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National Oceanic and
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Economic Statistics for NOAA

sixth edition

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New For This Year:

Economic Dimensions of NOAA Products and Services

Program Planning and Integration

PPI

Office of the NOAA Chief Economist

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Foreword

This is the sixth edition of ***Economic Statistics for NOAA,*** a compendium of economic statistics relevant to NOAA's mission and programs. It is intended to serve as a common reference to the economic impacts and benefits of NOAA programs and provide a consistent set of economic statistics for NOAA management and staff when preparing for Congressional visits and testimony, budget preparation, speeches, and other external events. ***Economic Statistics for NOAA*** illustrates the economic importance of NOAA's programs to the Nation's economy and public well-being.

Economic Statistics for NOAA was prepared by Rodney Weiher, NOAA Chief Economist, and Avery Sen, Policy Analyst, in Program Planning and Integration, with the assistance and input of staff throughout NOAA. The section on "Economic Dimensions of NOAA Products and Services" was prepared by Professor Charles Colgan at the University of Southern Maine in Portland, Dr.Tom Teisberg, Principal of Teisberg Associates in Charlottesville, Va., and Rodney Weiher.

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March 2008

Introduction: NOAA and Value Creation

NOAA's responsibilities range from forecasting weather and climate to a lead role in assuring the sound management of the nation's ocean and coastal resources. In fulfilling its diverse missions, NOAA programs create economic value.

NOAA's research and forecasts lead to reduced damages from storms and other natural hazards. NOAA provides information that helps businesses make decisions and allows key industries like transportation and agriculture to operate more efficiently. NOAA's management programs for ocean and coastal areas help enhance both the current and future productivity of these economically vital resources.

It is not possible to reduce all of NOAA's economic contributions to the Nation – and to the world – down to a single number. There are many different services that NOAA provides which affect the economy in diverse ways, and there are a variety of ways in which those effects are measured by economists.

Economic Statistics for NOAA provides a summary of statistics and findings of recent research that either directly measures economic benefits of particular programs, or indicates the general economic context in which particular NOAA programs create economic value.

This revised edition includes updated statistics on harmful algal bloom impacts, weather and health statistics, fishery economics, the most recent available statistics on coastal populations and economic output, and additional statistics on the economic benefits of meteorological satellites.

Two criteria were established for inclusion. The first is relevance and importance to NOAA's mission and activities. Second is the ability to cite a credible source in either peer-reviewed or gray literature or correspondence.

Statistics are grouped into three general categories.

- **General Economic and Social Impacts** reflect how natural marine, atmospheric, and coastal phenomena affect the general public. For example, weather and climate sensitive industries account for nearly 30 percent of the Nation's GDP.

- **Contributions to U.S. Income, Employment, and Output** are statistics that directly reflect the market value and human uses of resources impacted by NOAA's programs. For example, the economic value added to the national economy by the U.S. commercial fishing industry was approximately $29 billion in 2002. Other statistics are a direct measure of the economic benefits of investing in NOAA programs, such as improvements in El Niño forecasts.

- **Coastal Ocean Economics, Population, Employment and Benefits** statistics illustrate the demographic, social, and economic importance of the Nation's coastal areas. They also reflect the quantitative importance of so-called "nonmarket" benefits of coastal resources such as beaches and recreational boating, which are not directly measured in dollar terms.

This edition of ***Economic Statistics for NOAA*** also contains a new section, "The Economic Dimensions of NOAA Products and Services," which provides a brief introduction to how NOAA creates economic value and the different concepts and methods of measuring the economic value that are represented in ***Economic Statistics for NOAA.***

The NOAA Library *(*http://www.lib.noaa.gov*)* serves as the repository for information in this publication. You may also access many of the sources on the NOAA Economics & Social Science website's electronic library (http://www.economics.noaa.gov/library/library.htm).

NOAA is also developing a comprehensive Economics website which will include not only **Economic Statistics for NOAA** citations, but a broad range of economic data on benefits, impacts, users, and uses of NOAA products. Completion of the site is expected in the spring of 2008.

General Economic and Social Impacts

Weather and Climate Impacts

Weather and climate sensitive industries, both directly and indirectly, account for about one-third of the Nation's GDP [note: $4 trillion in 2005 dollars] ranging from finance, insurance, and real estate to services, retail and wholesale trade and manufacturing.

> **Cite:** Dutton, John A., *Opportunities and priorities in a new era for weather and climate services,* Bulletin of the American Meteorological Society, September 2002, volume 83, no. 9, pp 1303-1311.

Industries directly impacted by weather such as agriculture, construction, energy distribution, and outdoor recreation account for nearly 10 percent of GDP.

> **Cite:** U.S. Department of Commerce, National Oceanic and Atmospheric Administration, *The economic implications of an El Niño.* NOAA Magazine Online, March 6, 2002, available only online at: *http://* www.noaanews.noaa.gov/magazine/stories/mag24.htm.

A recent analysis of the impact of weather on gross economic output over the last two and a half decades estimates that 3.4% of the of variation in mean gross state output is explained by weather alone. Variation in output due to weather across sectors ranges from 12.1% in agriculture to 2.2% in wholesale trade. The largest absolute variation in dollar terms is in the fire and other casualty insurance sector, ranging on the order of $132 billion annually. Aggregate dollar variation in U.S. economic activity attributable to weather variability is $260 billion a year of 2000 gross domestic product.

> **Cite:** Harrod, Megan, Peter H. Larsen, Jeffrey K. Lazo, and Donald M. Waldman. 2007. "Sensitivity of the U.S. Economy to Weather Variability" NCAR Societal Impacts Program, Boulder, Colorado working paper.

The costliest U.S. drought of the past forty years occurred in 1988 and caused more than $61 billion (in 2002 dollars) of economic losses. More than 5,000 heat-related deaths were also attributed to the heat wave associated with that event.

> **Cite:** Lott, N., and T. Ross, *Tracking and evaluating U.S. billion dollar weather disasters, 1980-2005,* 86th AMS Annual Meeting, 29 January - 2 February 2006, Atlanta, Georgia, combined preprints [CD-ROM], American Meteorological Society, Boston, MA, 1.2, 7 p. (January 2006)

Drought is estimated to result in average annual losses to all sectors of the economy of between $6-8 billion.

> **Cite:** *Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services,* NOAA Magazine, September 17, 2002. Website:

http://www.noaanews.noaa.gov/magazine/stories/mag51.htm.

Although drought does not have major impacts on the overall viability of U.S. agriculture it does impose costs on regional and local agricultural economies. The 1999 drought, for example, led to farm net income losses of approximately $1.35 billion. Areas of the Northeast encountering extreme and severe drought bore 62 percent of these losses. Farm net income losses were equivalent to only three percent of the U.S.'s expected net farm income for 1999; however, 25 percent of U.S. harvested cropland and 32 percent of pastureland were affected.

Cite: *Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services*, NOAA Magazine, September 17, 2002. Website: http://www.noaanews.noaa.gov/magazine/stories/mag51.htm.

Severe fire seasons due to drought and frequent winds can result in billions of dollars in damages. The Western Fire Season Spring-Summer 2000 resulted in nearly seven million acres burned and an estimated $2 billion in damage costs (includes fire suppression).

Cite: *Economic Impacts of Drought and the Benefits of NOAA's Drought Forecasting Services*, NOAA Magazine, September 17, 2002. Website: http://www.noaanews.noaa.gov/magazine/stories/mag51.htm.

Average annual damage from tornadoes, hurricanes, and floods is $11.4 billion, of which:

- hurricanes average $5.1 billion and 20 deaths per year;
- floods account for $5.2 billion, and average over 80 deaths per year,
- tornadoes cause $1.1 billion in damages.

Cite: National Center for Atmospheric Research (NCAR), Environmental and Societal Impacts Group, and the Atmospheric Policy Program of the American Meteorological Society, 2001, *Extreme Weather Sourcebook 2001: Economic and Other Societal Impacts Related to Hurricanes, Floods, Tornadoes, Lightning, and Other U.S. Weather Phenomena*, National Center for Atmospheric Research, Boulder, Colo. Available only online at http://www.sip.ucar.edu/sourcebook/.

The costliest U.S. hurricane was in 1926 in Miami, causing $90 billion in damage (in 2000 dollars). By contrast, Hurricane Andrew (1992) caused $35 billion (in 2000 dollars).

Cite: Jarrell, Jerry D., Landsea, Christopher W., Mayfield, Max, and Rappaport, Edward N. October 2001 update, *The Deadliest, Costliest, and Most Intense United States Hurricanes from 1900 to 2000 (and Other Frequently Requested Hurricane Facts)*, NOAA Technical Memorandum NWS TPC-1. Hurricane Research Division, Miami, Fl. Available online at: http://www.aoml.noaa.gov/hrd/Landsea/deadly.

In 2002, severe weather caused $5.8 billion in damages which was less than in 2001. Weather-related injuries showed upward trends in 2002, rising to 3,090 from 2,718 in 2001.

> **Cite:** *2002 U.S. Natural Hazard Statistics Report, Summary of Natural Hazard Statistics for 2001 in the United States*, updated Nov. 12, 2003. Website: http://www.nws.noaa.gov/om/hazstats.shtml .

$6 billion annually is lost in economic efficiencies as a result of air traffic delays, of which 70 percent is attributed to weather.

> **Cite:** *2002 State of the U.S. Airline Industry: A Report on Recent Trends for U.S. Carriers*, Air Transport Association, Washington, D.C., 2002. Website: http://www.airlines.org/public/industry/display1.asp?nid=1026.

Lightning causes $4 to 5 billion in losses each year in the civilian sector.

> **Cite:** Kithil, R., 2*1st Century Lightning Safety for Facilities & Structures*, Presented at the International Lightning Detection Conference, Tucson, Ariz., October, 2002.

Lightning has consistently been one of the top three causes of weather-related deaths in the country. It kills between 50 and 70 people and injures hundreds more each year.

> **Cite:** NWS Office of Climate, Water, and Weather Services. Thirty and 10 year average fatalaties for various weather types can be viewed at: http://www.nws.noaa.gov/om/hazstats.shtml.

Lightning costs about $2 billion annually in airline operating costs and passenger delays.

> **Cite:** Northeast States Emergency Consortium, Wakefield, Mass., 2002. http://www.serve.com/NESEC.

The costliest U.S. tornado outbreak caused nearly $1.6 billion in insured losses on May 3-7, 1999, with the greatest losses in the Oklahoma City, OK area.

> **Cite:** Insurance Information Institute, 2002. http://www.disasterinformation.org.

The U.S. has sustained 70 weather-related disasters over the past 27 years in which overall damages/costs reached or exceeded $1 billion. The total normalized losses for the 70 events exceed $560 billion. 61 of these disasters occurred during the 1988-2006 period with total unadjusted damages/costs exceeding $430 billion.

> **Cite:** Lott, N., and T. Ross, *Tracking and evaluating U.S. billion dollar weather disasters, 1980-2005*, 86th AMS Annual Meeting, 29 January - 2

February 2006, Atlanta, Georgia, combined preprints [CD-ROM], American Meteorological Society, Boston, MA, 1.2, 7 p. (January 2006)

Economic costs of snow arise from:

- snow removal (exceeds $2 billion per year for U.S.),
- road closures that cause lost retail trade, wages, and tax revenue (exceeds $10 billion per day for closures in eastern U.S.),
- flight delays ($3.2 billion per year for U.S. carriers),
- damage to utilities (up to $2 billion per event),
- flooding from snowmelt ($4.3 billion for 1997 floods), and
- cost to agriculture and timber from frost and ice (up to $1.6 billion per ice storm).

Cite: Adams, R., Houston, L., Weiher, R., *The Value of Snow and Snow Information Services*, Report prepared for NOAA's National Operational Hydrological Remote Sensing Center, August, 2004.

During 2005, there were 5,301 hospital discharges related to excessive heat. Of those treated, 27 % were between the ages of 65-84, 45% were receiving Medicaid/Medicare and 34% classified as low income.

During 2005, there were 3,405 hospital discharges related to excessive cold. Of those treated, 24% were between the ages of 65-84, 61% were receiving Medicaid/Medicare and 33% classified as low income.

During 2005, the average length of stay to treat hospital stays related excessive heat and cold was 3.5 days and the average mean charges to treat excessive heat and cold was $16,741 and the national hospital bill to treat excessive heat and cold is $1,492,981,042.

Cite: Healthcare Cost and Utilization Project (HCUP), Nationwide Inpatient Sample, Agency for Healthcare Research & Quality, Department of Health and Human Services. Available through the HCUPnet on-line query system at: http://hcupnet.ahrq.gov/.

notes

Insured Losses

Natural catastrophes (storm, flood, hail, etc.) caused insured losses of $15 billion across the globe. In contrast, man-made disasters (explosions, aviation, accidents, etc.) caused just under $2 billion. Natural catastrophes were thus responsible for significantly more losses than major man-made disasters in 2003. The bulk of the damage from natural catastrophes, $8 billion, was caused by storms.

Five insured billion-dollar losses in 2003, mounting to $8 billion, were the result of natural catastrophes in North America. These included events in the following table:

Costly insured losses in 2003:

Event	**Insured losses (US dollars)**	**Victims (dead and missing)**	**Country**
Tornadoes	$3.2 billion	45	US
Hurricane Isabel	$1.7 billion	36	US, Canada
Storms and hail	$1.6 billion	--	US
Cedar fire, urban forest fires	$1.1 billion	14	US (CA)
Old fire, urban forest fires	$1.0 billion	4	US (CA)

Cite: Swiss Re sigma preliminary estimates of catastrophe losses. December 16, 2003. http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM [If the following web link does not work, go to www.swissre.com, then click on media centre, news, news releases 2003 (in left hand column) and then click on 16 Dec 2003 news release.]

Catastrophe (cat) bonds are little-known securities through which investors bet on hurricanes, earthquakes and even terrorist attacks. Insurance companies issue them to help pay excess claims from such events. Last year, $1.73 billion in new cat bonds were issued in eight transactions. At the end of 2003, about $4 billion in cat bond debt was outstanding worldwide, about $1.3 billion of it relating to North Atlantic hurricane risk. "There is no question that this marketplace could not exist if we did not have sophisticated natural-disaster models... and the models are just getting better all the time."

Cite: The New York Times, *Storm Chasing on Wall Street*, September 19, 2004.

Other Extreme Weather (both insured and uninsured):

- The costliest U.S. drought of the past forty years occurred in 1988 and caused more than $56 billion (in 2000 dollars) of economic losses. More than 5,000 heat-related deaths were also attributed to the heat wave associated with that event.
- The costliest U.S. wildfire of the past forty years occurred in October 1991 in Oakland, Calif., resulting in more than $3 billion in losses (in 2000 dollars) and 25 deaths.
- The costliest U.S. flood event occurred in the Midwest during the summer of 1993, resulting in more than $26 billion in losses (in 2002 dollars) and 48 fatalities.
- Two of the most costly ice storms in U.S. history occurred during the 1990's—in the Northeast in January 1998 (more than $1.5 billion) and in the Southeast in February 1994 (more than $3.7 billion).

> **Cite:** Lott, N., and T. Ross, *Tracking and evaluating U.S. billion dollar weather disasters, 1980-2005*, 86th AMS Annual Meeting, 29 January - 2 February 2006, Atlanta, Georgia, combined preprints [CD-ROM], American Meteorological Society, Boston, MA, 1.2, 7 p. (January 2006)

A dollar spent on mitigation saves society an average of $4, with positive benefit-cost ratios for all hazard types studied. In addition to savings to society, the federal treasury can redirect an average of $3.65 for each dollar spent on mitigation as a result of disaster relief costs and tax losses avoided.

> **Cite**: *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, Multihazard Mitigation Council of the National Institute of Building Sciences, 19 December 2005. Available at: http://www.nibs.org/MMC/mmcnews.html

notes

Solar Storms

- In January 1997, a geomagnetic storm severely damaged the U.S. Telstar 401 communication satellite, which was valued at $200 million, and left it inoperable.
- A geomagnetic storm in 1994 damaged two Canadian communication satellites, which were replaced at a cost of about $400 million.
- A geomagnetic storm in 1989 "blacked out" the power distribution system for Quebec, Canada, and left 6 million people without electricity for 9 hours at a cost of $300 million.
- Although these events and their specific impacts were not predicted, current technology promises to provide real-time warnings and measures to contend with solar-induced storms.

> **Cite:** Green, Arthur W. and Brown, William, *Reducing the Risk from Geomagnetic Hazards*, USDOI and USGS Fact Sheet 177-97. Website: http://geohazards.cr.usgs.gov/factsheets/html_files/geomag/geomag.html.

Diverted polar flights can cost up to $100,000 each because of the additional fuel required. In the period 17-24 January 2005, United Airlines was forced to operate 26 of these less-than-optimum flights due to space weather.

> **Cite:** Genene Fisher, *Integrating Space Weather and Meteorological Products for Aviation.* Atmospheric Policy Program, American Meteorological Society, Washington, D.C., 2003 Website: http://www.ametsoc.org/atmospolicy/documents/Fisher_BAMS_Nov03.pdf

$500 million in satellite insurance claims from 1994 to 1999 were the direct or indirect result of space weather.

> **Cite:** Kunstadter, C., 2002. U.S. Aviation Underwriters Inc. New York City.

The U.S. Department of Defense has estimated that disruptions to government satellites from space weather cost about $100 million a year

> **Cite:** Rodgers, David J., Lesley M.Murphy, Clive S.Dyer, 2000. *Benefits of a European Space Weather Programme.* DERA report no. DERA/KIS/SPACE/TR000349. ESWPS-DER-TN-0001. Issue 2.1 December 19, 2000. ESA Space Weather Programme Study (ESWPS).

notes

El Niño Impacts

California storm losses in the 1997-98 El Niño were $1.1 billion.

Overall, the 1997-1998 El Niño is estimated to have had total U.S. economic impacts on the order of $25 billion.

> **Cite:** Changnon, Stanley A., ed. *El Niño 1997-1998: The Climate Event of the Century,* Oxford University Press, 2000.

Property losses were $2.6 billion; crop losses approached $2 billion.

> **Cite:** Weiher, Rodney F. (ed.), *Improving El Niño Forecasting: The Potential Economic Benefits,* U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Policy and Strategic Planning, Washington, D.C. (2000), p. 18. Also available online at: http://ioc.unesco.org/goos/ed_nino.pdf.

notes

Coastal Storm & Tsunami Impacts

Coastal storms account for 71 percent of recent U.S. disaster losses annually. Each event costs roughly $500 million. With 14 events in a year, losses would total $7 billion per year.

> **Cite:** The H. John Heinz III Center for Science Economics and the Environment, *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation*, Island Press, 2000, Washington, D.C.

On the morning of 26 December 2004, an earthquake occurred in the Indian Ocean west of Sumatra. It was the largest earthquake in 40 years. There were approximately 170,000 people killed, 100,000 missing and more than 1,000,000 homeless. The estimated economic losses exceed $10 billion.

> **Cite:** *Annual Review: Natural Catastrophes 2004* in the Munich Re Group Knowledge Series, Topics Geo, 2005, p. 60

Since 1900, over 200 tsunami events were observed or caused effects on the coasts of the United States and its territories. These events caused more than 500 deaths and more than $186 million damage which included damage to buildings, piers, ferry terminals, and boat harbors.

> **Cite:** *Tsunamis Affecting Alaska, 1737-1996*, by James Lander, National Geophysical Data Center Publication KGRD No. 31, 1996, p. 195
>
> *Tsunamis Affecting the West Coast of the United States, 1806-1992*, by James Lander, P. Lockridge, and M. Kozuch, National Geophysical Data Center Publication KGRD No. 29, 1993, p.242.
>
> *United States Tsunamis, 1690-1988*, by James Lander and P. Lockridge, National Geophysical Data Center Publication 41-2, 1989, p. 265

False tsunami warnings result in additional significant economic impact. The State of Hawaii estimated $40 million in evacuation costs from a 1986 false tsunami warning.

> **Cite:** http://www.magazine.noaa.gov/stories/mag153.htm

notes

Hurricane Impacts

Hurricane Katrina was the deadliest hurricane to strike the US since 1928 (approximately 1,300 deaths versus 2,500 in Southeast Florida in 1928).

Hurricanes Katrina, Rita, and Wilma produced a record 2.773 million insurance claims.

Seven of the 10 most expensive hurricanes in US history occurred in the 14 months from August 2004-October 2005: Katrina ($40.0 billion insured losses), Rita ($4.7), and Wilma ($6.1).

Katrina is the costliest hurricane in United States history. Even after adjusting for inflation, the estimated total damage cost of Katrina is roughly double that of Hurricane Andrew (1992). Normalizing for inflation and for increases in population and wealth, only the 1926 hurricane that struck southern Florida surpasses Katrina in terms of damage cost.

The property/casualty insurance industry will likely experience a $20 billion + event approximately every 10-12 years, on average—mostly associated with hurricanes.

> **Cite:** *Hurricane Season of 2005: Impacts on US P/C Insurance Markets in 2006 and Beyond*, Insurance Information Institute, NY, NY, December 7, 2005 http://www.disasterinformation.org/disaster2/facts/presentation

Hurricane Katrina affected the entire states of Mississippi and Louisiana, plus twenty two counties in Alabama and nine in Florida. Rita affected all of Louisiana plus twenty six counties in Texas. The coastal zone counties of the four states comprise nearly a quarter of employment and wages in the four states. In Louisiana, the coastal parishes (counties) are more than half of the state's economy. The combined coastal zone and watershed counties on the Gulf of Mexico comprised 14% of employment in Alabama, 4% in Mississippi, 6% of Florida, but 33% of Texas employment and more than 80% of Louisiana.

The region accounts for more than a quarter of U.S. employment in marine construction, more than a fifth of employment in fisheries and ship and boat building, and almost two thirds of the employment in the ocean-related component of oil and gas exploration and production. It also accounts for a disproportionate share of marine transportation related employment.

> **Cite:** Colgan, C. and Adkins, J., *2005 Hurricane Damage to the Gulf of Mexico Ocean Economy*, Monthly Labor Review, February, 2006.

[The US Minerals Management Service] estimates that 3,050 of the Gulf's 4,000 platforms and 22,000 of the 33,000 miles of Gulf pipelines were in the direct path of either Hurricane Katrina or Hurricane Rita. Because of the large amount of

infrastructure in the path of hurricane-force winds and waves, the amount of damage was substantial. In comparison with Hurricane Ivan in 2004, Hurricanes Katrina and Rita accounted for considerably more damage because of the paths taken by these two devastating storms. However, there was no loss of life or significant oil spills from wells on the outer continental shelf (OCS) attributed to either storm.

One hundred percent of Gulf oil production, which is approximately 1.5 million barrels a day, was out of production during both storms and 94 percent of gas production, which is 10 billion cubic feet of gas a day, was out of production during Hurricane Katrina. More than 90 percent of the manned platforms and 85 percent of working rigs were evacuated at one time.

> **Cite:** Mineral Management Service, U.S. Department of the Interior, Press Release, January 19, 2006.
> http://www.mms.gov/ooc/press/2006/press0119.htm

Hurricanes Charley and Ivan are the second and third costliest U.S. hurricanes on record, $14 and $13 billion, respectively.

> **Cite:** The National Hurricane Center Web site
> http://www.nhc.noaa.gov/archive/2004/tws/MIATWSAT_nov.shtml

Prior to 2005, the costliest hurricane seasons were:
2004: ~$42 billion in U.S. damage
1992: ~$35 billion in U.S. damage (adjusted for inflation, 2000 values)
1989: ~$10.6 billion in U.S. damage

> **Cite:** The National Hurricane Center Web site
> http://www.nhc.noaa.gov/archive/2004/tws/MIATWSAT_nov.shtml

Since 1900, hurricanes and tropical storms making landfall on the U.S. Gulf Coast have caused more than 9,000 deaths and more than $100 billion in damages (adjusted to 2004 dollars) to homes and property.

> **Cite:** NOAA, Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division. Located at
> http://www.aoml.noaa.gov/general/lib/mgch.html

Some key economic impacts of Hurricane Isabel on the Washington, DC, MSA area were:

- Two million lost riders to Metro with a $2.6 million loss in revenue.
- 257,443 Federal Government non-essential DC employees losing 2 days of employment with a $147.4 million loss in revenue.
- 530,000 lost customers to PEPCO and $40 million in revenue loss.
- 1.3 million Private/Non-Governmental DC employees losing 2 days of employment and $485.4 million in revenue loss.

Cite: Margaret Fowke, *Key Economic Impacts of Hurricane Isabel*, Office of Strategic Planning and Policy, NWS/NOAA, November 2003. Copies available from NOAA Central Library, Silver Spring, Maryland. Website: http://www.lib.noaa.gov.

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Harmful Algal Bloom (HAB) Impacts

A median estimate of the annual economic impacts of harmful algal blooms (HABs) in the United States is about $97 million over the period 1987-2006. These impacts are the sum of different kinds of *direct output* impacts across four categories of effects: public health (divided between ciguatera and shellfish poisonings); commercial fishing; recreation and tourism; and monitoring and management costs. Direct output impacts include lost sales in markets that are directly affected by HABs. Such effects may involve shellfish bed closures, labor losses due to illness, tourism losses, and costs of beach cleanups and enforcement of shellfish laws, etc. Economic impacts of these types do not measure changes in economic *value* (*e.g.*, lost consumer and producer surpluses). Further, these estimates ignore potential gains in other markets or loss mitigation as consumers switch seafood suppliers and recreation destinations and producers switch inputs.

> **Cite:** Hoagland, P. 2006. The public policy of harmful algal blooms. Keynote presentation at the 12th International Conference on Harmful Algae. International Society for the Study of Harmful Algae, Copenhagen (4-8 September).

Some of the most recent (last ten years) local estimates of economic impacts from HABs are reported below.

2005: Lost sales of shellfish in Maine and Massachusetts due to closures imposed as a consequence of the 2005 bloom of *Alexandrium fundyense* are estimated to be $18.4 million for the months of June and July in Massachusetts and for the months of May through September in Maine. Economic impacts of these types do not measure changes in economic *value* (*e.g.*, lost consumer and producer surpluses).

> **Cite:** Jin, D., E. Thunberg and P. Hoagland. 2007. Economic impact of the 2005 red tide event on commercial shellfish fisheries in New England. Mimeo. Woods Hole, Mass.: Marine Policy Center, Woods Hole Oceanographic Institution (15 March).

2005: Lost sales of oysters in Florida as a consequence of a five-month closure due to red tide blooms and high levels of pathogens occurring subsequent to hurricanes Dennis and Katrina are estimated to be $6 million.

> **Cite:** Vail, V. 2005. Personal communication with the Section Leader, Marine Fisheries Services, Florida Fish and Wildlife Conservation Commission, Tallahassee, FL (29 September). Cited in: Bauer, M., ed. 2006. *Harmful Algae Research and Response: A Human Dimensions Strategy*. Woods Hole, Mass.: National Office for Marine Biotoxins and Harmful Algal Blooms, Woods Hole Oceanographic Institution, p. 8.

2002-2003: Washington State closed its recreational fishery for razor clams, which occurs on the tidelands along the coast. This closure has been estimated to result in economic impacts of $10-12 million. Economic impacts of these types measure reductions in expenditures for recreational fishing. They do not measure changes in economic *value* (*e.g*., lost consumer surplus).

> **Cite:** Ramsdell, J.S., D.M. Anderson and P.M. Gilbert, eds. 2005. Harmful Algal Research and Response: A National Environmental Science Strategy (HARRNESS) 2005-2015. Washington: Ecological Society of America.

2002: Invasive algal blooms along Maui's Kihei coast cause over $20 million in potential revenue lost each year to the State of Hawaii. This loss includes reductions in property values, lost rental incomes, and clean up costs.

> **Cite:** Herman, C., P. Van Beukerring, P., S. Pintz, S., and J. Dierking. 2002. Economic valuation of the coral Reef of Hawaii; Hawaii Coral Reef Initiative Research Program Final Report

2000: in Galveston County, Texas, the direct economic impacts of a red tide on tourism, commercial oyster harvests, and beach cleanups were estimated to be $10 million. Total direct, indirect, and induced impacts may have been between $16 and $18 million, affecting as many as 400 jobs. Economic impacts of these types do not measure changes in economic *value* (*e.g*., lost consumer and producer surpluses).

> **Cite:** Evans, G. and L. Jones. 2001. Economic impact of the 2000 red tide on Galveston County, Texas: a case study. TPWD No. 666226, FAMIS 403206. College Station, Tex.: Department of Agricultural Economics, Texas A&M University (19 June).

1997: A bloom of *Pfiesteria spp.* led to an estimated $43 million in lost sales of seafood in Maryland. Economic impacts of these types do not measure changes in economic *value* (*e.g*., lost consumer and producer surpluses).

> **Cite:** Lipton, D.W. 1999. *Pfiesteria's* economic impact on seafood industry sales and recreational fishing. *In* B.L. Gardner and L. Koch, eds., *Proc. Economics of Policy Options for Nutrient Management and Pfiesteria*. College Park, MD: Center for Agricultural and Natural Resource policy, University of Maryland, College Park, pp. 35-38.

1997: A bloom of *Pfiesteria spp.* led to estimated surplus losses to seafood consumers in the mid-Altlantic region of the United States at between $37 and $72 million in the month following the bloom.

> **Cite:** Whitehead, J.C., T.C. Haab and G.R. Parsons. 2003. Economic effects of Pfiesteria. *Ocean and Coastal Management* 46:845-858.

1996: The impacts from a 1996 red tide in Louisiana on commercial oyster harvesters, dealers, processors, distributors, and retailers were estimated to be more

than $4 million. [Economic impacts of these types do not measure changes in economic *value* (*e.g*., lost consumer and producer surpluses).]

Cite: Lavergne, D.R. 1997. Estimated economic impact to the Louisiana oyster harvester due to red tide. Mimeo. Baton Rouge, La.: Louisiana Department of Wildlife and Fisheries (July).

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notes

Seafood Impacts

Bacteria species or strains (termed "isolates") of the bacterial genus *Vibrio* may produce illness or death. As with toxigenic cholera, these effects most likely result from the consumption or handling of uncooked seafood or direct contact with marine or estuarine waters, fish, shellfish, or other marine wildlife. Exposures occur most frequently in the summer months. In 2004, 479 cases of illness were reportedly due to *Vibrio* isolates. Of these cases, 179 resulted in hospitalization. There were 39 mortalities. It is unknown how many of these cases were contracted from exposures in other countries. The majority of deaths resulted from exposures to *Vibrio vulnificus*. During the summer of 2004, there was an outbreak of 62 cases of *Vibrio parahaemoliticus* resulting from the consumption of raw oysters in Alaska. All of these numbers are likely to be underestimates, as only toxigenic *Vibrio cholerae* must be reported at the national level. There are no published economic impact estimates of *Vibrio* morbidities or mortalities in the United States.

> **Cite:** Anon. 2004. Summary of human Vibrio isolates reported to CDC, 2004. Last accessed on 28 March 2006. Centers for Disease Control and Prevention (CDCP). 2005. *Fact Sheet: Vibrio vulnificus.* Washington: Department of Health and Human Services (September 8).

Scombrotoxic Fish Poisoning (SFP): On average, there are 81 cases of scombrotoxic fish poisoning (also known as scombroid or histamine poisoning) originating in the United States each year. SFP is caused by the bacterial spoilage of seafood, especially tuna, mackerel, and bonito. During the ten-year period from 1988 to 1997, scombroid fish poisoning was reported in 145 outbreaks involving 811 persons from at least 20 states. National surveillance data on SFP is based on outbreaks of acute foodborne disease reported by state health departments to CDC. Many cases probably are not reported. There are no published economic impact estimates of SFP morbidities.

Cite: Anon. 2000. Scombroid fish poisoning--Pennsylvania, 1998. *MMWR Weekly* 49(18):398-400 (12 May).

Shellfish Poisonings: Shellfish poisonings are caused by the human consumption of shellfish from environments where significant blooms of toxic algae (a variety of algal species produce toxins) have occurred. Shellfish feed naturally on these algae, and the toxin is sequestered in the body of the shellfish. Shellfish poisonings include paralytic (PSP), neurotoxic (NSP), amnesiac (ASP), and diarrhetic (DSP), among others. Many shellfish poisoning cases go unreported, and public health experts utilize multiples of reported cases to arrive at estimates of the total number of shellfish poisonings. During 1987-92, the total number of reported cases in the United States averaged 21 per year, including one death in Alaska in 1990. The total number of cases, including both reported and unreported illnesses, averaged 207 per year. The cost of illnesses from these three types of shellfish poisonings have been estimated to average about $500,000 per year (2006 dollars).

Cite: Hoagland, P., D.M. Anderson, Y. Kaoru and A.W. White. 2002. The economic effects of harmful algal blooms in the United States: estimates, assessment issues, and information needs. *Estuaries* 25(4b):677-695.

Human sickness and death from tainted seafood resulted in lost wages, medical treatment, and investigation averaging $22 million per year.

Cite: Anderson, D.M.; Hoagland, P.; Kaoru, Y.; White, A.W.*; Estimated Annual Economic Impacts from Harmful Algal Bloom (HABs) in theUnited States,* Technical Report WHOI-2000-11 Woods Hole Oceanographic Institute, Woods Hole, Mass., p. 5.

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notes

Coastal Pollution and Hazardous Waste Site Impacts

More than 700 coastal hazardous waste sites have contaminated sediments in our Nation's estuaries that reduce the economic and ecological productivity of coastal resources.

> **Cite:** *Coastal Hazardous Waste Site Review*, NOAA Office of Response and Restoration, NOAA, 1999.

Polluted runoff caused over 16,000 beach closings and swimming advisories in 2001.

> **Cite:** *Testing the Waters 1999: A Guide to Water Quality at Vacation Beaches*, Natural Resources Defense Council (NRDC), July 1999, Table 3, "Sources of Beachwater Pollution." 2002 and August 2003 version is at http://www.nrdc.org/water/oceans/ttw/titinx.asp

NOAA has successfully recovered compensation for restoration at over 110 hazardous waste and oil spill sites around the Nation.

> **Cite:** Office of Response and Restoration, NOAA National Ocean Service, Policy Working Paper 02-1, May 2002.

Since 1990, NOAA has recovered over $300 million for restoration of coastal and marine resources injured from chemical releases and oil spills.

> **Cite:** *Reversing the Tide: Restoring Our Nation's Coastal and Marine Environment*, NOAA Damage Assessment and Restoration Program, 2002 and 2003.

Pollution has rendered 44 percent of tested US estuaries and 12 percent of ocean shoreline waters unfit for uses such as swimming, fishing, or supporting aquatic life.

> **Cite:** *Health of the Oceans Report 2002*, The Ocean Conservancy, http://www.oceanconservancy.org/dynamic/downloads/healthOceans.pdf. p. 44.

notes

Aquatic Nuisance Species

Pimentel *et al*. assembled a comprehensive review and update of invasive species and associated cost estimates for the United States in 2005. The total damage and control cost is at least $120 billion per year (includes plant and animal species, both terrestrial and aquatic, as well as human diseases) and might be "several times higher" if they were "able to assign monetary values to species extinctions and losses in biodiversity, ecosystem services, and aesthetics." Of the $120 billion in total damage and control estimates, $2.5 billion are associated with aquatic nuisance species. States having experienced significant aquatic nuisance species impacts include California, Florida, and Hawaii. Also, zebra mussels have caused significant impact in the Great Lakes region.

> Cite: Pimentel, D., R. Zuniga and D. Morrison. 2005. *Update on the environmental and economic costs associated with alien-invasive species in the United States*. Ecol. Econ. 52:273-288

notes

Contribution to U.S. Income, Employment, and Output

Fisheries Contributions

Commercial landings by U.S. fishermen in 2005 were 4.4 million metric tons, valued at $3.8 billion.

> **Cite:** Fisheries of the United States, 2005, http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

The U.S. total value of imported fishery products was $25.1 billion in 2005. U.S. imports of edible fishery products totaled 5.1 billion pounds in 2005 and were valued at a record $12.1 billion.

> **Cite:** Fisheries of the United States, Foreign Trade Section 2005 http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

U.S. exports of edible fishery products in 2005 were 2.9 billion pounds, valued at $4.1 billion; total U.S. exports of fishery products (edible and non-edible) in 2005 was valued at $13.6 billion.

> **Cite:** Fisheries of the United States, Foreign Trade Section 2005 http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

Nationwide, anglers spent $14.6 billion on marine recreational fishing in 2000, which generated over $30.5 billion in sales, $12 billion in income and supported nearly 350,000 jobs.

> **Cite:** Steinback, Scott, Brad Gentner, and Jeremy Castle. 2004. The economic importance of marine angler expenditures in the United States. NOAA Prof. Paper NMFS 2, 169 p.

U.S. consumers ate 16.2 pounds of seafood per capita in 2005. The United States is the third largest consumer of seafood in the world.

> **Cite:** Fisheries of the United States, Per Capita Section, 2005, p. 73 http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

Approximately 65,690 people were employed in the seafood processing and wholesale sectors in 2005.

> **Cite:** Fisheries of the United States, 2005, Employment, Crafts and Plant Section, p. 82, http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

The value added to gross domestic product (GDP) by the commercial fishing industry was $32.9 billion in 2005.

> **Cite:** Fisheries of the United States, 2005

http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

Total expenditures for fisheries products are estimated at $65.2 billion yearly. [Expenditures include the final retail value of seafood products sold through stores and food service outlets plus secondary wholesale and processing of industrial products.]

Cite: Fisheries of the United States, 2005, http://www.st.nmfs.noaa.gov/st1/fus/fus05/index.html

The west coast and New England groundfish, Gulf of Mexico shrimp, swordfish, and shark fisheries can support 2,167 vessels sustainably.

Cite: Kirkley, James, John Ward, John Walden, and Eric Thunberg, The Estimated Vessel Buyback Program Costs to Eliminate Overcapacity in Five Federally Managed Fisheries A Preliminary Report, Division of Fisheries Statistics and Economics, Office of Science and Technology, NOAA Fisheries, Silver Spring, Md., June 28, 2002.

The Northeast Multispecies Fishery Management Plan was designed to rebuild 19 fish stocks found in the northwest Atlantic and managed by NOAA Fisheries to levels mandated under the Sustainable Fisheries Act (SFA). Before implementation, it was critical to determine the net national benefits which would result from the proposed action. Model results showed that the preferred alternative resulted in increased national benefits of $161 million dollars over the status-quo alternative when all stocks are rebuilt in 2026.

Cite: New England Fishery Management Council (NEFMC). 2003. Amendment 13 to the Northeast Multispecies Fishery Management Plan.

Implementing days-at-sea leasing in the Northeast Multispecies Fishery

The primary management tool used to control fishing mortality under the northeast multispecies plan is limits on allowable fishing days. NMFS established rules that would allow fishing vessels to lease days at sea to one another and estimated the likely price for leased quota, and whether vessels could lease days and still be profitable.

After the first year, from May 1, 2004 – April 30, 2005, over 6,000 days were leased at a value of $2.5 million. The average number of days leased was 24 and there were 174 lessors and 163 lessees. It was also shown that the program enhanced the profits earned by the vessels that leased days. The program's success has led to consideration of other market based arrangements for managing fishery resources.

Cite: New England Fishery Management Council (NEFMC). 2006. Framework Adjustment 42 to the Northeast Multispecies Fishery Management

Plan and Framework Adjustment 3 to the Monkfish Fishery Management Plan. Draft Version.

Nationwide, anglers spent $14.6 billion on marine recreational fishing in 2000, which generated over $30.5 billion in sales, $12 billion in income and supported nearly 350,000 jobs.

Cite: Steinback, Scott, Brad Gentner, and Jeremy Castle. 2004. *The economic importance of marine angler expenditures in the United States.* NOAA Prof. Paper NMFS 2, p.169.

The buyback program costs for the five federally managed New England groundfish fisheries are $999.6 million (dollars deflated to a 2002 base year), including the cost of removing latent permits.

Cite: Kirkley, James, John Ward, John Walden, and Eric Thunberg, *The Estimated Vessel Buyback Program Costs to Eliminate Overcapacity in Five Federally Managed Fisheries A Preliminary Report*, Division of Fisheries Statistics and Economics, Office of Science and Technology, NOAA Fisheries, Silver Spring, Md., June 28, 2002.

Forty-five percent of the 73 federally managed fisheries reviewed in seven regional reports by NOAA Fisheries are at sustainable capacities.

Cite: Ward, John M.; Brainerd, Theo; and Milazzo, Matteo; *Identifying Harvest Capacity and Over-Capacity in Federally Managed Fisheries, A Preliminary Qualitative Report*, Office of Science and Technology and Office of Sustainable Fisheries, Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Fisheries, March, 2001.

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notes

Aquaculture

U.S. aquaculture sales total almost $1 billion per year, including both marine and freshwater products.

> **Cite:** *Fisheries of the United States*, U.S. Commercial Landings, 2002, p. 23.

It is estimated that 44 jobs are created for every 1,000 metric tons of aquaculture grown.

Each 1 million tons of aquaculture is estimated to reduce fish imports by $2.5 billion. [Note: due to typographic error, the printed version of this booklet erroneously states that the figure is *200 million tons* and *$5 billion*.]

> **Cite:** Office of Constituent Services, *U.S. Marine Aquaculture; Possibilities, Potential, and Capacity*, Draft Final Report, NMFS, May 26, 2004, p.22.

The global aquaculture industry has expanded greatly in the last 20 years; particularly in the production of carp, shrimp, salmon, and shellfish. For example, cultured shrimp production has increased steadily since the 1970s to over 1 million metric tons--or 27% of total world production of 3.6 million metric tons.

While wild production of shrimp has leveled off at approximately 3 million metric tons, cultured production is projected to increase to approximately 2 million metric tons by 2005, and represents 40% of global production.

Salmon, also of economic importance to the US, has shown even more startling farmed production figures since the 1970s. While wild salmon production increased from under 500,000 metric tons prior to 1979 to a peak level of 1.1 million metric tons in 1995, it has since dropped to around 800,000 metric tons.

At the same time, farmed salmon production increased from virtually nothing in the 1970s to 1.2 million metric tons in 2001, and now represent 60% of the global salmon supply.

> **Cite:** *Relationship of Aquaculture to the US Seafood Supply and Seafood Trade*, Briefing paper to the NOAA Executive Council, November, 2003. Copies available from NOAA Central Library, Silver Spring, Maryland. Website: http://www.lib.noaa.gov.

notes

Coastal Contributions

In 2000-2001, the artificial and natural reefs off the four-county area of southeast Florida (Palm Beach, Broward, Miami-Dade and Monroe counties) supported almost 28 million person-days of recreational diving, fishing and viewing activities. These activities generated about $4.4 billion in local sales, almost $2 billion in local income, and 70,400 full and part-time jobs.

> **Cite:** Johns, G.M., Leeworthy, V.R., Bell, F.W. and Bonn, M.A. *Socioeconomic Study of Reefs in Southeast Florida. Hazen and Sawyer, Final report for Broward, Palm Beach, Miami-Dade and Monroe Counties*, Florida Fish and Wildlife Conservation Commission and National Oceanic and Atmospheric Administration. October 19, 2001. Available at: http://marineeconomics.noaa.gov/reefs/02-01.pdf.

Hawaii's coral reefs generated $172.1 million in value added to the economy of Hawaii from reef related recreation and tourism, aquarium trade and commercial Fishing. Recreation and tourism accounted for $170.8 million in value added while aquarium trade and commercial fishing accounted for $2.5 million in value added.

> **Cite:** Cesar, Herman, Pieter van Beukering, Sam Pintz and Jan Dierking. 2002. Economic Value of the Coral Reefs of Hawaii, Final Report, December 23, 2002. Research funded by National Oceanic and Atmospheric Administration, Coastal Ocean Program under awards NA87OA0381, NA96OP0187, NA060A0388, and NA 160A1449 to the University of Hawaii Coral Reef Initiative Research Program (HCRI). *http://www.hawaii.edu/ssri/hcri/reports-cesar.htm*..

In 1997-98, recreational fisherman and divers that used artificial reefs off Northwest Florida spent $415 million in the five-county area of Bay, Walton, Okaloosa, Santa Rosa and Escambia counties. This spending generated $83.66 million in wages and salaries, which supported 8,163 full and part-time jobs in the five-county area.

> **Cite:** Bell, F.W., M.A. Bonn and V. R. Leeworthy. 1998. Economic Impact and Importance of Artificial Reefs in Northwest Florida. Under contract Number MR235, Office of Fisheries Management and Assistance Service, Florida Department of Environmental Protection, Tallahassee, Florida. December 1998. This report can be obtained at the following: http://marineeconomics.noaa.gov/Reefs/nwfl.pdf.

Through innovative approaches to spill preparedness, response, damage assessments and restoration, NOAA contributes approximately $75 million annual to the U.S. economy.

> **Cite:** Office of Response and Restoration, NOAA Oceans and Coasts, Policy Working Paper 02-1 May 2002

Travel and tourism is the Nation's largest employer and second largest contributor to the GDP, generating over $700 billion annually. Beaches are the leading tourist destination, with coastal states earning 85 percent of all U.S. tourism revenues. Approximately 89.3 million people vacation and recreate along U.S. coasts every year.

> **Cite:** Leeworthy, Vernon R., *Preliminary Estimates from Versions 1-6: Coastal Recreation Participation, National Survey on Recreation and the Environment (NSRE) 2000,* National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office. Website: http://marineeconomics.noaa.gov.

In 1995-96, economic impacts of coastal recreation in Monroe County, home to the Florida Keys National Marine Sanctuary, were $1.33 billion in sales/output, $506 million in income, and 21,850 jobs.

> **Cite:** English, D.B.K., Warren Kriesel, Vernon R. Leeworthy, and Peter C. Wiley. Economic Contribution of Recreating Visitors to the Florida Keys/Key West. Linking the Economy and Environment of the Florida keys/Florida Bay. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Silver Spring, MD. November 1996. This report can be obtained at http://marineeconomics.noaa.gov/SocmonFK/publications/96-26.pdf.

Fishing represents a large portion of marine recreation in the United States. Saltwater fishing alone draws nearly 21.3 million participants nationwide which accounts for 10.3 percent of the population age 16 or older. Saltwater fishing ranked third most popular activity in marine recreation in the United States.

Saltwater fishing is expected to attract over 24 million participants by 2010.

California ranks second in the nation in terms of participation in saltwater fishing with more than 2.7 million participants, falling only behind Florida. Texas is ranked third with more than 1 million fewer saltwater fishing participants than in California.

Based on the 2000 participation estimates and an estimated value range of $75 to $200 per participant per year, the annual **expenditures** associated with recreational fishing in California ranged from $205 million to $545 million in the year 2000.

…in the span of ten years (2005-2010), the nation will see an increase in fishing participation of 12%. Based on these national estimates, the **expenditures** associated with marine recreational fishing in California could increase to between $230 million and $610 million.

Based on the 2000 participation estimates (20.3 million person-days) and an estimated value range of $15 to $90 per person day, the annual **[non-market]** value

of recreational fishing in California likely ranged from $305 million to $1.83 billion in the year 2000.

…in the span of ten years (2005-2010), the nation will see an increase in recreational fishing activity of 12%. Based on these national estimates, the **non-market** value of marine recreational fishing in California could increase to $342 million to over $2 billion annually by the year 2010.

Nationally, **non-market** values for marine recreational fishing …range from $17 per day in Delaware to $146 per person day in Alaska. (2005 dollars).

> **Cite:** Pendleton, L., and Rooke, J., *Understanding the Potential Economic Impact of Recreational Fishing*, (March 2006), "Non-Market Literature Portal," www.oceaneconomics.org

Numerous studies have demonstrated the economic value of wildlife viewing, especially whale watching. We estimate that whale watching in California alone probably generates on the order of $20 million in **gross revenues annually** and **net revenues** of between $4 million and $9 million…We estimate the **non-market value** for whale watchers alone at more than $40 million annually.

Annual **expenditures** associated with marine wildlife viewing (exclusive of whale watching) range from $7-10 million in California [Krass, 1989] to $26 million in Stellwagen Bank in New England. **Non-market** benefits range from $35 million in New York [Johnson, et. al., 2000] to $287 million in Florida [Leeworthy and Bowker, et. al., 1997].

> Cite: Pendleton, Linwood, *Understanding the Potential Economic Impact of Marine Wildlife Viewing and Whale Watching in California,* (December 2005), "Non-market Literature Portal", www.oceaneconomics.org

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notes

Beach Visitation

Going to the beach is a family affair, with nearly four in ten (37 percent) U.S. households visiting the beach and taking a child on the trip. Just 23 percent of overall traveling households include a child when traveling. Nearly 110 million person-trips were made by U.S. households to the beach last year, up seven percent from the year before. A person-trip is one person traveling 50 or more miles, one-way, away from home. Households visiting the beach spend an average of $850 per trip, excluding transportation to their destination, compared to just $463 for overall traveling households. More than one-third (35 percent) of beach trips last seven nights or more. On average, overnight beach trips last an average of 5.9 nights, compared to 4.1 nights for overall travel. Beach travelers are more likely than overall traveling households to stay in a condo or timeshare (16 percent vs. four percent) or in an RV (eight percent vs. five percent).

> **Cite:** Coastal States Organization, *Travel Industry of America Domestic Travel Market Report, 2002 and 2003.*

In 2000, an estimated 63.7 million Americans from the civilian, non-institutionalized population 16 years of age or older visited a saltwater beach for outdoor recreation and spent 878.7 million days at the beach. This was projected to increase to 67.6 million participants spending 927.7 million days in 2005 and to 70.9 million participants spending 969.6 million days at the beach in 2010.

> **Cite:** Leeworthy, Vernon R., Bowker, J. M., Hospital, Justin D., and Stone, Edward A. 2005. Projected Participation in Marine Recreation: 2005 & 2010. National Survey on Recreation and the Environment 2000. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects, Silver Spring, Maryland. March 2005, p.152. http://marineeconomics.noaa.gov/NSRE/NSREForecast.pdf

California's coastal industries contribute more than $17 billion and 370,000 jobs to the state's economy.

> **Cite:** *How Much is the Beach Worth? Calculating the Value of the Environment*, see the web site for the NOAA Coastal Services Center's magazine, volume 4, issue 1, Jan./Feb.2001 Coastal Services, http://www.csc.noaa.gov/magazine/2001/01/worth.html. Note: Check the URL prior to quoting numbers from this website site as it gets updated periodically.

In the summer of 2000 (June-August), it is estimated that there was almost $1 billion in spending on beach activities in Los Angeles and Orange counties, California. An estimated 58,600 full and part-time jobs are supported annually by beach visitors to Los Angeles and Orange county beaches.

> **Cite:** Hanemann, W. Michael, Linwood Pendleton, and David Layton, 2001.

Summary Report on Expenditure Module, the Southern California Beach Valuation Project, Dec. 16, 2001. Report can be obtained at http://marineeconomics.noaa.gov/SCBeach/4Summary_Expenditures.pdf.

In 1999-2000, the top three states for beach visitation were Florida (15.2 million participants and 177.2 million days), California (12.6 million participants and 151.4 million days), and Hawaii (3.6 million participants and 101.2 million days).

Cite: Leeworthy, V.R. and Wiley, P.C., *Current Participation Patterns in Marine Recreation,* Table A-3, p. 25.Website: http://marineeconomics.noaa.gov/NSRE/NSRE_V1-6_May.pdf.

In seven estuaries alone, tourism and beach going activities generate economic benefits of more than $16 billion to their respective regions.

Cite: *Natural Resources Valuation: A Report by the Nation's Estuary Program*, Environmental Protection Agency (EPA), 1997.

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notes

Satellites

A new generation of weather satellites called the National Polar Orbiting Environmental Satellite System (NPOESS) is under development to replace data from the current POES satellites and civilian data from the military DSMP satellites. The value of civilian benefits of NPOESS to the U.S. between 2013 and 2026 is estimated at $0.9-$1.2 billion per year in year 2007 dollars, with a present discounted value of $12.6-$16.8 billion, discounted at 7%. Benefits include both continuity of observations and improvements. A general analytic framework that emphasizes productivity gains and environmental security is suggested.

> **Cite:** Leveson, Irving, NPOESS Civil Benefits and Contributions to Economic and Environmental Security, study prepared for the NPOESS Integrated Program Office, Leveson Consulting, April, 2007.

In 2003, sales by the commercial remote sensing industry, including aerial and satellite segments, were estimated at USD$ 2.6 billion, with the satellite segment representing roughly a third of the total sales.

By 2010 sales could reach USD$ 6 billion with USD$ 2 billion for the satellite segment.

> **Cite:** CRSL Industry Statistics, as reported by *Space 2003: Exploring the Future of Space Applications*, by OECD, 2004

Since 1993, 22 licenses have been granted by NOAA for the operation of approximately 40 commercial remote sensing satellites, representing over $2 billion in system investments.

> **Cite:** NOAA Licensing Files, International and Interagency Office, NOAA Satellites and Information.

10 of the 30 satellites scheduled to orbit by 2007 will be commercial.

> **Cite:** Stoney, William E, Mitertek Systems, *Markets and Opportunities*, Earth Imaging Journal, Jan Feb 2005, Vol 2, No.1.

Each year from 1980 to 1995, on average, five commercial jets encountered volcanic ash clouds in flight. About 10 percent of these encounters resulted in loss of power.

> **Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation–Volcanic Ash Avoidance*, Marine Policy Center, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The overall economic risk from airborne volcanic ash effects historically is about

$70 million per year.

> **Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation–Volcanic Ash Avoidance*, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The benefit from NPOESS data to volcanic ash avoidance in commercial aviation is estimated at $10 million per year.

> **Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Aviation–Volcanic Ash Avoidance*, Woods Hole Oceanographic Institute (WHOI), October, 2000.

The economic value of an operational geomagnetic storm forecasting system in the North American electricity industry is estimated at about $450 million over three years, well above the $100 million cost of the system.

> **Cite:** Tiesberg, T. J., and Weiher, R., *Valuation of geomagnetic storm forecasts: An estimate of the net economic benefits of a satellite warning system*, Journal of Policy Analysis and Management, Vol. 19, No. 2, 2000, pages 329-334.

The total annual marginal benefits from the Advanced Baseline Images (ABI) and Hyperspectral Environmental Sounder (HES) on GOES-R are approximately $638 million annually with discounted sum-of-direct benefits of approximately $3.1 billion over a 13-year effective benefit lifecycle.

> **Cite:** *GOES-R Sounder and Imager Cost/Benefit Analysis*; NOAA, NESDIS Office of Systems Development, November, 2002.

Collectively, the world fleet undertakes in excess of 33,000 ocean transits annually. The expected average annual benefit to ship routing from NPOESS data in the two decades following the launch of NPOESS in 2007 is about $95 million per year. Because of the U.S. share of world trade, perhaps 20 percent of the total benefit–some $20 million per year–will be realized by consumers in the United States.

> **Cite:** Kite-Powell, Hauke, *Benefits of NPOESS for Commercial Ship Routing–Transit Time Savings*, Marine Policy Center, Woods Hole Oceanographic Institute (WHOI), October, 2000.

In 2005, NOAA satellites, with their sophisticated search and rescue technologies, brought 222 people to safety from dangerous and potentially life threatening ordeals--from Alaska to New York State.

NOAA's satellites, along with Russia's Cospas satellites, are part of an elaborate international Search and Rescue Satellite-Aided System (COSPAS-SARSAT). Since the system became operational in 1982, almost 18,000 lives have been saved worldwide with the assistance of CPSPAS-SARSAT, including more than 5,100 lives in the US.

Cite: Cospas-Sarsat Information Bulletin No. 18, February 2006
http://www.cospas-sarsat.org/Documents/informationBulletin.htm

NOAA Press Release 2006-008, NOAA, U.S. Department of Commerce
http://www.publicaffairs.noaa.gov/releases2006/jan06/noaa06-008.html

A Cost Benefit Analysis concluded that for every Federal dollar spent on the national Search and Rescue Satellite Aided Tracking (SARSAT) program the Nation derived more than 11 dollars in benefit. In summary, the total benefit of the program exceeded $259M in 2004

Cite: Search and Rescue Satellite Aided Tracking (SARSAT) Program Cost Benefit Analysis (Draft), NESDIS, NOAA, March 2006

A recent analysis estimated the benefits of improved data from GOES-R measured in term of the cost avoided or benefits gained by each industry or sector resulting from more accurate forecasts, reduced operations costs, and fewer accidents and deaths (using the methodology as endorsed by OMB guidelines for calculating benefit-cost analysis of federal programs). Data are presented as of the year 2005, and future benefits/savings from 2015 to 2027 (the period in which when the satellite becomes operational) have been discounted at 7% to the year 2005 to determine present value of the future streams of expected savings in each of the following five sectors:

- Improved tropical cyclone forecasting resulting in more effective action to protect property and to enable evacuation of individuals residing in the path of the storm: $0.450 billion in 2015 (average of $130,000 per U.S. coastline mile from Maine to Texas) and $2.4 billion from 2015 to 2027 (average of $690,000 per U.S. coastline mile from Maine to Texas)

- Enhanced aviation forecasting resulting in improvements in avoidable delays, value of passenger time avoided, avoidable repair costs due to volcanic ash, and avoidable risk of aircraft/life lost: $0.169 billion in 2015 and $0.768 billion from 2015-2027

- More accurate temperature forecasts contributing to improved energy demand expectations and savings in the electricity and natural gas sectors: $0.512 billion in 2015 and $2.56 billion from 2015-2027

- Enhanced forecasts leading to more efficient irrigation of crops — resulting in water savings, energy savings by not having to pump water, and revenue gains from selling excess water: $0.061 billion in 2015 and $1.09 billion from 2015-2027

- Improved forecasting of tropical cyclones resulting in reduced losses to the recreational boating industry: $0.031 billion in 2015 and $0.141 billion from 2015-2027

Across the five activities, the combined annual value for 2015 exceeds $1.2 billion. The present value of the combined estimated benefits for the 2015-2027 period approaches $7 billion.

> **Cite:** Centrec Consulting Group, LLC., *An Investigation of the Economic and Social Value of Selected NOAA Data and Products for Geostationary Operational Environmental Satellites (GOES)*, report submitted to NESDIS, February 2007

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notes

Marine Commerce

Last year, United States deep-draft seaports and seaport-related businesses generated approximately 8.4 million American jobs and added nearly $2 trillion to the economy, according to a just-completed study by a Lancaster, PA-based business consulting service that specializes in port-sector economic impact studies.

Of the 8,397,301 Americans working for ports and port-related industries in 2006, nearly 7 million were employed by firms involved in handling imports and exports, such as retailers, wholesalers, manufacturers, distributors and logistics companies.

In addition, the new study also shows that businesses providing goods and services to U.S. seaports directly and indirectly paid $314.5 billion in total wages and salaries. Of this total, $207.4 billion came directly from businesses involved in handling international waterborne commerce.

> **Cite:** American Association of Port Authorities news release, August 28, 2007 (www.aapa-ports.org)

More than 78 percent of U.S. overseas trade by volume and 43.5 percent by value comes and goes by ship, including 9 million barrels of imported oil daily.

> **Cite:** *2003 Pocket Guide to Transportation* Table 5-5, U.S. Department of Transportation, http://www.bts.gov/publications/pocket_guide_to_transportation/2007/

Waterborne cargo alone contributes more than $742 billion to the U.S. GDP and creates employment for more than 13 million citizens.

> **Cite:** *An Assessment of the U.S. Marine Transportation System, A Report to Congress,* U.S. Department of Transportation, September 1999. http://ntl.bts.gov/DOCS/report.

26,000 miles of commercial waterways serve 361 ports, which have more than 5,000 waterfront facilities. 3.3 billion barrels of oil are imported through U.S. ports annually. 8,000 foreign vessels make 50,000 port calls annually.

> **Cite:** Peters, Katherine McIntyre, *Covering the Waterfront,* Government Executive, September 1, 2004-11-15 , p. 44.

Annually, the U.S. marine transportation system moves more than two billion tons of domestic and international freight; imports 3.3 billion barrels of oil to meet U.S. energy demands; supports 110,000 commercial and recreational fishing vessels that contribute $111 billion to state economies.

> **Cite:** *An Assessment of the U.S. Marine Transportation System, A Report to*

Congress, U.S. Department of Transportation, September 1999. http://ntl.bts.gov/DOCS/report.

Every year, 134 million passenger-day trips are ferried to work and other destinations on U.S. waterways, along with five million cruise ship passengers.

Cite: *Maritime Transportation System Report to Congress*, 1999, p. vii, Executive Summary. Website: http://www.dot.gov/mts.

The Maritime Transportation System ships 48 percent of the oil needed to meet U.S. energy demands.

Offshore oil and gas development currently produces 22 percent of all domestically produced oil and 27 percent of natural gas. Federal royalties and taxes on offshore production average about $4 billion per year.

Cite: http://www.pewoceans.org/articles/2001/10/04/brief_19075.asp

Waterborne Commerce Facts:

- Crude petroleum comprised 65.7% of U.S. waterborne in-transits, while primary manufactured goods ranked second with 10.7% based on weight in 2005.
- The top five U.S. ports ranked by dollar value of foreign traffic for calendar year (CY) 2005 were the same as CY2004: Los Angeles, CA; Long Beach, CA; New York, NY and NJ; Houston, TX; and Charleston, SC.
- In 2005, 9.7% of all U.S. waterborne commerce by weight was containerized (2.0% of domestic and 14.9% of foreign).
- The Consolidated Port of Hampton Roads exported the largest volume of coal in the U.S., 16.7 million short tons in 2005, down 8.2% from 2004.
- The St. Lawrence Seaway Development Corporation reported 31.3 million metric tons (34.5 million short tons) moving on the Montreal-Lake Ontario section of the St. Lawrence Seaway for calendar year 2005, a 1.5% increase from 2004.
- Great Lakes traffic for 2005 was down 7% from last year, and remains well under the average tonnage for the 1990's.
- Tonnage on the Gulf Intracoastal Waterway (GIWW) was 116 million tons, down from last year's all-time high of 123 million tons, mainly due to Hurricanes Katrina and Rita.
- In 2005, a year marked by the devastation of Hurricane Katrina, the Port of New Orleans was down 15.6% from 78.1 million tons to 65.9 million. Although the Port of South Louisiana, was down 5.3%, it still registered the 6th highest total in

the history of the port with 212.2 million tons.

Cite: “The U.S. Waterway System – Transportation Facts,” Navigation Data Center, U.S. Army Corps of Engineers, February 2007. Available at: http://www.iwr.usace.army.mil/ndc/factcard/fc06/factcard.pdf

notes

Coastal Ocean Observing Systems

Preliminary estimates of the potential economic benefits from new investments in regional coastal ocean observing systems in US waters range from $500 million to $1 billion per year, estimated largely in terms of increased economic activity and social surplus realized as a result of improved information about coastal marine conditions. The estimates are constructed for ten geographic regions encompassing all coastal waters of the United States, and cover a wide range of industrial and recreational activities including recreational fishing and boating, beach recreation, maritime transportation, search and rescue operations, spill response, marine hazards prediction, offshore energy, power generation, and commercial fishing.

> **Cite**: Kite-Powell, H.L., C.S. Colgan, M.J. Kaiser, M. Luger, T. Pelsoci, L. Pendleton, A.G. Pulsipher, K.F. Wellman, and K. Wieand. 2004. Estimating the economic benefits of regional ocean observing systems. A report prepared for the National Oceanographic Partnership Program. Marine Policy Center, Woods Hole Oceanographic Institution.

The annual economic return to the U.S. economy of NOAA's El Niño ocean observing and forecast system is between 13 and 26 percent, which is significantly higher than the Office of Management and Budget's 5.8 percent minimum rate of return specified for Federal projects.

> **Cite:** Sassone, P., and Weiher, R., *Cost-Benefit Analysis of TOGA and the ENSO Observing System.* In R. Weiher (ed.) *Improving El Niño Forecasting: The Potential Economic Benefits,* NOAA, Office of Policy and Strategic Planning, 1999. p. 47. Website: http://ioc.unesco.org/goos/el_nino.pdf.

Estimates suggest that $11.9 million in direct annual economic benefits can be attributed to Physical Oceanographic Real-Time System (PORTS) data in the Houston/Galveston area with a reasonable degree of confidence. Another $2.2 to $3.7 million in annual benefits are less easily traced but may be linked to PORTS; and an additional $1.8 to $2.8 million could potentially be realized with the full utilization of PORTS data. Thus, our best estimate of the presently realized quantifiable benefit from the Houston/Galveston PORTS data is $14.1 to $15.6 million. This estimate is best interpreted as a lower bound on total benefits flowing from PORTS data, since not all uses of PORTS data can be quantified.

> **Cite:** Kite-Powell, H., *Estimating Economic Benefits from NOAA PORTS Information: A Case Study of Houston Galveston*, The Port of Houston Authority, Houston, TX, March 2007.

Estimates suggest that $2.4 to $4.8 million in direct annual economic benefits can be attributed to PORTS data in the Tampa Bay area with a reasonable degree of confidence. Another $2.2 million in annual benefits are less easily traced but may

be linked to PORTS; and an additional $2.2 million could potentially be realized with the full utilization of PORTS® data. Thus, our best estimate of the presently realized quantifiable benefit from Tampa Bay PORTS® data is $4.4 to $7.0 million. This estimate is best interpreted as a lower bound on total benefits flowing from PORTS® data, since not all uses of PORTS® data can be quantified.

Cite: Kite-Powell, H., *Estimating Economic Benefits from NOAA PORTS® Information: A Case Study of Tampa Bay*, Tampa Bay Harbor Safety & Security Committee, Tampa Bay, FL, July 2005.

Weather, Climate and Storm Warnings

The largest single customer of NOAA products are the 105 million U.S. households who consult the daily forecast at least once a day. NOAA's annual budget for weather forecasting (NWS/NESDIS) is about $1,383 million. The average U.S. household, therefore pays about $13 a year for NOAA's weather services.

A detailed National survey using stated-preference nonmarket valuation approaches to elicit household values for both current and improved weather forecast services revealed:

- the average value of all current weather forecast information from public and private sectors is approximately $109 per household, with a total national value of $11.4 billion per year.
- the annual value of improving the daily forecast in terms of more accurate one-day and multi-day forecasts, geographic detail, and frequency of updates is $16 per household, or $1.73 billion per year.

Total annual Federal spending for weather information is about $25 per household (including aviation and defense, in addition to NOAA), which produces an annual benefit-cost ratio of 4.4 to one to U.S. households alone, or net national benefits of $8.8 billion a year. This does not include benefits in agriculture, transportation, construction, or benefits to households in other countries that rely on weather information from the U.S.

> **Cite:** Lazo, J. and Chestnut, L., *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector*, report prepared for NOAA's Chief Economist by Stratus Consulting, Boulder, CO, November 2002.

Weather derivatives are financial contracts in which money changes hands based on seasonal average temperatures, degree days, or precipitation amounts. According to the Weather Risk Management Association (WRMA 2005), the total "notional value" of seasonal weather derivatives executed between parties has been about $2 billion per year in 1998-2000, $4 billion in 2001-2002, $4 billion in 2002-2003, $4.5 billion in 2003-2004 and $8.4 billion in 2004-2005. This has resulted in a total notional value of $24 billion in weather risk management contracts worldwide over the past six years, with about 1/3 of this in the latest year.

> **Cite:** WRMA, 2005: Fifth annual industry survey. Website: www.wrma.org.

The size of the Private/Commercial Meteorological value added sector is estimated to be approximately $400-700 million in annual gross receipts, with the number of firms estimated at 400, most of which are sole proprietorships, and employment of approximately 4,000 people.

> **Cite:** Commercial Weather Services Association

NOAA's National Weather Service forecasts, warnings, and the associated

emergency responses result in a $3 billion savings in a typical hurricane season. Two-thirds of this savings, $2 billion, is attributed to the reduction in hurricane-related deaths, and one-third of this savings, $1 billion, is attributed to a reduction in property-related damage because of preparedness actions.

> **Cite:** Dr. Hugh Willoughby, HRD/AOML, *Costs and Benefits of Hurricane Forecasts*, minutes of 55th Interdepartmental Hurricane Conference, 5-9 March 2001, Orlando, FL.

Estimates indicate that the value of existing 48-hour hurricane forecast information to oil and gas producers averaged roughly $8 million per year during the 1990s, which substantially exceeds the operating budget of the National Hurricane Center... Forecast value dramatically increases with improvements in accuracy, rising by more than $15 million per year with a simulated 50% improvement in 48-hour forecast accuracy.

> **Cite:** Considine, Timothy J., Christopher Jablonowski, Barry Posner, and Craig H. Bishop, *The Value of Hurricane Forecasts to Oil and Gas Producers in the Gulf of Mexico*, Journal of Applied Meteorology: Vol. 43, No. 9, pp. 1270-1281.

Reducing the length of coastline under hurricane warnings saves at least $640,000 per coastal mile in costs of evacuations and other preparedness actions.

> **Cite:** Various sources but note in particular per mile evacuation costs are highly variable with reports in the literature varying from under $100,000 to $1 million. Hence, this estimate must be applied with great care, especially in program evaluation.

National implementation of the Advanced Hydrologic Prediction Service (AHPS) will save lives and an estimated $240 million per year in flood losses, and will contribute an additional $520 million per year in economic benefits to water resources users.

> **Cite:** *Use and Benefits of the NWS River and Flood Forecasts*, National Hydrologic Warning Council, April 1, 2002. http://www.nws.noaa.gov/oh/ahps/AHPS%20Benefits.pdf

Potential benefits from better forecasting of snow and snow events include:

- improvements in frost forecasts (up to $6,000/hectare/yr for fruit orchards),
- long-range stream flow forecasts (over $170 million/year in hydropower benefits for three river systems),
- temperature predictions (over $500 million/year from natural gas and electric utility providers),
- icing diagnostics at airports (exceeds $600 million/yr at U.S. airports),
- predictions of road ice formation and fog (exceeds $29 million/yr from rerouting trucks in U.S.), and

- marine forecasts of winds and waves (exceeds $95 million/yr from transit time savings and cargo loss reductions in U.S. coastal waters).

  Cite: Adams, R., Houston, L., Weiher, R., *The Value of Snow and Snow Information Services*, Report prepared for NOAA's National Operational Hydrological Remote Sensing Center, August, 2004.

Installation of Doppler radar by the NWS reduced [tornado] fatalities by 45% and injuries by 40% from their already historically low levels in the late 1980s and early 1990s.

Cite: Sutter, D., and Simmons, K., *WSR-88D Radar, Tornado Warnings, and Tornado Casualities*, Weather and Forecasting, 20(2): 301-310, 2005

Between 1992 and 2004, the NWS's NEXRAD radar system prevented over 330 fatalities and 7800 injuries from tornadoes, at a monetized benefit of over $3 billion, compared with a total capital and site acquisition and preparation cost of less than $1.7 billion (in 2004 dollars).

Tornadoes during the day are much less dangerous than at night, with fatalities 64% lower and injuries 43% lower for daytime tornadoes. This provides indirect evidence that tornado warnings are saving lives, but suggests that improvements in the dissemination of warnings at night could save more lives.

Residents of mobile homes remain at risk from tornadoes; over 40% of fatalities occur in mobile homes, and the fatality rate is more than ten times greater than that for residents of permanent homes.

In 2002, 186 million person hours were spent under tornado warnings in the U.S., and the value of this time was about $3 billion. The NWS is experimenting with refining its tornado warnings from the current county basis. This could reduce the person hours under tornado warnings by half or more.

Cite: Sutter, D., and Simmons, K., *The Value of Tornado Warnings and Improvements* in *Warnings*, presentations at the American Economics Association annual meeting (Boston, January, 2006), and the American Meteorological Society annual meeting (February, 2006).

Utility Industry

US electricity generators save $166 million annually using 24-hour temperature forecasts to improve the mix of generating units that are available to meet electricity demand.

Incremental benefits are relevant in assessing the merits of investments that will improve forecast accuracy.

The *incremental* benefit of an improvement in forecast accuracy is estimated to be about $1.4 million per percentage point of improvement per year.

For a 1 degree centigrade *improvement* in accuracy, the benefit is about $59 million per year.

> **Cite:** Teisberg, T., Weiher, R., and Khotanzad, A.; *The Economic Value of Temperature Forecasts in Electricity Generation*, Bulletin of the American Meteorological Society, December, 2005; pp. 1765-71.

For temperatures below 0F and above 80F (below -18C and above 27C) there can be 350MW of excess or insufficient electricity generated in the TVA region for every 1F error. The exact cost of an imperfect forecast will depend on the market price of electricity, but the marginal cost could exceed $1million per degree day. [Note that this is the marginal cost of energy with respect to time and does not necessarily mean an absolute cost of $1 million.]

> **Cite:** Sen, Avery, *The Benefits of Remote Sensing for Energy Policy*, Space Policy, Vol. 20, pp. 17-24, 2004.

The Tennessee Valley Authority [TVA] generates 4.8% of the nation's electricity. Forecasts over its 80,000 square miles have been wrong by an average of 2.35 degrees these last 2 years, fairly typical of forecasts nationwide. Improving that to within 1.35 degrees would save TVA as much as $100,000 a day, perhaps more.

> **Cite:** USA Today; June 19, 2001.

The value of understanding the interrelationships between weather variables and electric load can save a small utility at least $0.5 M annually through improved temperature forecasts.

> **Cite:** Tribble, A.N., 2003: The relationship between weather variables and electricity demand to improve short-term load forecasting. Ph. D. dissertation, School of Meteorology, University of Oklahoma, 221 pp., from Building The National Cooperative Mesonet: Program Development Plan For COOP Modernization" dated October 2003.

By effectively using accurate rainfall forecasts in our hydro operations, Duke Power can save several million dollars annually in preventing ‘wasted’ water—water moved past the hydro station but not used for hydroelectric generation.

Cite: Bill Coley, President of Duke Power; comments at the First AMS Policy Forum in January 2001.

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notes

Agriculture

Monthly precipitation data was the key to determining the outcome of a $2 billion lawsuit brought by several southwest Indian tribes against the U.S. government concerning the overgrazing of reservation rangeland.

> **Cite:** Future of the National Weather Service Cooperative Observer Network 1998, The National Academy Press, p. 7, http://www.nap.edu/openbook/0309061466/html.

The dispensation of $500 million in federal drought insurance was decided by precipitation records from the Cooperative Weather Observing Network (COOP) stations during the 1988 drought in the Midwest. In one case, $6 million was paid on the basis of records from one station.

> **Cite:** Future of the National Weather Service Cooperative Observer Network 1998, The National Academy Press, p. 7, http://www.nap.edu/openbook/0309061466/html.

There are 600,000 irrigated acres across Oklahoma. It costs $4 to put one inch of irrigated water on each acre. If more scientific irrigation strategies were adopted based on reliable local data, it is likely that one acre-inch of irrigated water could be saved each year. As a result, the agriculture industry in Oklahoma would realize an annual savings of $2.4 million.

> **Cite:** Professor Ron Elliott, Oklahoma State University.

The value of weather forecasts for Australia and U.S. agriculture is about $1/acre (equal to 2 to 3 percent of U.S. farm income).

> **Cite:** Weiher, Teisberg, and Adams, Valuing Weather Forecasts, conference workshop, World Bank, Roshydromet, NOAA; Moscow, Russia, November 2003.

A recent study of potential benefits of improved NOAA hydrological information by the Office of the NOAA Chief Economist examined the potential economic value of soil moisture information for private irrigation management in the semi-arid Great Plains. The study estimated significant benefits to farmers that, if aggregated for the states of Nebraska and Kansas, are worth $55 million per year and potentially over $200 million per year. About 45 percent of these benefits result from more profitable irrigation and 55 percent from the opportunity value of conserved groundwater. Other private or public benefits of soil moisture data would add to these benefits.

Cite: Supalla, R., Martin, D., Adams, R., Weiher, R., *Potential Economic Value of Soil Moisture Data for Irrigation Management in the Central Great Plains*, October, 2005, www.economics.noaa.

Measuring and explaining annual variability in forage production will improve with time as soil moisture and grass yield data become increasingly available… Considering the linkages between rainfall and herbage production, a flexible, profit maximizing strategy is preferable to a constant (livestocking) strategy when producers have reasonably accurate long-range weather forecasts (e.g., 6 month lead time)… Improved weather forecasts have the potential to increase ranch returns by as much as 40% over levels obtained with a constant stocking rate that does not adjust to forage conditions.

Cite: Torell, L., McDaniel, K. and Hurd, B. *Exploratory Case Study on the Value of Improved Soil Moisture Forecast Information for Rangeland Management*, July, 2007, www.economics.noaa.

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notes

Better preparation, response, and mitigation will reduce the average cost ($500 million per event) of storm-related disasters by 10 percent ($50 million per event). A 10 percent reduction in the cost of storm-related disasters means a $700 million in savings per year (with an average 14 events saving $50 million each per year).

Cite: *Evaluation of Erosion Hazards,* H. John Heinz III Center for Science, Economics, and the Environment, Washington, DC, April 2000.

Economists have quantified the benefits of improved El Niño forecast in various sectors:

- Benefits to U.S. agriculture by altering planting decisions have been estimated at $265-300 million annually, throughout El Niño, normal, and La Niña years.
- Similarly, benefits to Mexican agriculture range from $10 to $25 million annually.
- Benefits in U.S. corn storage could approach $200 million annually.
- Even in a small Northwest Coho salmon fishery, annual benefits are estimated at $250,000 to $1 million.
- Worldwide agriculture benefits of better El Niño forecasts are at least $450 to $550 million per year.
- An analysis of NOAA's operational El Niño forecasting system, comparing forecast systems costs with anticipated benefits in just the U.S. agriculture sector, yielded an estimated annual rate of return on that investment of between 13 to 26 percent.

Cite: Weiher, Rodney, ed. *Improving El Niño Forecasting: The Potential Economic Benefits,* NOAA, U.S. Department of Commerce, 1997, p. 29, p. 41, p. 43, p.47, for U.S. Agriculture, Corn Storage, Fisheries and Operational Forecast System, respectively.

Adams, R.M.; Houston, L.L.; McCarl, B.A.; Tiscareno, M.L.; Matus, J.; and Weiher, R.F., *The Benefits to Mexican Agriculture of an El Niño Southern Oscillation (ENSO) Early Warning System*, Journal of Agricultural and Forest Meteorology, 2003, vol 115, pp. 183-194.

McCarl, B., and Kim, M., *The Value of El Niño and NAO Information in Worldwide Agriculture,* Working Paper, Department of Agriculture Economics, Texas A&M University, College Station, Texas.

NOAA Satellites and Information's Air-Freezing Index (AFI) reduces construction costs by $330 million per year and saves an equivalent of 8.6 million gallons of heating fuel.

Cite: *Economic Value for the Nation,* NOAA Satellites and Information,

September 2001.

A Heat Watch/Warning System used in Philadelphia since 1995 is estimated to have saved 117 lives over its first three years of operation. The total dollar benefits of this system are estimated to be $468 million, while costs are on the order of $200,000, for this three year period. Philadelphia's is one of 17 such systems running in the U.S. and one of 29 worldwide.

Cite: Teisberg, T., Ebi, K., Kalkstein, L., Robinson, L., and Weiher, R., *Heat Watch/Warning Systems Save Lives: Estimated Costs and Benefits for Philadelphia 1995-1998,* Bulletin of the American Meteorological Society, 85:1067-74.

For every $1 that energy companies spend in acquiring NOAA climate station data, they receive a potential benefit of saving $495 in infrastructure costs that would be required to maintain their own climate database storage, archiving, and reporting system. Extrapolating the savings to the entire U.S. energy market yields a potential benefit of $65 million.

Cite: *Investigating the Economic Value of Selected NESDIS Products,* Centrec Consulting Group, LLC, January, 2003.

For every $1 that railway companies spend acquiring NOAA climate data, they receive a potential benefit of saving almost $13,140 in infrastructure costs that would be required to maintain their own climate data base storage, archiving, and reporting system. Extrapolating the savings to the entire U.S. railway market yields a potential benefit of $11.5 million.

Cite: Centric Consulting Group, LLC., *The Economic Value of Selected NOAA Products within the Railway Sector, report submitted to NESDIS*, June 2005. http://www.centrec.com/public_client_project.htm (listed as PDF)

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notes

Research

Air Quality

It is estimated that by the year 2010, $10B and 65,000 jobs will have been saved by Texas' revisions of their air quality management plan, according to an independent economic analysis by the University of Chicago and University of Houston. The revisions were made based on NOAA's discoveries of previously unexpected factors that cause the Houston area to experience the highest ozone levels in the nation.

> **Cite:** Tolley, George and Smith, Bruce, *An Economic Evaluation of Alternative Strategies Cleaning Up Houston's Act,* Final Report to Greater Houston Partnership from RCF, Inc. January, 2001.

Supercomputers

Using conservative assumptions about the contribution of a new supercomputer to the potential overall improvements in weather forecasting indicates discounted benefits in:

- the household sector (ordinary day-to-day forecasts, not including severe weather) at $69 million
- certain agriculture sectors at $26 million
- avoided weather fatalities at $21 million

> **Cite:** *Benefit analysis for NOAA High Performance Computing System for Research Applications*, Stratus Consulting, Boulder, CO, December, 2003.

Estimated benefits of approximately $1 billion are attributable to a planned 50 percent increase in high performance computing power at NOAA's Geophysical Fluid Dynamics Laboratory. Benefits include better understanding of both gradual and abrupt climate change, extreme climate and weather, and air quality.

> **Cite:** *GFDL Benefit/Cost Analysis*, Geophysical Fluid Dynamics Laboratory, Princeton, NJ, June, 2002

notes

The “Long Range Weather Forecasting Support of Energy Use at Navy Activities” (LRF) program has documented in excess of $60 million of savings over the past 15 years.

Cite: Chief of Naval Operations Memorandum, 20 April 1998.

A decision to relocate the Norfolk harbor fleet could cost $5 million and require 72 hours advance notice. This includes costs to recall personnel and make ready ships in maintenance or being overhauled. It costs $17 million to move out of port all of the Navy’s ships along the east coast .

Cite: International Hurricane Conference 2001 meeting presentation.

During Hurricane Floyd in 1999, the Command’s early warning gave the Atlantic Fleet sailors time to move 82 ships and submarines out of harm’s way. The sortie costs the Navy over $17 million, but a decision to not sortie may have resulted in billions of dollars in damages.

Cite: *Navy Promotes Hurricane Awareness*, News Release from the Naval Meteorology and Oceanography Command, June 16, 2000.

notes

Sea Grant

In 2005-06, Sea Grant Extension in the Cleveland Region has focused on retaining and expanding small local businesses by actively initiating contacts, developing surveys and proactively responding to the needs of local businesses to aid them in their efforts to remain viable and competitive. A total of 65 new jobs were created and over $27.9 million was invested in local businesses in the coastal zone.

Cite: Ohio Sea Grant Annual Report, 2006.

With increasing competition from imports, the North Carolina seafood industry needs to develop new "value-added" seafood products—and to "brand" them as North Carolina specialties. Between 2001 and 2005, North Carolina Sea Grant and the NC State University Seafood Laboratory helped six North Carolina businesses develop 54 value-added products. Thirty of those products were selected for commercial production and marketing to grocery stores, caterers and other businesses. With Sea Grant assistance, one processor developed the "Coastal Treasure" brand, and has shared the experience with others in the industry. Another processor is selling "ready to eat" seafood products, including spreads and salads, under the "Carolina's Finest Seafood" brand. The projects not only resulted in specific new seafood products, but also generated Sea Grant extension/information products that explain how to make the move to new markets. A "Blueprint" publication shows processors the steps needed to create a "brand identity" for value-added seafood. Sea Grant also works with the processors to ensure that the new products for retail and wholesale markets are developed and produced in line with state and national seafood safety regulations.

Cite: North Carolina Sea Grant Annual Report, 2006.

Boaters see the importance of water quality in the Chesapeake Bay and are willing to pay an estimated $7.3 million a year for water quality improvements, a new study finds. The study, published in Marine Resource Economics, is believed to be the first of its kind nationwide to estimate the importance of water quality to boaters.

Cite: Maryland Sea Grant Annual Report, 2006.

Scientists and resource managers are alarmed by documented overfishing and declines of 50 percent and more in shark populations in the northwest Atlantic. Experts suspect comparable if not greater declines globally. Genetics provides a useful way to collect catch and trade data for more effective fisheries management. Sea Grant Researchers have developed a revolutionary, rapid and reliable method of DNA analysis to identify shark species from fins, carcasses and other body parts. This one-step forensics technique now puts teeth in NOAA's efforts to identify and prosecute U.S. fishing vessels suspected of catching and selling protected species such as the dusky and the great white shark. In one recent period, this technology helped federal prosecutors confirm the presence of prohibited species in four of five

investigations, resulting in fines of more than $100,000. Thus far, the team has fully developed and tested DNA markers for 18 U.S. Atlantic shark species.

Cite: Florida Sea Grant Program Assessment Briefing Book, 2005.

With USDA support, Sea Grant initiated a multi-faceted program to assist fishermen who face the dual threat of a flood of seafood imports and dropping prices for their catches. As part of the program, WSG trains fishermen in marketing and business management, partners with the publisher of Fishermen's News to deliver networking workshops, assists direct marketing efforts at fish piers in Bellingham, Seattle, Blaine, and Port Townsend, and provides quality control training for coastal salmon trollers. Direct marketing by Bellingham fishermen netted them $27,000 in profits above regular catch value; 54 non-tribal and 20 tribal fishermen have begun Intensive Technical Assistance in managing their fishing businesses; Makah tribal salmon trollers are receiving from $0.50 to $0.75 more per pound in 2006 for higher-quality king salmon.

Cite: Washington Sea Grant Annual Report, 2006.

Conflicts between ocean-going tugs and Dungeness crab gear have historically caused severe problems along the Pacific Coast. Crab pots foul tugs and barges and loss of crab gear is a severe economic problem for fishermen. Over the years, WSG has brought the two industries together to negotiate towlanes and this year introduced electronic versions of towlane charts to greatly simplify entering and accessing data. The agreement increases the safety of towboat operations and saves the two industries an estimated $1 million annually by lowering crab gear replacement needs, reducing towboat repair costs, and minimizing additional fuel expenses for both industries.

Cite: Washington Sea Grant Annual Report, 2006.

In Virginia alone, there are over 100,000 licensed saltwater recreational anglers, who make over 4 million fishing trips each year and spend in excess of $550 million. Use of live bait is one popular method used in catching fish. The Virginia Sea Grant Marine Advisory Program developed a demonstration baitfish culture system in collaboration with a local bait/tackle dealer (industry partner). Cultured spot (Leiostomus xanthurus) have been sold for $1.50 per fish and the small-scale recirculating tank restocked with cultured bull minnows. As a result of the small-scale project, the industry partner has requested assistance in designing a larger baitfish culture system capable of producing 10,000 spot annually. This will serve as an economic model that can be used for others.

Cite: Virginia Sea Grant Annual Report, 2006.

[A] framework can be applied at the county, state, regional and national levels to allow the estimation of direct, indirect and induced output; value added; and employment impacts for each industrial sector (tourism, fishing, public health, etc.) and for aggregate sectors. Estimates for the national direct output impacts average

$75 million per year; the indirect impacts average $27 million per year; and the induced impacts average $56 million per year. This approach will provide policy makers, resource managers, and stakeholders a tool to better understand the scale of impacts from HABs as well as the distribution of impacts across economic sectors.

Cite: WHOI Sea Grant Annual Report, 2006.

Alaska Sea Grant researchers developed a process to microencapsulate oil from an underutilized species of flatfish, the Arrowtooth flounder. The product, a protein powder, is used in glazes to coat salmon filets, extending their freshness and shelf life. Seafood buyers are evaluating the powder. Production of these Alaska fish oil supplements is expected within the next two years.

Cite: Alaska Sea Grant Annual Report, 2006.

Oregon Sea Grant and Alaska Sea Grant assisted seafood processing plants in finding ways to become more energy efficient and therefore more productive. Experiments at seafood processing plants in Alaska and Oregon showed that seafood freezing times were reduced by as much as 30 percent by using more freeze-friendly packaging, balancing air flow through blast freezers, and reducing fan speed at non critical times, and other steps that would be expected to benefit processors with significant gains in energy efficiency, plant productivity, and product improvement. Published in 2006, the publication, Planning Seafood Cold Storage, draws from the successes of Sea Grant's work with Oregon and Alaska seafood processors.

Cite: Oregon Sea Grant Annual Report, 2006.

Alaska Sea Grant provided crucial help to an Alaska Trade Delegation visiting China in early 2006, arranging tours for two processing plants, a flatfish growing facility (turbot and halibut), and a sea cucumber growing facility. Sea Grant assisted seafood companies and state representatives in relationship-building with Chinese industry personnel and presented research on Omega-3 fatty acid levels of premium Copper River sockeye and farmed salmon to more than 100 Chinese retailers, wholesalers/distributors, and news media in Shanghai. As a direct result of the trade delegation, one Alaska processor contracted to sell three containers of pink salmon each month to a Chinese importer. Another processor has thus far sold four containers of arrowtooth flounder to a Chinese importer, and more shipments are expected. Walmart in China, Korea, and Japan invited Alaska to conduct in-store promotions in different store locations in Fall 2006. A China-based Korean importer/processor is in contact with an Alaskan producer to import premium grade salmon into selected retail stores in Shanghai. The Southeast Alaska Dive Fishery Association requested Alaska Sea Grant assistance in developing a live shellfish product program with China. Alaska Sea Grant will continue efforts in this important international arena, and has been asked to assist with future trade delegations and relationship-building in China.

Cite: Alaska Sea Grant Annual Report, 2006.

Sea Grant funded biologists have identified the molecular mechanisms by which marine sponges synthesize their silica skeletons. They are now translating these mechanisms to develop new approaches for low-cost synthesis of semiconductors. Compared to current manufacturing practices, the methods they have developed operate at low temperature and use no harmful or caustic chemicals. Materials with novel structures and electronic properties are being produced. Results are especially encouraging for lowering manufacturing costs and improving energy efficiency of solar energy (photovoltaic) converters.

Cite: California Sea Grant Annual Report, 2006.

A growing problem among many commercial fisheries is the disposal of shell waste (chitin) from crustaceans they harvest. Sea Grant research has shown derivatives of this waste can be used to produce bandages, burn dressings, dietary supplements and cosmetics. Presently, Sea Grant scientists at the University of Alabama are investigating the use of waste chitin as a starting material for engineering “designer solvents” that will replace the need for traditional toxic, flammable, and volatile organic solvents.

Cite: Mississippi-Alabama Sea Grant Annual Report, 2006.

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notes

U.S. Coastal Economy Impact and Benefits

Ocean Economics

Coastal States

- In 2004, the thirty coastal states with 82% of the US population contributed 83%, or $9.7T, of the national GDP on only 22% of the US land, a 9% increase in GDP from 2000.
- Coastal states GDP grew at about the same pace as the United States GDP between 2000 and 2004 (US 9%; Coastal States 9%; Coastal Counties 8%; Watershed 9%).
- While GDP increased 9% between 2000 and 2004, there was little change in all coastal states employment, which was 79% of national employment, or 102,096,734 jobs in 2004.
- Alaska's employment experienced the highest growth (8%) between 2000 and 2004, although its employment base was also one of the lowest of coastal states.
- Coastal states wages increased only slightly between 2000 and 2004 (less than 1%).
- In 2004 the average coastal states wage was $36,733 compared to the national average wage of $35,874.

Coastal Counties

- In 2004, total coastal counties (with 34% of total coastal state land) contributed the following to coastal states:
    - 58% of the GDP
    - 54% of the employment
    - 59% of the wages
    - 53% of the Population
    - 52% of Housing
- From 2000 to 2004, total coastal counties
    - GDP increased 8%
    - Employment decreased 0.7%
    - Wages increased 0.2%

GDP

- All coastal counties contributed $5.6T to the national GDP in 2004, an 8% increase between 2000 and 2004.
- The coastal counties of California, New York, Florida, and New Jersey contributed $3T or 25% to the national GDP in 2004.
- Florida's and South Carolina's shoreline counties experienced the 2 largest GDP increases (>17%) of any comparable geography between 2000 and 2004.

Employment and Wages

- While GDP increased by 8% for all coastal counties, employment declined slightly and wages remained about the same between 2000 and 2004.

Comparison of States

- Florida's GDP growth rate was almost twice that of California between 2000 and 2004, with only half the population and less than half the size of the economy,
    - CA: 9% ($1.4T in 2004)
    - Florida: 17% ($.5T in 2004)

- In 2004, on just 25% of state land area (which is almost 1.1% of U.S. land area), California's coastal counties provided:
    - 11% of U.S. economy
    - 86% of CA state GDP or over $1.4T
    - 81% of CA workforce or 12M jobs

- In 2004, on just 0.3% of U.S. land, Florida's shoreline counties provided:
    - 4% of U.S. economy
    - 78% of FL state GDP or $0.5T
    - 76% of FL workforce or 5M jobs

- Shoreline Adjacent employment growth rate comparison between 2000 and 2004:
    - GDP: Florida 17% vs. California: 12%
    - Employment: Florida 6% vs. California: -0.2%
    - Wages: Florida 10% vs. California: 1%

- In the Gulf of Mexico, approximately 50% of Louisiana's economy was dependent on its coastal counties in 2004: wages = 49%; GDP = 51%; and jobs = 51%.

- In the Gulf of Mexico, over 80% of Louisiana's economy was dependent on its watershed counties in 2004: wages = 81%; GDP = 83%; and jobs = 83%.

  Cite: National Ocean Economics Project, http://noep.mbari.org/Market/coastal/coastalEcon.asp

Population and Housing

- Coastal states population increased 6% between 2000 and 2006. 82% of the population lived in coastal states on just 22% of the land (including Alaska and HI) in 2006.

- The United States was most heavily populated in the coastal counties with 183 persons/ square mile compared to the United States density of 33 per square mile in 2006.

- Inland county population grew at a faster rate than shore-adjacent population between 2000 and 2006.
    - Shore-adjacent growth rate: 4%.
    - Coastal state growth rate: 6%.

  Cite: National Ocean Economics Project, http://noep.mbari.org/Demographics/demogSearch.aspx

Ocean Economy

- The total Ocean Economy increased 15% between 2000 and 2004 to $128.3B.

- Tourism & Recreation was the largest Ocean Economy sector with almost $70B in GSP in 2004.

- Marine Transportation grew faster than all other sectors at 41% compared to 13% for Tourism & Recreation between 2000 and 2004.

  Cite: National Ocean Economics Project, http://noep.mbari.org/Market/ocean/oceanEcon.asp

Fisheries

- Sea scallops ($433M) and American lobster ($417M) generated the highest landed value of all U.S. fisheries in 2005.

- Of the top-ten U.S. fisheries by value in 2005, only half the species were finfish; the rest were shellfish, mollusks, and crustaceans.

  Cite: National Ocean Economics Project, http://noep.mbari.org/LMR/

Offshore Oil and Gas

- Total offshore oil production value (for first purchase price) was almost 30% of total U.S. oil production in 2004 or $27B.

- Total gas value at well head was approximately 20% of total U.S. gas production in 2004 or $20B.

  Cite: National Ocean Economics Project, http://noep.mbari.org/Minerals/

Coastal Benefits

In 1999-2000, over 43 percent of the civilian population 16 years and older participated in at least one of the 19 marine outdoor recreation activities, which translates into over 89 million participants.

> **Cite:** Leeworthy, Vernon R. and Peter C. Wiley. 2001. Current *Participation Patterns in Marine Recreation.* National Survey on Recreation and the Environment (NSRE 2000), National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects Office, Silver Spring, MD. November 2001. This report can be obtained at: http://marineeconomics.noaa.gov/NSRE/NSRE_2pdf.

Overall, the total number of people participating in all forms of marine recreation is expected to increase with the largest increases expected for beach going activities. California ranks second only to Florida in the number of participants in coastal recreation (17.6 million participants). While California also ranks second to Florida in the percent of its population that participates in marine recreation (10.7% for Florida, 8.7 % for California), its large population places California first in the Nation in the number of residents that participate in marine recreation annually (12.2%).

> **Cite:** *Pendleton, L., and Rooke, J., Understanding* the Potential Economic Impact of *Marine Recreational Fishing: California*, (March 2006), "Non-Market Literature Portal" www.oceaneconomics.org

A survey of almost 900 people living in the four-county area (Los Angeles, Orange, Riverside, and San Bernardino) over a one year period revealed their 1999 beach-going activities. An economic model was developed to estimate how changes in beach characteristics (e.g., water quality, parking, life guards) and user characteristics are related to changes in economic welfare (consumer's surplus). The model was used on five policy/management scenarios involving changes in water quality and beach closures to estimate changes in economic welfare. In addition, a scenario was run which closed all 51 beaches in Los Angeles and Orange Counties for an entire year. The total changes are presented here.

- An improvement in water quality of one letter grade at Malibu Surfrider Beach results in an increase in consumer's surplus of $140,564.
- A degradation of water quality of five letter grades at Zuma Beach results in a decrease in consumer's surplus of over $5.2 million.
- A closure of Huntington Beach (HB) for one day in July would result in a welfare loss of $115,657.
- A month-long closure of HB during July would result in a decrease in consumer's surplus of over $3.5 million.
- A season-long beach closure (all of June, July, and August) at HB would result in a loss of welfare of over $9 million.

- A loss of all trips to all 51 beaches in this two-county area (over 53.3 million trips) would result in a loss of consumer's surplus of over $4.7 billion.

Cite: Hanemann, Michael, Pendleton, Linwood, and Mohn, Craig. 2005. *Welfare Estimates for Five Scenarios of Water Quality Change in Southern California, A Report from the Southern California Beach Valuation Project.* Research Funded by the National Oceanic and Atmospheric Administration, The Minerals Management Service, The California Office of Spill Prevention and Response, the CA State Water Resources Control Board, and the Santa Monica Bay Restoration Commission. Available at: http://marineeconomics.noaa.gov/SCBeach/laobeach1.html

The nonmarket coastal resource value in the Channel Islands area of southern California is at least $575 million (1994 dollars), for the protection of Bald eagles, Peregrine falcons, White croaker and Kelp bass.

Cite: *Prospective Interim Lost Use Value Due to DDT and PCB Contamination in the Southern California Bight,* Natural Resource Damage Assessment, Inc., La Jolla, Calif., September, 1994.

To prevent oil spills off the coast of Central California over a 10-year period, Californians would be willing to pay $75 per household.

Cite: *The Value of Preventing Oil Spill Injuries to Natural Resources along California's Central Coast,* Natural Resource Damage Assessment Inc., San Diego, Calif., March, 1996.

Prevention of another major oil spill similar to the *Exxon Valdez* is valued at approximately $3 billion to the U.S. public (1990 dollars).

Cite: *A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill,* Natural Resource Damage Assessment, Inc., La Jolla, Calif., November, 1992.

Estimates of annual California beach visitation range from 150 million visits to more than 378 million beach visits. Using a conservative estimate of 150 million beach visits, we estimate that market expenditures by beach-goers in California could substantially exceed $3 billion each year. Using a conservative estimate of 150 million beach visits, and a range of estimates for the non-market value of a California beach day (the value placed on access to the beach beyond travel costs, parking fees, and tolls), we estimate that non-market expenditures by beach-goers in California could substantially exceed $2 billion each year.

Cite: Pendleton, L. and Kildow, J., *The Non-market Value of Beach Recreation in California,* February, 2006, "Non-market Literature Portal." Available at: oceaneconomics.org.

In 2000-2001, annual nonmarket recreation values for the artificial and natural reefs of southeast Florida by both residents and visitors was estimated at $256 million and an asset value of $8.5 billion.

> **Cite:** Johns, G.M., Leeworthy, V.R., Bell, F.W., and Bonn, M.A., 2003. So*cioeconomic Study of Reefs in Southeast Florida*, Final Report October 2001 and revised June 2003. Report for Broward, Palm Beach, Miami-Dade and Monroe Counties, Florida Fish and Wildlife Conservation Commission, National Oceanic and Atmospheric Administration. Report can be obtained at http://marineeconomics.noaa.gov/Reefs/02-01.pdf.

In 2003, annual non-market recreation values for the artificial and natural reefs of Martin County, Florida, by both residents and visitors was estimated at $3.6 million and an asset value of $172 million.

In 2003, the expenditure due to reef related activities in Martin County, Florida, supported almost 529,000 person-days of recreational snorkeling, diving, and fishing activities. These activities generated about $13.1 million in local sales, about $5.8 million in local income, and over 180 full- and part-time jobs.

> **Cite:** Hazen and Sawyer. 2004. *Socioeconomic Study of Reefs in Martin County, Florida, Final Report.* Hazen and Sawyer for Martin County, FL: Hollywood, FL. p.120. Available at: http://marineeconomics.noaa.gov/Reefs/MartinCounty2004.pdf

In 1995-96, the Florida Keys National Marine Sanctuary had a total annual nonmarket economic use value of $1.2 billion, based on visitation. $910.5 million of this annual value was attributed to natural resource-based activities and $294.4 million was attributed to non-natural resource-based activities. The total asset value of Sanctuary, based on visitation for natural resource-based activities, was estimated at $30.4 billion (using a 3 percent discount rate).

> **Cite:** Leeworthy, Vernon R. and J.M. Bowker. 1997. Nonmarket Economic User Values of the Florida Keys/Key West. *Linking the Economy and Environment of Florida Keys/Florida Bay.* October 1997. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Silver Spring, MD and USDA, Forest Service, Southern Forest Research Station, Outdoor Recreation and Wilderness Assessment Group, Athens, GA. The report can be obtained at: http://marineeconomics.noaa.gov/SocmonFK/publications/97-30.pdf.

In 1997-98, artificial reef use, by recreational fishermen and divers (visitors and residents) of a five-county area of Northwest Florida, had an estimated annual nonmarket economic use value of $24 million and an asset value of $801 million.

> **Cite:** Bell, F.W., M.A. Bonn and V. R. Leeworthy. 1998. *Economic Impact and Importance of Artificial Reefs in Northwest Florida.* Under contract Number MR235, Office of Fisheries Management and Assistance Service,

Florida Department of Environmental Protection, Tallahassee, Florida. December 1998. This report can be obtained at the following: http://marineeconomics.noaa.gov/Reefs/nwfl.pdf.

In 2000, Hawaii's coral reefs around the Main Islands had an annual nonmarket economic value for recreation and tourist reef-related use of $133.3 million. Amenity value (measured as reef-related property value) was estimated at $40.05 million. Biodiversity value was measured by expenditures for all scientific research related to the Main Islands (a proxy for scientific value) and non-use or passive economic use value was based on a benefits transfer. Biodiversity was estimated to have an annual value of $17.84 million. Total annual nonmarket value was estimated to be about $191 million with an asset value of about $6.4 billion using a 3 percent discount rate.

Cite: Cesar, Herman, Pieter van Beukering, Sam Pintz and Jan Dierking. 2002. *Economic Value of the Coral Reefs of Hawaii*, Final Report, December 23, 2002. Research funded by National Oceanic and Atmospheric Administration, Coastal Ocean Program under awards NA87OA0381, NA 96OP0187, NA060A0388, and NA160A1449 to the University of Hawaii for the Hawaii Coral Reef Initiative Research Program (HCRI). http://www.hawaii.edu/ssri/hcri/rp/cesar/noaa_final_report_01-02/cesar_final_report-01.

While it is not clear how SCUBA and snorkeling activities are distributed across the state, we estimate that diving in California, statewide, probably generates on the order of $138 million to $276 million in annual gross **revenues** from SCUBA diving alone. The potential magnitude of expenditures associated with snorkeling is similar.

We estimate that snorkeling in California may have generated between $153 million and $344 million. Diving and snorkeling also generates non market benefits for the many divers along the California coast. We estimate the **non-market** use value for California divers at between $21 million and $69 million annually and a range of $19 million to $115 million for snorkeling.

Cite: Pendleton, L., and Rooke, J., *Understanding the Potential Economic Impact of SCUBA Diving and Snorkeling*: *California*. (February, 2006), "Non-Market Portal" www.oceaneonomics.org

notes

The Economic Dimensions of NOAA Products and Services

I. Introduction: NOAA and Value Creation

NOAA's responsibilities range from weather and climate forecasting to a lead role in assuring the sound management of the nation's ocean and coastal resources. In fulfilling its diverse missions, NOAA programs create economic value. NOAA's research and forecasts lead to reduced damages from storms and other natural hazards. NOAA provides information that helps businesses make decisions and allows key industries like transportation and agriculture to operate more efficiently. NOAA's management programs for ocean and coastal areas help enhance both the current and future productivity of these economically vital resources.

It is not possible to reduce all of NOAA's economic contributions to the nation – and to the world – down to a single number. There are many different services that NOAA provides which affect the economy in diverse ways, and there are a variety of ways in which those effects are measured by economists. ***Economic Statistics for NOAA*** provides a summary of statistics and findings of recent research that either directly measures economic benefits of particular programs, or indicates the general economic context in which particular NOAA programs create economic value.

What follows is intended to provide a brief introduction to how NOAA creates economic value and the different concepts and methods of measuring economic value that are represented in ***Economic Statistics for NOAA*** (hereafter *Economic Statistics*). The appendix provides guidance on how different estimates of value and economic activity can be compared.

II. Overview: How NOAA Contributes to the U.S. Economy

NOAA contributes to the economy in two fundamental ways: First, by providing information that people find valuable, and second, by managing, or helping to manage, natural resources that are themselves valuable. Understanding the economic value created by NOAA basically involves asking how people use/value the information that NOAA provides, or how the values of resources are enhanced through NOAA management.

A. Value of The Information NOAA Provides

The information that NOAA provides can be placed into two general classes: operational information and research information. Both kinds of information derive their value from the ways in which people use the information, but there are significant differences in the challenges involved in estimating their values.

1. Operational Information.

Much of the information created by NOAA is "operational" in nature. This category includes the full range of weather information together with ocean conditions and forecast information. Such information is valuable because people, businesses, and governments use it regularly to make better decisions. Improved decisions range

from critical decisions about preparation for dangerous storms, to significant business decisions, such as how much electricity needs to be available tomorrow for air conditioning, to routine individual decisions, such as how to plan a weekend outing.

Operational information is valuable when it is accurate and timely. Accuracy means the information correctly predicts what will happen and where. Timeliness means that the information gets to people and organizations in time for them to respond appropriately. Information is most valuable when it is most precise and when it is available sooner rather than later.

A key example of operational information provided by NOAA is storm forecasts. When this information is accurate and timely, people can respond in ways that limit the costs of storms. To measure this type of value, economists try to assess the life and property damages that could result from storms and to assess how information coupled with changes in behavior reduces those damages. This damage reduction is the value created by the information. Important examples of storm forecasts include tornado warnings and hurricane warnings.

Regarding tornado forecasts, ***Economic Statistics*** cites a study that estimates that the NWS's NEXRAD radar system prevented over 330 fatalities and 7800 injuries from tornadoes, with a monetized benefit of over $3 billion between 1992 and 2004 (compared with a total capital cost of less than $1.7 billion) (p.50).

In the case of hurricane warnings, an accurate forecast makes it possible to target the hurricane evacuation zone correctly and gives sufficient time to allow the evacuation to be safe and orderly. This is important because evacuation itself has very high cost, but so does failure to evacuate if a life-threatening storm strikes. ***Economic Statistics*** cites estimates that reducing the length of coastline under hurricane warnings saves at least $600,000 per coastal mile in cost of evacuation and other preparedness actions (p.49).

Other operational information provided by NOAA includes routine weather forecasts that improve business decisions and productivity. For example, ***Economic Statistics*** cites a study that estimates US electric generators save $166 million annually using 24-hr temperature forecasts to improve the mix of generating units that are available to meet electricity demand (p. 51).

Routine weather forecasts provided by NOAA are also used by individuals in their daily lives. While this information may not seem very important relative to storm forecasts or critical business decisions, there are so many such routine individual decisions made in the US every day that significant total value is created by the forecasts that improve this decision-making. ***Economic Statistics*** notes that America's 105 million households consult the daily forecast at least once each day (p. 48).

NOAA also provides routine types of operational information, in the form of charts and navigational information, which are needed for safe and efficient operation of

the nation's marine transportation and recreational boating industries. Although this information does not need to be updated as often as weather forecasts, the accurate measurement of tidal heights and water depths in the coastal waterways, often in real time, is just as important to safety of lives and property as are storm forecasts. One study cited in ***Economic Statistics*** estimates benefits of $15 million annually to shipping in the Houston/Galveston port alone from real time physical oceanographic data (p. 47).

2. Research Information

Research in a number of fields is also a key part of the information that NOAA provides. NOAA is a world leader in weather and climate research and also in all aspects of oceanographic research. NOAA's research at both the basic and applied levels is critical to a wide variety of activities and decisions in the U.S. and around the world.

Measuring the economic value of NOAA's research programs is a difficult task because the transformation of research into human activities that have economic value often takes a great deal of time, and the connections between specific research and outcomes are hard to trace. A good example is research into climate change, where the effects of change, and the best mitigating policy responses, are still very uncertain and still lie some time into the future.

Nevertheless, there have been some economic studies on the value of information flowing from specific research investments, such as those in air quality, supercomputers, and the Sea Grant Program. One example, cited in ***Economic Statistics***, estimates that new supercomputers used in research have a potential contribution to improved weather forecasting of $115 million annually (p.57). Another example is the transition of tropical ocean research to an operational ENSO forecasting system, with estimated annual benefits to US agriculture of $256-300 million annually (p. 55).

B. Value of NOAA Resource Management Activities.

NOAA has direct responsibility for management of the nation's fisheries resources in the areas beyond state jurisdiction. NOAA also manages a network of protected areas in estuaries and in the coastal waters. Finally, in cooperation with other federal agencies and with state and local governments, NOAA assists in the management of the diverse and complex human and natural ecosystems of U.S. coastal areas, including the Great Lakes. Enhancing the values of these natural resources means dealing with complex tradeoffs among competing resource uses using state of the art environmental information and decision support tools.
In managing ocean fisheries, NOAA creates value through policies that prevent over-fishing and consequent decline of key fish stocks, which would reduce the value of the fishing industry and the values to consumers of fish.

For areas such as marine sanctuaries and estuarine reserves, NOAA seeks to preserve unique natural or historical resources on which people may place high values because they are historically unique (e.g. the U.S.S. *Monitor* wreck site) or

because they contain unusual natural features that are rare or unique. People may value such places because of the opportunity to visit and experience their features or they may value them because they are unusual, even if they never intend to visit them. For example, a study cited in ***Economic Statistics*** estimates that visitors to the Florida Keys National Marine Sanctuary derived a total economic value of $1.2 billion annually (p. 70).

The management of coastal resources affects a complex mix of values. The relatively small coastal areas of the U.S. are home to half the economic activity in the country, so what happens here has significant effects on the overall U.S. economy. Coastal counties have 183 persons/square mile compared to the US density of 33 per square mile. Coasts contain some of the areas where many, if not most, Americans go for recreation, such as beaches. These are valuable in part because of the economic activity they generate and partly because of the simple experience of a "day at the beach". For example, a recent study estimates market expenditures by California beach goers exceed $3 billion annually and non-market values (values that beach goers places on access to the beach beyond what they pay in terms of travel cost, parking fees, etc.), exceed $2 billion (p. 69). Coasts also contain important natural resource features, such as the habitats that are spawning areas for most commercially important fisheries; these are sources of value in their own right.

This brief overview of the many services that NOAA provides gives a general sense of the ways in which NOAA creates value. The following sections discuss in greater detail the different approaches that have been taken to estimate these values, and the various metrics that are used in making these estimates.

III. Approaches: Measuring NOAA's Value Creation

A. Direct vs. Suggestive Measures of Value Created by NOAA

Economic Statistics summarizes a large collection of estimates of both the economic value created by NOAA and the scale of economic activities affected by NOAA's programs. At one extreme are statistics that explicitly estimate the direct benefits derived from NOAA programs. For example, there is a citation of a study that indicates NOAA forecasts and associated responses to hurricanes save $3 billion in a typical hurricane season (p. 49). At the other extreme, there are numbers that simply suggest the general importance of a particular context in which NOAA programs create value, without directly measuring the difference that NOAA programs actually make in that context. For example, a cited study estimates that every 10 to 12 years, we should expect a storm event (typically a hurricane) costing $20 billion (p. 18).

1. Direct Measures of Value

Estimates of the direct benefits derived from a NOAA program are generally based on studies of the difference between an economic situation with the NOAA program and the situation without that program. There are at least three general ways to go

about producing such estimates: survey methods, simulation modeling, and historical data analysis.

In survey methods, a carefully designed and tested survey is used to ask people to consider two or more different situations (e.g. having NOAA weather forecasts vs. not having them) and state the benefit they perceive in having the forecasts. For example, a detailed sample survey of U.S. households estimated that they are willing-to-pay about $110 annually for weather forecast information--$11.4 billion annually in total (p.48).

In simulation modeling, business decision-making is effectively replicated in a computer model, with and without availability of NOAA forecasts or services, and the economic consequences calculated for both situations. In an example referred to earlier, simulation studies of farmer's crop selection decisions estimate benefits of approximately $275 million annually with an improved seasonal forecast (p. 55).

In data analysis, historical information is analyzed to determine how much change in benefits occurred due to the availability of NOAA forecasts or services. For example, the reduction in heat-related deaths following the introduction of new heat-wave forecasts in Philadelphia since 1995 is estimated to have saved 117 lives over its first three years, for total benefits of $468 million (p.56).

2. Suggestive Measures of Value

Suggestive measures of the value created by NOAA programs are often easier to produce than direct measures of the difference that NOAA programs actually make. This is because suggestive measures do not have to ask how the situation would be different if there were no NOAA program and what that difference would mean in terms of the economic value that is generated.

There are many examples of such suggestive measures of value in ***Economic Statistics.*** For example, one study estimates that travel and tourism generates over $700 billion of GDP annually, and that 85 percent of this is spent in coastal states (p. 36). These numbers suggests that NOAA programs that contribute to the health of the coast and coastal communities produce value, but they say nothing about how much value those programs actually create.

B. Metrics Used to Measure Value

Whether a study produces a direct or a suggestive measure of value created by NOAA programs, it may use any of a large variety of metrics for quantification. These metrics range from economic welfare measures which attempt to measure the dollar value individuals or institutions would be willing to pay for a program or an economic activity, to monetary economic activity measures such as Gross Domestic Product (GDP), to physical counts such as number of visits to a beach or deep-sea fishing trips.

1. Economic Welfare Measures of Benefits.

Economic welfare measures are determined solely from the point of view of the individual and then summed up across the relevant population (e.g. the nation, a region, a beach, etc.). These measures are sometimes called "non-market benefits" because they are not fully captured by the market prices that people pay for the goods and services they purchase, often because there are no observable market prices for these goods (e.g. recreational fishing, boating, beach visitation). Measures of non-market benefits are particularly important in the areas of health and safety and recreation benefits.[1]

Health and Safety Benefits. Of particular importance to NOAA are benefits of programs that save lives, reduce injuries, or otherwise improve health that are most naturally expressed in raw numbers – fewer deaths, fewer injuries, fewer doctor/hospital visits, etc. However, these benefits are sometimes converted into dollar measures of economic welfare because doing so makes it possible to compare them to the dollar costs of the programs that produce those benefits. Though sometimes controversial, the estimation of the monetary value of health and safety is essential for understanding the economic rationale for many government programs.

Many Federal agencies frequently must compare the costs of programs (e.g. to limit air pollution, reduce highway accidents) to the benefits obtained – reduced risk of premature death, illness, reduced highway deaths, etc. A great deal of research has been done to determine the most appropriate number to use, especially for reduced deaths. This research has considered data on the extra compensation earned in high-risk occupations, as well as individuals' stated willingness to incur a higher risk of death in exchange for economic benefits. Based on such research the EPA, for example, uses a value of $6 million per life saved. The benefits of NOAA's NEXRAD's radar system cited earlier (over $3 billion between 1992 and 2004) are based on such estimates (p. 56).

Recreation Benefits. Expressing non-monetary benefits in terms of monetary values applies to a wide variety of non-market benefits besides health and safety, including many forms of recreation values central to NOAA's activities such as recreational fishing and beach and coastal recreation. A good example is the value of beach and related recreational activities like snorkeling. People pay large amounts of money to go to the beach, often traveling long distances. These expenditures are often counted as economic activity (see below), but the real value to the person on the beach is not what they spend on a hotel room or airplane or restaurant meal, but the net value of the opportunity to engage in this activity, i.e. to swim, sun, snorkel, surf, or just sit in a cool place on a hot day.

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[1] Estimating economic welfare or social surplus benefits involves concepts and measurement of "producer and consumer surplus". Consumer surplus is essentially the difference between what a person is willing-to-pay for an item less what she has to pay, summed over all consumers of the item. Producer surplus is the difference between what a producer would be willing to sell a product for and what he actually receives for it, summed over all producers. Combining producer and consumer surplus is a measure of social surplus, or economic welfare, and changes in social surplus from a policy or management action is essentially a measure of economic benefits of the action.

This is the value they receive, and it is net of the out-of- pocket costs incurred to engage in the activity. This net value can be thought of "willingness-to-pay" for the opportunity to have the recreational experience. For example, visitors to the Florida Keys National Marine Sanctuary had a total annual non-market economic use value of $1.2 billion in 1995-96 (p. 70). Willingness-to-pay, however, is not directly observable and must be obtained from survey responses or inferred from other economic data.

Many studies of the value of NOAA programs focus on losses that might be avoided with proper management. For example, beaches closed because of pollution or recreational fishing opportunities damaged by lost habitat would reduce the economic benefits that people receive from those resources. Avoiding these losses is a benefit because people are better off if the losses are avoided or reduced. A study of Los Angles and Orange County California beaches indicates that if all trips (over 53.2 million annually) were cancelled as a result of beach closures involving water quality, the loss of consumer surplus would exceed $4.7 billion annually. (p. 69)

Economic welfare studies have one major advantage and one major disadvantage. The advantage is that they are in many ways the best measure of economic value because they measure the real net welfare change that occurs as a result of a particular decision or action. The disadvantage is that these types of studies are difficult and costly to undertake. As a result, there are too few estimates of welfare benefits associated with NOAA's activities, and other ways must sometimes be found to provide at least some economic measures for the full range of those activities. The next section explains some of the other economic measures that may be used.

2. Economic Activity Measures of Benefits —GDP, Sales, Jobs

Measures of economic activity such as "growth in the economy" or "jobs growth" are frequently of great interest to policy makers since these types of economic changes are among the most widely understood and easily perceived changes in economic value. However, saying that economic activity has increased (more output, more jobs) is not necessarily the same as saying that economic benefits have increased in the welfare sense discussed above (although the term "benefit" may be loosely applied to both).

Monetary Measures of Economic Activity. Four categories of activity measurement are expressed in dollar terms based on the prices of goods and services sold in markets. These measures, GDP, Value Added, Industry Sales and many types of Avoided Costs, are collectively sometimes called market measures because they rely on prices set in markets to determine their value. The term "market values" distinguishes them from the economic welfare concepts discussed above which do not rely solely on market transactions to fix values. Each of these monetary measures of activity is discussed in more detail in the sections below.

a. Output -- GDP. The most commonly used "national product" number is Gross Domestic Product (GDP). Other very closely related numbers at the national level include Gross National Product, Net National Product, Net National Income, and some others. At the state level, the analogous statistic is the Gross Domestic Product-state.

The GDP figure regularly released measures final products sold to consumers (as opposed to intermediate goods used as inputs in making final products) at their market prices. For example, if 100 loaves of bread are produced and sold to consumers for $2 per loaf, then the contribution of this bread to GDP is $200. Note that this is simply what is spent on bread, and thus it is a measure of economic activity in the making of bread, including all the steps from the wheat farmer, grain elevator operator, train, and baker. It does not inform us about how much consumers' value the opportunity to buy bread, or producers value the opportunity to sell bread.

b. Output – Value Added. Value added is very closely related to GDP. Value added essentially measures the portion of GDP that is generated at each stage of production (e.g. raw materials made into intermediate goods, intermediate goods made into final goods). So the sum of value added amounts produced along a sequence of steps from raw materials to final product equals the value of the final product, which is the contribution of that product to GDP.

In the bread example above, the baker might have bought bread ingredients and other supplies (packaging, electricity, etc.) for $50. In this case, the value added by the baker would be $150. The sum of the value added amounts for all his suppliers, and their suppliers in turn, would have to be $50. An example from ***Economic Statistics*** is $32.9 billion in value added to GDP by the commercial fishing industry (p. 31).

c. Output – Industry Sales/Consumer Expenditures. Value added is a difficult figure to estimate, and is available only at the state and national levels. Because of these limitations "industry sales" is often used to express the total dollar volume of goods or services sales from a particular activity. The sales by an industry are equivalent to the expenditures to buy the industry's output, so "sales" or "expenditures" are used more or less interchangeably. ***Economic Statistics*** has several such citations like $2.6 billion in sales by the commercial remote sensing industry in 2003 (p. 40) or $415 million spent by recreational fisherman and divers of Northwest Florida annually (p.35).

It is important to note that "sales" and value added are not the same measurement. When one industry produces and sells to another industry, the result is what is called an "intermediate" input. For example, when the fish harvesting industry sells to fish processors and distributors, the sales ("landed values") of the harvesting industry are an input to the production of processed fish foods (for example, frozen filets), which are then sold to the consumer. The sales of fish harvests are a cost to processors. This is why the full accounting for levels of economic activity by industry is done using the "value added" measure discussed above.

d. Avoided costs (also losses, damage). The term "avoided costs" is used in a variety of situations in which information or some action by NOAA results in avoiding some loss of economic value measured as lost GDP, lost employment, or reduced value of assets such as property. For example, weather and climate predictions have been shown to result in avoided costs measured as potentially lost sales, lost GDP, lost employment, or the lost value of property such as housing. Avoided costs can also mean avoiding public costs in the form of government expenditures that do not have to be made.

In some cases, avoided cost can be a true economic welfare measure like social surplus. For this to be true, the cost avoided has to be one that would have been incurred except for the NOAA program. The avoided cost also must be measured as the minimum possible expenditure that would have been required to restore welfare to its previous level if the cost had not been avoided. Under these circumstances, avoided cost is what people would willingly pay to avoid the cost, and it is a valid welfare measure that can be compared to the cost of the NOAA program that makes this cost avoidance possible.

Avoided property value losses or damages are the most common type of avoided losses that may be true welfare measures. If a NOAA program results in avoidance of such losses, people would be willing to pay up to the amount of those losses to have the program that makes the loss avoidable.

While all of the above monetary metrics are denominated in dollars, it is important to recognize that these numbers cannot safely be added across different studies. This is because they are often derived from different points of view. For example, an estimate of sales in one fishery cannot be added to another estimate of value added in a related fishery to arrive at a meaningful total for the combined fisheries.

Non-monetary Measures of Economic Activity. Many studies of economic activity associated with NOAA programs measure the economic activity in non-monetary terms. Most commonly these studies use employment or the levels of physical outputs from various activities.

a. Employment. Employment that exists because of natural systems is a fairly common measure of the benefit derived from those systems. For example, nearly 70,000 thousand people were employed in the seafood processing and wholesale sectors in 2005. Since jobs are generally desirable and relatively easy to count, they are an appealing measure. Jobs are a measure of activity levels and thus are useful primarily as a way of comparing the relative importance of different economic sectors—70,000 jobs in seafood processing and wholesale verses 8.4 million in sea port sector activities as reported in ***Economic Statistics*** (p. 31; p. 44) **.** However, jobs are not a measure of economic welfare, nor are they very easily converted into such a measure.

b. Physical Outputs. Much of the readily available data about the resources of concern to NOAA are measured most directly as units of activity. For example, the

port systems are measured by vessel traffic and tons of cargo or number of passengers. Recreational activity counts, such as trips to the beach or deep-sea fishing trips, are another type of direct activity measure. Because many government agencies keep track of these units of production, they are often the economic data that most people see. But they are obviously limited in their ability to demonstrate economic value.

IV. Conclusion

This brief introduction to the various ways of defining and measuring economic value is intended to help the user of ***Economic Statistics*** to understand the different ways that NOAA's programs and activities create economic value and the types of metrics and studies that are used to measure these values. Users will have to decide whether the definitions and ways of approaching the estimation of values in the studies referenced here are appropriate to their needs.

A short Appendix that follows provides additional guidance for users on what to look for in economic studies and guidance on when it is or is not appropriate to compare numbers from different studies.

Appendix: Understanding How Numbers Can Be Compared

The diverse ways in which economic value can be expressed raises the question of which numbers can be compared with one another and which cannot. Users often want to know what proportion of some larger measure is represented by a particular estimate, for example what portion of the national economy is accounted for by a particular state. Also, users may wish to add one type of measure to another to better gauge the size of benefits or economic activity.

The following provides a rough guide to how different measures should be used. One aspect of use is comparability of estimates. The guide identifies comparability in terms of additivity, that is, whether adding two numbers together gives a meaningful result. The principle of additivity means that two numbers that can be added together can also usually be combined through other arithmetic means. However, users are warned that details of specific estimates or methodologies contained in the references may limit or preclude comparability, so it is generally advisable to consult the original studies.

- Social surplus measures can usually be added.

  When studies present their results as estimates of "economic benefits" within the meaning of valuing welfare as discussed in the introduction, the results can usually be considered comparable. Producer surplus plus consumer surplus equals social surplus. The only limitations occur when studies may overlap in terms of populations or time periods studied.

- Among the monetary measures of economic activity, compare sales with sales, and GDP with GDP, but not sales with GDP.

  Many studies estimate the value of industry or firm sales, for example the sales related to marine recreational fishing. These estimates are very useful for understanding the size of economic activity in a local economy, but they are not the same thing as measuring output as GDP or GDP-state (gross state product). These latter measures are designed to be added up across regions and industries without double counting, while sales figures are not designed to do this.

- Employment is a measure of economic activity, not of economic benefits

  Many studies identify employment as an important economic value affected by a program or issue of concern. Employment is a good example of a measure of economic activity with which many people are familiar, and which often provides a good measure of levels and changes in activity. But employment (or more precisely wages) is not a welfare benefit and should not be compared with other welfare benefits.

- Stocks and flows are two different, but related, values

One of the most frequently asked questions about many of the resources examined in the cited studies is "what is the value of that resource?" For example, "what is the value of fisheries spawning habitat in an estuary" or "what is the value of a beach" or "what is the value of property at risk from a tsunami?" These questions raise the difference between what economists call the value of a stock and the value of a flow.

At one level the distinction is simple. Consider a bond issued by a company or the US Treasury. The income earned from ownership of the bond is not the same thing as the value of the bond. The income is a flow (the value "flows" over some period of time in the form of regular interest payments, ending with a final repayment of principal). The current value of the bond is a stock value -- it is the current value of the future flows to be received by virtue of owning the bond. Obviously, the value of the stock and the value of the flows due to it are related to one another.

Studies that attempt to estimate the stock value of a natural resource, such as wildlife habitat, face the problem that there is no market price for the land (or water) in use as wildlife habitat. Or if there is a market price, it is usually for some use other than wildlife habitat. In these cases economists make use of the relationship between flow value and stock value to calculate the stock value of the habitat in terms of the future flows of use and nonuse values from the habitat.

When estimating the values of specific resources, therefore, it is important to distinguish between the value of the flows of goods and services, which occur over time, and the value of the stock (or asset value) of that resource, which is its value at one particular point in time. Studies that attempt to estimate such values will usually make this distinction and users citing such studies should be careful which figures are being referenced. In a study cited earlier, the total asset value of the Florida Keys National Marine Sanctuary was estimated at $30.4 billion using a 3% discount rate, while the annual value (flow) was $1.2 billion (p.70).

- Damage and loss calculations should handle insurance appropriately

Because many of NOAA's information services seek to avert damages from a variety of sources, many of the studies related to the economic value of NOAA services seek to identify actual or potential damages avoided. One aspect of such studies that varies widely is the extent to which insurance is taken into account in the estimates.

The simplest way to calculate welfare loss from a particular storm is to add the actual damages (calculated as the cost of restoring damaged assets to their pre-damaged values), regardless of whether these damages are covered under insurance or not. This loss is a true societal welfare loss, as someone in society will have to pay to replace what was lost, or do without what was lost.

The role of insurance is somewhat complicated. In the short run, insurance only affects who actually pays for a loss that has occurred -- whether it is the asset owner or his insurer. In the long run, the insured owner of the asset will pay the expected value of his losses, because the premiums paid by people carrying insurance must be sufficient to cover the losses incurred by these people, over the long run. (A caveat here is that administrative costs would have a minor effect on the equivalence of premiums and expected losses.) Also, when insurance is subsidized by the government, as is the case with some flood insurance, premiums need not cover expected losses, but the difference will be made up for by payments from taxpayers in general.

Because of this connection between expected losses and premium payments, it would be possible, in theory, to estimate the losses from insured perils using insurance premiums (including subsidies). It would also be possible, in theory, to measure the benefits of NOAA programs that reduce losses by calculating reductions in insurance premiums (including subsidies) attributable to the NOAA program. However, these approaches would present some significant analytical challenges.

Perhaps the main message here is that the role of insurance in measuring losses is complicated, and studies that rely on insurance premiums and/or insured loss data need to be scrutinized carefully to assess whether they address these complications adequately.

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