United States Department of Commerce
National Oceanic and
Atmospheric Administration

Economic Statistics for NOAA

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fifth edition

Program Planning and Integration
Office of the NOAA Chief Economist

Contents

Foreword

This is the fifth edition to **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.

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.

Economic Statistics for NOAA is noteworthy in that it illustrates the economic importance of NOAA's programs to the Nation's economy and public well-being. This revised edition includes additional statistics on the major 2005 hurricanes, utilities, fishery economics, the most recent available statistics on coastal populations and economic output, and additional statistics on coastal recreation values.

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

Questions and comments should be directed to NOAA Chief Economist Dr. Rodney Weiher by e-mail at rodney.f.weiher@noaa.gov or by phone at (301) 713-3322.

Vice Admiral Conrad C. Lautenbacher Jr. (USN-ret.)
Under Secretary of Commerce for Oceans and Atmosphere
Administrator, National Oceanic and Atmospheric Administration
Washington, DC
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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 [editor's 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 4.5% of the of variation in mean gross state output is explained by weather alone. Variation in output due to weather across sectors ranges from 21% in agriculture to 1.4% in wholesale trade. The largest absolute variation in dollar terms is in the fire and other casualty insurance sector, ranging on the order of $51 billion annually.

> Cite: Lazo, J., and Larsen, P., "Overall U.S. Economic Sensitivity to Weather," presented to the American Meteorological Society , February 2, 2006, Atlanta, Ga., NCAR Societal Impacts Program, Boulder Colorado

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://sciencepolicy.colorado.edu/sourcebook/data.html.

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., *21st 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, Okla. area.

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

During 1980-2003, the U.S. sustained 58 weather- or climate-related disasters, with damages and costs exceeding $1 billion per event. Total inflation adjusted direct losses from these events were more than $350 billion.

Cite: *Billion Dollar U.S. Weather Disasters*, 1980-2003. Tom Ross and Neal Lott, NOAA National Climatic Data Center, 2003. Website*:* http://www.ncdc.noaa.gov/oa/reports/billionz.html.

Economic costs of snow arise from:

- snow removal (exceeds $2 billion/yr for U.S.),
- road closures that cause lost retail trade, wages, and tax revenue (exceeds $10 billion/day for closures in eastern U.S.),
- flight delays ($3.2 billion annually 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.

notes

Insured Losses

Natural catastrophes (storm, flood, hail, etc.) caused insured losses of USD 15 billion across the globe. In contrast, man-made disasters (explosions, aviation, accidents, etc.) caused just under USD 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 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. flood event occurred in the Midwest during the summer of 1993, resulting in approximately $24 billion in losses (in 2000 dollars) and 48 fatalities.
- 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.
- Two of the most costly ice storms in U.S. history occurred during the 1990's—in the northeast in January 1998 (more than $1.4 billion) and in the southeast in February 1994 (more than $3 billion).

Cite: Lott, N. and T. Ross, *A Climatology of Recent Extreme Weather and Climate Events*, NCDC Technical Report 2000-02, Asheville, N.C., NOAA National Climatic Data Center, 2000. Also available online at http://ols.nndc.noaa.gov/plolstore/plsql...re.prodspecific?prodnum=C00517-PUB-A0001

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:** INTEGRATING SPACE WEATHER AND METEOROLOGICAL PRODUCTS FOR AVIATION Genene Fisher, 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

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.

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

> **Cite:** Changnon, Stanley A., ed. *El Niño 1997-1998: The Climate Event of the Century*, Oxford University Press, 2000, p. 22.

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 SE 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 & 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*, February, 2006, Monthly Labor Review, forthcoming.

[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.

notes

Harmful Algal Bloom (HAB) Impacts

Estimates of the economic impacts of harmful algal blooms (HABs) in the United States average $75 million annually over the period 1987-2000. 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. Some of the most recent (last ten years) local estimates of economic impacts from HABs are reported below.

[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).]

> **Cite:** Hoagland, P. and S. Scatasta. 2006. The economic effects of harmful algal blooms. *In* E. Graneli and J. Turner, eds., *Ecology of Harmful Algae*. Ecology Studies Series. Dordrecht, The Netherlands: Springer-Verlag, Chap. 29.

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 $11 million for the months of June and July in Massachusetts and for the months of May through September in Maine.

[This estimate was obtained by compiling historical statistics from the US Department of Commerce on regional shellfish harvests and aquaculture production and multiplying by the market price. An estimate of lost sales such as this does not measure changes in economic *value* (*e.g.*, lost consumer and producer surpluses).]

> **Cite:** Hoagland, P. and S. Scatasta. 2006. The economic effects of harmful algal blooms. *In* E. Graneli and J. Turner, eds., *Ecology of Harmful Algae*. Ecology Studies Series. Dordrecht, The Netherlands: Springer-Verlag, Chap. 29.

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.

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).

Economic impact of HABs in United States average annually $49 million but individual outbreaks can cause economic damage that exceeds the annual average—outbreaks in Chesapeake Bay (1997) cost the Maryland seafood and recreational fishing industries almost $50 million in just a few months.

Total public health impacts due to shellfish poisoning from HABs averaged $22 million over a six-year interval from 1987-1992.

Commercial fishery impacts from HABs, including wild harvest and aquaculture losses, average $18 million per year.

> **Cite:** Hoagland, D.M. Anderson, Y. Kaoru and A.W. White. August 2002. *The economic effects of harmful algal blooms in the United States: estimates, assessment issues, and information needs*. Estuaries 25 (4b): 819-837.

Invasive algal blooms along Maui's Kihei coast cause over $20 million in potential revenue lost each year to the State of Hawaii. Loss includes reduction in property value, rental income, and clean up costs.

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

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 were reported of illnesses 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), 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.

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 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 2004 were 4.4 million metric tons valued at $3.7 billion.

Cite: *Fisheries of the United States, 2004,* http://www.st.nmfs.noaa.gov/st1/fus/fus04/index.html

U.S. exports of edible fishery products in 2004 were 2.9 billion pounds, valued at $3.7 billion; total U.S. exports of fishery products (edible and non-edible) in 2004 was valued at $13.6 billion. The U.S. total value of imported fishery products was $22.9 billion in 2004. U.S. imports of edible fishery products totaled 4.95 billion pounds in 2004 and were valued at $11.3 billion.

Cite: *Fisheries of the United States,* Foreign Trade Section 2004 http://www.st.nmfs.noaa.gov/st1/fus/fus04/index.html

The value added to gross domestic product (GDP) by the commercial fishing industry was $31.6 billion in 2004.

Cite: *Fisheries of the United States, 2004,* http://www.st.nmfs.noaa.gov/st1/fus/fus04/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, p.169.

U.S. consumers ate a record 16.6 pounds of seafood per capita in 2004, 0.3 pounds more than in 2003. The United States is the third largest consumer of seafood in the world.

Cite: *Fisheries of the United States,* Per Capita Section, 2004, p. 78 http://www.st.nmfs.noaa.gov/st1/fus/fus04/index.html

Approximately 65,300 people were employed in the seafood processing and wholesale sectors in 2004.

Cite: *Fisheries of the United States,* 2004, Employment, Crafts and Plant Section, p. 87, http://www.st.nmfs.noaa.gov/st1/fus/fus04/index.html

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

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 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.

Total consumer expenditures for fisheries products are estimated at $61.2 billion yearly. [Consumer expenditures are 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, 2004, http://www.st.nmfs.noaa.gov/st1/fus/fus04/index.html

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.

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 represent 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 800,00 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. Novermber 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 nation wide 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 Stillwagen 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

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, pp152. 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.

notes

Satellites

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

notes

Marine Commerce

More than 78 percent of U.S. overseas trade by volume and 38 percent by value comes and goes by ship, including nine million of barrels of imported oil daily.

Cite: *2003 Pocket Guide to Transportation Tables 20 & 21*, U.S. Department of Transportation, http://www.bts.gov/publications/pocket_guide_to_transportation/2003/index.html?submit=View+Online

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

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 $2.4 to $4.8 million in direct annual economic benefits can be attributed to Physical Oceanographic Real-Time System (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, FL, December, 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 different 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-h 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-h 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 $1.7 billion (in 2004$).

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 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-h 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 larger 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.

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.

notes

General Commerce

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 in $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 is one of 17 such systems running in the U.S. and 12 additional in other countries.

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 data base 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 in 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)

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, N.J., June, 2002

notes

Defense

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 all of the Navy's ships along the east coast out of port.

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 harms 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

Sea Grant saved taxpayers $120,000 in the annual Beach Sweep/River Sweep litter cleanup program. Over the past 14 years, more than 75,000 volunteers have collected 728 tons of trash and have saved state taxpayers more than $1.6 million.

Cite: South Carolina Sea Grant 2003 Program Assessment

Sea Grant has contributed to the founding or operation of eight pearl farms, four demonstration and training pearl hatcheries, 15 giant clam farms (including the largest commercial giant clam aquaculture venture in the Pacific) and 20 sponge farms (Micronesia is the only area that farms sponges). Overall, the number of aquaculture enterprises in the Hawaiian Islands has reached 126 farms valued at $25.2 million dollars, which translates into approximately 630 jobs.

Cite: Hawaii Sea Grant 2003 Program Assessment

The Sea Grant training program at 5,000 seafood processing plants will prevent 20,000 to 60,000 seafood-related illnesses a year, which could cost consumers as much as $115 million annually.

Cite: *National Sea Grant College Program Biennial Report, 1998-1999.*

In North Carolina, 200 of the 205 new oceanfront homes built to the Sea Grant hurricane standards survived Hurricane Fran in 1996, compared more than 500 older oceanfront houses in the same area that were destroyed.

Cite: *National Sea Grant College Program Fact Sheet,* August 2001.

Sea Grant research and outreach on Manila clams and blue mussels have resulted in new industries worth $19 million annually.

Sea Grant research and extension work for hybrid striped bass aquaculture has expanded this species from being a demonstration project ten years ago to a $25 million dollar annual business.

No mussel culture industry existed in the Northeast prior to 1980 and after a five-year Sea Grant research effort landings of wild and farmed mussels are now valued at $6 million.

Cite: *Science Serving the 21st Century,* National Sea Grant Program, Publication OHSU-B-053, March 1999, page 2.

Sea Grant research efforts to develop new drugs from marine organisms have

resulted in discovery and description of more than 1,000 compounds that may be vitally important to the health industry.

Efforts to develop state designated underwater preserves have led to new diving activity in Great Lakes coastal communities providing an economic stimulus of at least $1.5 million over a two-year period.

Results of Sea Grant studies on sewage effluents and coastal systems allowed Orange County, California to receive secondary treatment waivers saving taxpayers as much as $50 million.

Research on modification of salmon gillnets prevented closure of Puget Sound sockeye salmon fishery saving hundreds of jobs and millions of dollars.

> **Cite:** *Science Serving America's Coast—Three Decades of Impacts*, National Sea Grant Association, February, 2002. Available online at http://www.sga.seagrant.org/pdf/sga_impacts_fs.pdf

notes

Coastal Ocean Economics, Population, Employment, and Benefits

Coastal Population

In 2003, approximately 153 million people (53 percent of the nation's population) lived in the 673 coastal counties, an increase of 33 million people (28 percent) since 1980.

The Nation's coastal population is expected to increase by more than 7 million by 2008 and 12 million by 2015.

Coastal population within the Pacific region showed the largest gain between 1980 and 2003, with almost 12 million people, followed by the Northeast with 8 million people.

The Southeast region exhibited the largest rate of change with a 58 percent increase, followed by the pacific region at 46 percent, and the Gulf of Mexico at 45 percent.

California led in coast population change increasing by 9.9 million people, followed by Florida with an increase of 7.1 million people. For California this represents an increase of 1,179 persons every day.

Coastal counties contain 53 percent of the nation's population, yet, excluding Alaska, account for only 17% of U.S. land area.

> **Cite:** Crossett, K.M., T.J. Culliton, P.C. Wiley, and T.R. Goodspeed, 2004. *Population Trends Along the Coastal Untied States: 1980-2008*. National Oceanic and Atmospheric Administration, NOAA's National Ocean Service, Special Projects: Silver Spring, MD.

It was estimated that by July 1, 2005, 155.2 million people (52 percent of the Nation's population) lived in the 673 U.S. coastal counties (17 percent of the total land area excluding Alaska).

This is an increase in coastal county population by 45.2 million or 41% since 1970.

By 2015 the total coastal county population is expected to be approximately 169.1 million. By 2025 it is expected to be approximately 184.6 million.

In 2005, Northeast region was the most populated region with 53.2 million people (34.3% of the nation's coastal county population).

From 1970 to 2005 the Pacific region showed the greatest absolute change, increasing by approximately 17 million people.

From 1970 to 2005 the Gulf of Mexico and Southeast regions showed the greatest percent change increasing by 111 percent and 98 percent, respectively.

From 1970 to 2005 the Great Lakes region had the slowest growth overall, increasing by only 1.5 million people, or 5.7 percent.

> **Cite:** 2005 population figures compiled from U.S. Census Bureau. 2006. County population and estimated components of population change, all counties: April 1, 2000 to July 1, 2005. http://www.census.gov/popest/datasets.html, accessed 3/27/06.
>
> Number of coastal counties from*:* Crossett, K., Culliton, T., Wiley, P., and Goodspeed, T. 2004. Population Trends Along the Coastal United States: 1980-2006. National Ocean Service, National Oceanic and Atmospheric Administration.
>
> 1970 population figures compiled from: National Ocean Service, NOAA. 2006. Spatial Trends is Coastal Socioeconomics Web Site. http://stics.noaa.gov, accessed 3/27/06
>
> Population projection figures compiled from: Woods and Poole Economics, Inc. 2003. 2003 Desktop Data Files. Washington, DC: Woods and Poole Economics, Inc.

Trends in Development

In 2000, there were approximately 61.5 million housing units in coastal counties, 52% of the nation's total housing supply.

In 2000, there were approximately 2.1 million seasonal housing units in coastal counties, 54% of the nation's total.

In coastal counties from 1999-2003, 2.8 million building permits were issued for the construction of single-family housing units (43% of the nation's total) and 1 million building permits were issued for the construction for multi-family housing units (51% of the nation's total).

More than 1540 single family housing units are permitted for construction everyday in coastal counties.

> **Cite:** Housing unit figures compiled from: U.S. Census Bureau. 2001. Summary File 1, 2000 Census of Population and Housing, Washington, DC. Obtained via Geolytics, Inc., East Brunswick, NJ.
>
> Seasonal housing unit figures and building permit figures from: Crossett, K., Culliton, T., Wiley, P., and Goodspeed, T. 2004. Population Trends

Along the Coastal United States: 1980-2006. National Ocean Service, National Oceanic and Atmospheric Administration.

Characteristics of the Coastal Population

In 2000, the average coastal county median income is approximately $39,700. This is 13% higher than the average national median income.

Between 1980 and 2000, middle-aged adults rose from 21 to 30 percent of the population in coastal counties.

Cite: *2000 income figures compiled from the following data source:* National Ocean Service, NOAA. 2006. Spatial Trends is Coastal Socioeconomics Web Site. http://stics.noaa.gov, accessed 3/27/06.

Age figures from the following publication: Crossett, K., Culliton, T., Wiley, P., and Goodspeed, T. 2004. Population Trends Along the Coastal United States: 1980-2006. National Ocean Service, National Oceanic and Atmospheric Administration.

notes

Ocean Economics

Population

Population growth in coastal regions has been constant over the past three decades. During most of that time, coastal population growth rates have been similar to overall population growth rates. Thus pressure of population growth in coastal regions comes from the increasing size of the population within a fixed land area, not from a disproportionately large amount of growth.

In 1970, the coastal watershed counties held 53% of the U.S. population. In 2000, they held 52% of the population, all on slightly less than 25% of the land area. But during those three decades, a population equal to the State of California today was added to those counties, increasing the population density of these counties from 123 people per square mile to 167 people per square mile. (Coastal watershed counties are defined by NOAA as those counties lying with watersheds of coastal rivers flowing to the Atlantic and Pacific oceans, the Gulf of Mexico, and the Great Lakes.)

The issue of population density is particularly acute in the near shore area. This region contains 11% of U.S. population on 4% of the land. At over 230 persons per square mile, the population density of the near shore is three times that of the nation as a whole. (The near shore area is defined as shore-adjacent zip codes.)

Employment

The most dramatic changes in the coastal economy have come about from employment and economic growth, particularly in the near shore area rather than population growth. Nationally, employment growth was nearly three times population growth nearest the shore. North Carolina more than doubled its employment in the near shore area between 1990 and 2000, while four other states (Alabama, Mississippi, Florida, and New York) saw employment grow by more than 50% in the near shore area.

Economic Activity

Economic activity in coastal regions is very large. Seventy-five percent of the nation's Gross State Product came from the coastal states in 2003. Almost half of the national economy came from the coastal watershed counties, and more than one-third came from those counties in which states operate their Coastal Zone Management programs. The near shore area, which is 4% of the nation's land, produces more than 11% of the nation's economic output.

That portion of the U.S. economy that depends directly on the ocean is also large, with 2.2 million people employed and $197 billion in output (gross state product) in 2003.

More than 90% of the employment in the ocean economy is located in urban areas, but the ocean economy comprises a much larger proportion of employment in rural areas.

The ocean economy is generally proportionate to the size of each state's economy, but it is more important in some states than others. Ocean economy employment is largest in Hawaii (16.5%) and Alaska (12.6%), as might be expected given their geography. The ocean economy as a proportion of gross state product is also largest in Alaska (23%) and Hawaii (9%). Among the continental states, ocean employment comprises the largest proportion of the economy in Washington State (3%) and the largest proportion of gross state product in Louisiana (11%)

The industries in the ocean economy that have been growing most rapidly are those that pay the lowest average wages. The average wage in 2003 in the tourism and recreation sector was $17,407, compared with over $70,037 in the minerals sector. Employment in the tourism and recreation sector is often highly seasonal, which distorts annual average figures to some extent. In fact, employment in ocean tourism is, on average, 10% higher in the summer than the annual average employment.

Cite: National Ocean Economics Project, www.oceaneconomics.org.

notes

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 study of southern California beaches (Los Angeles and Orange County beaches) surveyed the people living in the four-county area (Los Angeles, Orange, Riverside, and San Bernardino). A panel of almost 900 people was surveyed over a one year period on 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.

- In 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

Nonmarket coastal resource values in the Channel Islands area of southern California for the protection of Bald eagles, Peregrine falcons, White croaker and Kelp bass amounts to over $575 million (1994 dollars).

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.

A number of different sources estimate beach visitation days for California. These estimates of annual 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…non-market values represent the value that day users place on access to the beach beyond what they pay in terms of travel costs, parking fees, and tolls. Using a conservative estimate of 150 million beach visits, and a range of estimates for the non-market value of a California beach day, we estimate that 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. Socioeconomic 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, visitors to the Florida Keys National Marine Sanctuary had a total annual nonmarket economic use value of $1.2 billion. $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 visitor 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 value 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

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