Economic Statistics for NOAA

May 2005 – Fourth Edition

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

Contents

Forward

This is the fourth 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.

- **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 hurricanes, utilities, and coastal populations.

Economic Statistics for NOAA was prepared by Rodney Weiher, NOAA Chief Economist and Avery Sen 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).

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Under Secretary of Commerce for Oceans and Atmosphere
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April 2005

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, or $3 trillion, 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.

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

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

> **Cite:** NWS Office of Climate, Water, and Weather Services. Thirty and 10 year average fatalities 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.

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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

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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.

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 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.

notes

Hurricane Impacts

The 2004 hurricane season will go down as the most costly season on record in the U.S. Highlights include: 9 hurricanes/6 tropical storms; 6 of the 9 hurricanes were major hurricanes (the average number of intense hurricanes is 2); estimated U.S. damage $42 billion (costliest U.S. hurricane season on record). U.S. deaths total 59, while deaths outside of the U.S. are estimated at over 3,000.

The spate of hurricanes in 2004 — the largest being Ivan — disrupted production, damaged pipelines and delayed arrivals of shipments from overseas. That has added $5 to $6 a barrel to the price of oil, roughly the equivalent of about 14 cents per gallon for motorists.

> **Cite:** The Atlanta Journal-Constitution, *Higher oil prices byproduct of storms,* September 27, 2004.

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

Costliest hurricane seasons:
2004: ~$42 billion in U.S. damage
1992: ~$35 billion in U.S. damage (adjusted for inflation, 2000 values)
1989: ~$10.6 billion in U.S. damage

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

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

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

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

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

employment and $485.4 million in revenue loss.

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

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notes

Harmful Algal Bloom (HAB) Impacts

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.

notes

Seafood Impacts

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

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

Fisheries Contributions

Commercial landings by U.S. fishermen in 2003 were 4.3 million metric tons valued at $3.3 billion.

> **Cite:** *Fisheries of the United States, 2003,* http://www.st.nmfs.gov/st1/fus/fus03/index.html

U.S. exports of edible fishery products in 2003 were 2.4 billion pounds, valued at $3.27 billion; total U.S. exports of fishery products (edible and non-edible) in 2003 was valued at $12 billion. The U.S. total value of imported fishery products was $21.3 billion in 2003. Seafood imports totaled 4.9 billion pounds in 2003 and were valued at $11.1 billion.

> **Cite:** *Fisheries of the United States,* Foreign Trade Section 2003, p.60 http://www.st.nmfs.gov/st1/fus/fus03/index.html

The value added to gross domestic product (GDP) by the commercial fishing industry was $31.5 billion in 2003; the value added by the recreational fishing industry to GDP was $12 billion in 2003.

> **Cite:** *Fisheries of the United States, 2003,* http://www.st.nmfs.gov/st1/fus/fus03/index.html

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

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

U.S. consumers ate an estimated 16.3 pounds of seafood per capita in 2003, 0.7 pounds more than in 2002. The United States is the third largest consumer of seafood in the world.

> **Cite:** *Fisheries of the United States,* Per Capita Section, 2003, p. 84 http://www.st.nmfs.gov/st1/fus/fus03/index.html

Approximately 67,500 people were employed in the seafood processing and wholesale sectors in 2003.

> **Cite:** *Fisheries of the United States,* 2003, Employment, Crafts and Plant Section, p. 93, http://www.st.nmfs.gov/st1/fus/fus03/index.html

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

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

The 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, 2003, http://www.st.nmfs.noaa.gov/st1/

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

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

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notes

Aquaculture

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

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

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

Each 200 million tons of aquculture is estimated to reduce fish imports by $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.

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notes

Beach Visitation

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

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

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

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

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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 2003, NOAA satellites, with their sophisticated search and rescue technologies, brought 224 people to safety from dangerous and potentially life-threatening ordeals--from Alaska to New York State. The figure is a jump from the 171 people rescues in 2002.

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 17,000 lives have been saved worldwide with the assistance of CPSPAS-SARSAT, including more than 4,600 lives in the US.

> **Cite:** *NOAA Press Release 04-008*, NOAA, US Department of Commerce, January 22, 2004.
> http://www.publicaffairs.noaa.gov/releases2004/jan04/noaa04-008.html

For every $1 that the "Energy Company" (a sample utility in the midwest US) spends in acquiring weather data, they are receiving a potential benefit of not having to spend $495 to acquire that data on their own. When extended to the entire industry, the potential benefits are approximately $65 million per year.

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

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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

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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.

notes

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 2003), the total notional value of seasonal weather derivatives executed between parties has been about $2 billion per year in 1998-2000 and $4 billion in 2001 and 2002. This has resulted in a total notional value of $15.9 billion in weather risk management contracts worldwide over the past six years.

> **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. WRMA, 2003: Third 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.

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notes

Utility Industry

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.

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 10 such systems running in the U.S. and three 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, forthcoming.

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.

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notes

Research

Air Quality

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

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

Supercomputers

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

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

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

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

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notes

Coastal Ocean Economics, Population, Employment, and Benefits

Coastal Ocean Economics, Population, Employment

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.

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 2000. 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 2.3 million people employed and $117 billion in output (gross state product) in 2000.

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 (18%) and Alaska (11%), as might be expected given their geography. The ocean economy as a proportion of gross state product is also largest in Alaska (19%) and Hawaii (10%). Among the continental states, ocean employment comprises the largest proportion of the economy in Washington State (6%) 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 2000 in the tourism and recreation sector was $16,321, compared with over $60,000 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.

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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.

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.

Recreation use values for three southern California beaches (1989) include annual nonmarket values of $360 million and an asset value of $12 billion.

> **Cite:** Leeworthy, Vernon R. and Peter C. Wiley. 1993. Recreational Use Value for Three Southern California Beaches. National Oceanic and Atmospheric Administration, Office of Ocean Resources Conservation and Assessment, Strategic Environmental Assessments Division, Rockville, MD.

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 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.

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