THE ECONOMIC VALUE OF NARRAGANSETT BAY

A Review of Economic Studies

by

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Executive Summary

Goods and services provided by natural ecosystems form the basis of human welfare. Natural ecosystems provide food, materials, fuels, and water that are necessities in human lives. The ability of ecosystems to provide these goods and services depends on the ecosystem processes through which goods and services are created and maintained. Constanza et al. (1997) categorized natural resources by the specific services they provide to humans. The ecosystem service framework includes the following services: gas regulation, climate regulation, disturbance regulation, water regulation, water supply, erosion control, soil formation, nutrient cycling, waste treatment, pollination, biological control, refugia, food production, raw materials, genetic resources, recreation, cultural services, and commercial and industrial services.

While the concept of economic value is not necessarily based on money, economists often estimate monetary values for ecosystem goods and services. Economists have two approaches for natural resources valuation: the "income" concept and the "gains from trade" concept. Typically, the "income" concept measures the income generated by industries related to natural resources. The "gains from trade" concept measures the benefits received by consumers and producers related to natural resources.

Constanza et al. (1997) provided a useful framework for analyzing ecosystem services values on a global scale. Ideally one might hope to apply this framework to the ecosystem services of Narragansett Bay. However, unit values needed for this framework are not easily available and existing estimates are not comparable.

This paper attempts to review the studies estimating values of the Narragansett Bay ecosystem. It also identifies gaps in information about values of the Bay's natural resources, not only among the types of ecosystem services studied, but also between the concepts of economic value.

Most of the studies reviewed in this paper assess value to only the ecosystem services that can be directly linked to economic activity (e.g. raw materials, food production, recreation services, cultural services, and commercial and industrial services). For valuation of other ecosystem services no studies have been found.

Several estimates suggest that the total value of the natural resources of the watershed exceeds several billion dollars per year. A 1997 adaptation of the Constanza results suggests $2.1 billion in 1994 dollars. The Tyrrell and Harrison value added estimation suggests a minimum of $2.3 billion in 1997. However, willingness to pay estimates of Tyrrell and Harrison for recreational resource use was $6.7 billion in 1997. The wide range in values exemplifies the implications of the difference in methodologies.

Four major obstacles were encountered in the effort to estimate overall watershed values. First, different measures have been used to quantify the value of resources. These are often misunderstood and frequently incompatible. Second, few estimates measured non-market values. Third, the geographical scope of the studies available is usually limited to the counties of the state of Rhode Island, which include only a portion of Narragansett Bay, and not the entire watershed. Fourth, there are few studies of the economic value of ecosystem services that are not directly linked to economic activities.

Future research should address these problems. First, the concepts of economic value need to be reconciled and related to other measures of economic impact. Second, non-market valuation studies should be encouraged and the potential for using value estimates derived out of the region should be explored. Third, future studies of natural resources valuation should cover the broader geographical scope of the entire Narragansett Bay watershed. Finally, ecosystem services that are not directly related to specific economic activities should be studied.

Chapter 1. Natural Resources: Values and Valuation

Goods and services provided by natural ecosystem form the basis of human welfare. Natural ecosystems provide food, materials, fuels, and water that are necessities in human lives. The ability of ecosystems to provide these goods and services depends on the ecosystem processes through which goods and services are created and maintained.

Economic Value of Natural Resources

Economists use two general philosophical bases to guide natural resources valuation: the utilitarian approach and the intrinsic rights approach. The utilitarian approach maintains that resources have value to the extent that they confer satisfaction to humans. The intrinsic rights approach maintains that natural entities have value independent of whether they provide satisfaction to humans (Goulder and Kennedy, 1997). Despite its inability to deal with certain ethical issues, the utilitarian approach is the most thoroughly developed approach to valuation and provides a systematic method for directing attention to relative values of services generated by natural resources.

The true utilitarian value of natural resources is infinite – the human race cannot exist without water, soil or atmosphere. However, knowledge of the relative contribution of natural resources to human welfare at the margin helps design public policies to enhance quality of life. While it may not be possible to quantify the loss associated with the total elimination of a natural resource, it is reasonable and useful to estimate the value of a marginal change in the quantity or quality of a resource.

Economic value "expresses the utility of some particular object and sometimes the power of purchasing other goods" (Adam Smith). These two meanings suggest two different concepts for valuing natural resources: the income concept of value and the "gains from trade" concept of value.

Measurement of Economic Values

The Income Concept

The income concept of value (also called the "value added" approach to value) is based on the power to purchase goods and services and describes the general capacity to obtain goods and services, independent of the amount of satisfaction received to humans. Value added can be computed as gross output minus costs of intermediate goods and services and is a measure of the income generated by any industry. This concept is the basis for Gross National Product and its Gross State Product counterpart. The advantage of the income concept for value is that provides finite measures.

A related economic indicator is Gross Product Originating (GPO) that measures the value added of all natural resource-dependent industrial sectors and of the sectors providing their intermediate inputs.

The Gains from Trade Concept

The gains from trade concept is based on the "willingness to pay" for a good or service by a consumer and the "willingness to sell" that good by the producer. Hence, value is obtained after a consumer receives and a producer delivers a particular good or service (consumer surplus and producer surplus). This concept of value describes the satisfaction received from any good or service that an individual receives whether from food ingested or a beautiful view appreciated. It does not require that a good or service actually be purchased with money, only that it be consumed. One of the major advantages of the gains from trade concept is that it provides a dollar measure of satisfaction received from natural resources by consumers. Disadvantages are that this concept does not provide finite measures and that empirical estimates are subject to a variety of errors.

A more detailed discussion of these two economic value measures can be found in Tyrrell and Harrison (2000).

Other Economic Measures

A variety of other economic indicators are used to quantify the value of natural resources. They include revenues, wages, employment, and expenditures. The advantage of these indicators is that they are easily obtainable. The disadvantage is that these indicators do not accurately measure either concepts of income or gains from trade.

Linkages between Economic Values and Indicators

Figure 1 illustrates the relationships between the two concepts of economic value and a variety of economic indicators. It can be seen that the two concepts overlap by industry profits. Also, none of the economic indicators have the ability to completely describe wither of the two concepts of economic value.

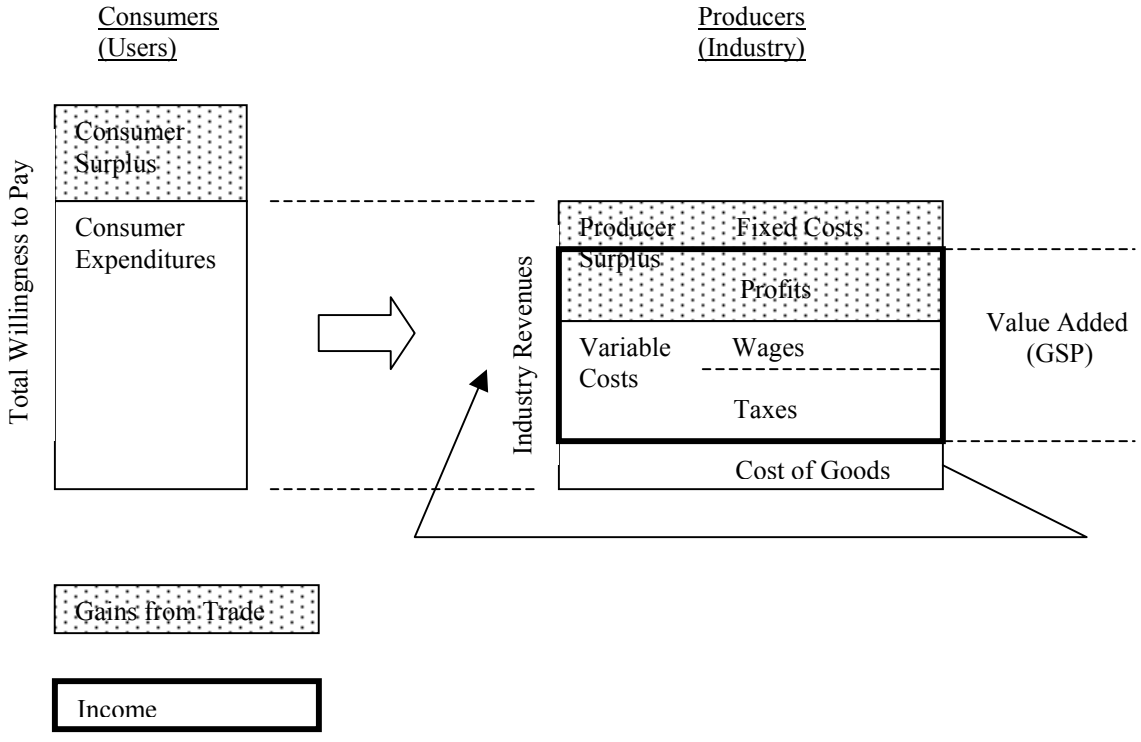

Figure 1. Economic Value Concepts and Measures

Chapter 2. The Value of Natural Resources in Narragansett Bay

The Ecosystem Services Approach

The ecosystem services approach values natural resources by the services they provide. Hence, natural resources can be categorized by the specific services they provide to humans in an ecosystem services framework (Constanza et al., 1997). Ecosystem services are the processes by which the environment produces resources such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants.

A marine and coastal ecosystem services framework is presented in Table 1 (adapted from Constanza et al., 1997). Some of the ecosystem services listed in the framework can be immediately linked to measurable economic activities. These include food production, raw material extraction, recreational, cultural, and commercial and industrial services. Other ecosystem services can also be linked to economic activities, but their economic value is difficult to measure. These include gas regulation, disturbance regulation, erosion control and sediment retention, waste treatment, biological control and refugia. Finally, some ecosystem services are only indirectly linked to economic activities and they are very difficult to value. These include climate regulation, soil formation, nutrient cycling, pollination, and other genetic resource services.

Constanza et al. (1997) provided a useful framework for analyzing ecosystem services values on a global scale. The authors used various methods to estimate economic market and non-market values of the goods and services in different ecosystems. According to Constanza et al. (1997), natural capital is divided into two major categories: marine biomes and terrestrial biomes. These categories are further divided into fourteen subcategories reflecting the differences in ecological activities that take place within them. Marine biomes include open ocean biomes and coastal biomes (estuaries, sea grass/algae beds, coral reefs, shelf). Terrestrial biomes include forests, grass/rangelands, wetlands, lake/rivers, desert, tundra, ice/rock, cropland, and urban. The reported values for each type of ecosystem type can be used as a basis for estimates relevant to specific regions.

Tyrrell and Harrison (2000) attempted to determine a linkage of Rhode Island's natural resources to the biomes categories (Table 2 on page 12 in Tyrrell and Harrison, 2000). This linkage provides some information on the acreage of different types of biomes for Narragansett Bay (although the figures include only the Rhode Island portion of the Bay, not the entire watershed). Hence, estimates for ecosystem goods and services for this region can be calculated using Constanza's $/hectare estimates (Table 2). These unit values are not always comparable, so the total value for the Bay could be either under- or over-estimated. Using the Constanza results, ecosystem services in Narragansett Bay in Rhode Island can be valued at approximately $2.1 billion per year (in 1994 dollars). This value can be divided on ecosystem types. The ecosystems that highly contribute to this overall value are the Bay's estuaries ($926 million), its wetlands ($612 million), and its grassland ($555,700). Also, the economic value of Narragansett Bay's continental shelf is $326 million, of its forestland is $125 million, and of its lakes and rivers is $65 million per year.

Ecosystem Services in Narragansett Bay

This chapter reviews existing estimates of economic values associated with natural resources and their ecosystem services in Narragansett Bay. Most of the studies assess value to only the ecosystem services that can be directly linked to economic activity (e.g. raw materials, food production, recreation services, cultural services, and commercial and industrial services). For valuation of other ecosystem services no studies have been found.

One of the major sources of data for this review is a study conducted at the University of Rhode Island, Department of Resource Economics from August 1 through October 31, 1994 (Tyrrell, Devitt, and Smith, 1994). The study was an overview of the available data on the uses and values associated with the Rhode Island portion of Narragansett Bay and computed estimates that reflected the relative importance of services provided by its natural resources. The variety of importance measures overlapped and could not be added. It was clear that a framework was needed in which the study's estimates could be compared. Tyrrell and Harrison (2000) attempted to rectify some of these problems in a new study. They categorized natural resources for quantification purposes and they used a more justifiable approach to value these resources attempting valuation to the extent possible using secondary data.

Raw Materials Services

Raw materials ecosystem services are defined as the portion of gross primary production extractable as raw materials (Constanza et al., 1997). Examples include the production of timber, fuel or fodder. Hence, they are directly related to harvesting and extraction sectors as Forestry and Mining.

Two studies were found estimating raw materials services of Narragansett Bay. They refer to the Rhode Island portion of the Bay, not at the entire watershed and they used value added and wages indicators to measure economic value (studies are summarized in Table 3).

First, Tyrrell and Harrison (2000) assumed that for all raw materials 100% of their industrial output is dependent on natural resources. Hence, they estimated a resource dependent value added measure (including profits, wages, and taxes) for the Forestry and Mining sectors of Rhode Island to be equal to $22 million in 1997.

Second, according to the Rhode Island Department of Environmental Management's Forestry Asset Management Plan (2001), for the state of Rhode Island, the timber industry represented 2.7 percent of the manufacturing workforce, with a payroll of $60 million in the year 2000 (Keller, Tosches, and Mycroft, 2001). This wages indicator is high since it does also include manufacturing industry wages for the timber sector.

Food Production Services

Food production services of an ecosystem are defined as the portion of gross primary production extractable as food (Constanza et al., 1997). Examples include the production of fish, game, crops, nuts, and fruits by hunting, gathering, subsistence farming or fishing. Hence, they are directly related to harvesting sectors as Agriculture and Commercial Fisheries.

All studies that were found estimating food production services of Narragansett Bay did only refer to the Rhode Island portion of the Bay, not at the entire watershed and used the revenues, value added, and wages economic indicators (studies are summarized in Table 4). The fishery

resources of Rhode Island range from sessile shellfish (oysters and quahogs), that remain in Narragansett Bay through all life history stages, to migratory species that only visit the Bay's waters on a seasonal basis.

Tyrrell, Devitt, and Smith (1994) provided an estimate of $24 million for the revenues from commercial fish catch from Narragansett Bay in 1993.

A study conducted by Save the Bay of Rhode Island (2002) reported that in 1994 the state of Rhode Island's combined revenues from commercial finfish and shellfish landings totaled $77 million. The most profitable fishery of Narragansett Bay is the quahog (hard clam), accounting for 84 percent of the Bay's total fishing revenues. The revenues from the quahog catch in Rhode Island were $7.6 million in 1994.

According to the Rhode Island Department of Environmental Management, Division of Fish and Wildlife, Marine Fisheries Section, in 1996, the entire seafood industry in Rhode Island generated revenues of $700 million, taking into account dollars generated through domestically marketed landings such as restaurant and fish market sales ($146 million), fish and shellfish sold an exported to other states and countries ($95 million), and the additional economic activity associated by these sales such as transportation and storage ($132 million) (Rhode Island Department of Environmental Management, Division of Fish and Wildlife, 2002). According to the same study, the revenues from commercial fishery resources landings in 2000 were approximately $73 million. These estimates are confirmed by a Narragansett Bay Summit white paper (DeAlteris, Gibson, and Skrobe, 2000). The study estimated the revenues from landings of commercial fisheries of Rhode Island at approximately $75 million per year and the revenues of seafood production at approximately $700 million per year.

National Marine Fisheries Services (2000) estimated the revenues from commercial fishery landings at major U.S. ports in 2000. For the Narragansett Bay watershed area, generated revenues from landed fisheries in the port of Point Judith, RI were $41.4 million and in the port of New Bedford, MA were $146.3 million. Note that these catches include fish caught outside Rhode Island waters.

Aquaculture, broadly defined as the cultivation of aquatic animals and plants under controlled or semi-controlled conditions, has a proud history in Rhode Island and in Narragansett Bay. A Narragansett Bay Summit white paper (Scott et al., 2000) reports that the total farm gate revenues generated by the aquaculture industry was $213,861 in 1999.

Assuming that for only 75% of Agriculture and Commercial Fisheries industrial sectors are directly dependent on natural resources, Tyrrell and Harrison (2000) estimated the resource dependent value added for Agriculture and Fisheries to be equal to $135 million in 1997.

Colgan and Kite-Powell (2001) studied Rhode Island's ocean economy, which includes activities and resources that are directly or indirectly tied to the ocean and the coast. The basic concept of the ocean economy seeks to measure that economic activity which in one way or another uses the ocean as input. The methodology used was developed as part of the National Ocean Economics project and used the value added-type indicator, the Gross Product Originating (GPO). The ocean economy includes living marine resources: commercial fish harvesting and processing. The study estimated that these industries produced $103 million in value added (GPO) and paid $19 million in direct wages.

Recreational Services

Recreational services of an ecosystem are defined as providing opportunities for recreational activities (Constanza et al., 1997). Examples include tourism, sport fishing, and other outdoors-recreational activities. Hence, they are directly related to resource dependent recreational and tourism activities.

Only one study was found to estimate recreational services for the entire Narragansett Bay estuary (Warziniack and Creason, 2001). All other studies found referred only to the Rhode Island portion of the Bay. Also, only one study used the gains from trade concept to measure economic value (Tyrrell and Harrison, 2000). All other studies used revenues, expenditures, and value added indicators (studies are summarized in Table 5).

Tyrrell, Devitt and Smith (1994) estimated revenues from Bay-related tourism industry at $391 million in 1993. For the same year, tourism industries generated $84 million in wages. Non-wage Bay-related tourism expenditures were $990,946 in 1993.

In a Narragansett Bay Summit white paper, Colt, Tyrrell and Lee (2000) estimated, for the year 1998, the sales revenues attributable to travelers and tourists in the state of Rhode Island at $2.5 billion ($500 million in wages). The revenues from major ocean-related tourism events were estimated as $1 million per event.

Tyrrell and Harrison (2000) used the gains from trade concept of economic value to estimate recreational ecosystem values. While the authors recognize that it is impossible to accurately estimate consumer surplus derived from all ecosystem services, they only attempted to approximate the consumer surplus associated with outdoor recreational activities. A statewide survey of outdoor recreation participation (Tyrrell, 1986) was used to estimate the number of days of use by Rhode Island residents of the State's natural resources. These were multiplied by net economic values per activity day to estimate consumer surplus generated from each economic activity. The economic values were taken from a survey of values of outdoor recreation activities (Walsh, Johnson, and McKean, 1998) and adjusted to 1997 average dollar. The calculations provided a total value (total willingness to pay) of all outdoor recreation activities of $6.7 billion per year. The total annual willingness to pay for Bay-related outdoor recreation activities was $2.0 billion per year.

In an economic profile of the Narragansett Bay National Estuary Program (Warziniack and Creason, 2001) including counties of Bristol, Norfolk, Plymouth and Worcester in Massachusetts and the counties of Bristol, Kent, Newport, Providence, and Washington in Rhode Island, the total tourism industry revenues for this region were estimated as $2.1 billion.

The Rhode Island's ocean economy study (Colgan and Kite-Powell, 2001) using the Gross Product Originating (GPO) as a value added indicator estimated that in 1997 the tourism and recreation industries (on both water and land) produced $140 million in Gross Originating Product and paid $52 million in wages.

Tyrrell, Devitt and Smith (1994) estimated expenditures for recreational fishing trips at $62 million.

In a Narragansett Bay Summit white paper by DeAlteris, Gibson, and Skrobe (2000) it was estimated that recreational fishermen make about 1 million fishing trips annually in Rhode Island waters and the revenues from this activity were approximately $150 million.

The Department of Environmental Management, Division of Fish and Wildlife (2002) estimated that the recreational industries' tackle shops, marinas and charter boats in Rhode Island generated revenues of $150 million in 2000.

A Rhode Island Department of Environmental Management, Office of Strategic Planning and Policy (2001) management plan for the Rhode Island Park and Beach System (RIBPS) estimated that RIBPS park generated revenues totaled approximately $3.15 million annually. In 1999, non-resident beach fees contributed $875,277 to the general fund. In 1996, the Rhode Island Department of Environmental Management surveyed East Bay Bike Path users. On average, bike path users spent $5.24 for each visit to the bike path and this translates to $2.2 million spent annually at stores and venders near the bike path.

Cultural Services

Cultural services of an ecosystem are defined as providing opportunities for non-commercial uses (Constanza et al., 1997). Examples include aesthetic, artistic, educational, spiritual, and scientific values of ecosystems. Hence, they are directly related to resource dependent government, NGO, and non-market activities.

All studies that were found estimating cultural services of Narragansett Bay referred only to the Rhode Island portion of the Bay, not at the entire watershed, and used the expenditures and value added indicators to measure economic value (studies are summarized in Table 6).

Tyrrell, Devitt, and Smith (1994) calculated total expenditures for research and regulation in Narragansett Bay at $38 million.

The Rhode Island Senate Policy Office's (2002) study on Rhode Island's marine related economy (the marine cluster) reports that in 1998 the Naval Undersea Warfare Center (NUWC) expenditures budget covered $637 million (Source: Providence Business News, April 11, 2001), and the 1999-2000 research expenditures budget for University of Rhode Island's Graduate School of Oceanography covered $22 million.

The Rhode Island's ocean economy study (Colgan and Kite-Powell, 2001) using the Gross Product Originating (GPO) as a value added measure estimated that in 1997 the government industrial sectors related to research, defense, and ocean management produced $119 million in Gross Originating Product and paid $106 million in wages.

Industrial and Commercial Services

Industrial and commercial services of an ecosystem are defined as providing inputs for commercial and industrial uses (Tyrrell and Harrison, 2000). They are directly related to resource dependent manufacturing, wholesaling, retailing, and services industries.

All studies that evaluated industrial and commercial ecosystem services referred only to the Rhode Island portion of the Bay and used the value added and wages indicators to measure economic value (studies are summarized in Table 7).

Using the resource dependent value added estimation for manufacturing, transportation, communication and utilities, wholesale and retail trade, finance, insurance and real estate, and services, Tyrrell and Harrison (2000) estimated the resource dependent value added for these industries to be equal to $1.7 billion in 1997.

The Rhode Island's ocean economy study (Colgan and Kite-Powell, 2001) using the Gross Product Originating (GPO) as a measure of output estimated that in 1997 the construction and rehabilitation industries (piers, wharves, dredging, beach restoration) produced $6 million in value added Gross Product Originating (GPO) and paid $4 million in wages and that transportation industries (ocean transportation of goods and passengers) produced $58 million in GPO and paid $46 million in wages.

Tyrrell, Devitt and Smith (1994) estimated average annual wages of Bay-related industry as $167 million in 1993.

Chapter 3. Recommendations for Future Work

Four major obstacles were encountered in the effort to estimate overall watershed values. First, different measures have been used to quantify the values of resources. These are often misunderstood and frequently incompatible. Second, few estimates measured non-market values. Third, the geographical scope of the studies available is usually limited to the counties of the state of Rhode Island, which include only a portion of Narragansett Bay, and not the entire watershed. Fourth, there are few studies of the economic value of ecosystem services that are not directly linked to economic activities.

Future research should address these problems. First, the concepts of economic value need to be reconciled and related to other measures of economic impact.

Second, non-market valuation studies using the willingness-to-pay concept should be encouraged and the potential for using value estimates derived out of the region should be explored. The willingness to pay concept of value covers a much wider range of human utility. An ecosystem ability to add to monetary wealth is not only determined by the consumptive use of ecosystem's goods and services, but also by non-consumptive uses as gaining pleasure from hiking, birdwatching, and other outdoor recreational activities. Some of the methods that economists use to measure non-market values are the contingent valuation method, the travel cost method and the hedonic approach.

Third, future studies of natural resources valuation should cover the broader geographical scope of the entire Narragansett Bay watershed.

Finally, ecosystem services that are not directly related to specific economic activities should be studied. Comparable and transferable methodologies should be completed to study and measure economic value for ecosystem services that are not directly related to specific economic activities

(e.g. gas regulation, disturbance regulation, erosion control, waste treatment, biological control, climate regulation, soil formation, nutrient cycling, pollination, and other genetic resource services).

Table 1. Marine and Coastal Ecosystem Services and Functions

No.	Ecosystem Service	Ecosystem Function	Economic Activities
1	Gas Regulation	Regulation of atmospheric chemical composition	Air pollution
2	Climate Regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at local levels	
3	Disturbance Regulation	Capacitance, damping, and integrity of ecosystem response to environmental fluctuations	
4	Water Regulation	Regulation of hydrological flows	Irrigation
5	Water Supply	Storage and retention of water	Public water supply
6	Erosion Control and Sediment Retention	Retention of soil within an ecosystem	Public erosion control
7	Soil Formation	Soil formation processes	
8	Nutrient Cycling	Storage, internal cycling, processing and acquisition of nutrients	
9	Waste Treatment	Recovery of mobile nutrients and removal of breakdown of excess or xenic nutrients and compounds	Public waste treatment
10	Pollination	Movement of floral gametes	
11	Biological Control	Trophic-dynamic regulations of populations	
12	Refugia	Habitat for resident and transient populations	Habitat protection
13	Food Production	That portion of gross primary production extractable as food	Harvesting sectors: Agriculture, Commercial Fisheries
14	Raw Materials	That portion of gross primary production extractable raw materials	Harvesting and extraction sectors: Forestry, Mining
15	Genetic Resources	Sources of unique biological materials and products	
16	Recreation	Providing opportunities for recreational activities	Resource dependent recreational and tourism activities
17	Cultural	Providing opportunities and inputs for non-commercial uses	Resource dependent Government, NGO, and non-market activities
18	Commercial and Industrial	Providing inputs for commercial and industrial uses	Resource dependent Manufacturing, Transp., Wholesaling, Retailing, Services, etc.

Note: Adapted from Constanza et al. (1997), pp. 254

Table 2. Estimates of Narragansett Bay Ecosystem Values[1]

Ecosystem Service	Global values by ecosystem service ($/acre)[2]							
	Estuaries	Shelf	Forest	Grass/Range	Wetlands	Lakes/Rivers	Cropland	Urban
Gas Regulation				2.8	53.8			
Climate Regulation			57.1	0.0				
Disturbance Regulation	229.5		0.8		1836.9			
Water Regulation			0.8	1.2	6.1	2203.6		
Water Supply			1.2		1537.8	856.7		
Erosion Control			38.9	11.7				
Soil Formation			4.0	0.4				
Nutrient Cycling	8539.1	579.1	146.1					
Waste Treatment			35.2	35.2	1690.4	269.1		
Pollination				10.1			5.7	
Biological Control	31.6	15.8	0.8	9.3			9.7	
Habitat/Refugia	56.9				123.0			
Food Production	210.8	27.5	17.4	27.1	103.6	16.6	21.9	
Raw Materials	10.1	0.8	55.8		42.9			
Genetic Resources			6.5	0.0				
Recreation	154.2		26.7	0.8	232.3	93.1		
Cultural	11.7	28.3	0.8		356.5			
Area (acres)[3]	100,208	500,000	318,995	5,636	102,249	18,756	50,112	191,572
Total Value ($1000/year)	**926,312.7**	**325,750.0**	**125,077.9**	**555.7**	**611,786.4**	**64,503.8**	**1,869.2**	**0.0**
						TOTAL ($1000/year):	**2,100,000**	

Note: Blank cells = not available; Shaded cells = service does not occur or is negligible

[1] Estimates refer only to the Rhode Island portion of Narragansett Bay, not the entire watershed

[2] Calculated from the $/hectare estimates of Constanza et al. (1997) based on conversion factor of 2.471 acres/hectare. All values are in 1994 U.S. dollars.

[3] Source: Tyrrell and Harrison (2000)

Table 3. Raw Materials Services Values of Narragansett Bay

Study	Geographic Scope	Basis for Valuation	Year	Value Estimates
Tyrrell and Harrison (2000)	Rhode Island	Resource dependent value added for forestry and mining industrial sectors	1997	$22,000,000
Keller, Tosches, and Mycroft (2001)	Rhode Island	Annual average wages for the timber industry	2000	$60,000,000

Table 4. Food Production Services Values of Narragansett Bay

Study	Geographic Scope	Basis for Valuation	Year	Value Estimates
Tyrrell, Devitt and Smith (1994)	Rhode Island waters only	Revenues from commercial fish catch	1993	$23,878,000
Save the Bay (2002)	Rhode Island landings	Revenues generated by commercial fish landings	1994	$77,000,000
Rhode Island Department of Environmental Management, Division of Fish and Wildlife (2002) DeAlteris, Gibson, and Skrobe (2000)	Rhode Island	Revenues generated by the Rhode Island's seafood industry Revenues from commercial fishery landings	1996 2000	$700,000,000 $73,000,000
National Marine Fisheries Services (2000)	Rhode Island and Massachusetts landings	Revenues from commercial fishery landings in Narragansett Bay's ports	2000	Point Judith, RI: $41,400,000 New Bedford, MA: $146,300,000
Scott et al. (2000)	Rhode Island	Farm gate revenues of aquaculture industry	1999	$213,861
Tyrrell and Harrison (2000)	Rhode Island	Annual resource-dependent contributions to the Gross State Product (value added) in agriculture and fisheries	1997	$135,000,000
Colgan and Kite-Powell (2001)	Rhode Island	Gross Product Originating (GPO) and wages from living resources industries (fisheries and living marine resources)	1997	GPO: $103,237,998 Wages: $19,117,279

Table 5. Recreation Services Values of Narragansett Bay

Study	Geographic Scope	Basis for Valuation	Year	Value Estimates
Tyrrell, Devitt and Smith (1994)	Rhode Island	Revenues, average annual wages and expenditures of Bay-related tourism industry	1993	Revenues: $390,748,000 Wages: $83,651,000 Expenditures: $990,946
Colt, Tyrrell, and Lee (2000) Tyrrell and Harrison (2000)	Rhode Island	Revenues attributable to travelers and tourists Revenues from ocean-related events ($/event) Total annual willingness to pay for natural resource - based recreation Total annual willingness to pay for Bay-related outdoor recreation activities	1998	$2,500,000,000 $1,000,000 $6,700,000,000 $2,000,000,000
Warziniack and Creason (2001)	Narragansett Bay Estuary	Revenues from tourism industry	1998	$2,115,000,000
Colgan and Kite-Powell (2001)	Rhode Island	Gross Product Originating (GPO) and wages from tourism and recreation (on both water and land)	1997	GPO: $140,051,675 Wages: $51,570,360
Tyrrell, Devitt and Smith (1994) NMFS (1994)	Rhode Island	Expenditures of recreational fishing trips (All angling in state)	1993	$62,652,000
DeAlteris, Gibson, and Skrobe (2000)	Rhode Island	Industry revenues from recreational fishing trips	1998	$150,000,000
Rhode Island Department of Environmental Management, Division of Fish and Wildlife (2002)	Rhode Island	Revenues generated by recreational industries' tackle shops, marinas, and charter boats	2000	$150,000,000
Rhode Island Department of Environmental Management, Office of Strategic Planning and Policy (2001)	Rhode Island	Park generated revenues Revenues from non-resident beach fees Revenues from spending at stores and venders near the East Bay Bike Path	1999 1996	$3,150,000 $875,277 $2,200,000

Table 6. Cultural Services Values of Narragansett Bay

Study	Geographic Scope	Basis for Valuation	Year	Value Estimates
Tyrrell, Devitt and Smith (1994)	Rhode Island	Expenditures for research and regulation of the Bay	1993	$38,161,317
Rhode Island Senate Policy Office (2002)	Rhode Island	Expenditures for research of Naval Undersea Warfare Center (NUWC) Expenditures for research of University of Rhode Island, Graduate School of Oceanography	1998 1999	$637,000,000 $22,423,129
Colgan and Kite-Powell (2001)	Rhode Island	Gross Product Originating (GPO) and wages from government industries (related to research, defense, ocean management)	1997	GPO: $118,623,873 Wages: $105,992,618

Table 7. Industrial and Commercial Services Values of Narragansett Bay

Study	Geographic Scope	Basis for Valuation	Year	Value Estimates
Tyrrell and Harrison (2000)	Rhode Island	Annual resource-dependent contributions to the Gross State Product (value added) for construction, manufacturing, transportation, trade, FIRE, and services industrial sectors	1997	$1,724,000,000
Colgan and Kite-Powell (2001)	Rhode Island	Gross Product Originating (GPO) and wages from construction and rehabilitation (piers, wharves, dredging, beach restoration) Gross Product Originating (GPO) and wages from transportation (ocean transportation of goods and passengers)	1997	GPO: $5,964,790 Wages: $3,950,192 GPO: $57,645,043 Wages: $46,329,748
Tyrrell, Devitt and Smith (1994)	Rhode Island	Average annual wages of Bay-related industry	1993	$167,431,800

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