.3 Advanced Visualization Tools

Advanced visualization techniques gaining ground in recent years for coastal and ocean planning include web-based GIS platforms (e.g., interactive decision support tools) and immersive and reality theater (e.g., 360° screens and high-quality sound systems).

9.4.3.1 Advanced GIS

Web-based systems known as software as a service (SaaS)[5] are being tailored to planning initiatives. They allow anyone with a web browser to actively participate in marine and coastal planning efforts. These applications use GIS and they are becoming more participatory, intuitive and user-friendly all the time.

Some of these services are quite basic – they allow "layers" of information to be uploaded and displayed. By turning layers "on" or "off", these systems inform users about what exists where. Online images show the geographic location of marine and coastal infrastructure, use areas, environmental conditions and proposed locational boundaries. Other applications are more complex; they apply algorithms that consider preferences, weights or chosen measures of efficiency (see Chap. 10). By processing information organized as GIS layers, a recommended or preferred option or group of options is produced.

An example of the first type of application, used for collaborative planning design, is SeaSketch (http://www.seasketch.org/). It allows users to initiate a project by delimiting a study region, uploading map layers from existing web servers and defining "sketch classes", indicating the graphic boundaries of

[5] Sometimes referred to as "on-demand software", SaaS is a software delivery mode in which software and associated data are centrally hosted on the cloud (internet).

proposed uses such as for marine protection, transportation zones or renewable energy sites. Other application features allow users to sketch and receive automated feedback on those designs, such as the ecological value or the potential economic impacts of a marine protected area, and to share sketches and discuss them with other users in a map-based chat forum.

There are also complex GIS-based decision support tools that can be used for planning such as Zonation and Marxan with Zones. These have been frequently used for marine and coastal planning, mostly with the goal of balancing conservation with development (Stewart et al. 2007; Leathwick et al. 2008). Zonation offers the use of a number of algorithms to design a spatial management plan based on what is considered a step-wise heuristic. Its meta-algorithm starts from the full landscape and iteratively removes those areas (cells in a grid) whose loss causes the smallest marginal (incremental) loss in overall conservation value. Marxan uses stochastic optimization routines (i.e., spatially explicit simulated annealing) to generate spatial reserve systems that achieve particular biodiversity representation goals with reasonable optimality (both discussed in Chap. 10).

The choice of which type of application to use and whether to use existing software or to develop an application depends on the resources available and the ultimate goals of a planning process or management approach. If public participation is very important, then it would be wise to carefully weigh options, starting with an exercise that identifies all possible users and their needs. This can be done by devising a set of "user cases" (Fig. 9.4) and carefully researching existing possibilities. Options are continuously evolving as visualization cartography and channels of communication develop over time.

9.4.3.2 Reality Theater

Visualization techniques have been used in planning, first through the use of models, then drawing and painting. Initially, perspective drawings were used. These evolved into before-and-after replications based in real-world views. Analog and then digital photomontage techniques became the next generation technology. Now, virtual environments have become the cutting-edge tools for simulating land and seascapes to obtain subjective evaluation and/or solicit public participation. Such simulations use theater-like laboratories to recreate reality. These visual "realities" can be completely fabricated (synthetic) or combine both real (photo) and digitally created images, usually referred to as "mixed reality".

Whereas audiences will often forget information they see in graphs, when they come closer to actually experiencing what they see through visualization techniques, impressions may be "unforgettable". Multimedia scene simulation (e.g., including sound and physical changes that affect viewing experience) includes virtual immersive reality and can be connected to spatial and temporal display of maps and even data set presentations.

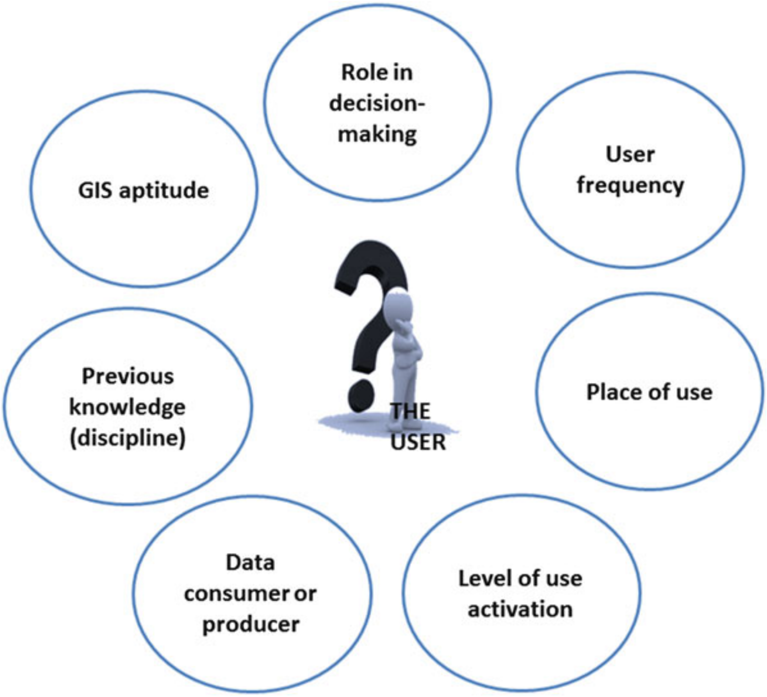

Fig. 9.4 User cases address all these factors and can lead to successful PGIS, which, in turn, can lead to better information and data and greater participation in decision making

An advantage of advanced visualization techniques, including virtual reality, 3D and interactive viewing, is that environments that don't yet exist or are inaccessible can be reached virtually. For the marine environment, physically being present in a submarine location is often either too expensive or impractical and in these cases, visualization has much to offer.

9.5 Summary

Communicating about oceans and coasts is an important subset of the overall field of environmental communication. As a discipline, environmental communication considers myriad modes of interaction, from discourse and rhetoric in popular media to further goals of conservation and environmental protection (see Cox 2013). This chapter has provided an overview of the topic of environmental communication with the general public and with policy/decision makers within the marine and coastal planning context.

Communication is about influencing minds and influencing and even changing behaviors, as is most environmental planning and management. Some say that planners have a moral obligation to communicate choices regarding the marine and coastal environment to the public and policy makers. In order to be effective and change behaviors, planners must often affect perceptions based on what they know about the environment and others have yet to learn.

At the same time, however, planners need to solicit responses. To do so requires more than just transferring information through maps and graphs to viewers. It demands the use of best practices, the latest technologies appropriate to the context in terms of available resources and viewer capacities, as well as abiding by certain standards. There is much available research to draw on, much of it from work done on terrestrial environments, particularly in the field of climate change. Communicating about the submerged environment has particular challenges as described herein, and more research is needed. In the meantime, the emerging field of visualization for oceans and coasts can best be served by drawing on other fields such as landscape architecture and planning, cartography and conservation planning.

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Chapter 10
Decision Support Tools for Coastal and Ocean Planning and Management

The progress of rivers to the ocean is not so rapid as that of man to error.

– Voltaire

Abstract This chapter addresses the use of decision support tools (DSTs) for marine and coastal planning. DSTs are integrative tools, meaning that they can help achieve a wide range of goals and objectives relevant to planning. Today, myriad software applications facilitate the use of these tools for the marine and coastal environment. This chapter starts with how DSTs contribute to the field of conservation planning and describes three such applications with examples of their use for marine planning. While such tools support environmental planning for oceans and coasts, they do have shortcomings, mentioned herein, and their products are usually the starting points of discussions about planning scenarios and options.

Keywords Decision making • Decision support • Heuristics • Multi-criteria analysis • Optimal solutions • Optimization algorithms • Planning units

Planning and management of coastal and marine environments aims to promote efficient use of marine space and resources while reducing use-use and use-ecosystem conflicts. To achieve these goals, environmental planners apply various methods to allocate space and to make decisions about how resources should be protected or exploited. However planning is approached and whatever theories or paradigms are used (e.g., incremental, participatory, rational, etc.), they will involve making decisions. Spatially explicit tools that aid in decision-making processes are increasingly employed by planning practitioners and other professionals involved in various aspects of ocean and coastal planning.

Decision support tools (DSTs) help incorporate data from ecological, economic and social systems, transparently assess management alternatives and trade-offs, involve stakeholders, and evaluate progress towards management objectives (Coleman et al. 2011). Many DSTs have been developed into software applications

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sold either as packages (e.g., DEFINITE)[1] or available as freeware (e.g., Marxan and Zonation). The latter two examples are state-of-the-art GIS-based DSTs tailored for spatial conservation prioritization which use targeted optimization algorithms.

DSTs facilitate science-based decision making and, in many cases, the involvement of stakeholders, the public at large and experts from various backgrounds, either practitioners or researchers. Whoever is involved, DSTs do not relieve planners of the requirement of understanding the issues at hand and the methods and models used by these tools. Also, no matter which DSTs are employed, and there are many, it is often the planner's job to make sure that the tool is appropriate and, if necessary, adapt it to the specific planning context.

This chapter starts with an overview of the purpose of DSTs, describes and reviews a few examples, and concludes with some general advice about fitting the choice of DST to particular decision-making contexts. I close by pointing out some salient limitations of DSTs. As appropriate for a book on environmental planning, problems to be solved focus on environmental quality and environmental protection issues, starting with how DSTs contribute to the field of conservation planning.

10.1 DSTs for Systematic Conservation Planning

As discussed in Chap. 8, systematic conservation planning is a science-based framework that aims to improve the designation, planning and management of marine protected areas (MPAs). It strives to optimally locate, select, prioritize and design areas in which biodiversity and other important conservation values are represented and protected so that they can persist over time. One of the most important planning actions is place-based prioritization of protection. This usually results in the determination of zones within a marine or coastal reserve, each with varying levels of protection, or, at a larger scale, results in the determination of where marine reserves should be located overall (see Chap. 6). The latter could be within the territorial waters of a nation state, an EEZ, along an entire coastline, a region or within a regional sea.

Decision support methods[2] (some in software applications such as Marxan, Zonation, C-Plan, ResNet and DEFINITE) are available for conducting spatial prioritization. There are many examples of the use of these methods for developing MPA management plans (Villa et al. 2002; Leathwick 2006; Portman 2007; Klein et al. 2008; Ban et al. 2009; Mazor et al. 2014). These methods solve spatial prioritization problems parameterized using data that are as comprehensive as possible and which reflect those elements of the environment needed for the persistence of biodiversity or other conservation features.

[1] DEFINITE stands for: decisions on a finite set of alternatives. It is also known by the Dutch acronym BOSDA. It is available through the SPINLab at the Vrije Universiteit Amsterdam's website: http://www.feweb.vu.nl/gis/research/?ResearchID=301&MenuStat=5

[2] Also referred to as decisions support software (DSS).

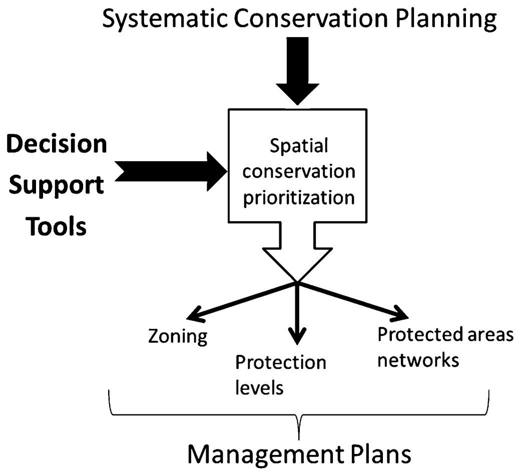


Fig. 10.1 Schematic showing the use of DSTs for systematic conservation planning

Many of these software applications use spatial design techniques to achieve goals set according to quantitative, species-specific thresholds, species' habitats or ecological processes. DSTs can use specific spatial objectives to help develop plans that define the necessary accompanying restrictions (regulations) in each spatially explicit area or zone. Such regulations and conditions are implemented through management plans (Fig. 10.1).

The first quantitative methods for systematically identifying "good" reserve sites were developed in the mid-1970s. These methods used numerical scoring to rank candidate sites according to multiple criteria, such as species richness, rarity, naturalness and size (Smith and Theberge 1986). The use of multiple criteria with regards to conservation originated in the use of such methods for planning in general; choice problems became increasingly important in urban and regional planning. Several methods were developed for the evaluation of alternative choices (first referred to as "situations") by means of a number of multidimensional evaluation criteria (van Delft and Nijkamp 1976), sometimes called multi-criteria decision analysis or multi-criteria assessment (MCA).

MCA serves to inventory, classify, analyze and conveniently arrange the information concerning choice possibilities. The method starts with a number of explicitly formulated criteria or standards of judging. These criteria can show considerable difference, i.e., they can be of various units, and they can take account of very explicit or very general priorities (Voogd 1983). Priorities can be gleaned from expert opinions or stakeholder preferences, and can be arrived at by using numerous ranking conventions.

Although first used for urban planning, a recent review of the use of multi-criteria decision analysis in environmental sciences (Huang et al. 2011) shows significant growth in its use over the past decade across all application areas. For conservation planning, spatial and impact analyses are of interest; they are found in relatively high percentages among all papers considered in Huang et al.'s (2011) study: 30 % and 42 % respectively. Examples include Brown et al. (2001), Villa et al. (2002) and Portman (2007), which use MCA for marine conservation applications in the Caribbean, Italy and the Red Sea respectively. Of these, Brown et al. (2001) uses MCA for a trade-off analysis of impacts without a spatial component. DEFINITE (mentioned above), is an example of a software package that automates the MCA process; it can be used for many types of environmental decision making, including those involving conservation actions.

In the conservation context, MCA usually results in the scoring (describing "concordance" or suitability) of areas for different levels of conservation or protection (Villa et al. 2002; Portman 2007). Beyond aiming to propose a zoning scheme involving different restrictions or allowances of uses within a single reserve, the method could be used to determine a network of MPAs. A subset of reserve sites – usually those with the highest scores – would be recommended. Shortcomings of using the MCA approach for such a purpose are that the top-ranked sites will usually contain similar sets of species while missing others, and that an unreasonably large number of sites is needed to represent the desired species or features (Ferrier and Wintle 2009).

10.2 Beyond Scoring: Two DSTs for Conservation Planning: Marxan and Zonation

Because scoring systems are not designed to solve a well-defined problem, do not make use of advantages of mathematical programming and struggle to deal with spatial design criteria needed for conservation, some experts discourage conservation planners from using them (Moilenan et al. 2009). By contrast, systematic DSTs that make use of mathematical algorithms allow users to ask the question: What is the minimum number of sites needed to represent all conservation targets?

Box 10.1: What Is a Heuristic Algorithm?

For the purposes of systematic conservation planning, heuristics are a general class of sub-optimal algorithms that use time-saving strategies, or "rules of thumb", to solve problems.

The origin of the term "heuristic" comes from the Greek verb meaning "find" or "discover". A heuristic is any approach to problem-solving, learning or discovery that employs a practical methodology not guaranteed to be optimal or perfect, but sufficient for the immediate goals.

Two such DSTs are Marxan and Zonation. Both of these tools use heuristic algorithms (Box 10.1) to find the best conservation planning solution, given particular targets and constraints, with each taking a slightly different approach. Marxan uses spatially explicit simulated annealing and Zonation is a reverse step-wise heuristic. It is considered "reverse" because its meta-algorithm starts from the full landscape and iteratively removes those cells whose removal causes the smallest marginal loss in overall conservation value. While these may sound like very sophisticated (and confusing) mathematical techniques perhaps beyond the understanding of the professional planner, the reality is that when they are explained, broken down and tried, they can be extremely helpful, albeit not void of critique (see Sect. 10.5).

DSTs for conservation planning work around the concept of complementarity, whereby, in order to achieve comprehensive conservation, a set group of spatially explicit planning units is identified. Complementarity is sought by identifying efficient sets of planning units (PUs), which minimize the costs of the considered conservation action and ensure that the proscribed biodiversity features (e.g., species, vegetation types, etc.) receive some level of conservation investment (Possingham et al. 2006). In some cases, the principle of complementarity is used to ensure that the PUs prioritized for conservation complement those that have already been prioritized for investment by contributing unrepresented biodiversity features to an existing set of planning units.

Other important concepts are adequacy and persistence. One approach to address adequacy in spatial conservation prioritization is to set conservation goals as a target percentage of the original extent of a population or as a target population size that is large enough to ensure persistence of a specific conservation feature. Although there is usually much uncertainty in regards to these points, which depend on ecological theory, data availability and more, there are known ways to move forward. Some options are the use of surrogates, extrapolation techniques and the use of species distribution models (Wilson et al. 2009).

10.2.1 Marxan

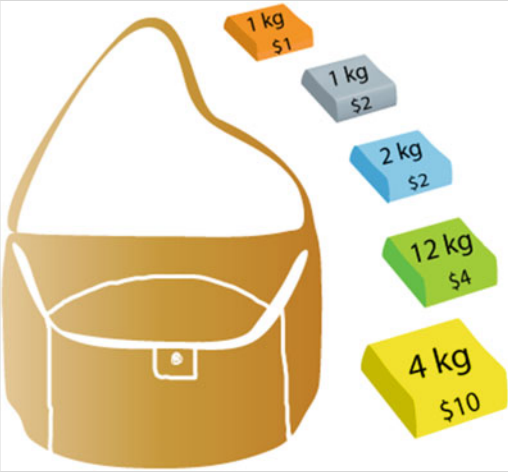
As mentioned, Marxan's optimization algorithm uses a method referred to as "simulated annealing". The term (and inspiration for) annealing comes from metallurgy, where it describes a technique involving the heating and cooling of materials in a way that increases their strength while reducing their defects. An advantage of simulated annealing algorithms is their ability to find near-optimal solutions in a reasonable amount of time. Marxan compares sets of sites for conservation consisting of PUs in a grid based on user-defined targets and costs. The preferred set will be that which achieves the declared objectives most effectively (Box 10.2).

Marxan software targets particular conservation features and works according to their desirability, but it also considers other design parameters such the continuity of an area versus its boundary length. During runs of the application, PUs are added until biodiversity targets are met. The optimal spatially explicit solution will depend on PU selection frequency during multiple runs of the algorithm.

Marxan includes or excludes a PU for protection, which is a binary proposition; the PU is either slated for protection or not (i.e., unprotected). Marxan with Zones expands on the basic reserve design problem, broadening utility for further practical application. Marxan with Zones can be used for a wide range of natural resource management and spatial planning problems beyond those of protected area design.

In the marine environment, this includes marine spatial planning (Watts et al. 2009; Coleman et al. 2011). Both Marxan and Marxan with Zones applications are freeware, available at: http://www.uq.edu.au/marxan/.

Box 10.2: The Duffle Bag Problem (The Basis of Marxan)
Systematic conservation planning often seeks to solve a type of combinatorial optimization problem such as that faced by someone constrained by a fixed-size duffle bag in which they can only carry their most valuable items. Each of the items has a real weight and a value designating its importance (e.g., monetary or ordinal) and these determine the number of each of the items that will be included. The total weight must be less than or equal to a given limit (constraint) while achieving as large as possible (maximized) total value. There are actually two possibilities for maximizing the value contained within the bag: one in which there is a single constraint – that of keeping the overall weight under or equal to 15 kg – and one in which multiple constraints, considering both the weight and volume of the boxes, are involved.



Solutions: if any number of each box is available, then three 4 kg boxes and three 1 kg ($2) boxes is the best combination; if the only available boxes are those shown, then one of each box, except the 12 kg box, is the best combination.

10.2.2 Zonation

As its name implies, Zonation produces a hierarchical zoning scheme of regional conservation priority, indicating those areas that should be protected based on

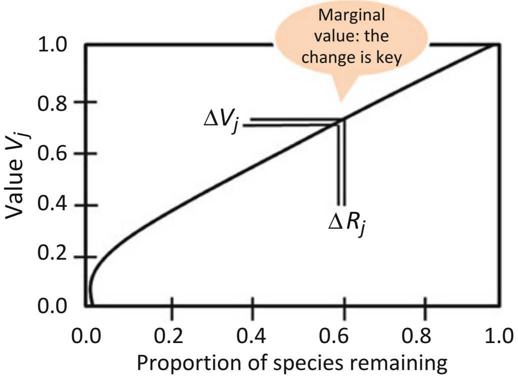


Fig. 10.2 The basis for the additive benefit function is the incremental (marginal) value of the remaining portion of the species. ΔR_j is the increment in the remaining portion of species j. The change in value is determined by how much of the species remains (i.e., where you are on the graph). (Reproduced with permission from A. Moilanen)

indicated constraints or targets. As with Marxan, Zonation's objective is to maximize the value of the reserve network; however, whereas Marxan determines the spatially explicit location of PUs slated for protection based on selection, Zonation works by cell removal. Another difference is that Zonation's cell removal base algorithm depends more specifically on concepts of species population viability analysis.

The underlying assumption is that cells will be iteratively removed from the full land or seascape according to their benefit, which changes as fewer cells remain. For example, the additive benefit function (one of several choice options, see Fig. 10.2) removes the cell with the least marginal benefit from among the remaining cells with each consecutive run of the software (Moilanen 2007). The core area function and target benefit functions are other variants which can be employed by Zonation to determine how cell removal works; each function is conceptually different in how it trades off between species in the planning of protected areas. The user modulates these differences to arrive at various optimal solutions for reserve design.

A well-known study in the marine realm concerns the determination of marine protection priorities offshore of New Zealand (Leathwick 2006). The measure of biodiversity protection used in this study was the average proportion of the predicted geographic ranges of over 100 fish species that would be contained in the reserve areas. Some species are more important than others (e.g., due to endemism or commercial importance). Therefore, weights are applied to indicate the importance of species' characteristics. A cost layer was incorporated such that the costs of prohibiting uses such as trawling or very intense commercial fishing could be minimized. The study concluded that equivalently sized reserve areas indicated by Zonation analysis could deliver roughly two and a half times the conservation benefits over the already existing reserve system. Marine managers could also avoid instating "no-take" policies and other use prohibitions on areas essential for commercial fisheries (Leathwick et al. 2008).

10.3 DST for Other Marine Issues

Originally developed for the management of fish stocks, Ecopath with Ecosim (EwE) is an ecosystem modeling software suite. It has the ability to explore management policy options, to address ecological questions and to model the effects of environmental change. The package has three main components: Ecosim, Ecopath and Ecospace.

The basic Ecopath model creates a static, mass-balanced snapshot of the resources in an ecosystem and their interactions (Polovina 1984). The average state of an ecosystem, based on the structure and function of ecosystem components, is used to depict changes in biomass and trophic interactions (Pauly et al. 2000). The second module, Ecosim, infuses a time element into the basic Ecopath model, and Ecospace adds a spatial dimension so that effects in space are also considered. The mass-balance approach used by EwE to construct food web (biomass dynamics) models of marine ecosystems is based on two master equations: one that describes the functional groups' biomass production and one that describes its energy balance.

The advantage of EwE is that, by simulating perturbations, one can use models to evaluate how ecosystems respond over time. Generally, the model seeks to determine the growth rates of grouped species (functional groups) over time and space based on their growth efficiency, considering factors such as total consumption by group, predation, natural mortality rates, fishing mortality, emigration and immigration. Consumption rates are calculated based on the "foraging arena" concept, which explains the trade-off in animal behavior between fitness and predation. According to this concept, animals constantly move between vulnerable and invulnerable states; the transfer rate between these states is used in the model to determine if control in the system is top-down (i.e., Lotka-Volterra),[3] bottom-up (i.e., donor-driven), or of an intermediate type, related not only to predator-prey interactions, but also to human activities.

Using Ecosim on data samples, a user can simulate relatively simple future measures such as functional group or species extinction resulting from overfishing or intense predation. More sophisticated sampling that indicates the effects of human activities, such as development or commercial fishing, can lead to an understanding of the effects on each of the functional species groups in the ecosystem.

The spatial component of Ecospace dynamically allocates biomass across a grid map while accounting for: (a) symmetrical movement of species from a cell to its four adjacent cells, modified by whether a cell is defined as "preferred habitat" or not; (b) user-defined increased predation risk and a reduced feeding rate in non-preferred habitats; and (c) a level of fishing effort that is proportional in each cell to the overall profitability of fishing in that cell and whose distribution can also be made sensitive to costs.

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[3] Based on a mathematical model that uses a differential equation to describe the interactions between predator and prey (Chauvet et al. 2002).

In an interesting case study, Ainsworth et al. (2008) used EwE to develop ecosystem models to help manage fisheries in the Raja Ampat Archipelago, located west of New Guinea, where the marine environment was increasingly threatened by destructive fishing, land-based pollution and outbreaks of corallivores.[4] The simulation model enabled evaluation of the likely ecosystem-wide effects of several fisheries management options. These included alternatives such as various harvest strategies (for example, restricted grouper fishery, increased tuna fishery), as well as fisheries gear changes (e.g., excluding net fishing, increasing blast fishing). The study showed the advantages to be gained by such DST techniques, even in situations of poor data and weak policy implementation.

10.4 Decision Support for Marine Spatial Planning

The widespread interest in systematic conservation planning together with the emphasis on ecosystem-based management (EBM) in marine planning have contributed to the use of DSTs for general marine spatial planning (MSP). Such tools are now commonly used for much more than improving conservation outcomes.

The systematic component, often desired as part of MSP, provides a framework for more comprehensive, flexible and science-based planning processes. The term “spatial” indicates a place-based emphasis. This is necessary because, in the past, marine policy and management has not been particularly “place-based”. MSP goals often consist of promoting efficient use of marine space. To achieve MSP goals aimed at the efficient use of resources together with the reduction of use-use and use-ecosystem conflicts, planners and managers need spatially explicit tools. Most of the DSTs used in marine management are GIS-based, meaning that their spatial component and the third dimension (depth) is key.

There are many advantages to using DSTs for MSP. They can facilitate the integration of different types of data (e.g., ecological, economic and social), provide transparency, help weigh management alternatives and trade-offs, improve stakeholder involvement and evaluate progress towards management objectives.

If DSTs include modelling capabilities, they can play an important role in supplementing field observations. They can fill observational data gaps, investigate and clarify processes and can try out theoretical scenarios. They can also assist in setting ecological targets in order to fulfill legal obligations with regard to directives, international conventions and agreements, or national legislation. Model applicability and usefulness for marine management not only depends on the quality of the output, but also on the possible range of relevant model products (Mohn et al. 2011).

[4] Refers to outbreaks of large populations of coral polyp-eating organisms, e.g., starfish.

A useful decision guide published by Stanford University's Center for Ocean Solutions (Coleman et al. 2011) delineates a number of DSTs that have been specifically designed to help planners conduct MSP in their own jurisdictions (such as SeaSketch) or have been used for MSP although originally designed for ecosystem services assessment (such as InVEST). The guide provides a brief description of a number of DSTs and explains how each tool works for purposes of spatial planning. It also gives information about other aspects of the tools, such as what level of technical expertise is needed to operate them, where they have been used in the past, how to access them, and who funds their development.

10.5 Limitations of Decision Support Tools

Anyone who believes DSTs are a panacea for the challenges of decision making in the marine environment will be disappointed. There are many decision-making challenges that cannot be solved by DSTs. In addition, many decisions must be explicitly made for the operation of these tools prior to and during their use. For example, Marxan requires numerous decisions to be made about the quality and quantity of conservation targets. Also, whatever system of weighting is used for MCA (see Huang et al. 2011), it is hard, if not impossible, to avoid some level of bias.

There is much confusion about what exactly DSTs do and don't do. A baseline understanding of the specific character of each tool is a prerequisite to choosing one, in order to match expectations to realistic outcomes and to get maximal benefit from their use. For example, the difference between decision support tools and visualization tools (see Chap. 9) must be clear. While the main purpose of visualization tools is to display information, they also have the potential to improve decision making, especially when stakeholder involvement and public participation are paramount in a planning process. However, visualization methods are not designed exclusively for decision making.

DSTs use algorithms and modeling, and they indicate solutions through the processing of data. As these tools develop, in the form of software applications, they have a tendency to become more generalized. For example, while Marxan, originally developed specifically for protected area management (using a binary, reserved/not reserved output), it now can consider myriad uses, related to both conservation and development, at different intensities and levels (e.g., Mazor et al. 2014). Thus, Marxan with Zones has become a common tool for MSP (Coleman et al. 2011). Still, many DSTs are better suited to solving particular types of problems because they were developed with a particular use in mind. The trick is to choose the right one for the task at hand. This is often the planners' job.

Lastly, the results of DSTs must be understandable. In other words, if the process of arriving at outcomes is beyond the reasonable understanding of constituents, whether project proponents, politicians or the public at large, there is a high likelihood they will not be accepted – despite fancy algorithms. Rather than being the endpoints, the products (or outcomes) of DSTs are often the starting points of discussions with stakeholders and among planning professionals (Portman 2007).

10.6 Summary

For decades, simple scoring methods have been applied to environmental decision making, including spatial prioritization problems; these are among the most straightforward and easy-to-apply decision support methods used for planning. However, many marine policy experts claim that they have significant shortcomings. If technological skill and understanding supports the use of more sophisticated methods, there are many options available. Software applications that use automated optimization algorithms to aid decision making have been used in the marine environment, both for conservation and spatially explicit planning, zoning and resource management.

This chapter has described three example DSTs used for marine and coastal planning, but there are many others. For the most part, those described here are integrative tools, meaning that they can be applied to a wide range of goals and objectives relevant to planning in the coastal environment. There are many more software applications, techniques and methods used for specific aspects of planning. For example, in the realm of resource extraction, seismic survey tools can help decision making regarding actions related to offshore oil exploration and extraction; other software can aid in making decisions related to preparedness for catastrophic oil spill events, tsunamis, coastal vulnerability, resilience and more.

The reasons that DSTs have been used in conservation planning, particularly in the establishment of a network of MPAs, has to do with the difficulties in finding optimal solutions in a reasonable amount of time using data available, given that not all the factors and parameters involved are known. Most cutting-edge DSTs seek a range of near-optimal solutions, essential when resources for conservation investment are scarce and when mounting threats to the environment demand immediate attention.

Despite their growing use by academics and practitioners, there are some disadvantages to the use of these applications. Mathematical complexity, over-reliance on expert opinion and theoretical knowledge, as well as inappropriate choice of a DST for the task at hand may complicate matters. More research is needed to follow up on the use of DSTs in planning praxis, following the course of changes made to the proposed DST outcomes. Most case studies (e.g., Brown et al. 2001; Villa et al. 2002; Portman 2007; Mazor et al. 2014) present outcomes that may or may not be used in the future by planners or accepted by stakeholders and policy makers. What determines their fate? This is an important topic for further investigation.

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Chapter 11
Current Issues: Coastal Adaptation to Climate Change

. . . in any contest between man and Mother Nature. . .Mother Nature will always win. We try to be thankful for the time we have with the land here, but we know it is always borrowed.

– Chatham Coastal Resources Director, facing the last remnants of a residential structure floating out to sea following the breach of Chatham barrier, Cape Cod. *Boston Globe* Jan. 16, 2008

Abstract Responding to climate change effects requires increasing awareness on the part of environmental planners, especially by those working in marine and coastal environments where such effects are keenly felt. This chapter covers the implications of climate change for planning, mostly as hazards expected to occur along coasts. The chapter also briefly mentions other types of hazards, not directly related to climate change, such as tsunamis. Mitigation and adaptation are two different strategies that planners use in confronting climate change. Mitigation refers to tackling the causes. Adaptation refers to coping with consequences and is the main approach in which planners will be involved. Adaptation policies should be appropriate to the context, guiding planners towards the achievement of multiple objectives, some of which need to be achieved regardless of the impacts of climate change.

Keywords Adaptation • Adaptation capacity • Coastal defense • Hard and soft coastal protection • Mitigation • Resilience • Vulnerability

It is common knowledge that changes in climate on a global scale – mostly warming effects – are caused by greenhouse gases being emitted into the Earth's atmosphere. Greenhouse gases (GHG), such as carbon dioxide (CO_2), methane, nitrous oxides and halocarbons, prevent the Earth's heat from passing through the atmosphere to outer space. The effects of GHGs are analogous to those of glass that traps heat within a greenhouse. The greenhouse effect is a natural phenomenon that

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helps regulate the Earth's temperature. As described in Chap. 3, if this phenomenon did not occur, the average temperature of the air around us would be like that on Mars, and quite cold.

The natural carbon cycle involves various stocks of carbon such as biomass "sinks" in soils, seaweeds and vegetation, dissolved in seawater and held as gases in the atmosphere. There are flows of carbon up and down between the Earth and the atmosphere, which are kept roughly in balance through photosynthesis, volcanic activity, growth and decay of organisms, etc.

Since the beginning of the Industrial Revolution, human activity has continuously liberated rising quantities of prehistoric carbon which were maintained for centuries in underground reserves of coal, oil and gas, in old-growth forests, land and sea vegetation, and in soils. Carbon is a basic element that is not destroyed by burning; rather, it shifts from form to form (e.g., solid-state hydrocarbons to gaseous CO_2). The carbon cycle, as modified by human activities such as fossil fuel burning for power generation, transportation, industrial processes and the releasing of carbon from pent-up stocks (e.g., melting permafrost), adds a net flow of GHGs of about 8–9 gigatons of carbon per year into the atmosphere. Roughly half of this is reabsorbed into the ocean and into biomass as carbonic acid (Sheppard 2012).

This chapter covers both what is expected to transpire within the ocean and coastal environment as a result of climate change, and what can be done to adapt to such conditions. Although an important topic related to climate change is mitigation (also described herein), the main focus is on adaptation processes, strategies and tools which should be considered by planners, especially when addressing vulnerable coastal human populations and resources, both biotic and abiotic.

11.1 The "Snowball" That Is Climate Change

Despite great debate about global warming in recent years, particularly pertaining to its causes, there is little controversy now (at the writing of this chapter) that by 2050 the Earth's atmosphere will contain approximately 550 parts per million (ppm) of CO_2. This compares with estimates of around 280 ppm CO_2 in the atmosphere at the beginning of the Industrial Revolution.[1] The relationship of GHG emissions to climate change effects is not linear. It can be understood much like a snowball that is small when it begins to roll down a hill, but gets larger and larger as it rolls.

[1] Atmospheric CO_2 concentration increased at an average rate of 2.0 ± 0.1 ppm per year during 2002–2011. This decadal rate of increase is higher than during any previous decade since direct atmospheric concentration measurements began in 1958 (Ciais et al. 2013).

Generally, climate change involves synergies and feedbacks. Synergies occur when the combined effects of two phenomena are greater than their effects in isolation of each other. For example, fish weakened by radiation have been shown to be more easily damaged by thermal pollution (e.g., increased temperatures) than are healthy fish. Feedbacks occur when an ecosystem, an organism or any other complex entity is disturbed by some perturbation; the effect on that entity (expressed, for example, as a temperature change or an alteration of species diversity) is the sum of both direct and indirect effects. For example, because of a warmer climate, people will likely use more air conditioning, and thus burn greater amounts of fossil fuel and emit more CO_2, causing a feedback effect (Harte 2010).

High levels of carbon emissions from direct human activity compounded by synergies and feedbacks accumulate in the atmosphere and trap more of the sun's heat on Earth. The results include rising sea levels, increasingly more frequent and severe extreme weather events (e.g., storms and storm surges), altered precipitation and runoff, elevated sea surface temperatures and ocean acidification (CRC-URI 2009). Other less commonly mentioned effects related to sea level rise (SLR) are salinization of surface and ground waters (e.g., coastal underground aquifers) and degradation of coastal habitats such as wetlands (Nicholls 2011). These factors impact most aspects of the human environment, including land use, food supplies and population distribution (Stern 2007; Sheppard 2012).

11.1.1 Sea Level Rise and Flooding

Rising sea level, the result of melting ice, and rising seawater temperature, poses a severe threat to countries that have heavily populated coastal regions that are intensely exploited for human activity. Melting ice releases water from glaciers situated on land, and as seawater warms, it expands. The Working Group (II) on Impacts, Adaptation and Vulnerability of the Inter-governmental Panel on Climate Change (IPCC) estimated in the Fourth Assessment Report that sea level will rise 0.6 m or more by 2100. The more recent report, the IPCC's Fifth Assessment Report, predicts that global sea level will rise by up to 1 m by the year 2100 (IPCC 2014). Massive deglaciation (the uncovering of land previously completely covered by glaciers) in Greenland, for example, suggests that glacial melt may play a significant role in creating an even greater rise in sea level, i.e., 1–3 m in this century (Dasgupta et al. 2007).

Global SLR has already contributed to increased coastal inundation, erosion, ecosystem change and loss of ecosystem services. These trends are expected to continue. As a result, coastal systems and low-lying areas will increasingly experience adverse effects, i.e., submergence, coastal flooding and accelerated erosion, compounded by population growth, economic development and urbanization. Some low-lying developing countries and small island states (Box 11.1) are expected to face very high impacts with associated damage costs exhibited as several GDP percentage points (IPCC 2014).

Box 11.1: Perspective: Hope for Some Small Islands

President Anote Tong of Kiribati has been warning for years that SLR means "total annihilation" for his country, composed of 33 coral islands (atolls) spread over a swath of the Central Pacific the size of India. Under Tong's direction, the island nation of Kiribati paid $8.7 million to purchase 22 km^2 of land on Vanua Levu in Fiji. This purchase is aimed at providing a safe haven for displaced citizens of Kiribati, expected to be forced to abandon their homelands in one of the first large waves of climate change refugees.

However, recent geologic studies suggest that the coral reefs that support sand atoll islands will grow and rise simultaneously with the sea. Islanders who will have to move, like people in other parts of the world, will do so because they are living too close to the shore and not because of complete disappearance of the islands.

Geomorphologists have found that during episodes of high seas – such as during El Niño events in the Central Pacific, which raise the sea level there – storm waves wash over increasingly higher sections of atoll islands. But rather than causing erosion, they deposit sand produced from broken coral, coralline algae, mollusks and foraminifera (single-celled protists with shells), thus elevating the islands. Reefs can grow 10–15 mm/year, which is faster than the rate of SLR expected to occur later this century.

Some evidence that a healthy reef can keep up growth to outpace SLR is found by drilling deep cores into reef islands to probe the past. Researchers have found that the island of Jabat in the Marshall Islands emerged on a reef 4,000–4,800 years ago when SLR was occurring approximately at the rate expected over the next century.

Other research reveals that poor shoreline management is the cause of damage from SLR. People have settled on marginal land and therefore are suffering the consequences of eroded shorelines and damage to essential resources. Current washover events dump salt water onto freshwater "lenses" – pockets of rainwater trapped in porous coral below the surface layer of sand – rendering it undrinkable for weeks. Already, people living densely on narrow sections of islands (like South Tarawa Island, Kiribati, where 50,000 people are packed into 15 km^2) are extremely vulnerable.

Whether or not shore - huggers on South Tarawa will be able to find safer land in Kiribati remains to be seen. But by most accounts, the islands' problems are due to human activities, either in the coastal zone (through faulty management) or indirectly through global effects caused largely by people in other parts of the world.

Source: Pala (2014)

11.1.2 Warming Oceans

Although rising ocean water temperatures is only one global climate change effect, it has numerous consequences for SLR, storm activity (which causes flooding and destructive wave action) and the continued existence of sea flora and fauna. How can we anticipate what the consequences of a warmer ocean will be?

Empirical research analyzes past changes in the ocean and coastal environment in view of changes in atmospheric conditions, and it can help unravel their connections. To anticipate the impacts of warming ocean water on ocean and coastal biodiversity, scientists conduct controlled experiments in laboratories or in situ, referring to experiments conducted “in the field”. Another possibility is analysis of conditions following occurrences of warming that “mimic” possible future scenarios. In either case, they monitor physiological changes in organisms or in survival rates of a particular species or group of species.

Perfect suitability of some marine organisms to the environmental conditions in which they evolved, together with their existence near areas that exhibit threshold conditions, can result in hypersensitivity of those organisms to even small changes in air or water temperature. For example, heat-shock proteins in marine snails living in the intertidal zone respond rapidly and pointedly to relatively small changes in both air and water temperatures to which they are exposed at different times of the diurnal tidal cycle. Thus, temperature fluctuations related to changing global conditions can have significant effects on the survival of these organisms at a local level (Tomaneki and Somero 1999).

Knowledge about future impacts can also be gleaned from (natural or man-made) situations in which ocean water has warmed. An example is information gained from research that empirically examined changes in benthic (bottom-dwelling) organisms in a nearshore area warmed due to the operation of a power plant along the California coast (Schiel et al. 2004).

Another case which gave insight about expected changes was a heat wave in Europe, in 2003. This heat wave caused seawater temperatures to temporarily increase to levels comparable to those predicted by long-term climate change forecasts. Massive death counts among 25 species of benthic macro-invertebrates were documented in waters of up to tens of meters deep in the western Mediterranean (Garrabou et al. 2009). In general, it is known that changes in habitat related to warming waters shift the distribution of marine organisms to other geographic regions of warmer or colder waters, depending on species’ limitations. Also, invasive species (Fig. 11.1) gain new footholds as temperatures warm and habitats change.

Weather patterns are such that warm water masses in the ocean drive storm development (as explained in Chap. 3). Storms that develop over the ocean hit land as hurricanes, typhoons and monsoons, all of which have become more frequent and more severe in recent years. Examples include Hurricane Katrina, which wreaked havoc on New Orleans in 2006, Hurricane Sandy, which pounded New York in 2012 and Typhoons Haiyan and Rammasun, which struck the Philippines in 2013 and 2014 respectively. Each of these storms led to widespread destruction, economic damages, population displacement and casualties.

Fig. 11.1 The invasive lionfish, native to tropical Indian and western Pacific waters, has spread rapidly over the past 30 years. Seen for the first time in the reefs off Brazil's southeastern coast in 2014, it spells trouble for native fish (Reproduced with permission from G. Porat)

In the short term, there is a great need to improve the emergency responses on a global scale that are necessary to help affected areas recover more rapidly from such extreme storm events. Long term responses require more strategic planning, including the management, protection and restoration of natural coastal systems such as marsh, mangroves, seagrass beds and barrier islands.

11.1.3 Ocean Acidification

Marine creatures are being hit with a double whammy through the release of copious amounts of CO_2. Not only are organisms impacted by higher water temperatures resulting from the greenhouse effect, but intensified CO_2 absorption is now occurring in seawater. This process forms carbonic acid. Although a weak acid (which you likely drink in beverages such as cola and club soda), so much of it is now finding its way into the oceans that seawater chemistry is changing. This has a direct effect on marine creatures.

It is difficult to carry out long-term realistic manipulations of CO_2 levels, and therefore scientists have used areas with naturally-occurring high CO_2 levels to forecast the effects of ocean acidification. In an elaborate census offshore of Naples, Italy, divers collected data around deep-sea volcanic vents[2] to find out which species, habitats and processes are resilient to and/or adversely affected by ocean acidification. At several hundred meters from the vents, scientists observed

[2] Deep-sea volcanic vents, also called "black smokers", are known to be relatively acidic environments. While these "mini-volcanoes" are known to host unique flora and fauna, they also introduce substances, such as hydrogen sulfide, into the seafloor environment, which are toxic to most species.

seaweeds of different types, sea cucumbers and urchins (by counting both sedentary flora and fauna and observing creatures passing by). Closer to the vents, they observed that species dropped out. As pH levels dropped in proximity to the vents (indicating higher acidity), macroalgal habitats were found to be significantly altered. Also, mollusks or limpets which came close to the vents exhibited dissolved shells (e.g., with holes in them) (Porzio et al. 2011).

So far, a tenth of a decimal (0.01) change has occurred, on average, in the acidity of the oceans. Though this doesn't sound like much, because the pH scale is logarithmic, this represents a 30 % increase in acidity. If we continue on our present course, by the end of the century we will cause a 0.4 increase, representing a 150 % change in acidity (Kolbert 2014)! Ocean acidification acts together with other global changes (e.g., warming, sea water expansion) (Fig. 11.2) and with local changes (e.g., pollution, eutrophication); these simultaneous pressures and stresses lead to interactive, complex and amplified impacts for species and ecosystems (IPCC 2014).

11.2 Climate Change and Coastal Hazards

The term "coastal hazard" refers to any threat to human populations that relates to their living in and using the coastal environment (for work, play, etc.). Coastal storms of greater frequency and magnitude are one type of hazard that results from climate change. Some of these have already been acutely felt, even in the developed world where populations have the greatest capacity to take precautions and recover – such as Hurricane Katrina and Hurricane Sandy, which hit New Orleans and New York City respectively.

Some coastal hazards have little or nothing to do with climate change. One of these was the 2004 tsunami in the Indian Ocean that led to the death of over 270,000 people and injured half a million others, with as many as five million affected in some way. The tsunami was caused by an undersea megathrust earthquake, whose epicenter was off the coast of Sumatra, Indonesia.

In addition to the tragic loss of life, the overall effects of such hazards on coasts can be economically devastating if we consider, for example, coastal tourism. As a result of the above-mentioned tsunami, tourism infrastructures in Thailand, Sri Lanka and the Maldives were severely damaged. January 2005 saw an 85 % decline in international tourists in these areas. Hotel occupancy rates fell to 10 %. Overseas arrival into Phuket, Thailand dropped by 67.2 % in the first half of 2005, and approximately 500 tourism enterprises (employing over 3,000 people) collapsed in 2005 (UNEP 2009).

The Tohoku earthquake, in 2011, was similarly devastating, although it affected entirely different types of coastal activities. It was the most powerful earthquake to hit Japan and the fifth most-powerful earthquake in the world since modern record-keeping began, in 1900. With its epicenter approximately 70 km offshore of Japan's Pacific coast, the earthquake triggered tsunami waves reaching up to heights of over 40 m. The tsunami caused meltdowns at three

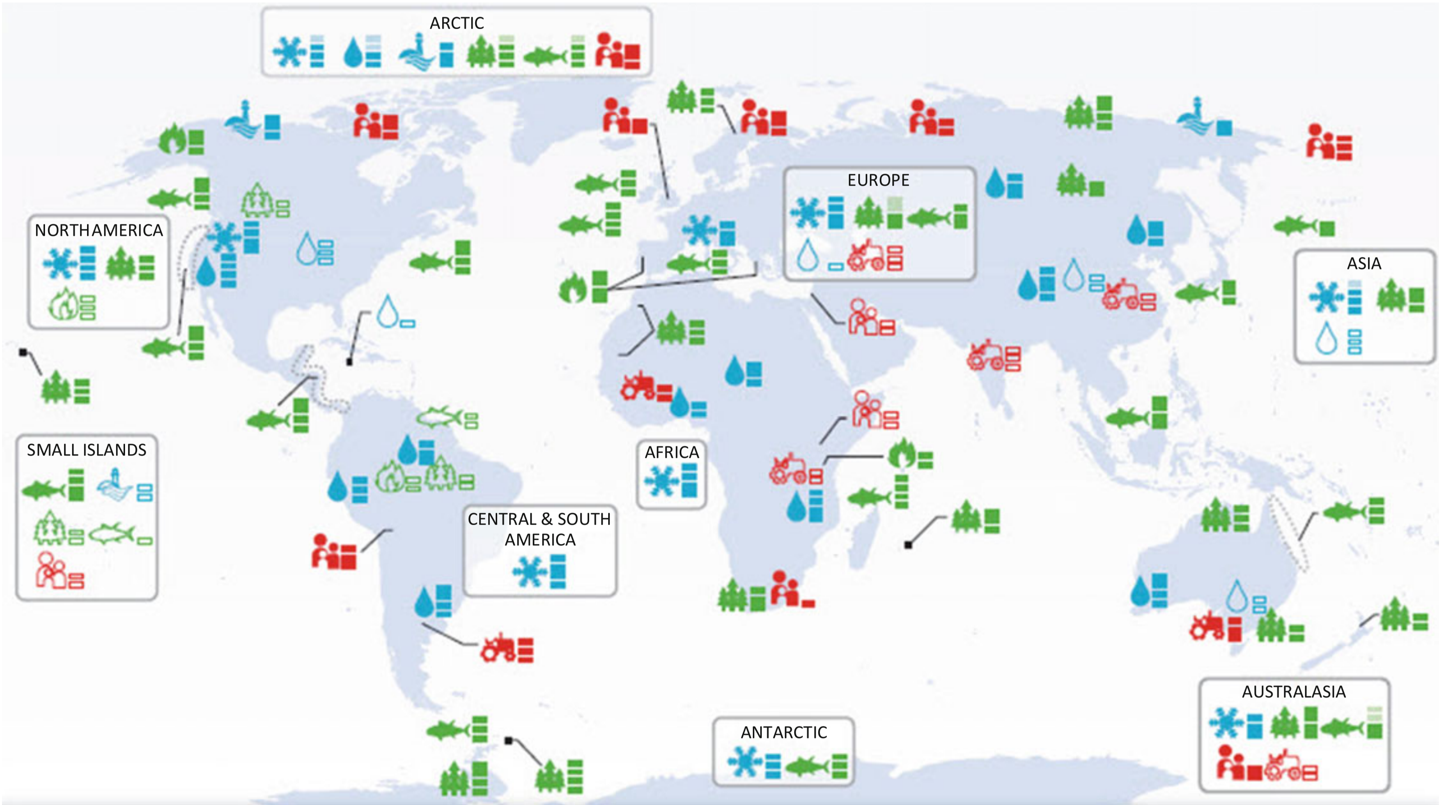

Fig. 11.2 Widespread impacts in a changing world. *Symbols* indicate observed impacts attributed to climate change for physical systems (*blue*), biological systems (*green*) and human and managed systems (*red*). *The outlined and filled symbols* indicate minor and major contributions respectively (see supplementary Table SPM.A1 in IPCC 2014 for descriptions of the impacts)

Fig. 11.3 A sign indicating an evacuation route on Isla Negra, Chile (Reproduced with permission of M. Angelopoulos)

nuclear reactors in the Fukushima Daiichi Nuclear Power Plant complex. The resulting evacuation affected hundreds of people, but many had no chance to escape. The death toll rose to almost 16,000, with tens of thousands injured and missing across 20 municipalities.

What can be done to prepare for these disasters and minimize their impacts on people and on the coastal environment? Unlike storms, floods and SLR, the damage from tsunamis cannot be helped by curbing GHG emissions. However, some of the same adaptation strategies apply, including wise coastal zone management planning and careful choices regarding near-shore development, wherever possible. Strategies to this effect should involve limiting development to water-dependent uses[3] and implementing well-developed, detailed evacuation routes for both floods and tsunamis (Fig. 11.3). The rest of this chapter is devoted solely to coastal hazards related to climate change, specifically those that call for mitigation or adaptation.

11.3 Mitigation vs. Adaptation

The extent or intensity of future climate change effects experienced by coastal communities will be determined by choices that society at large makes about emissions today. Lower emissions of heat-trapping gases means less future

[3] These are uses that demand a coastal location, such as coastal tourism, desalination of seawater and some power generation infrastructures.

warming and less severe impacts. Emissions can be lowered through improved energy efficiency and by switching to low-carbon or non-carbon, renewable energy sources.

Mitigation means implementing actions to reduce greenhouse gas emissions. It can also involve increasing the amount of carbon dioxide absorbed and stored by natural and man-made carbon sinks (Bierbaum et al. 2014). Mitigation often involves technological change and substitutions in production processes that reduce resource inputs and lead to lower emissions per unit of output. As such, it involves treating the symptoms of the problem at their core or origin.

The term "mitigation" may be confusing to environmental planners. Mitigation, in a planning context, sometimes involves offsetting to compensate for disrupting natural processes, ecosystems or habitats.[4] For example, the Massachusetts Wetlands Protection Act requires replication of wetlands impacted by some types of development. This traditional type of mitigation is aimed at replacing displaced wetlands or other types of coastal habitats (e.g., sea grass beds). Given appropriate design criteria and good compliance and enforcement, such an approach can be quite effective (Brown and Veneman 1998). Such actions constitute offsetting mitigation (Box 11.2).

Box 11.2: A Mitigation Case Study

France is moving forward with the development of marine renewable energies, especially offshore wind farm (OWF) projects, in order to meet the ambitious EU climate and energy legislation package aimed at reducing the country's GHG emissions. By doing so, France plans to further develop its "green" industry sector. Several potential prime locations for OWFs have been identified through a consultation process, and in 2012/2013 the French government awarded several tenders to competing developer consortiums.

As with most development projects occurring within a European country, an OWF proposal requires an environmental impact assessment (EIA), prepared in accordance with national and European-level regulation. This involves application of a "mitigation hierarchy" – the envisioning of measures that avoid, reduce and, if possible, offset significant adverse effects on ecosystems and human activities caused by OWFs. The hierarchy seeks to ensure no net ecological losses, thus reconciling development and biodiversity conservation. An ecological equivalency is required between ecological losses caused by a development project and ecological gains provided by offsets.

(continued)

[4] Offsetting, as required by legislation, will require a compensatory action to be taken as reparation for damage caused.

Box 11.2 (continued)

But how feasible is the ambition to achieve ecological equivalence with offsets? Policy researchers have identified a number of pitfalls in the implementation of the "no-net-ecological-losses" objective. Heading these challenges are failures in the scientific field. Scientific knowledge about many marine ecosystem functions is still limited and complicates the EIA process. Moreover, the design of offsetting strategies is constrained due to the limited number of compensatory actions available in the marine environment. Some experts posit that the design of offsetting as a mitigation strategy might end up favoring anthropocentric goals to the detriment of ecocentric ones.

Source: Bas et al. (2015)

Climate change mitigation refers to the avoidance of global temperature rise. Some environmentalists believe it is too late for mitigation of this type. In any case, despite the best intentions, quantities of GHG in the Earth's atmosphere continue to rise and the ongoing warming of the global climate is now a fact. There is little that can be done at this point to stop these trends (IPCC 2014), making adaptation to climate change an inevitable necessity.

Whereas mitigation refers to reduction strategies, adaptation refers to actions taken to prepare for and adjust to new conditions in order to reduce harm and take advantage of new opportunities. Although few measures have been actually implemented to date, adaptation planning is relevant to both public and private sectors and to all levels of government. Adaptive capacity refers to the ability of a society to plan for and respond to change in a way that makes it better equipped to manage its exposure and sensitivity to climate change. Invariably, the adaptation measures adopted will depend on governmental (and society's) adaptive capacity. Overall, climate change adaptation strategies contribute to a community's resilience. Resilience is the ability to absorb, accommodate and recover from hazards quickly and efficiently, including through the preservation and restoration of basic community structures and functions (UNISDR 2012). As such, it is a sought-after goal of environmental planning.

11.4 Planning for Adaptation

In general, there are two types of adaptation – reactive and planned. Reactive adaptations are the changes in policy and behavior that people and organizations adopt after they have observed or experienced risks and changes that result from global climate change processes (CRC-URI 2009). Reactive responses are extremely important and must be considered; there is a significant body of literature

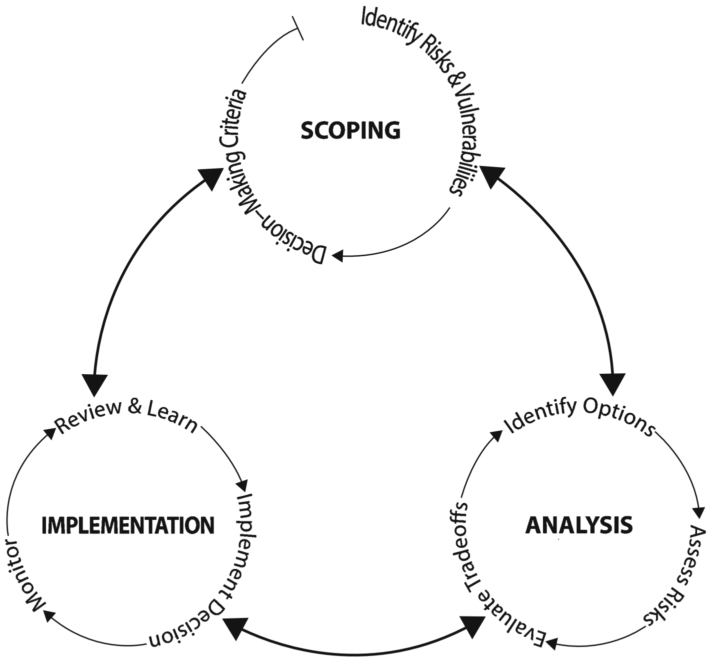

Fig. 11.4 The three major steps of climate change adaptation (Adapted from IPCC 2014)

that deals with this type of adaptation (Bernd-Cohen and Gordon 1999; Cooper and McKenna 2008; Higgins 2008; Smith et al. 2009).

Environmental planners will most likely be expected to address the type of adaptation that is strategic, intentional and proactive, referred to as planned adaptation. Planned adaptation should match adaptive capacity; it occurs at the societal level and can be implemented at various scales from local to national (Tribbia and Moser 2008; CRC-URI 2009). Plans devised and put in place by planners will most likely be designed to implement responses decided upon in a political process to achieve certain goals.

The IPCC Working Group on Impacts, Adaptation and Vulnerability propose a simplified scheme for climate change adaptation as an iterative, risk management process with multiple feedbacks. The process entails the major steps of scoping, analysis and implementation (Fig. 11.4). Science, research and investigation, as well as compromise, conflict resolution and a good understanding of social processes, should inform any planning aimed at designing adaptation.

More specifically, planners progress through five steps (Fig. 11.5) in planning how a set of adaptation measures for coastal and marine areas will be implemented. These consist of: (a) assessing vulnerability; (b) selecting a course of action; (c) mainstreaming coastal adaptation; (d) implementing adaptation; and (e) evaluating the adaptation implemented to make adjustments (CRC-URI 2009). For example, in areas of climate-related acute erosion, planned approaches will

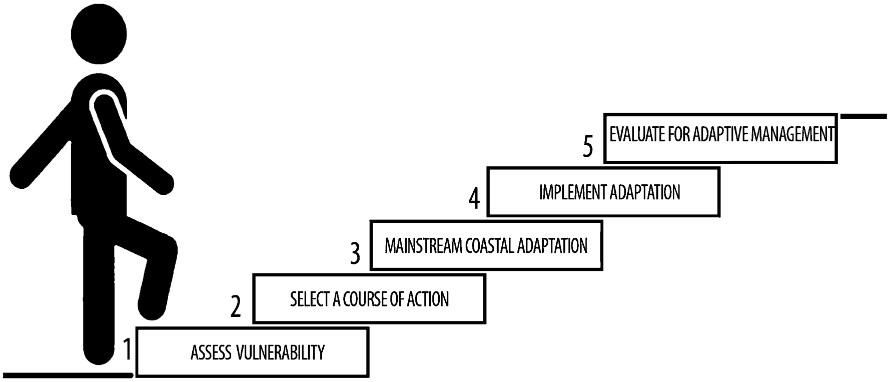

Fig. 11.5 The steps to guide proactive adaptation planning (Adapted from CRC-URI 2009)

dictate time-sensitive actions to be taken for protection, accommodation and/or retreat (see Nicholls 2011). Vulnerabilities will need to be assessed to determine scope and extent of the actions needed, and preferred actions identified. These will be embedded and formalized through existing or new legislation, guidance or policy, implemented and evaluated for success.

11.5 Vulnerability Assessment

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character, magnitude and rate of climate variation to which a system is exposed, the sensitivity of the system and its adaptive capacity (Bierbaum et al. 2014). Vulnerability assessment for climate change in specific coastal regions considers three factors: (a) the nature and magnitude of climate variability and change; (b) the human, capital and natural assets that will be exposed to and impacted by climate change; and (c) the capacity of coastal communities and ecosystems to adapt to and cope with climate impacts (CRC-URI 2009).

The effects of global climate change will vary from place to place; therefore, it is important to start with an assessment of the nature and magnitude of changes expected for an environment of interest. The *USAID Guide for Climate-Resilient Development* puts greater emphasis on the initial stages of scoping, assessment and design than the process modelled in Fig. 11.4. It also looks most carefully at community resilience. The USAID five-step process consists of: scoping, assessment, design, implementation, management and, lastly, evaluation and adjustment (USAID 2014).

To conduct forward-looking scoping and assessment, information from the reports of the IPCC can help determine the biogeophysical impacts of climate change. Many studies have used these forecasts as models upon which to research various aspects of adaptation needs (Anthoff et al. 2010; Bin et al. 2011; Lichter and

Felsenstein 2012). Other studies and frameworks have been applied in an effort to develop a basis on which to identify the important socioeconomic impacts of climate change (Hinkel et al. 2014). However, many of these studies lack detailed local level guidance.

A good tool, which can be used at the assessment stage, is DIVA (Dynamic and Interactive Vulnerability Assessment). The tool was developed as part of a larger project that involved intense collaborations between geologists, ecologists and engineers (Hinkel and Klein 2009). DIVA enables its users to produce quantitative information on a range of coastal vulnerability indicators, for user-selected climatic and socioeconomic scenarios and adaptation strategies on national, regional and global scales. An advantage of the model is that it is integrative, encompassing both biogeophysical and socioeconomic dynamics and feedback. It has a powerful graphical user interface and is freely available for download. That said, it is less appropriate for use at a local scale where these types of analyses are often needed most for decision making about climate change adaptation options.

At the local scale, some case studies have attempted to characterize socioeconomic impacts of climate change on coastal communities (e.g., Tribbia and Moser 2008). Some borrow from tools of economic impact analysis. For example, Bin et al. (2011) integrate geospatial and hedonic property data for a representative cross-section of coastal geographic distribution and economic development in North Carolina, USA; where rates of SLR are approximately double the global average, North Carolina has a highly vulnerable coastline. High-resolution topographic LiDAR[5] data were used to provide accurate inundation maps for impacted properties under six different sea level rise scenarios based on the IPCC Fourth Assessment Report projections. Researchers estimated that property value losses in four coastal counties would reach about $526 million (without discounting for inflation) for the mid-range SLR scenarios and up to $1.2 billion for the high-range SLR scenarios.

While most integrated assessments focus on exposure to risk, some consider specific adaptation responses. Anthoff et al. (2010) use the coastal module of an integrated assessment model, Climate Framework for Uncertainty, Negotiation and Distribution (FUND), for planning response. This model compares the costs of retreat with those of protection, including the effects of “coastal squeeze”. Coastal squeeze refers to the loss of habitats in close proximity to shore protection infrastructure. These habitats become trapped between a landward boundary fixed by infrastructure such as a sea wall and rising sea levels and/or increased storminess. This causes habitats to diminish in quantity and quality (Pontee 2013).

At the national scale, FUND calculates the welfare loss for a number of socioeconomic scenarios, assuming some basic adaptation of humans to sea level rise (e.g., protect or retreat). Using this tool, Anthoff et al. (2010) showed that “hard” coastal defense, the most common adaptation strategy and perhaps the optimal one from a costs-benefit perspective, results in substantial wetland loss

[5] Light detection and ranging is a remote sensing technique used for data collection and imaging along coasts.

under most scenarios. The geographic distribution of these costs, as calculated in their study, showed that a few regions will experience most of the costs, particularly North America, Europe and South and East Asia.

Another aspect of vulnerability that needs to be taken into account is institutional capacity. Research tells us that more diverse, heterogeneous governance regimes typically have greater adaptive capacity (Pahl-Wostl 2009), implying that higher vulnerability would be found in homogeneous regimes. Institutional capacity often corresponds to socioeconomic status. For example, certain socioeconomic characteristics among populations are associated with the capacity of municipal leaders to implement responses to environmental challenges that require collective action (Posey 2009). Clearly, more theoretical work and case studies are needed to fully explain the reasons for these types of associations.

Whether the emphasis is on economic characteristics, social parameters or institutions and governance, it is clear that factors influencing vulnerability relate to a community's or population's ability to adapt to change. In any case, more multidisciplinary research is needed. It is likely that understanding and insights from many aspects of environmental planning and management are relevant for planning responses to climate change along coasts and in oceans; for example, earthquake preparedness is relevant also to stormwater flood preparedness. Planning for these distinct phenomena have common elements and therefore engender important lessons for understanding adaptation capacity.

11.6 Measures and Technologies for Adaptation

Many possible coastal adaptation measures are available for consideration. Some measures, such as retreat or "hold-the-line" approaches (Fig. 11.6), are technical in nature and will be chosen to implement an overall policy, as opposed to providing response to a particular event. Many options are familiar to planners and have been used for decades for watershed management, integrated coastal management and even offshore infrastructure development. In most cases, the climate change context is new, but the tools themselves are not.

Planners should consider adaptation measures in terms of their benefits in promoting coastal and ocean management goals. Frequently, adaptation measures are chosen which yield benefits independent of long-term climate change forecasts. These are referred to as "no-regrets" approaches. These measures address current vulnerabilities and focus on increasing the ability of ecosystems and communities to cope with existing environmental pressures and climate variability. This approach makes sense when there are many unknowns. After all, the full extent of future climate change effects is uncertain, no matter how much modeling and forecasting is done.

Adaptation measures should be context specific; they should consider a region or locale's climate, natural resources, infrastructure, technological state, economy, governance and so forth. Key criteria for deciding the best adaptation given the local context are technical effectiveness, costs, benefits and implementation

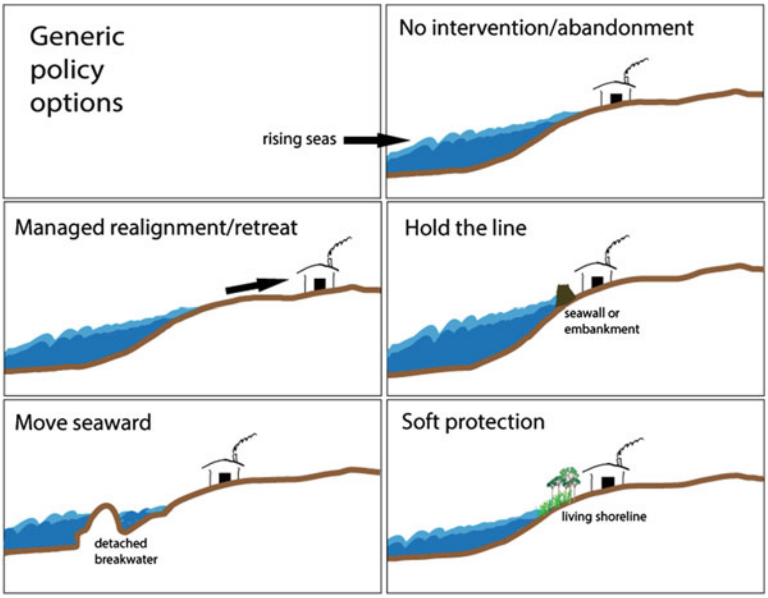

Fig. 11.6 Five generic policy options for responding to SLR

considerations (CRC-URI 2009). Technical suitability seeks to make sure that the option will be effective in solving problems which arise from climate change while also meeting development or conservation goals. Cost-benefit analysis addresses feasibility concerns, the types and magnitudes of benefits and, if done correctly, the distribution of benefits. General implementation considerations weigh the difficulty in design, level of skill for operation and maintenance, and whether the option is appropriate to the temporal and spatial scales of concern.

Some adaptation measures focus on the enhancement of human health and safety; for example, community-based disaster risk reduction and flood hazard mapping. Other measures focus on the functioning of healthy ecosystems. These measures may include wetlands protection and restoration, conservation agreements or payment for ecosystem services which protect from erosion or other climate-related consequences. Some options will render the built environment less exposed such as beach and dune nourishment, building standards and setbacks, and living shorelines (Box 11.3).[6]

[6] Setbacks are lines past which buildings are not allowed, usually measured from parcel boundaries or infrastructure such as a sidewalk or street. Living shorelines are those for which natural bank stabilization techniques (as opposed to hard engineered structures) have been applied. Living shorelines use plants, sand and limited supplies of rock to provide shoreline protection and maintain valuable habitat.

Box 11.3: Restoring Reefs with Biorock

Seawater temperature rise damages coral reefs, which has impacts beyond the loss of the corals themselves as beautiful artifacts of nature and hubs of biodiversity. Loss or downgrading of coral has implications for coastal protection.

One high-tech option currently researched for restoring reefs involves making "biorock". This substance is created by passing a low-voltage electrical current through seawater, which causes dissolved minerals to precipitate onto surfaces. The aggregated minerals eventually grow into limestone structures, similar to those that make up coral reefs, and nourish tropical, white sand beaches.

Biorock has been shown to accelerate coral growth in areas subject to environmental stress and to help form structures subsequently populated by a range of coral reef organisms such as fish, clams, octopuses, lobsters and sea urchins. Biorock structures continue to grow and get stronger with age, in contrast to most other marine construction materials. As such, biorock could be a viable technology for coastal protection and for restoring and enhancing near-shore marine ecosystems.

Source: Goreau (2010)

Specific adaptations used for coasts and ocean development can be categorized as techniques that aim to protect coasts and offshore infrastructures or as strategies of retreat, abandonment and accommodation (Fig. 11.6). Protection techniques, making up the first category, can be either "hard" or "soft". Hard structures include dykes, sea walls, tidal barriers and detached breakwaters that protect the shoreline from storm surges and SLR. Soft techniques are dune or wetland restoration or creation, and beach nourishment. Establishing setbacks, relocating buildings (retreat) or simply abandoning them are techniques that fall into the second category; one of response but not protection.

Other retreat/abandonment-type strategies include creating upland buffers and rolling easements, which phase out development in exposed areas. Accommodation, like measures designed to protect human health and safety, consist of developing effective early-warning evacuation systems, hazard insurance, implementing new agricultural practices (such as the cultivation of salt-resistant crops), new building codes and improved drainage systems (UNFCCC 2006).

As alluded to, implementing adaptation measures frequently involves the continued or amplified use of many technologies that are already being applied, even in some of the least-developed areas of the world. Nevertheless, as with any form of technology, there is always the risk that adaptation measures will be more accessible to wealthier communities. Policy makers therefore need to ensure that new forms of adaptation do not heighten inequality, but rather contribute to a reduction in poverty as much as possible.

11.7 Summary

The latest IPCC report, as of the writing of this chapter, places "death or harm from coastal flooding" as the number-one risk from climate warming. The report estimates that the current investment in adaptation measures is far less than what is needed to address the critical problem: a rapidly expanding population, with many poor, living in proximity of ever-rising seas. Most coastal environments will be at great risk in the coming years. These include tidal deltas and low-lying coastal plains with sandy beaches and barrier islands, coastal wetlands, estuaries and lagoons. Offshore areas will also be affected, and coral reefs and atolls that provide numerous types of ecosystem services, from tourism to coastal protection, will degrade.

Environmental planners with expertise in coastal and marine environments will be in demand to address these problems. While mitigation and adaptation are two different strategies that planners may use in confronting climate change, because the influences of warmer global temperatures and increased atmospheric CO_2 are already underway, planners will increasingly find themselves considering adaptation tools and measures.

As discussed, while adaptation will require addressing both coastal (near-shore) and marine (off-shore) environments, in the short term most adaptation will take place along the shore. Adaptation will be required to address both the effects of SLR and more frequent and intense storm activity which originates offshore but is experienced in vulnerable coastal areas as extreme storms and flood events.

Climate change adaptation policies should be appropriate to the context, guiding planners towards the achievement of multiple objectives, some of which need to be achieved in any case (e.g., the protection of wetlands or intertidal mangrove forests). Adaptation measures and actions will implement chosen policies to achieve certain goals, some or all of which will be related to climate change risks. Successful adaptation must consider vulnerabilities, competencies and capacity to adapt. Planners have at their disposal various tools upon which to base varying scenarios for planning. As for all types of environmental planning, scenarios should go beyond the simple forecasting of geophysical and biophysical effects to consider socioeconomic conditions of community members and populations such as institutional readiness and societal capacity for collective action.

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Chapter 12
Conclusions: Can Environmental Planning Save the Oceans?

We are tied to the ocean. And when we go back to the sea, whether it is to sail or to watch – we are going back from whence we came.

— John F. Kennedy

Abstract This chapter reiterates the main messages of this book. It also articulates fundamental definitions of the methods, tools and technologies used for environmental planning of oceans and coasts, the targeted benefits of their use, the possible pitfalls of implementation and how shortcomings can be overcome. Methods described include ecosystem-based management, ecosystem services and the precautionary principle; tools discussed are marine protected areas and pollution prevention policies; technologies briefly described include those aimed at improving communication about the coastal environment and decision support applications. Change, both in marine and coastal environments and in the field of environmental planning, is emphasized throughout.

Keywords Decision support • Ecosystem-based management • Ecosystem services • Environmental communication • Environmental planning • Marine pollution prevention • Marine protected areas • Marine spatial planning

This book began with an emphasis on change – changes in weather and climate patterns, changes in our relationship to oceans and coasts (due to technological innovation and lack of available resources on land) and changes in the inherent nature of ocean and coastal environments.

Clearly, some areas of the globe are more affected by the environmental changes of our time than others, and these changes may engender both positive and negative consequences. For example, interest in the very vulnerable region of the Arctic is driven by the dramatic changes taking place. These include a warming climate (causing sea-ice retreat, thawing permafrost and coastal erosion etc.), globalization and the increasing demand for resources (increasing population and an expanding middle class) and evolving geopolitics (claims on extended continental shelves and potential northern shipping routes). Taken together, these factors create opportunities

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and challenges, all of which require preparation which should be informed by knowledge acquired through good data collection, research and planning.

Change is also occurring in the planning field. The planning profession is often thought of as a field dedicated to the balancing of interests. On a practical, simplistic level, it involves a suite of activities that lead to the identification, articulation and sometimes, quite plainly, the *creation* of a way to get from point A to point B. Environmental planning, as described throughout this book, is the application of planning methods to the treatment and resolution of environmental problems (Randolph 2011). As we move forward in time, so many of humanity's place-based problems (i.e., problems that have spatial dimensions) will be environmental in nature.

And so it is for ocean and coastal issues. Through interaction with marine and coastal environments, we change them beyond the extent to which they would change naturally, without human intervention. Therefore, planning is part and parcel of our relationship with the sea, even though it has rarely been thought of as such until recently. The advent of marine spatial planning (MSP) is evidence of this new perspective. Professional planners are becoming involved, and planning schools, originally focused on urban environments and more recently on myriad types of terrestrial environments, are now realizing that they need to think beyond the edge of the land, to address the sea.

The message of this book is an environmental one. It aims to give planners interested in working on coastal and marine environments knowledge, methods, tools and technologies to care for such areas and protect them. I hope to bestow a message of the need for stewardship. Moreover, I submit that to "save" the oceans we must adopt and maintain an ethic of humility before the forces of nature. Certainly, the edge of the sea or land is a place where these forces are overtly palpable.

What makes such humility essential is, perhaps, the precarious point at which humans exist vis à vis nature. The planet is at a crossroads. By and large, the consensus among environmentalists is that the scale of policy and management responses to environmental issues is far from commensurate with the tasks at hand. Nowhere is the crisis we are facing more apparent than in oceans and along coasts.

At the very least, we need the protections that there are on land for the sea. Over 200,000 protected areas the world over cover about 15 % of the land area, but only 3 % of the ocean area is currently protected. The World Wildlife Fund's Living Planet Report confirmed a 52 % drop in the global populations of mammals, birds, reptiles, amphibians and fish between 1970 and 2010 (WWF 2014). The Global Biodiversity Outlook 4 report of the Convention on Biological Diversity concluded that international efforts to prevent wildlife and habitat loss will fail to meet the overall 2020 targets (Secretariat of the Convention on Biological Diversity 2014). While some protection progress is reported on land and despite the recent establishment of large marine protected areas (such as in the Pacific Ocean and elsewhere), the goals for protecting the biodiversity of the oceans are far from being met.

The problems are clear. We see them all around us in what we read and in what we observe as environmental professionals. The solutions are less clear. This book attempts to focus on some of the solutions and raise awareness about them. There is much that planners can do.

This final chapter reviews some of the main points made throughout this book. In synopsis form, it covers the essential methods, tools and technologies that can be used by planners. Lastly, it attempts to take some of the mystery out of marine planning. After all, planners have been planning for decades and there is no reason why they should "reinvent the wheel" when applying "tricks of the trade" to a different environment, especially if there is interest in integrating landscape units – terrestrial, coastal and marine. At the same time, planning has not solved all environmental problems on land and it can't do so for the oceans either.

12.1 A New Horizon for Planning

Some people believe that by applying planning principles to the marine and ocean realms, where freedom of the seas has ruled for centuries, we are bringing unnecessary constraints, checks and balances where they don't belong. This is perhaps why MSP has become, of late, a partisan issue in the US (Olsen et al. 2014). The reality is that, like it or not, due to the intensification of conflicts over ocean and coastal spaces, the application of planning is likely inevitable and is more a question of time than whether or not it will take place.

The traditional/classical field of planning has much to offer. In addition to different types of planning process models – rational-comprehensive, incremental, advocacy, contingency, adaptive and participatory planning – the relationship between policy and planning should be acknowledged (Ehler and Douvere 2009; Portman 2015). Environmental planning, defined above, stands out as a subset of general planning. Applying planning methods, tools and techniques to address human-environment interactions at a number of levels and scales has the potential to improve environmental protection. Environmental protection is relevant for oceans and coasts today because these environments are so threatened and so fragile.

But what is coastal planning? And what constitutes marine planning? Why have these types of planning been set apart from terrestrial planning in the past? Planners have been specifically addressing coastal environments for at least four decades (Cicin-Sain and Knecht 1998), whereas marine planning is relatively new (Agardy et al. 2011). Some coastal planning initiatives include the marine environment and some marine planning efforts include the coastal (upland) environment (Douvere et al. 2007; European Commission 2013). For planners, despite many definitions (for example, of the "coastal zone" by Sorensen 1997; Beatley et al. 2002; Davis and Fitzgerald 2004; UNEP 2006), distinctions between oceans and coasts may be on the way out. The concept of integration, which guides planners to consider various landscape units comprehensively and inclusively (i.e., *integrated* coastal zone management and *integrated* marine planning), highlights the importance of being less concerned with definitions and more concerned with the actual attributes of these environments.

More so than for other types of planning, environmental planning is influenced by a range of human values and perspectives. These values and perspectives reflect the changing paradigms of man's relationship to the natural world (Mace 2014).

Over time, environmental planning and management has morphed from a simple desire to live with nature to taking on responsibility for it and realizing that, in the midst of the Anthropocene, there is no getting away from the fact that humans need a healthy and functioning environment.

12.2 Progress in Methods, Tools and Technologies

Much progress has been made in recent years – since WWII – in our ability to understand and "know" the sea. But still, we know more about Mars than we do about the life forms found at the extreme depths of the sea. In many cases, policy makers responsible for allocating funds to scientific inquiry are willing to increase financial support for extraterrestrial exploration while they slash funds for monitoring the Earth (McNutt 2015). Exploration that does occur is usually aimed at exploitation of the sea; for example, the seeking of minerals such as manganese nodules or new sources of fossil energy. It is rarely aimed at marine conservation.

Even when marine protection is the goal of data collection, activities center around the designation of protected areas. Based on terrestrial experience, all the areas currently protected are not enough to secure the many endangered habitats and species on the brink of extinction. More activities need to be focused on restoring ecosystem functionality. Such an approach, called restoration ecology, calls for a continuum of efforts ranging from restoration of localized degraded sites to restoration of entire landscapes for production and/or conservation purposes. Key processes in restoration include identifying and dealing with actions that lead to degradation in the first place, determining realistic goals and measures of success, developing methods for implementing goals and incorporating them into planning strategies, and monitoring the restoration and assessing success (Hobbs and Norton 1996). Planners may recognize some of these actions as being similar to steps in a planning process.

A similar approach is that of reconciliation ecology – the science of establishing and maintaining habitats to conserve species diversity in places where people live, work or recreate. The approach shares principles with marine ecosystem-based management described in the next section (Rosenzweig 2003). Its focus is on "reconciling" stringent nature protection actions (such as restrictions on resource extraction) with different anthropocentric uses. Through this approach, conservation may be achieved at a broad spatial scale and costs associated with setting aside large swaths of marine areas as no-take zones can be reduced.

One of the problems with both restoration and reconciliation ecology (especially the former) is that steady baselines for marine communities are elusive, or non-existent (Pauly 1995; Bolster 2012), thus complicating the establishment of goals. Fluctuations of geologic, climatic and ecological systems are becoming the norm, albeit at varying time scales. Short-term economic forces such as overfishing or destruction of habitats by energy-seeking activities can push ecosystems into states never seen before. These novel ecosystems are animal and plant communities which exist in places that have been altered in structure and function by human agency to the point to which there is no natural analog (Bridgewater and Yung 2013). For planners, these are new horizons that require environmental problem solving and knowledge from many fields.

12.3 Methods for Marine and Coastal Protection

Threats to ocean and coastal environments bring about the need for new methods that will provide solutions. First and foremost among these methods is integrated planning and management. Integration is nothing new – it has been the guiding principle for many types of environmental policies for several decades. Integration has many dimensions which can be categorized overall as related to spatial and temporal scales, to governance and to the science-policy divide (see Chap. 4).

The push to integrate science and policy has encouraged greater reliance on planning techniques, often aimed simultaneously at integrating users, uses, landscape units and more. Decisions made and outcomes arrived at through integrated planning processes frequently make use of methods for improving and protecting environmental quality. Three frequently used, science-based approaches with such aims are ecosystem-based management, ecosystem services assessment and the precautionary principle.

Ecosystem-based management (EBM) is defined as an approach to management which considers the entire ecosystem, including humans within it. Ideally, the approach can maintain an ecosystem in a healthy, productive and resilient condition while simultaneously providing the services humans depend on. EBM focuses on multiple species within an ecosystem or area and myriad human use sectors, activities or concerns. Despite there being nothing particularly marine about EBM, the approach has become widely associated with best practices of marine planning (Douvere et al. 2007; Ehler and Douvere 2009; Mengerink et al. 2009).

An advantage to the approach is its comprehensive, broad-based and integrative focus. If policy makers and planners succeed in management based on entire ecosystems, considering all the systems' elements and functions, then there is a chance that ecosystems will continue to function and to provide humans with needed resources such as fish, energy and minerals. Like integration itself, EBM is a holistic approach to environmental management which has repercussions for planning.

Despite its wide appeal, EBM implementation is challenging; like for ICZM (Rupprecht Consult 2006), policy makers, planning professionals and other marine and coastal management experts are often confused about what it means and how to implement it. Although EBM can mean many things to many people, the approach usually engenders the valuation of ecosystem services and seeks to adopt a precautionary approach. The latter approach means taking a conservative route – one that protects the environment – whenever there is uncertainty about the impacts of human activities on coastal and marine environments, as explained below.

Ecosystem services are the benefits that humans derive from nature and natural processes. They can be services provided (such as consumable fish), regulatory services (such as those that regulate climate), supporting services (such as habitat for reproduction of commercial fish) or cultural services. The latter are those services, usually without a marketable, monetary value, that provide feelings of well-being, spirituality and/or enjoyment.

There is a lot of interest in this approach, especially among academic and research communities. However, the incorporation of the approach in planning praxis is challenging. Part of the problem is the lack of consensus on how to value the different types of services (Portman 2013). More applied research is required, as well as experience infusing the results of ecosystem services assessments into policy.

The precautionary principle posits that activities which may have numerous unknown or unmeasurable consequences in the foreseeable future should not occur at sea or along coasts. Often this means adopting a "worst-case scenario" view of what could happen. Doing so will ultimately have costs, such as monetary investments needed to construct infrastructure dedicated to the high-level treatment of sewage generated on land before it is dumped at sea. Despite initial outlays, such infrastructure will likely avert and reduce costs that would be accrued in the future from the loss of recreational revenues if beaches were closed due to high incidence of E. coli or due to health costs associated with sickness resulting from exposure of bathers to insufficiently-treated sewage in coastal waters.

12.4 Tools for Marine and Coastal Protection

Among the most common tools for the protection of coastal and marine environments are marine protected areas (MPAs) and regulation aimed at pollution prevention (PP). MPAs are much like terrestrial protected areas, but the idea of designating large areas of the oceans for protection has lagged far behind the idea of establishing such areas on land. Think of the large national parks in the US established in the nineteenth century. In the marine environment, such large swaths of ocean have been protected only recently (such as Pacific Remote Islands Marine National Monument,[1] declared by US President Obama in 2014).

Marine pollution prevention regulations, which have come about as a result of crisis events (such as catastrophic oil spills; see Chap. 5), have been in place for several decades, but they face many challenges. Regulations for PP rarely involve only place-based measures like those required for declaration and enforcement of

[1] Obama expanded the reach of the initial protected area (declared by President George W. Bush in 2009) by combining a cluster of reserves southwest of Hawaii. Covering 1 million km^2, the area protected within this national monument is now three times with size of California and six times larger than the monument's previous size.

protected areas. Challenges faced by PP have to do with the characteristics of the oceans, including the ocean's "fluid" nature and the lack of institutional capacity on an international level.

There are many types of MPAs, but, in general, they are defined as discrete geographic areas of the sea established by international, national, territorial, tribal or local laws, designated to enhance the long-term conservation of natural resources therein (Claudet 2011). Overall, MPAs aim to protect the marine environment and biodiversity; through management plans, they can also support socioeconomic development and sustainable use activities within them. Common objectives of MPAs are conservation and protection of natural resources, restoration of damaged or previously overexploited habitats, improved fishing yields, resolution of conflicts between user groups, enhancement of knowledge about the marine environment and protection of heritage and cultural values (Claudet and Pelletier 2004).

MPAs are critical to ensuring healthy marine ecosystems, improving the chances of EBM and more, but some critique their ability to achieve expectations. While research has shown that marine reserves (i.e., those specific types of MPAs within which all extractive uses are forbidden (Claudet 2011)) lead to increases in fish density, biomass, specimen size and diversity in all functional groups (Halpern 2003), they may still be limited as solutions to marine environmental degradation.

MPAs are not isolated from impacts, they are often too small to be effective and enforcement within them is often sorely lacking. Some experts have even gone as far as saying that MPAs are flawed because they create "illusions of protection" (Agardy et al. 2011). Communities residing within marine reserves are strongly influenced by the highly variable conditions of water masses that flow through them, and MPAs offer little or no protection from important threats such as contamination by chemicals, ocean acidification and warming water temperatures (Ban et al. 2012; Edgar et al. 2014). To a greater extent than for terrestrial systems, the scales of fundamental processes needed for marine species protection, such as population replenishment, are often much larger than MPAs can encompass (Allison et al. 1998). To overcome these challenges, adequate protection of species and ecosystems outside of MPAs is also needed. PP polices, while not providing solutions to global problems such as ocean acidification and warming waters, can at least complement contributions made by MPAs to biodiversity and habitat protection.

Pollution prevention refers to a suite of actions aimed at curbing pollution through proactive measures. PP policies (both for land and for oceans) were initially promulgated in response to environmental disasters such as the Torrey Canyon oil spill of 1967 off the UK coast and the 1969 oil spill in California marine waters. Sometimes PP regulation takes the form of a "permit to pollute". In such cases, any dumping or emitting of waste into the sea should be allowed only if the outcome of such action meets precautionary standards. Precaution is especially important because marine pollution regulators must often make decisions in an atmosphere of uncertainty about what will or could happen in the future.

As for general environmental protection, conditions may be imposed on an operator, development proponent or on the user of marine resources through "command and control". For such approaches, the regulator commands the polluting entity to meet standards in a specific way; for example, by using best available technology. This contrasts with the imposition of a general standard that must be met over an area or in a particular media – an "ambient" standard – imposed, for example, on seawater in a particular area.

Both PP and environmental planning tend to be proactive. Therefore, there are opportunities for synergy. Serious efforts at PP which are integrative in nature, science-based and involve multiple levels of governance (e.g., regional, national and local) can make significant contributions to the environmental quality of oceans and coasts, and have done so in the past. The problem is that the porous, fluctuating nature of the marine environment renders some types of pollution, such as marine litter, ubiquitous and persistent. Therefore, large scale, international and cross-boundary efforts are needed with strong, well-developed institutional capacities.

12.5 Technologies for Analysis and Communication

Until the mid-twentieth century, ocean depths were measured using lead lines – the same technology used by the ancient Egyptians! But now, scientists, explorers and industry have a slew of tools to choose from for "knowing" the coastal zone and the sea. A big part of recent exploration and monitoring has led to highly accurate ocean and coastal imaging and mapping. Environmental planners are direct beneficiaries of such tools.

Remote sensing technologies, such as multi-beam echo sounding and altimetry, provide extremely accurate measures of ocean floor depths and sea levels. Remote operated vehicles (ROVs) mounted with echo-sounding equipment make this technology almost limitless depth-wise. Near the coast, in waters too shallow for vessels mounted with echo-sounding gear or where they cannot maneuver over depths to be measured (e.g., around atolls or rocky outcrops), LiDAR (light detection and ranging) data, collected by aircraft, can fill the gaps.

Good, accessible data is a must for planners. The upshot is that such techniques are undergoing perpetual improvement and not just in the area of data collection. Regional and global databases are being developed, managed and organized, and most importantly, made accessible. Some good sources for general information include: International Coastal Atlas Network (see http://ican.science.oregonstate.edu/), AquaMaps (http://www.aquamaps.org/) and GRID Arendal (http://www.grida.no/).

Science-based classification schemes help organize information about coasts and oceans and their living systems. These include systems such as the Coastal and Marine Ecological Classification Standard (CMES), used by the US government, and the European Nature Information System (EUNIS), used for mapping biotopes. These systems are distinguished from one another by their emphases.

An example of such classification schemes are those devised based on marine benthic habitat types. Classifications distinguish between seafloor conditions commonly associated with a species of particular interest. Subsets of the overall habitat may be utilized differentially for foraging (subsistence), refuge, reproduction or rest. Physical (e.g., temperature, current speed and direction, depth), chemical (e.g., salinity, nutrients, minerals), geological (e.g., substrate type, seafloor morphology) and biological parameters (e.g., species density, percent cover of sessile or encrusting flora and fauna) can be used to determine habitat associations (Greene et al. 1999; Diaz et al. 2004).

In various areas of the world, different classification schemes have been applied. For example, in the mid-2000s, Geoscience Australia adopted a seabed habitat system based on the use of geological and oceanographic data inspired by the shelf classification used in eastern Canada developed by Roff et al. (2003). This system uses physical properties (sediment type, physiography, rugosity, wave and current regime) to define ecologically meaningful habitats. It is based on the premise that community types exploit the availability of any given habitat. Although the species occupying each habitat may be different because of environmental and biological factors (such as competition or predator-prey relationships), the overall community types can be predicted.

Standardization and wide use of classification systems are desirable so that different areas can be compared. This is challenging because of the contexts within which various analyses take place. However, it is likely that the more such classification systems are used (such as in Canada and in Australia, as described above) they will converge, thus facilitating comparative research efforts and more comprehensive (i.e., large-scale, regional and cross-border) planning.

Now that we have all this great data, what can be done with it? Communicating about oceans and coasts, like many aspects of planning, holds special challenges when compared to communicating about the terrestrial environment. Communicating environmental issues related to oceans (and coasts) is a subset of environmental communication; itself a relatively new discipline (Cox 2013). In order for environmental problems in the coastal and ocean environment to be recognized and identified, and to engender political will to do something about them, stakeholders, policy makers and professional planners must be able to articulate and "see" the issues at hand.

By describing (e.g., through narration) and visualizing (e.g., through imaging), planners can make problems real to various constituencies. They can also make more accurate assumptions about what is likely to happen in the future. Since the offshore marine environment is complex and hard to access, communication takes on a prominent role in participatory processes that depend on some basic level of "ocean literacy" (Steel et al. 2005). This is especially important because, although not easily accessible, the offshore coastal environment, and coasts themselves, are public resources held in trust by the state for the benefit of the public (i.e., as according to the public trust doctrine; see Chap. 2).

Other tools-of-the-trade for enhanced planning include those aimed at decision support. Some decision support tools are interactive software applications developed to enhance public participation and the work of planners (e.g., SeaSketch: www.seasketch.org). Some are online tools that allow the public to access data about marine and coastal environments, to propose designations, to obtain information about their choices and preferences and to communicate with planners (e.g., feedback can be sent via internet). Others are more complex downloadable applications, developed to solve problems such as achieving predetermined conservation targets at minimal cost (termed spatial conservation prioritization; see Moilanen et al. 2009) or matching desired uses to appropriate physical resources (see Coleman et al. 2011).

Despite their availability, the adoption of such tools has been slow. Advanced visualization tools (e.g., simulations in virtual reality labs) have been used for attempts to influence behaviors, as in the case of climate change mitigation (Sheppard 2012), but less for general marine and coastal planning purposes. Decision support tools have been employed during MSP processes, but their use has been inconsistent and has seldom been maintained over time (Collie et al. 2013). More research is needed on why this is so. It may be worth looking at such questions from a counterpoint: why are decision support tools so often promoted for use in marine planning processes as compared to terrestrial planning, which has a much longer history? Does the fact that marine planning is relatively new facilitate and encourage, or conversely, impede, the use of such tools?

12.6 The Promise and Peril of MSP

Because this is the last chapter of a book on environmental planning of oceans and coasts, some final words are in order on the subject of marine spatial planning. The expectations from an MSP process for protecting and rehabilitating the health of marine ecosystems are exceedingly high. A question about what MSP will produce posed in Ehler and Douvere's (2009) guidebook, is answered in this way:

> Our seas will be cleaner and healthier than they are now and they will be ecologically diverse and dynamic. Ecosystems will be resilient to environmental change so that they deliver the products and services we need for present and future generations. Representative, rare, vulnerable and valued species and habitats will be protected. Spatial and other management measures will be in place to make sure that there is no net loss of biodiversity as a result of human activities (p 12).

This is a tall order that calls for us to look critically at MSP initiatives, especially in striving for marine protection and improving the environmental quality of our oceans. Are they really able to deliver all these benefits?

Agardy et al. (2011) go as far as advocating for MSP as a way to compensate for the shortcomings of MPAs. Yet isn't the idea of MSP, in reality, a carving-up of the oceans for specific uses and the addition of *at least* one more layer of regulation? Only time will tell whether or not MSP has lived up to its expectations, as more plans are developed, implemented and evaluated over time. In the meantime, it is the task of environmentalists and environmental planners to ensure that MSP contributes to the protection of oceans and coasts and to the safeguarding of the resources they hold for future generations.

12.7 Summary Conclusions

The problems of the oceans are well known – they are the environmental crises of humankind playing out in slow motion, largely unchecked by the protections that we have on land. We suffer from depletion of fisheries due to overharvesting (as described in the 1960s by Thomas Hardin's *Tragedy of the Commons*). We face loss of heat absorption by the oceans (climate regulation functions considered ecosystem services). Acidity in the oceans has increased by 30 % since the start of the Industrial Revolution with negative repercussions for many organisms. From time immemorial, oceans have kept tropical latitudes cool and temperate latitudes warm, but the ongoing warming of seawater is likely to change ocean currents and, as a consequence, these important cooling and warming effects.

Although processes affecting ocean water quality and the seas' living resources have been the focus of this chapter, it is clear that the influence of landside activities on oceans and coasts cannot be ignored. For example, while many countries are experiencing increased flooding and sediment discharge in coastal rivers, in others the building of dams has trapped sediment and controlled discharge to the point where erosion now dominates regions that were once depositional. Further, coastal estuaries are vanishing due to population pressures, with coastal flooding exacerbated by the over-pumping of coastal aquifers.

The role of the environmental planner is an important one. No matter how overwhelming these problems seem, there is no need to go from the recognition of huge problems to complete despair. These problems call for stewardship, and environmental planners are in luck in that they can make a difference. Many of the problems facing the well-being of oceans and coasts, and humankind as a result, are global in nature, yet the role of the environmental planner is often a local one. For these situations, the famous phrase, "think globally and act locally", applies. Every "drop in the ocean", so to say, can help.

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