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Cultural context of ocean fertilization

Michael K. Orbach*

Duke University Marine Laboratory, Nicholas School of the Environment and Earth Sciences, Duke University, 135 Duke Marine Lab Road, Beaufort, North Carolina 28516, USA

ABSTRACT: All environmental law and policy, including potential policy governing ocean fertilization, involves trade-offs between the state of the world's biophysical ecology, by which we mean all of the non-human elements, and the state of the world's human ecology, by which we mean humans and their relationships with one another, including their governance institutions. All rules of governance affect — and only directly affect — human behavior, and through that behavior shape the biophysical world. All law is an expression of human culture. Legal statutes and rules are those elements of culture that we feel strongly enough about and share enough with each other that we write them down as rules of behavior and create some form of sanction for their transgression. In this paper I will discuss the broad-brush history of human value-based governance with respect to human use of the ocean and the kinds of decisions that face us with respect to the question of ocean fertilization. The general thesis is that ocean fertilization is essentially a 'cultivation' activity, even if done for the purpose of carbon sequestration for environmental conservation or market (carbon trading) purposes, and that such 'cultivation' is a new arena for ocean policy and regulation.

KEY WORDS: Ocean fertilization · Ocean policy · Carbon sequestration

INTRODUCTION

All environmental law and policy, including potential policy governing ocean fertilization, involves trade-offs between the state of the world's biophysical ecology, i.e. all of the non-human elements, and the state of the world's human ecology, i.e. humans and their relationships with one another, including their governance institutions. All rules of governance affect — and only directly affect — human behavior and through that behavior shape the biophysical world. The configuration of the biophysical environment, in turn, defines the form of the costs and benefits that can be incurred or received by humans in the use of that environment. Every decision regarding our relationship with the biophysical environment involves some form of tradeoff and all of the tradeoffs we make in our policy-making and implementation are guided by some set of human values. For example, achieving a higher standing stock of fish means extracting less through fishing, with attendant social and economic effects. In the present case, fertilizing the ocean to achieve higher productivity or for carbon sequestration and attendant 'credits' means altering the biophysical ecosystem and perhaps other social and economic benefits we presently enjoy from it. We do not always do this with will full knowledge or forethought, but there is at least a presumptive tradeoff made with each decision based on some human value structure.

In this paper I will discuss the broad-brush history of human value-based governance with respect to human use of the ocean and the kinds of decisions that face us with respect to the question of ocean fertilization.

LAW AND CULTURE

All law is an expression of culture. Legal statutes and rules are those elements of culture that we feel strongly enough about and share enough with each other that we write them down as rules of behavior and create some form of sanction for their transgression (Nader 1969). Culture varies throughout the world, and accordingly, so does law. Different local governments, different states, and different nations have

*Email: mko@duke.edu

different laws reflecting their common culture within their particular governance structure.

In general, when we set out to 'conserve' a part of the biophysical environment, we mean to be able to sustain its use or enjoyment by humans over time. Some of this use or enjoyment may be extractive, other, non-extractive. If we decide to enjoy part of the biophysical environment in a non-extractive way and develop rules accordingly, we often use the term 'preservation' rather than 'conservation,' as in the terms 'preservation ethic' and 'conservation ethic' associated with John Muir and Gifford Pinchot, respectively (Miller et al. 1987). The form of law and policy we construct reflects our cultural values and our preferred 'ethic' of interaction with the biophysical environment.

One of the significant questions we face with ocean fertilization is: How should we use the oceans? As I discuss below, humans have addressed this question, if imperfectly, for terrestrial — and even atmospheric — environments, but not yet for ocean environments. Should we, given both the similarities and the differences between them, treat the sea as we have the land, to be subject to private ownership and large-scale cultivation and alteration? Or should we treat it differently? Whatever law and policy we adopt for ocean fertilization will reflect our commonly-held cultural values with regard to this question, which itself is inherently international because of the biophysical nature of the ocean. Thus I will tend to use the terms 'law' and 'culture' somewhat interchangeably in this article.

HUMAN GOVERNANCE INSTITUTIONS

For most of the world's human population, the ocean is 'out of sight, out of mind.' Not only do most people not live or work on or in the ocean, but it is in fact an extremely hostile environment for humans. It is too salty to drink or to irrigate crops. Its density both smothers us if we are immersed in it and crushes us if we go too deep without elaborate protection. Its waves bash us on beaches and in boats, and its biochemical characteristics foul and corrode our machines and structures. Even though an increasing number of us live or work near the ocean, it is still not an 'intimate environment' for most people (Revelle 1969, Orbach 1982).

Governance on land and ocean

In the earliest days of human society most terrestrial space was 'open access, common pool,' owned or controlled by no-one. After the Neolithic Revolution around 10 000 to 14 000 yr BP and, especially with the aggregation of human populations into cities around 3000 to 5000 yr BP and the subsequent growth of major centers of 'civilization' in what are now Greece, China, Mexico, Peru and North Africa, human terrestrial governance institutions grew exponentially in number and complexity. One of the most important of these is the notion of 'private property', under which space and resources may be held, and their use dictated, exclusively by certain individuals or groups of individuals. The last 10 000 yr of human history have seen the complete carving up of terrestrial space and resources into property, some of which is held in trust for aggregates of people under institutions called governments under the general term 'public trust'. Our cultural understandings regarding this property have been codified over time through 'natural', Roman Civil, and English Common law (Coastal States Organization 1990, McCay 1998). An important point with respect to ocean fertilization is that on land we made the cumulative, but explicit decision to 'cultivate' the land and its resources. We set aside some portions of the terrestrial environment for parks, wildernesses and other special designations, but by and large we bought into the idea that it is permissible, even desirable, for humans to manipulate large portions of the terrestrial environment.

Not so with the ocean. With few exceptions, until the late 1700s nation-states did not even claim exclusive governance authority over any portion of the ocean (Eckert 1979, Wilder 1998). The exceptions were societies that depended heavily on ocean resources and were in the position to exert some form of control over the use of those resources. In the age of low technology, this was not very common, and the reach of such societies did not extend very far from shore. Even if a state claimed 'territory' or control over ocean resources, it was difficult, if not impossible, to enforce such claims. The areas in which such claims were most in evidence were in smaller, more enclosed, ocean areas such as the Mediterranean or North Seas, or in smaller, more remote insular areas such as the Pacific Islands (Johannes 1981). In virtually none of these situations was the decision made to cultivate ocean resources, but rather to make claims for purposes of extraction or other uses such as shipping or military transport.

Emergence of the 'freedom of the seas'

Long before fishing developed as a significant ocean use, merchant and military shipping were prominent (Revelle 1969, Wenk 1972). During the first half of the second millennium, attempts were made by many

countries and coalitions of countries to assert control over shipping. Beginning around the midpoint of the second millennium, large-scale attempts were made to carve up the ocean in terms of shipping access.

It was the inability of any nation or group of nations to actually control ocean use or access that led, in 1609, to the treatise by the Dutchman Hugo de Grotius titled, 'Mare Liberium', or 'freedom of the seas' (Wilder 1998). Under the commonly accepted doctrine that developed pursuant to this treatise, the world ocean remained 'open access, common pool', with no nation or group of nations controlling use or access. Combined with this doctrine was the notion of the ocean as a source of inexhaustible resources, the use of which need not be restricted. This also created, in essence, the exact opposite of the 'precautionary principle'.

This remained generally the situation until the late 1700s, when the then-new USA declared a 3 nautical mile (n mile) territorial sea off its shores, the term 'territorial sea' meaning the portion of the ocean that nation-states have the right to treat as they do their land areas, with all the attendant rights and responsibilities (Wilder 1998). Soon all ocean-adjacent nations had followed suit and the first phase of the 'ocean enclosure' movement, out to 3 n miles, was complete. This 3 n mile limit remained in effect in the USA as the main ocean enclosure until 1945, when President Harry Truman issued a presidential proclamation claiming the resources of the outer continental shelf adjacent to its shore for the USA. This proclamation, later codified in the Outer Continental Shelf Lands Act of 1953, had the effect of extending the USA's jurisdiction over certain ocean resources much farther than the traditional 3 n miles, to the outer limit of the continental shelf. It was, however, not a 'territorial' zone, but a 'resource control' zone. That is, neither the proclamation nor the act extended the sovereign territory of the USA, only its control over the use of certain space and resources for extractive purposes (Cicin-Sain & Knecht 2000).

Two more major steps bring us to our current formal enclosure situation. The first was the passage by the U.S. Congress of the Magnuson Fishery Conservation and Management Act (now the Magnuson-Stevens Act, or M-SFCMA) of 1976. The M-SFCMA extended the jurisdiction of the USA over fishery resources to 200 n miles. Most ocean-adjacent nations followed suit soon thereafter. Then, in 1983, in part in reaction to the then-recently completed United Nations 'Law of the Sea' convention, President Ronald Reagan, again by presidential proclamation, declared a 200 n mile Exclusive Economic Zone (EEZ) off the USA shores. This proclamation, which has still not been codified by the U.S. Congress, essentially turned a continental shelf and fishery resource jurisdictional system into an exclusive access system for all ocean and shelf resources within 200 n miles, including the water column itself. Again, most ocean-adjacent nations followed (and in some cases, led) suit (Cicin-Sain & Knecht 2000).

Thus, by the end of the second millennium the ocean enclosure movement had reached 200 n miles out to sea, and farther in cases of continental shelves that exceeded that distance. Once again, throughout this process little consideration was given to the question of large-scale manipulation of ocean environments, except perhaps in the context of fisheries extractions or oil and gas development. To fully understand the context of this situation, however, we must recount a parallel and somewhat broader international discussion regarding ocean spaces and resources that began in the early 1900s.

OCEAN SPACE AND RESOURCES IN THE BROADER PERSPECTIVE

Although merchant and military shipping had dominated ocean access discussions for most of the second millennium, in the latter part of that millennium extractive ocean uses became much more prominent. Ocean fisheries and offshore oil and gas, in particular, grew quickly in the wake of the industrial revolution of the 1800s, and by World War I extractive uses of the ocean had achieved the beginnings of their current (in some cases devastating) status. The technological advances of World War II completed this advance, and by the 1990s, for example, world ocean fish catches had leveled off in the face of ever-increasing fishing effort (Stone 1997). Offshore oil and gas, the other major extractive ocean use, continues to rise, as does world ocean shipping.

It was also clear, especially in the face of the open access, common pool character of ocean resources, that these issues had significant international dimensions. Not only are many of the resources of the ocean themselves mobile across national boundaries, but the human users themselves (fishermen, oil and gas activities, shipping) crossed those boundaries with increasing regularity as extractive technology (steam and diesel power, steel ships, radar, sonar, synthetic fibers, deep-sea engineering) developed. Beginning with the League of Nations early in the 1900s; through the Treaty of Paris in the 1930s; the 3 United Nations 'Law of the Sea' conventions (UNCLOS) beginning in 1958; and finally, in broader environmental discussions beginning in Stockholm in 1972 and continuing through Rio de Janeiro, Kyoto and Johannesburg, attempts have been made to further develop human governance institutions for ocean space and resources

(Hollick 1981, Cicin-Sain & Knecht 2000, Johannesburg Summit 2002).

These discussions have all had a curious dimension, owing to the culturally defined open access, common pool nature of ocean space and resources. Humans have always treated ocean space and resources differently from terrestrial resources. From time to time 'scientific' justifications have been given for this circumstance — for example, that many of the resources are mobile — but these justifications ring a bit hollow when exposed to scrutiny. Many terrestrial resources, for example, are (or were) also mobile, often highly migratory. Because of the density and intimacy of the use of terrestrial resources humans developed the notion of property on land (including many natural resources, such as forests and water) and governance institutions developed accordingly. There are, of course, categories of terrestrial or avian resources that under our governance institutions are formally called wildlife, which generally are not subject to private property access (Bean 1983). However, virtually all of the terrestrial space and resources have been divided up into property of either the private or public trust variety. This is opposed to the ocean, where even under the 200 n mile EEZ, some 60% of the ocean and its resources are 'high-seas' and thus principally open-access, common pool.

What was remarkably different in this history of ocean use and policy from the history of terrestrial use and policy, was that although the 'frontier' notion of the ability of anyone to enter the fray was the same, the ability of individuals and private sector organizations to make formal claims on ocean spaces and resources was absent. That is, there was no notion of private property in the oceans, and also — once again — virtually no discussion of the idea of actively cultivating the ocean.

One aspect of this distinction between land and sea became focused in the idea of ocean space and resources as the 'common heritage of mankind,' a phrase coined by Arvid Pardo, the United Nations Ambassador from Malta, in a speech to the United Nations in 1967 (Borgese 1998). That phrase, and a companion phrase, 'the new international economic order,' (NIEO) became common parlance in the third UNCLOS Convention (UNCLOS III) between 1973 and 1982 (Hollick 1981, Wilder 1998). These 2 phrases perpetuated the idea of ocean space and resources as different from the terrestrial; in particular, that they are and should remain common pool, if not open access. Significantly, however, they also advanced the notion that the governance of ocean space and resources should be institutionalized for the benefit of all humankind, not only those in ocean-adjacent nations or with ocean exploitation capability. More particularly, the idea was advanced that the benefits of ocean resources should be directed to those humans most in need of them on some sort of social equity basis, rather than simply to those with the ability to exploit them. This discussion remains prominent today, as evidenced recently in Johannesburg at the United Nations World Summit on Sustainable Development (Johannesburg Summit 2002).

In general, the common heritage principle has not been implemented, with 1 exception: ocean mining. In this case, those supporting the 'common heritage of mankind/NIEO' made an effort to both extend the notion of resource control beyond 200 n miles and to ensure the benefits of the exploitation of ocean minerals for the good of all humankind, not only those with exploitation capacity (International Seabed Authority 2000).

Even with ocean mining, however, the discussion was in the context of extracting some natural resource, in general with the idea that such extraction should be done in the most environmentally sound, if not benign, way possible. That is, the discussion did not consider, much less accept, the idea that human activity would create large scale alteration of ocean environments.

Who owns the ocean? As noted above, some 60% of the ocean space lies outside of the 200 n mile EEZ of individual nation-states. Within 200 n miles there are 3 different states of governance. The first is the 'territorial sea', now out to 12 n miles (again, in the USA, by presidential proclamation), within which the ocean is treated as sovereign territory of the adjacent nation as is the land (customs authority, etc.). The second is the area from 12 to 200 n miles, which is officially classed as EEZ, within which access to resources is controlled by the adjacent nation. The third governance situation involves resources that are migratory, meaning either common pool resources, such as migratory fish or ships registered to individual nation-states that cross international boundaries in their travels. In the case of migratory fish stocks the governing institution is the Convention on Straddling Stocks, which places the burden for cooperation in conservation for such stocks in the hands of nations within whose jurisdiction the fish occur, or whose fishermen take them either within or outside of any national jurisdiction (Burke 1994, Balton 1996). In the case of shipping, the 1996 Protocol for the London Convention places a similar burden in the hands of the nations of registry of the ships, again either within or outside of national jurisdiction (Van Dyke 2000).

Thus, in summary: (1) Shoreline to 12 n miles, territorial sea, (2) 12 to 200 n miles, EEZ, (3) outside of 200 n miles, high seas, and (4) special provisions for migratory resources and shipping.

It is useful in this regard to review the history of marine fisheries policy and management in the USA. Until 1976 there was no effective federal management of marine fisheries. Virtually all management, with the exception of international treaties, was done by the individual states within 3 n miles of their shorelines. There were various coordination mechanisms, such as the Interstate Marine Fisheries Commissions initiated in the 1940s, but the basic management authority existed in individual states and their respective jurisdictions. Until the advent of the Alaska Salmon Limited Entry system in the early 1970s, the management of marine fisheries had operated under an open-access principle. The Magnuson-Stevens Act created for the first time a uniform, authoritative marine fishery policy and management presence and included a provision for the development of 'limited access' systems. As of 2002, most of the USA's major marine fisheries are under some form of limited access system. Some of these systems, termed generally individual fisherman quota (IFQ) systems, create a form of property right of access to a certain portion of the fish harvest. These IFQ systems are controversial, in large measure because they introduce both the notions of restricted access and property rights to ocean spaces and resources (NRC 1998). However, I submit that they are becoming ubiquitous for exactly the same reasons that terrestrial space and resources eventually came under some form of private property (Christy 1996) — increased density of human use.

The question is: Should ocean resources be different from the terrestrial — in particular in the areas of access and property rights — and if so, in what ways? There is also the overarching general question of whether we should allow the large-scale manipulation of ocean environments through actions such as ocean fertilization.

DIFFERENCES BETWEEN OCEAN AND TERRESTRIAL SYSTEMS AND IMPLICATIONS FOR GOVERNANCE

I would suggest that there are 3 basic reasons that ocean and terrestrial space and resources require different systems of governance. The first is that ocean space and resources are intrinsically different from the terrestrial. The second is that practical aspects of dealing with ocean space and resources justify, and perhaps require, a governance system different from those on land. The third is what I will call the cultural preference rule: humans simply believe that ocean space and resources should be treated differently from those of the land, ideally for reasons that we can articulate clearly. Let us consider these 3 possibilities.

Are ocean space and resources intrinsically different?

In a special issue of Scientific American in 1969 dealing with the ocean, Roger Revelle and his colleagues enumerated the distinctive features of ocean space and resources: depth, density, fluidity, salinity, viscosity, organismal metabolism and mobility (Revelle 1969). Why, however, would these characteristics lead us to govern human behavior differently in the ocean realm? The atmosphere, also, has characteristics different from the land and we have developed governance institutions for activities such as aircraft, radio transmission, satellites, air space and air pollution that mimic, in principle, governance institutions for terrestrial space and resources (Wiener 1999a, Torres 2001, Sagarin et al. 2007).

Take, for instance, migratory resources such as terrestrial and avian wildlife. In both cases — similar to ocean resources — the populations themselves are mobile across jurisdictional (including national) boundaries. For many of them we created a specific category with specific legal standing: wildlife. In the case of most, if not all, of these resources we have developed a subsidiary cultural rule, translated into law, allocating these resources to recreational, as opposed to commercial, harvest. For those resources that remain the realm of commerce, we have applied the notions of private property and developed appropriate governance institutions. For those we consider wildlife, we also develop elaborate governance institutions, including rules of access, and many of these institutions are robust across national boundaries (Holt & Talbot 1978, Bean 1983). Why should we not do the same for ocean resources, throughout ocean space?

To the question at hand, one could also query whether manipulations such as ocean fertilization are appropriate uses of ocean environments. One goal of ocean fertilization, for example, is to stimulate phytoplankton growth in order to draw carbon out of the atmosphere and into the ocean, and in some cases to stimulate further ocean productivity. This would be achieved by spreading substances such as iron in the ocean in those locations where iron is currently in such low concentrations that it limits phytoplankton growth. The closest parallel to this process is probably the addition of feed to ocean environments during the process of ocean aquaculture, but the addition of the feed itself is ancillary to the overall process of catching, penning and harvesting the fish themselves, and the policy and regulatory process for ocean aquaculture itself is not well-developed (Cicin-Sain & Knecht 2000, USCOP 2004).

As with any issue that combines complex science, policy and economic drivers, different cultural value systems also come to bear on people's views about the

wisdom of iron fertilization. For example, every group of scientists consulted for this report will express a range of viewpoints based on their particular cultural value orientation. While all may address the need to be cautious with ecosystem engineering at any significant scale, some might also suggest that such engineering projects may be useful as part of a larger portfolio of ideas to reduce greenhouse gas concentrations, while others may express strong opposition to manipulating ocean ecosystems in this manner. Aside from the specific biophysical, economic, or social effects of such systems, these cultural value orientations reflect personal and organizational attitudes and perceptions regarding the appropriateness of different courses of action.

My conclusion from this general discussion is that ocean resources generally and ocean fertilization specifically are not intrinsically different from terrestrial or avian resource and environmental uses from a governance point of view. However, these above questions would have to be answered to yield a rational and effective regime for governance of ocean fertilization.

Do ocean space and resources have practical management conditions or constraints?

It is certainly true that 100, or even 50, yr ago technology and management systems did not exist to monitor ocean fish harvests, or the movements of merchant or military ships, or processes such as ocean fertilization. It is also true that even now there may be people who perceive the ocean and its resources to be inexhaustible, or its environments infinitely adaptable and resilient. I submit that neither of these circumstances is true today.

In the current era of computers, satellites and remote-sensing technology we can monitor the movements of, if not detailed behavior aboard, every boat and ship in the sea. There are, of course, economic factors and issues of confidentiality and privacy involved, but no more so than on the land or in the air. Although the ocean remains a difficult biophysical space for humans to deal with, for purposes of the monitoring of major ocean uses the technology is generally available, as is the underpinning of a legal framework for their governance (Wiener 1999b). With some technological development we certainly could monitor ocean fertilization experiments and, assuming effective theories and methods, their effects.

The question of whether we have the capability to effectively monitor and enforce whatever rules we might devise with respect to ocean fertilization is a very significant question. Because of the basic nature of the proposed process itself, the scientific uncertainties involved, and the presumed broad scale impact of the activity, the question of our ability to monitor and enforce would be significant.

The resources of the ocean are not inexhaustible and while it is technologically possible to monitor — and control — human behavior in the major extractive ocean uses with sufficient resources applied to that end, the question is less certain with respect to ocean fertilization.

The cultural preference rule

Just as humans have developed special governance institutions for such categories of resources as wildlife (and in the case of the USA, even more particular institutions in the case of marine mammals), we could decide that ocean space and resources simply deserve (read 'humans would prefer them') to be treated differently (Earle 1995). In the governance sense, this is a premise of the common heritage of mankind approach — that all humankind should share in some equitable way in the use of ocean resources in a way they do not with terrestrial resources, largely because of the existence of the pervasive notion of private property on land, which to a certain extent subverts equitable public purpose. In our present discussion of ocean fertilization, one significant question that we face is whether the ocean should be used for such purposes. There are, of course, overarching political, social and economic philosophies regarding this question, the discussion of which has reached across the millennia.

In a more practical vein, though, it may simply be a matter of deciding. The current discussion of the concept of marine protected areas (MPA) is an example of this. In one sense the MPA discussion involves the best way to conserve or protect specific ocean resources or ecosystems, but in a larger sense the question is simply how do we prefer to treat ocean space and resources? This is akin to the questions that John Muir and Teddy Roosevelt asked about terrestrial resources that led to the establishment in the USA of the national park system. Conservation is a consideration, yes, but so are aesthetics, existence value, perceptions of individual and societal well being and all of the other concepts that have emerged as we have developed governance institutions for our cities, farms, forests rivers and wildlife (Miller et al. 1987). The analogous question could be asked of the idea of active cultivation of ocean resources and environments.

My own conclusion from this brief exploration of these issues is that ocean space and resources are not significantly different from the terrestrial and atmospheric from the point of view of functionally appropriate governance institutions. It is our own cultural

assumptions that lead us to treat them differently. In this sense, the question of ocean fertilization is a cultural question. It is not until the cultural questions — the human values we wish to apply — are answered that we can begin to answer the rest of the questions pertaining to ocean fertilization.

DESIGNING THE OCEAN ENVIRONMENT

The answer to all of these questions lies in 2 areas. The first is increased knowledge of the biophysical ecology of the world's oceans and of the human ecology of our use of the oceans, in order that the tradeoff inherent in different rules of governance might be accurately estimated. The second is the ability to format the discussion in a reasonable and productive way and to use our increased knowledge to rationally construct law and policy.

In making public policy regarding ocean fertilization, we must necessarily choose among many different possible governance rules, all of which are interactive with human behavior, and law and policy in related policy arenas such as fisheries, shipping, oil and gas, etc. This is a case of what we might define as 'ecosystem management,' a much bandied-about term but useful in the present context. The important point is that we need to know as much in a documented way about the human ecological configuration as we do about the biophysical ecological configuration, including the structure of human values that underlie our current — and potential future — law and policy.

Following from this point, all of the resulting governance rules will be based on some set of human cultural values. These values will reflect our perceptions and attitudes regarding our desired state of the biophysical and human environments. In this sense, we are engaged in a design exercise for both the biophysical and human ecology, and the ways in which the two map onto one another. As we stated at the outset, we will have to decide whether to treat the ocean as we have the land and even the atmosphere — to be divided up into private property or exclusive access privileges and/or cultivated on a mass scale. In any event, to manage human behavior effectively at the scale necessary for the world ocean, we will have to proceed towards a 'policy enclosure' of the world ocean, in order that the resulting governance rules for all parts of the ocean ecosystem, both inside and outside of areas of national jurisdiction, can be effectively developed and applied (Orbach 2002). The future of ocean fertilization will be guided by the tradeoffs we make, the design we select for ocean environments and resources, and the pattern of human uses resulting from that design.

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