Ecological Indicators 44 (2014) 69–80

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Developing economic indices to assess the human dimensions of the South Florida coastal marine ecosystem services

Grace Johns[a], Donna J. Lee[b], Vernon (Bob) Leeworthy[c], Joseph Boyer[d], William Nuttle[e,*]

[a] Hazen and Sawyer, 4000 Hollywood Boulevard, Suite 750N, Hollywood, FL 33021, United States
[b] DJL Economic Consulting, 3029 Holei Street, Honolulu, HI 96815, United States
[c] NOAA/NOS/Office of National Marine Sanctuaries, 1305 East West Hwy., SSMC4, 11th Floor, Silver Spring, MD 20910, United States
[d] Center for the Environment, Environmental Science & Policy Department, Plymouth State University, 17 High Street, MSC #63, Plymouth, NH 03264, United States
[e] Eco-Hydrology, 11 Craig Street, Ottawa, Ontario, Canada K1S 4B6

ARTICLE INFO

Article history:
Received 28 June 2013
Received in revised form 6 April 2014
Accepted 7 April 2014

Keywords:
Ecosystem management
South Florida
Human dimensions
Ecosystem service
Economic indicator

ABSTRACT

Resource managers in South Florida are aware that coastal and marine ecosystems provide food, recreation, and a quality of life that are highly-valued by humans. Estimates of economic values in Florida, such as willingness-to-pay for a day of coral reef snorkeling or the change in this value from a change in coral cover, are not updated in a timely manner or are not available at all. Usually these studies are "baseline studies" that provide a snapshot of economic values under existing economic and environmental conditions. Therefore, to be useful to ecosystems management, human dimension (HD) economic indicators that are relatively easy to measure each year must be identified. In addition, they must be combined with a conceptual model that links these indicators to the ecosystem services; their relevant economic values; the HD non-economic metrics of well-being; and the quality and/or quantity of the environmental and ecologic attributes associated with the ecosystem service. Carefully selected HD economic indicators together with ecological, environmental, and non-economic human dimensions indicators can provide a rich source of information for managing the long term conservation and use of coastal and marine ecosystems.

In this paper, we specify criteria for selecting HD economic indicators that measure the change in demand for ecosystem services resulting from changes in the quality or quantity of the environmental attributes that comprise the service. We assessed a suite of candidate metrics and arrived at a final set of HD economic indicators for further evaluation. These HD economic indicators are the percentage change from year to year in: (1) coastal park visitation; (2) number of registered recreational boats; (3) pounds of commercial seafood landed; (4) number of live marine organisms landed; and (5) dollar value of insured flood damage claims paid.

We illustrated the use of these HD economic indicators with an empirical example for the Florida Keys and Dry Tortugas where the indicators are measured over a one year period. The changes were then scored and the scores were assigned a stop light rating of: green for good (or increasing), yellow for fair (or stable), and red for poor (or decreasing). Our empirical illustration of HD economic indicators offers a first step in developing metrics to rate the status of Florida's coastal and marine ecosystem services. The next steps are to propose a full suite of candidate HD economic indicators and metrics; final selection of HD economic indicators and their integration into the conceptual model; annual calculation of these indicators and their evaluation; and environmental/ecosystem assessment.

1. Introduction

The coastal marine ecosystems of South Florida are biologically varied, ecologically rich, and essential to the regional economy. South Florida's sub-tropical climate, its beaches, clear coastal waters, unique coral reefs and wild mangrove shoreline attract visitors from all over the world. Visitors to the southeast Florida

* Corresponding author. Tel.: +1 613 222 8413.
E-mail address: wnuttle@eco-hydrology.com (W. Nuttle).

http://dx.doi.org/10.1016/j.ecolind.2014.04.014
1470-160X/

coast, between Miami and Port St. Lucie, contribute $19 billion dollars annually to the local economy as measured by the value of goods and services produced (Catanese Center, 2005), and recreational activities on the reef tract just offshore of this stretch of coast contribute another $4.4 billion dollars per year (Johns et al., 2001).

Past approaches to evaluating the condition of ecosystems have focused on the impacts of human activities on resource degradation (Office of National Marine Sanctuaries, 2014a). This sets up a false dichotomy between the ecosystem and the economy that leads to underinvestment in marine protection and restoration. When humans are considered as part the functioning ecosystem it can be shown that investments in marine protection and restoration will benefit humans and the coastal economy. Our hope is to change the conversation from the false dichotomy between the ecosystem and the economy to a discussion of the positive linkages among ecosystems and economies and the impacts of resource management decisions on human values and wellbeing (Office of National Marine Sanctuaries, 2014b).

Reducing the impact of human activities on resources often entails short term costs and/or a reduction in benefits. By understanding and managing competing uses and tradeoffs, a greater proportion of human benefits provided by the coastal marine ecosystem can be sustained (e.g. market and non-market, including use and non-use values). Recognizing this, the Florida state legislature passed the Oceans and Coastal Resources Act in 2005 which calls for active management aimed at "restoring, rehabilitating, and maintaining the quality and natural function of [Florida's] oceans and coastal resources." The Act further calls for managers to employ an ecosystem-based approach supported by the development of regional goals and improved monitoring and assessment. The ecosystem-based approach requires managers to consider all human uses and values.

By characterizing humans and human activities as an integral part of the coastal marine ecosystem, candidate human dimension (HD) economic indicators were developed to inform coastal resource managers. The indicators identified in this paper are economic in nature in that they measure people's use of, or demand for, ecosystem services. Ecosystem services are the benefits that people receive from the ecosystem. The benefits result from the interface between humans and the coastal marine resources. Loomis et al. (2014) define and put forth non-economic human dimension indicators to track the status of non-monetary aspects of human well-being derived from healthy, coastal resources. The information provided by HD economic and non-economic indicators should be considered together with information provided by ecosystem state indicators (cf. other articles in this issue) to rate each ecosystem service (Office of National Marine Sanctuaries, 2014b).

2. Background: South Florida's coastal marine ecosystem

For many residents and visitors, the coastal marine environment defines South Florida. The South Florida coastal marine ecosystem (SFCME) comprises the coastal waters extending south from the St. Lucie Inlet on the east coast, through the Florida Keys, and then north through Charlotte Harbor and the Caloosahatchee estuary on the west coast (Fig. 1). The SFCME also encompasses estuarine embayments, including Lake Worth Lagoon, Biscayne Bay and Florida Bay, and several river-dominated estuarine systems, such as the Caloosahatchee and St. Lucie estuaries. The ecosystem has a variety of habitats, including sandy beaches, mangrove swamps, other coastal wetlands, oyster reefs, submerged aquatic vegetation, inshore coral and hard bottom communities, and offshore coral reefs.

Implementing ecosystem-based management (EBM) in the region requires the consideration of social, cultural, and economic

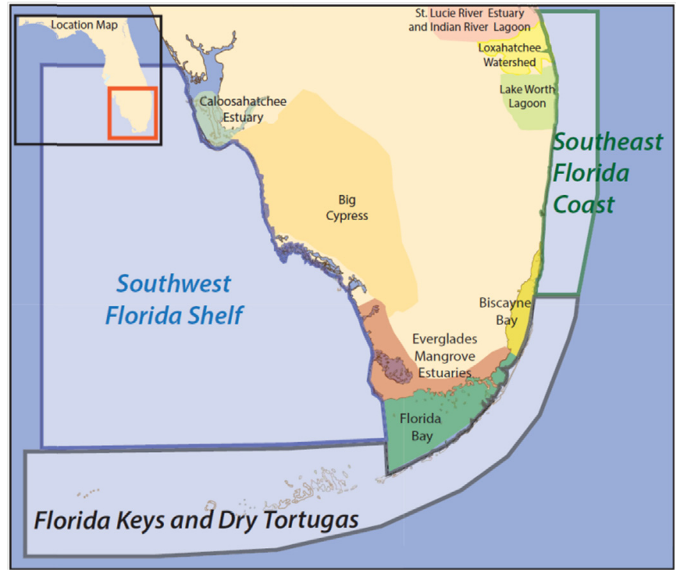

Fig. 1. South Florida coastal marine ecosystem, domain of the MARES project.

factors as well as the ecological components of the coastal marine environment (Weinstein, 2009; Cheong, 2008; Turner, 2000; Lubchenco, 1999; Visser, 1999). The Marine and Estuarine Goal Setting (MARES) Project built upon ongoing efforts to implement EBM in connection with the hydrological restoration of the Everglades, the vast freshwater wetlands that occupy the central portion of the south Florida peninsula. Ogden et al. (2005) developed conceptual ecosystem models of the Everglades ecosystem as the basis for selecting performance measures and indicators, implementing regional monitoring plans, and identifying critical research gaps. The conceptual models developed by the MARES Project extended these models geographically, by moving offshore into the coastal marine ecosystem, and conceptually by including people as an integral component of the ecosystem.

South Florida is home to 6.7 million residents and visitors who live near the coast, many of whom interact with the SFCME daily (Johns et al., 2001; Leeworthy and Morris, 2010; Leeworthy et al., 2010). The conceptual model framework developed in the MARES Project (EBM-DPSER; Kelble et al., 2013) identified attributes of the marine environment that people care about and listed the benefits people receive from ecosystem services. Similar to what had been done for the Everglades, the MARES Project identified biological, chemical, and physical indicators to provide information on conditions in the coastal marine environment. The MARES Project went one step further by identifying human dimension indicators which enables managers to track the status of human benefits with changes in the condition of coastal marine resources. An improvement in seagrass health for example will increase fish catch rates and improve coral coverage which in turn boosts customer satisfaction ratings on guided fishing and dive trips.

Healthy, functioning ecosystems provide people with a wide range of benefits. Increasingly, the term ecosystem services is being used to refer to the benefits that people derive from the environment (Farber et al., 2006; Yoskowitz et al., 2010). The MARES Project identified 12 distinct ecosystem services provided by the South Florida coastal marine ecosystem (Kelble et al., 2013), categorized by the type of benefit they provide: cultural, regulating, and provisioning, following the example of Farber et al. (2006). In this context, "Cultural" services are the benefits people derive from interacting with the ecosystem including spiritual, religious, recreation, ecotourism, esthetic, inspirational, educational, and cultural heritage. "Regulating" services are the benefits people receive from ecosystem processes including climate modulation, disease control, water volume regulation, water purification and pollination. "Provisioning" goods are products people obtain from the ecosystem such as food, fresh water, fiber, biochemical, and genetic resources.

3. Method for identifying economic ecosystem indicators

This paper demonstrates an approach to selecting HD economic indicators to measure changes in use and consumption of ecosystem services. The HD economic indicators build on a set of conceptual ecosystem models developed in the MARES project (Kelble et al., 2013). A principal goal of the MARES project was to develop a set of indicators for tracking changes in the state of coastal marine resources that closely relate to benefits people receive from ecosystem services. Using the conceptual models, one can relate the HD economic indicators developed here to changes in key attributes of the coastal marine environment. The HD economic indicators do not assign a monetary value to ecosystem services; however the data used to score the indicators can be used to assess market and non-market values, use and non-use values (Johns et al., 2013).

Here, we use the term "indicator" to refer to a well-defined, measurable variable that reflects a key characteristic and that can be tracked and used to signal what is happening within and across ecosystems (Heinz Center, 2008). Annual evaluation of the HD economic indicators would reveal changes in human use of coastal marine environment over time in response to changing environmental conditions. Our approach differs from approaches taken by others in developing similar HD metrics for marine systems. For example, Halpern et al. (2012) use an Ocean Health Index comprised of HD economic and non-economic data that assesses progress toward achieving goals, not ecosystem services. Jepson and Colburn (2013) used HD non-economic data to assess social vulnerability for communities where recreational and commercial fishing are socially significant. The index measures have been made available to 2900 coastal communities via an on-line tool (NMFS, 2014). Cutter et al. (2003) and Cutter and Finch (2008) used socioeconomic and demographic profiles as HD non-economic indicators to assess social vulnerability to natural hazards.

The approach to choosing and developing the HD economic indicators presented in this paper proceeded in two stages. The first stage engaged scientists, resource managers, and stakeholders and reviewed current restoration programs, conservation efforts, and local action strategies to compile a list of candidate indicators. We then applied selection criteria to this list to select a set of five HD economic indicators. The second stage developed a scoring system based on year-to-year changes in data that measure the use of ecosystem services. The scoring system includes making adjustments in the use data to account for the influence of non-environmental factors. Results of the scoring are communicated using a stoplight format, following the example of Doren et al. (2009), with red indicating an undesirable condition, yellow for a condition in transition, and green for good condition.

Although we report results here only for the Florida Keys subregion, our objective is to develop a set of HD economic indicators that can be applied throughout the entire South Florida region. Patterns in the use of ecosystem services vary across the South Florida region. Human population density and coastal land use differ markedly between the urbanized southeast coast and the less populated southwest coast and Florida Keys, as do key characteristics of the coastal marine environment. This sub-regional variation is of interest, and it can be captured by developing a set of indicators that can be scored using data available at a sub-regional level and then combined to provide a composite picture of the whole region. (Results for all three sub-regions identified in Figure 1 can be found in Lee et al., 2012.) This larger, regional focus constrains our selection of indicators. Generally, better HD data are available in the Florida Keys, in part owing to longstanding interest in assessing the impacts of the Florida Keys National Marine Sanctuary, which was established in 1990. However, the requirement to produce a set of indicators applicable widely throughout South Florida means that all the data available in the Keys cannot be used to the fullest extent; Halpern et al. (2012) encounter similar constraints.

Table 1
Human dimensions economic indicator criteria.

Criteria evaluation question	Characteristic
Is the indicator relevant? Is it linked to the condition of the ecosystem?	*Linked*
Is the indicator responsive? Does it vary immediately when conditions change? Can it be used to signal changing conditions?	*Quick*
Is the indicator response predictable?	*Predictable*
Is the indicator credible? Is there scientific and managerial support for use of the indicator?	*Credible*
Is the indicator feasible? Can it be measured? Is the data already being collected? Is the collection regular, rigorous, and dependable into the foreseeable future?	*Measureable*
Does the indicator measure a system-wide effect? Is it applicable for the entire ecosystem?	*System-wide*
Does the indicator denote value? Is it associated with human use or activity?	*Value*
Can the indicator be explained easily? Does it resonate with the public?	*Understood*
Is the indicator consistent? Will it show human gains only when the ecosystem condition improves?	*Consistent*
Can the indicator be used for setting goals and targets?	*Targets*
Is the indicator problem-specific? Can it provide direction for management?	*Specific*
Which component of the integrated system does the indicator address: Driver, Pressure, Ecosystem State, Ecosystem service or Response?	*DPSER*

3.1. Selection of economic indicators

We selected the HD economic indicators from a list of candidate indicators based on which ones best satisfied a set of criteria that expressed characteristics desired in an ideal indicator. The criteria adopted, Table 1, emphasize ease of communication, integration, reliability, and ease of application (e.g. data availability). These were compiled based on review of prior work, especially Doren et al. (2009) and Pendleton (2007). Similar criteria were used to develop non-economic HD indicators (Loomis et al., 2014) and indicators of the state of the environment (various; this issue).

3.2. Indicator scoring

Initial indicator scores were computed based on year-to-year changes in a related metric, for example: the annual number of park visitors. The scores were then adjusted to account for the influence of non-environmental factors, and the adjusted scores were converted to a five point scale adopted to provide a consistent measure for assessing ecosystem conditions across multiple South Florida regions specifically the Florida Keys, Dry Tortugas, Southwest Florida Shelf, Southeast Florida Shelf and multiple indicator types including: economic, non-economic human dimension, ecological, and environmental.

An initial score is assigned based on the percentage change in the indicator measurement from year to year, as shown by example in Table 2. Assignment of scores takes into account the magnitude of year-to-year change that managers and policy makers (in our

Table 2
Initial scoring of HD economic indicator measurements. Examples shown are for the case where an increase in the metric is desirable (e.g. Park Visits, etc.) and where a decrease is desirable (e.g. Insurance Claims).

Percent change from previous year	Park visits; boats; and commercial seafood/live marine landings Number of points	Dollar value of flood insurance claims paid
If greater than or equal to 20%	5.00	0.45
If greater than or equal to 10% and less than 20%	4.55	0.91
If greater than or equal to 5% and less than 10%	4.09	1.36
If greater than 1% and less than 5%	3.64	1.82
If greater than 0% and less than or equal to 1%	3.18	2.27
If equal to 0%	2.73	2.73
If less than 0% but greater than or equal to−1%	2.27	3.18
If less than −1% but greater than −5%	1.82	3.64
If less than or equal to −5% but greater than −10%	1.36	4.09
If less than or equal to −10% but greater than −20%	0.91	4.55
If less than or equal to −20%	0.45	5.00

experience) consider to reflect "stable" conditions" and the magnitude of change that is considered possible and would signal either extremely good or extremely bad conditions.

For example, year to year changes for the example indicators shown in Table 2 are not expected to be more than 20 percent or less than −20 percent so these two categories were the highest and lowest categories. The 11 categories within this range were selected based on a subjective determination of the relative importance of the percent changes to the manager or policy maker.

The authors have extensive experience analyzing annual indicator data such as marine park visitation data, boat registration data, and marine landings data; and working with Florida marine resource managers and policy makers to interpret the data. Annual variations of 5% or more have historically been considered significant and indicative of change. Annual variations of 1% or less have historically been viewed as not significant of change and over time indicative of stability. Once the 11 categories were determined, the incremental increase in the score between successive categories was increased by the same amount. Because a total of 11 percent change categories were believed to be relevant to the manager, the incremental change is 5 points divided by 11 or 0.4545.

The resulting scoring is a non-linear function of the percentage change in the metric, where small percentage changes garner higher marginal scores than larger percentage changes. This is a useful scaling method when small percentage changes, such as two percent or five percent, are typically more common for year-to-year changes than are 10 percent or 15 percent annual changes. If large percentage changes are more common than small percentage changes or are equally likely, then the scoring could be adjusted to reflect this characteristic.

The scoring function presented in Table 2 was used for the initial scoring of the indicators presented in this paper, but it is only one example. Different indicators may require a different scoring function based on characteristics of the metric used and on what values of the metric managers consider to be "good", "stable", or "bad". For example, if there is concern about the accuracy of the measurements from year-to-year, then perhaps a higher significance threshold, say 5 percent, would improve the scaling function. However, concerns regarding the accuracy of the measurement from year to year should be addressed during selection of the indicator.

Actual data from various sources were used to obtain measurement values and adjust the indicator scores. In actual application, the two years from which the changes are measured should be the same for all indicators. For illustrative purposes, the data used for the five indicators in this paper are the most recent two years available.

The initial scores were *adjusted* to account for the influence of non-environmental factors on people's use of ecosystem services. These factors included such things as fuel costs, currency exchange rates, and population growth. Ideally, one would rely on an econometric model to calculate changes in the demand for ecosystem services due to these types of factors. Lacking such a model, we rely on our knowledge and experience from conducting economic studies in south Florida to make adjustments in the indicator scores of the appropriate magnitude. For purposes of illustration in this paper, the system of score adjustments provided in Table 3 were developed in a manner similar to the initial scoring system. The percentage range categories were kept the same as was used in the initial scoring system. Values in the table are calculated by distributing a maximum adjustment of ± 1.25 points (on the 5-point scale) evenly over the ± 20% range of variation in measurement of the non-environmental factor.

The adjusted score for an indicator was calculated by adding the adjustment value, from Table 3, to the initial indicator score, from

Table 3
Adjustments to initial scores of indicator measurements.[a]

Range of values % change from previous year)	Point adjustment for positive factors[b]	Point adjustment for negative factors[c]
If greater than or equal to 20%	−1.25	1.25
If greater than or equal to 10% and less than 20%	−0.94	0.94
If greater than or equal to 5% and less than 10%	−0.47	0.47
If greater than 1% and less than 5%	−0.19	0.19
If greater than 0% & less than or equal to 1%	−0.03	0.03
If equal to 0%	0.00	0.00
If less than 0% but greater than or equal to −1%	0.03	−0.03
If less than −1% but greater than −5%	0.19	−0.19
If less than or equal to −5% but greater than −10%	0.47	−0.47
If less than or equal to −10% but greater than −20%	0.94	−0.94
If less than or equal to −20%	1.25	−1.25

[a] This table does not include the "Real Value of Insured Flood Insurance Claims Paid".
[b] Factors that have a positive influence on the indicator measure are Annual Percent Changes in Resident Population; Average State and US Employment Rate; U.S. Dollars Per Canadian Dollar Exchange Rate; Average Ex-Vessel Real Prices Received by Commercial Fishers for Seafood Landings and for Live Marine Animals.
[c] Factors that have a negative influence on the indicator measure are Real Retail Gasoline Price and Real Retail Diesel Price.

Table 4
Evaluation of candidate HD economic indicators: esthetic value, education opportunities, and scientific resources.[a]

Ecosystem Service	Aesthetic value			Educational opportunities	Scientific resources
Indicator	Property Values	Resident Population	Tourism	College course offerings	Research activity
Measurement units	*$ per home sold*	*Net migration*	*Number of Visitor - Days*	*Student credit hours in marine ecology courses*	*$ Federal and international research grant*
Linked	Y	M	Y	Y	Y
Quick	N	N	M	N	N
Predictable	Y	M	Y	N	N
Credible	Y	M	M	M	M
Measureable	Y	Y	Y	Y	Y
System-wide	N	N	N	Y	Y
Value	Y	Y	Y	Y	Y
Understood	Y	M	Y	Y	Y
Consistent	N	N	N	N	N
Targets	N	N	N	N	N
Specific	N	N	N	N	N
DPSER (b)	E	D, E	**D,E**	**E**	**E**

[a] Y = yes, N = no, M = maybe, somewhat, or depends.
[b] DPSER – Driver, Pressure, State, Ecosystem Service, Response.

Table 2. The intent is that the resulting adjusted indicator score reflects primarily changes in the quality and quantity of ecosystem services and the economic benefits generated. The final step is to convert the numerical indicator score into a categorical index value that can be reported using a stoplight color scheme – red, yellow, green. Details of how this is done are explained in detail with the results reported for the Coastal Park Visitation indicator, below.

More research is needed to identify factors that influence the indicator measurements and to improve the point adjustment system so that the final scores better reflect changes in ecosystem services in response to changes in the ecosystem state. The scoring method can be revised as new research becomes available. It is important to note that judgment regarding the impact of the environmental attributes on economic indicators also requires environmental and ecosystem attribute scores and HD non-economic indicator scores.

The data needed to quantify the indicators were obtained from the following publicly available information sources: Florida Department of Environmental Protection, University of Florida Bureau of Economic and Business Research, Bank of Canada, Florida Department of Highway Safety and Motor Vehicles, Florida Fish and Wildlife Conservation Commission, Florida Legislature, National Flood Insurance Program, NOAA Hurricane Center, University of Florida Bureau of Economic and Business Research, U.S. Census, U.S. Energy Information Administration (see notes in the tables referenced below for details).

4. Results

4.1. Selection of indicators

The MARES project conducted a series of workshops in South Florida for the purpose of formulating conceptual models of the coastal marine ecosystem and compiling lists of candidate indicators in three areas: HD economic, HD non-economic, and the state of the coastal marine environment (Kelble et al., 2013). The workshops were attended by scientists and managers who work in the regional ecosystem. Information gathered in the workshops was supplemented by reviewing the relevant scientific and economic literature. A list of candidate HD economic indicators was compiled by this process (see column headings in Tables 4–6). Economic indicators provide information on the type of use, quantity, quality, and/or the demand for services provided by coastal and marine ecosystems. Potential economic indicators for which data are not collected throughout South Florida, such as the quantity or value of recreational fish catch, were not included in this candidate list. For each candidate indicator, the criteria evaluation questions provided in Table 1 were answered with a “Yes”, “No”, or “Maybe/Somewhat/It depends” as presented in Tables 4–6.

The selected indicators assess conditions related to the following ecosystem services: recreation, food supply, ornamental resources, and property protection. The five HD economic indicators, listed in Table 7, were chosen for further development wherein the indicator would be measured and scored. Four of the indicators were chosen because they fared well with respect to the criteria and had a Yes answer for the “Measurable” criterion which meant that the data were readily available. One indicator, Dollar Value of Insured Flood Damage Claims Paid, did not fare as well but was selected for further development to assess if it could be useful to managers. Economic indicators corresponding to the ecosystem services of esthetic values, pollution treatment, and science and education benefits were not developed or evaluated at this time because the data needed to score such indicators was not available during this study.

4.2. Assignment of indicator scores

Initial scores were assigned to the HD Economic Indicators (Table 8) based on data collected from various sources and the

Table 5
Evaluation of candidate HD economic indicators: Food supply, Ornamental resources, Pollution treatment, and Property protection.[a]

Ecosystem Service	Food supply			Ornamental resources	Pollution treatment	Property protection
Indicator	Commercial seafood harvest	Value of harvested fish	Catch per unit effort	Marine life harvest	Treatment cost savings	Storm damage
Measurement units	*Pounds of seafood*	*$ per pound, ex-vessel*	*Pounds per unit effort*	*Number of animals landed*	*$ Treatment costs storm, waste, potable water*	*$ Flood insurance claims*
Linked	Y	M	Y	Y	Y	Y
Quick	Y	N	Y	Y	N	N
Predictable	Y	N	M	Y	N	N
Credible	Y	N	V	Y	M	M
Measureable	Y	Y	M	Y	Y	Y
System-wide	M	Y	M	N	N	N
Value	Y	Y	Y	Y	Y	Y
Understood	Y	Y	Y	Y	Y	Y
Consistent	Y	N	Y	N	N	N
Targets	Y	N	M	N	N	N
Specific	Y	N	Y	N	N	N
DPSER[b]	P, E	D, E	E	P, E	E	E

[a] Y = yes, N = no, M = maybe, somewhat, or depends.
[b] DPSER – Driver, Pressure, State, Ecosystem Service, Response.

scoring function described in Table 2. Adjustments to the indicator scores were made based on the set of factors summarized in Table 9 and the scoring adjustment function described in Table 3, except as noted below for the number of storms and hurricanes. A summary of all five economic indicator index values are provided in Table 8. While the reported scores reflect actual conditions in the ecosystem, the results reported here are intended primarily for use in evaluating and refining the implementation of these proposed HD economic indicators, i.e. are there data available that can be used to score each of the selected indicators?

For the number of major storms and hurricanes that influence the real dollar value of insured flood damage claims paid, the point adjustment system is provided in Table 10. The larger the increase in the number of hurricanes and major storms from the previous year, the more points that are added to the initial score. If the number of hurricanes and major storms falls from the previous year, then points are deducted from the initial score to reflect the fact that claims would have been lower the previous year had there been no hurricanes or major storms and the percent reduction in flood insurance claims paid would have been smaller. No hurricanes made landfall in the Florida Keys in the period covered by this paper; therefore no adjustment for this factor was made to the initial score of the “real dollar value of insured flood damage claims paid”. The point adjustment system for this HD economic indicator was developed based on simulations of how the final scoring would change and whether the resulting score would be meaningful to the manager or policy maker.

Overall – for park visits, boat registrations, pounds of commercial seafood landed, and number of live marine animals landed, the larger the percent increase from the previous year, the higher the initial score. For the dollar value of flood damage claims paid, the larger the percent increase from the previous year the smaller the initial score.

Factors that have a positive influence on the indicator measure are annual percent changes in: resident population; average state and US employment rate; U.S. dollars per Canadian dollar exchange rate; and the average ex-vessel real prices received by commercial fishers for seafood landings and for live marine animals. The U.S./Canadian exchange rate is used because Canada accounts for the largest proportion of international visitors to south Florida, and the U.S./Canadian exchange rate is a factor in year-to-year changes in visitation. As the annual percent increases in these factors grow larger, more points are deducted from the initial scores in order to net out the positive influence of these factors from year to year.

Factors that have a negative influence on the indicator measure are real retail gasoline price and real retail diesel price. As the annual percent increases in these factors grow larger, more points are added to the initial scores in order to net out the influence of these factors that negatively influence the measured indicator value from year to year. Once these factors are removed from the score, the final score becomes a better indicator of the impact of the environmental attributes on the economic indicator value.

Details of how we arrived at the index value, reported in Table 8, for the Coastal Park Visitation indicator are summarized in Table 11. This indicator represents the 2010–2011 change in the demand for ecosystem services due to changes in the environmental attributes. The final score is 4.28 points ($4.09 + 0.03 - 0.03 + 0.19 = 4.28$). Coastal park visitation increased by 6.65 percent in the Florida

Table 6
Evaluation of candidate HD economic indicators: recreational opportunities.[a]

Ecosystem Service	Coastal Recreation				
Indicator	Park use	Boat use	Recreational fishing interest	Recreational activity	Commercial activity
Measurement units	*Annual visits per park*	*Number of registered boats, Boat trips per year*	*Number of fishing licenses, Fishing trips, Fishing days*	*Participation rate, Spending per visit, Frequency of visits*	*Diving and fishing trips hired*
Linked	Y	Y	Y	Y	Y
Quick	Y	Y	Y	Y	Y
Predictable	Y	Y	Y	Y	Y
Credible	Y	Y	Y	Y	Y
Measureable	Y	Y	M	M	Y
System-wide	N	M	M	M	N
Value	Y	Y	Y	Y	Y
Understood	Y	Y	Y	Y	Y
Consistent	N	M	Y	N	N
Targets	Y	Y	Y	N	N
Specific	M	N	Y	N	N
DPSER [b]	E	E	E	E	E

[a] Y = yes, N = no, M = maybe, somewhat, or depends.
[b] DPSER – Driver, Pressure, State, Ecosystem Service, Response.

Keys and Dry Tortugas from 2010 to 2011 earning 4.09 points. Because the Florida Keys/Dry Tortugas resident population fell by 0.57 percent, 0.03 points is added to the 4.09 points to account for the negative influence of this factor's decrease on visitation. This reflects the expectation that park visitation would have been higher if the resident population had not changed.

The average Florida and U.S. employment rate increased by 0.72 percent and this increase helped increase park visitation. Therefore, 0.03 points is subtracted from the 4.09 points to account for the influence of tourists on park visitation. If the employment rate had been unchanged, then park visitation would have been lower. The number of U.S. dollars that can be obtained from one Canadian dollar fell by 3.98 percent. This reduced the number of international tourists to the Florida Keys/Dry Tortugas and made coastal park visitation lower than it would have been if there had been no change in the exchange rate. Therefore, 0.19 points is added to the 4.09 points to remove the influence of this factor from the indicator value.

To simplify presentation and communicate information accurately, we converted the adjusted indicator score, 4.28, to a 5-point index scale, where a 5 is "increasing or good," 3 is "stable or fair" and 1 is "decreasing or poor" as shown in Table 12. The breakpoints of the ranges reflect the initial scoring ranges in Table 2. If the total score is greater than 3.18, then visitation increased by more than 1 percent during the year and demand for the ecosystem services provided by coastal park recreation increased due to the qualities and quantities of the associated environmental attributes. If the score is between 2.27 and 3.18, inclusive, then the percent change in visitation was between −1 percent and 1 percent, inclusive, and the demands for the ecosystem services provided by coastal park visitation are stable. If the score is less than 2.27, then visitation fell by more than one percent and the demands for the ecosystem services are decreasing.

The Coastal Park Visitation Indicator index value for the Florida Keys/Dry Tortugas from 2010 to 2011 is 5 (last line in Table 11). This means that the demands for the recreation ecosystem services

Table 7
Candidate human dimension (HD) economic indicators evaluated.

Ecosystem service	HD economic indicator
Esthetic values	Property values, Resident Population, Tourism
Education opportunities and Scientific resources	College course offerings in coastal marine ecology and management, Research activity in coastal marine ecology and management
Food supply	Commercial fishery harvest, Value of harvest, Catch per unit effort
Ornamental resources	Marine life harvest
Pollution treatment	Avoided cost of treatment
Property protection	Avoided storm damage costs
Coastal recreation	Park visitation, Recreational boat registrations/Number of boating trips/Number of fishing trips or fishing days, Fishing licenses, Recreational participation rate or frequency/Expenditures, Commercial guided recreation services

Table 8
HD economic indicator scores.

HD Economic Indicator	Ecosystem Service Measured by Indicator	Indicator Measurement	Total-system Index Value
Coastal Park Visitation	Recreation - Beach and Wildlife-related recreation activities and reef snorkeling and diving	Annual percent change in annual attendance at all of the Florida State and National Parks located directly on the coast. Attendance is the number of people entering the park	5 **(Increasing)**
Number of Registered Recreational Boats 16 feet or larger	Recreation and Food Supply - Offshore marine and wildlife-related recreational activities; Opportunity to catch and consume recreational fishery species	Annual percent change in number of recreational boats registered in the counties that comprise each south Florida area	5 **(Increasing)**
Pounds of Commercial Seafood Landed (finfish, invertebrates and shrimp)	Food Supply - Opportunity to harvest and consume commercial fishery species	Annual percent change in pounds of seafood landed commercially in the counties that comprise each south Florida area	5 **(Increasing)**
Number of Live Marine Organisms Landed	Ornamental Resources - Opportunity to collect and culture tropical marine species	Annual percent change in number of commercial live marine plants and animals landed each year in the counties that comprise each south Florida area	5 **(Increasing)**
Dollar Value of Insured Flood Damage Claims Paid	Property Protection - Protection of property from coastal storm damages	Annual percent change in real dollar value of flood damage claims paid by the National Flood Insurance Program (NFIP) to those who live in the south Florida counties	1 **(Decreasing)**

Table 9
Annual percent change in factors affecting the HD economic indicator measurements in the Florida Keys/Dry Tortugas.

Factor	Percent change years	Florida Keys/Dry Tortugas
Resident Population	2010–2011	−0.57
Average Change in Florida and US Employment Rate	2010–2011	0.72
U.S. Dollars Per Canadian Dollar Exchange Rate	2010–2011	−3.98
Real Retail Gasoline Price per Gallon	2010–2011	24.86
Real Retail Diesel Price per Gallon	2009–2010	20.17
Average Real Ex-Vessel Price Received by Commercial Fishers for Seafood Landings	2009–2010	60.86
Average Real Ex-Vessel Price Received by Commercial Fishers for Live Marine Landings	2009–2010	−9.55
Number of Hurricanes and Major Storms	2009–2010	0.0

Table 10
Adjustments to score that reflect non-ecosystem factors affecting the real value of insured flood damage claims paid.

Range of values (change from previous year)	Point adjustment	
	Number of Hurricanes and Major Storms	Number of Hurricanes Greater than Category 2
If greater than or equal to 3	5.00	5.00
If 2	3.00	3.00
If 1	2.00	2.00
If 0	0.00	0.00
If −1	−2.00	−2.00
If −2	−3.00	−3.00
If less than −3	−5.00	−5.00

Table 11
Calculation of total adjusted score of the coastal park visitation indicator, 2010–2011.

Row no.	Measurements	Florida Keys/Dry Tortugas	
		% change	Points
(1)	% Change in Coastal Park Visitation[a]	6.65	4.09
(2)	% Change in Local Resident Population [b]	−0.57	0.03
(3)	Average % Change in State and US Employment Rate [c]	0.72	−0.03
(4)	% Change in U.S. Dollars Per Canadian Dollar Exchange Rate [d]	−3.98	0.19
(5)	Total Adjusted Points	4.28	
(6)	Indicator Index Value	5	

[a] The coastal park visitation data represent the years 2010–2011 and are from the Florida Department of Environmental Protection http://www.dep.state.fl.us/secretary/news/2011/07/files/park attendance.pdf and 2011 Florida Statistical Abstract, University of Florida Bureau of Economic and Business Research http://www.bebr.ufl.edu/data. Visitations at Big Cypress and Everglades National Park were not included because most of the visitation is inland.
[b] Local resident population in 2010 and 2011 represent Monroe County and are from the Florida Legislature, Office of Economic and Demographic Research http://edr.state.fl.us/Content/population-demographics/data/index.cfm.
[c] The State of Florida and US Employment rates are based on the respective unemployment rates in 2010 and 2011 that were obtained from the Florida Statistical Abstract 2011 published by the University of Florida Bureau of Economic and Business Research http://www.bebr.ufl.edu/data.
[d] The U.S. dollar to Canadian dollar exchange rate for 2010 and 2011 are from www.bankofcanada.ca.

Table 12
Indicator index value – scale total adjusted score to a number between 1 and 5.

Range of Total Adjusted Points	Indicator Index Value	Demand for Ecosystem Service due to Quality/Quantity of Environmental Attributes is:
If total points greater than 3.18	5	Increasing (Good or Green)
If total points greater than or equal to 2.27 and less than or equal to 3.18	3	Stable (Fair or Yellow)
If total points less than 2.27	1	Decreasing (Poor or Red)

increased due to the qualities and quantities of the associated environmental attributes. Bear in mind that the point adjustments used to calculate the score and the index value take into account the main non-ecosystem factors that affect park visitation – resident population and tourism. The manager should also take into account any known year to year changes in other non-ecosystem factors, such as increases in the number of parking spaces that may also have affected visitation. For these other factors, a similar point adjustment may be made.

As a second example, the calculation of the total adjusted score for the Number of Registered Recreational Boats Indicator in the Florida Keys/Dry Tortugas is provided in Table 13. This indicator represents the 2010–2011 change in the demand for ecosystem services due to changes in the environmental attributes. The final score is 4.43 points (3.18 + 0.03 − 0.03 + 1.25 = 4.43). The number of registered boats in the Florida Keys and Dry Tortugas increased by 0.51 percent from 2010 to 2011 earning 3.18 points. Because the Florida Keys/Dry Tortugas resident population fell by 0.57 percent, 0.03 points is added to the 3.18 points to account for the negative influence of this factor's decrease on boating. If the resident population had not changed, then the number of registered boats would have been higher.

The average Florida and U.S. employment rate increased by 0.72 percent and this increase helped increase the number of registered boats. Therefore, 0.03 points is subtracted from the 3.18 points to account for the influence of local resident wealth. If the employment rate had been unchanged, then the number of registered boats would have been lower. The percent change in the real retail gasoline price increased by 25 percent from 2010 to 2011. This reduced the number of registered boats and made the percent reduction in the number of registered boats higher than it would have been if there had been no change in gas prices. Therefore, 1.25 points is added to the 3.18 points to remove the influence of this factor from the indicator value.

The Number of Registered Recreational Boats Indicator index values for the Florida Keys/Dry Tortugas is 5 (last line in Table 13), meaning the ecosystem service is rated as "good or increasing." This means that from 2010 to 2011 the demands for the offshore

Table 13
Calculation of total adjusted score of the number of registered recreational boats indicator, 2010 to 2011.

Row no.	Measurements	Florida Keys/Dry Tortugas	
		% change	Points
(1)	% Change in Number of Registered Recreational Boats greater than 16 feet[a]	0.51	3.18
(2)	% Change in Local Resident Population	−0.57	0.03
(3)	Average % Change in State and US Employment Rate	0.72	−0.03
(4)	% Change in Real Retail Gasoline Price per Gallon [b]	24.86	1.25
(5)	Total Adjusted Points	4.43	
(6)	Indicator Index Value	5	

[a] The number of registered recreational boat data represent the years 2010 to 2011and are from Florida Department of Highway Safety and Motor Vehicles website http://www.flhsmv.gov/dmv/vslfacts.html;(accessed 27.06.13).
[b] The real retail gasoline price per gallon in 2010 and 2011 represents the Lower Atlantic Regular Conventional Retail Gasoline Price. The nominal prices are from the U.S. Energy Information Administration website http://www.eia.gov/petroleum/data.cfm#prices; (accessed 27.06.13). Average annual price per gallon. Lower Atlantic includes Florida, Georgia, North Carolina, South Carolina, Virginia and West Virginia. The nominal prices were converted to 2011 dollars using the GDP Chained Price Index from: http://www.whitehouse.gov/omb/budget/Historicals.

Table 14
Calculation of total adjusted score of the pounds of commercial seafood landed indicator, 2009 to 2010.

Row no.	Measurements	Florida Keys/Dry Tortugas	
		% change	Points
(1)	% Change in Pounds of Seafood Harvested[a]	13.57	4.55
(2)	% Change in Real Ex-vessel Seafood Price [b]	60.86	−1.25
(3)	% Change in Real Retail Diesel Fuel Price [c]	20.17	1.25
(4)	Total Adjusted Points	4.55	
(5)	Indicator Index Value	5	

[a] The pounds of commercial seafood landed represent the years 2009 to 2010 and are from the Florida Fish and Wildlife Conservation Commission website http://myfwc.com/research/saltwater/fishstats/.
[b] The prices used are the nominal ex-vessel prices by species from the Florida Fish and Wildlife Conservation Commission website. Average ex-vessel prices by species are weighted by the pounds of fish landed by species in each area. The nominal prices were converted to 2011 dollars using the GDP Chained Price Index from: http://www.whitehouse.gov/omb/budget/Historicals.
[c] The nominal average annual price per gallon of Lower Atlantic U.S. Number 2 Retail Diesel in 2010 and 2011 are from the U.S. Energy Information Administration website http://www.eia.gov/petroleum/data.cfm#prices; (accessed 27.06.13). Lower Atlantic includes Florida, Georgia, North Carolina, South Carolina, Virginia and West Virginia. The nominal prices were converted to 2011 dollars using the GDP Chained Price Index from: http://www.whitehouse.gov/omb/budget/Historicals.

Table 15
Calculation of total adjusted score of the number of live marine organisms landed indicator, 2009–2010.

Row no.	Measurements	Florida Keys/Dry Tortugas	
		% change	Points
(1)	% Change in Number of Live Marine Landings[a]	−4.60	1.82
(2)	% Change in Real Ex-vessel Marine Animal Price [b]	−9.55	0.47
(3)	% Change in Real Retail Diesel Fuel Price	20.17	1.25
(4)	Total Adjusted Points	3.54	
(5)	Index Indicator Value	5	

[a] The number of live marine organisms represent the years 2009 to 2010 and are from the Florida Fish and Wildlife Conservation Commission website http://myfwc.com/research/saltwater/fishstats/.
[b] The prices used are the nominal ex-vessel prices by species from the Florida Fish and Wildlife Conservation Commission website. Average ex-vessel prices by species are weighted by the pounds of fish landed by species in each area. The nominal prices were converted to 2011 dollars using the GDP Chained Price Index from: http://www.whitehouse.gov/omb/budget/Historicals.

marine recreational ecosystem services of this area were increasing due to the qualities and quantities of the associated environmental attributes. Bear in mind that the point adjustments take into account the main non-ecosystem factors that affect the number of registered boats – resident population, resident wealth and fuel cost. The manager should also take into account any known year-to-year changes in other non-ecosystem factors that might have a significant influence on the number of registered boats. For these other factors, a similar point adjustment may be made.

5. Results for remaining three HD economic indicators were obtained in a similar manner

Pounds of Commercial Seafood Landings (Table 14) increased by 13.57 percent from 2009 to 2010 scoring 4.55 points initially. Because the average price of seafood received by fishers at the dock (exvessel price) increased by 60.86 percent, 1.25 points was deducted from the initial score to remove the influence of seafood price from seafood landings. On the other hand, the real retail price of fuel increased by 20.17 percent which would reduce seafood landings, adding 1.25 points to the initial score in order to remove the influence of commercial fishing costs. The index indicator score for commercial seafood landings is 5 or good indicating that the ecosystem services reflecting fish productivity increased from 2009 to 2010.

Number of Commercial Live Marine Landings (Table 15) fell by 4.60 percent from 2009 to 2010 scoring 1.82 points initially. The average ex-vessel price received by fishers for live marine landings fell by 9.55 percent which results in a 0.47 point increase in the score to remove the influence of price. Likewise, the 20.17 percent increase in boat fuel price results in a 1.25 point increase in the score to remove the impact of fishing costs. The total adjusted point score is 3.54 which results in an index indicator score for live marine landings of 5 or good indicating that these ecosystem services increased from 2009 to 2010.

Real Dollar Value of Insured Flood Damage Claims Paid (Table 16) increased by 63 percent from 2009 to 2010 resulting

Table 16
Calculation of total adjusted score of the real value of insured flood damage claims paid indicator, 2009 to 2010.

Row no.	Measurements	Florida Keys/Dry Tortugas	
		% change	Points
(1)	Percent Change in Real Value of Insured Flood Damage Claims Paid[a]	63	0.45
(2)	Change in Number of Hurricanes & Major Storms from previous year [a]	0.00	0.00
(3)	Change in Number of Hurricanes Greater than Category 2 from previous year [b]	0.00	0.00
(4)	Total Adjusted Points	0.45	
(5)	Indicator Index Value	1	

[a] The nominal dollar value of insured flood damage claims paid represents the years 2009 to 2010 and is from the National Flood Insurance Program http://www.fema.gov/policy-claim-statistics-flood-insurance/policy-claim-statistics-flood-insurance/policy-claim-13; (accessed 27.06.13). Nominal dollars were adjusted to real 2011 dollars using the U.S. Gross Domestic Product (GDP) Chained Price Index http://www.whitehouse.gov/omb/budget/Historicals.
[b] The number of hurricanes and major storms are counted from information from the NOAA website http://www.nhc.noaa.gov/data/; (accessed 27.06.13) and the Monroe County website.

in an initial score of 0.45 points. Because there were no changes in the number of hurricanes and major storms, especially the number of hurricanes greater than category 2, no adjustments to the initial score need to be made. The index indicator score for the value of flood insurance claims paid in Florida Keys/Dry Tortugas is 1 or poor indicating that the environmental attributes that protect properties from flooding did not provide as great a level of protection in 2010 as they did in 2009.

In practice, the scores and index values would be calculated over a number of years and the trends observed and correlated with other indicators of the state of the coastal marine environment and the HD non-economic indicators to assess the impact of the ecosystem and environmental attributes on ecosystem services.

6. Discussion

The HD economic indicators developed in this paper provide a measure of the changes in the benefits that people derive from the coastal marine ecosystem in response to changes in environmental attributes change over time. The use of HD economic indicators will significantly expand the breadth of useful information available to South Florida managers. Oftentimes, the issues facing coastal managers are generated by a conflict between competing, incompatible uses of the coastal marine environment. One example is use of motor boats to access remote areas of Everglades National Park at the southern tip of the Florida mainland which diminishes the experience of users who traveled to the same location in non-motorized watercraft seeking a primitive wilderness experience. By compiling and tracking quantitative information related to these uses, such as recreational boat registrations and coastal park visitation, HD economic indicators provide managers with feedback on how users respond to and benefit from the conditions of the ecosystem.

This paper describes a procedure for identifying metrics that will mirror changes in the demand for ecosystem services resulting from changes in environmental quality and quantity. The change in demand then influences the value that people place on our coastal and marine ecosystems and demonstrates these values to managers and policy makers as they decide the uses and fate of our natural resources.

However, as environmental attributes change, without new economic estimates of the value of ecosystem services, economic indicators can only measure changes in the quantity consumed and not change in the value of the service. The empirical example provided in this paper is intended to lay the groundwork for more fully developing HD economic indicators for the South Florida coastal marine ecosystem. A major challenge in developing economic indicators of ecosystem services is the lack of relevant research into the factors that influence human uses and values of the south Florida marine ecosystem and the extent of their impact.

For example the point adjustment system used in this paper would benefit from empirical research to determine the factors that influence the rate of coastal park visitation, the number of boat registrations, the quantity of commercial fish harvest and the number of live marine landings. Short term economic indicators can potentially yield "false" signals about ecosystem services, for example, if natural capital is sacrificed for short-term economic gains. The depleted stock of natural capital would result in a reduced flow of ecosystem services in the future. Finally, managers and stakeholders must be involved in developing any indicators intended for use in decision-making.

A comprehensive assessment of the South Florida coastal marine ecosystem requires that the information provided by the HD economic indicators be combined with information from indicators of community well-being and indicators of the state of the coastal marine environment. A method for integrating the HD indicators with the ecological indicators; forming final ratings using the stoplight approach; and incorporating uncertainty has been described by the Office of National Marine Sanctuaries (2014b). They employed the Adelphi Method using experts in economics, other social scientists, and ecologists to come up with ecosystem service ratings and uncertainty ratings ranging from "very low" to "very high".

Existing indicators of ecosystem health typically focus on the ecological components of the ecosystem to the exclusion of human dimensions of the ecosystem (cf. Doren et al., 2009). The HD economic indicators provide a snapshot of trends in the use of ecosystem services based on data that are collected on a routine basis. The objective for combining these data into HD economic indicators is to provide managers with information on the use of ecosystem services that complements information they already receive on ecosystem health (cf. Palmer and Febria, 2012).

Acknowledgements

This paper is a result of research under the Marine and Estuarine Goal Setting (MARES) for South Florida Project funded by the National Oceanic and Atmospheric Administration Center for Sponsored Coastal Ocean Research (Coastal Ocean Program), under award NA08OAR4320889 to the University of Miami, NA09NOS4780224 to Nova Southeastern University, NA09NOS4780225 to the University of Massachusetts Amherst, NA09NOS4780226 to the National Audubon Society, NA09NOS4780227 to Florida Gulf Coast University, NA09NOS4780228 to Florida International University, and to the NOAA Atlantic Oceanographic and Meteorological Laboratory.

References

Catanese Center, 2005. Economics of Beach Tourism in Florida. Catanese Center at Florida Atlantic University, June 2005.

Cheong, S.-M., 2008. A new direction in coastal management. Mar. Policy 32, 1090–1093.

Cutter, S.L., Boruff, B.J., Shirley, W.L., 2003. Social vulnerability to environmental hazards. Social Sci. Quart. 84 (2), 242–261, online: http://onlinelibrary.wiley.com/doi/10.1111/1540-6237.8402002/pdf (accessed 11.02.14).

Cutter, S.L., Finch, C., 2008. Temporal and spatial changes in social vulnerability to natural hazards. Proc. Natl. Acad. Sci. U. S. A. 105 (7), 2301–2306, online: http://www.pnas.org/content/105/7/2301.full.pdf+html?sid=c4af1bdb-db5d-4457-ab10-5059fe0dbf7b (accessed 11.02.14).

Doren, R.F., Trexler, J.C., Gottlieb, A.D., Harwell, M.C., 2009. Ecological indicators for system-wide assessment of the greater Everglades ecosystem restoration program. Ecol. Indicators 9, s2–s16.

Farber, S., Costanza, R., Childers, D.L., Erickson, J., Gross, K., Grove, M., Hopkinson, C.S., Kahn, J., Pincetl, S., Troy, A., Warren, P., Wilson, M., 2006. Linking ecology and economics for ecosystem management. Bioscience 56, 121–133.

Halpern, B.S., Longo, C., Hardy, D., McLeod, K.L., Samhouri, J.F., Katona, S.K., Kleisner, K., Lester, S.E., O'Leary, J., Ranelletti, M., Rosenberg, A.A., Scarborough, C., Selig, E.R., Best, B.D., Daniel, R., Brumbaugh, D.R., Chapin, F.S., Crowder, L.B., Daly, K.L., Doney, S.C., Elfes, C., Fogarty, M.J., Gaines, S.D., Jacobsen, K.I., Karrer, L.B., Leslie, H.M., Neeley, E., Pauly, D., Polasky, S., Ris, B., St Martin, K., Stone, G.S., Sumaila, U.R., Zeller, D., 2012. An index to assess the health and benefits of the global ocean. Nature 488, 615–622, online: http://www.oceanhealthindex.org/About/Methods/ (accessed 11.02.14).

Heinz Center, 2008. The State of the Nation's Ecosystems 2008: Measuring the Land, Waters, and Living Resources of The United States. The H. John Heinz III Center for Science, Economics, and the Environment, Washington, DC, online: http://www.heinzctr.org/sites/default/files/pdf/The%20State%20of%20the%20Nation's%20Ecosystems%202008.pdf; (accessed 27.06.13).

Jepson, M., Colburn, L.L., 2013. Development of Social Indicators of Fishing Community Vulnerability and Resilience in the U.S. Southeast and Northeast. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-F/SPO-129, 64 pp., on-line: http://spo.nmfs.noaa.gov/tm/TM129.pdf; (accessed 11.02.14).

Johns, G., Kelble, C., Lee, D., Leeworthy, V.R., Nuttle, W., 2013. Ecosystem Services Provided by the South Florida Coastal Marine Ecosystem. MARES Whitepaper: Ecosystem Services, Version 20 April 2013, online: http://www.sofla-mares.org/docs/MARES_WhitePaper7_ESprovidedBySFCME_20130420.pdf (accessed 11.02.14).

Johns, G.M., Leeworthy, V.R., Bell, F.W., Bonn, M.A., 2001. Socioeconomic Study of Reefs in Southeast Florida. Broward County, Florida, October 19, 2001.

Kelble, C.R., Loomis, D.K., Lovelace, S., Nuttle, W.K., Ortner, P.B., Fletcher, P., Cook, G., Lorenz, J.J., Boyer, J.N., 2013. The EBM-DPSER Conceptual Model:

integrating ecosystem services into the DPSIR Framework. PLoS ONE 8 (8), e70766, http://dx.doi.org/10.1371/journal.pone.0070766.

Lee, D.J., Johns, G.M., Leeworthy, V.R., 2012. Selecting human dimension economic indicators for south Florida coastal marine ecosystems, online: http://sofla-mares.org/docs/MARES_WhitePaper9_SelectingHDSindicators_20130519.pdf; (accessed 08.05.13).

Leeworthy, V.R., Morris, C.F., 2014. A Socioeconomic Analysis of the Recreation Activities of Monroe County Residents in the Florida Keys/Key West 2008. Linking the Economy and the Environment of Florida Keys/Key West, Socioeconomic Research and Monitoring Program for the Florida Keys National Marine Sanctuary, Office of National Marine Sanctuaries, National Ocean Service, National Oceanic and Atmospheric Administration, Silver Spring, MD, online: http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/floridakeysres_report.pdf (accessed 11.02.14).

Leeworthy, V.R., Loomis, D.K., Paterson, S.K., 2010. Visitor Profiles: Florida Keys/Key West 2007–08. Linking the Economy and the Environment of Florida Keys/Key West, Socioeconomic Research and Monitoring Program for the Florida Keys National Marine Sanctuary, Office of National Marine Sanctuaries, National Ocean Service, National Oceanic and Atmospheric Administration, Silver Spring, MD, online: http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/pdfs/full_visitor_08.pdf (accessed 11.02.14).

Loomis, et al., 2014. Developing integrated ecosystem indices. Ecol. Indicators 44, 57–62.

Lubchenco, J., 1999. Entering the century of the environment: a new social contract for science. Science 279, 491–497.

National Marine Fisheries Service (NMFS), Office of Science and Technology, 2014. On-line tool for Social Indicators of Fishing Communities, online: http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index (accessed 11.02.14).

Office of National Marine Sanctuaries, 2014a. Sanctuary Condition Reports, online: http://sanctuaries.noaa.gov/science/condition/welcome.html; (accessed 11.02.14).

Office of National Marine Sanctuaries, 2014b. Guidance for Sanctuary Condition Reports, Silver Spring, MD.

Ogden, J.C., Davis, S.M., Jacobs, K.J., Barnes, T., Fling, H.E., 2005. The use of conceptual ecological models to guide ecosystem restoration in South Florida. Wetlands 25, 795–809.

Palmer, M.A., Febria, C.M., 2012. The heartbeat of ecosystems. Science 336, 1393–1394 (10.1126/science.122350).

Pendleton, L., 2007. Using historical narrative to analyze economic indicators of marine and coastal management. In: Proceedings of Coastal Zone 07, Portland, Oregon, July 22 to 26, online: http://www.csc.noaa.gov/cz/CZ07_Proceedings/PDFs/Wednesday_Abstracts/3568.Pendleton.pdf; (accessed 18.05.13).

Turner, R.K., 2000. Integrating natural and socio-economic science in coastal management. J. Mar. Syst. 25, 447–460.

Visser, L., 1999. Coastal zone management from the social scientific perspective. J. Coast. Conserv. 5, 145–148.

Weinstein, M.P., 2009. The road ahead: the sustainability transition and coastal research. Estuaries Coasts 32, 1044–1053.

Yoskowitz, D., Santos, C., Allee, B., Carollo, C., Henderson, J., Jordan, S., Ritchie, J., 2010. Proceedings of the Gulf of Mexico Ecosystem Services Workshop: Bay St. Louis, Mississippi, Harte Research Institute for Gulf of Mexico Studies , Texas A&M University-Corpus Christi, June 16–18, 16 pp.