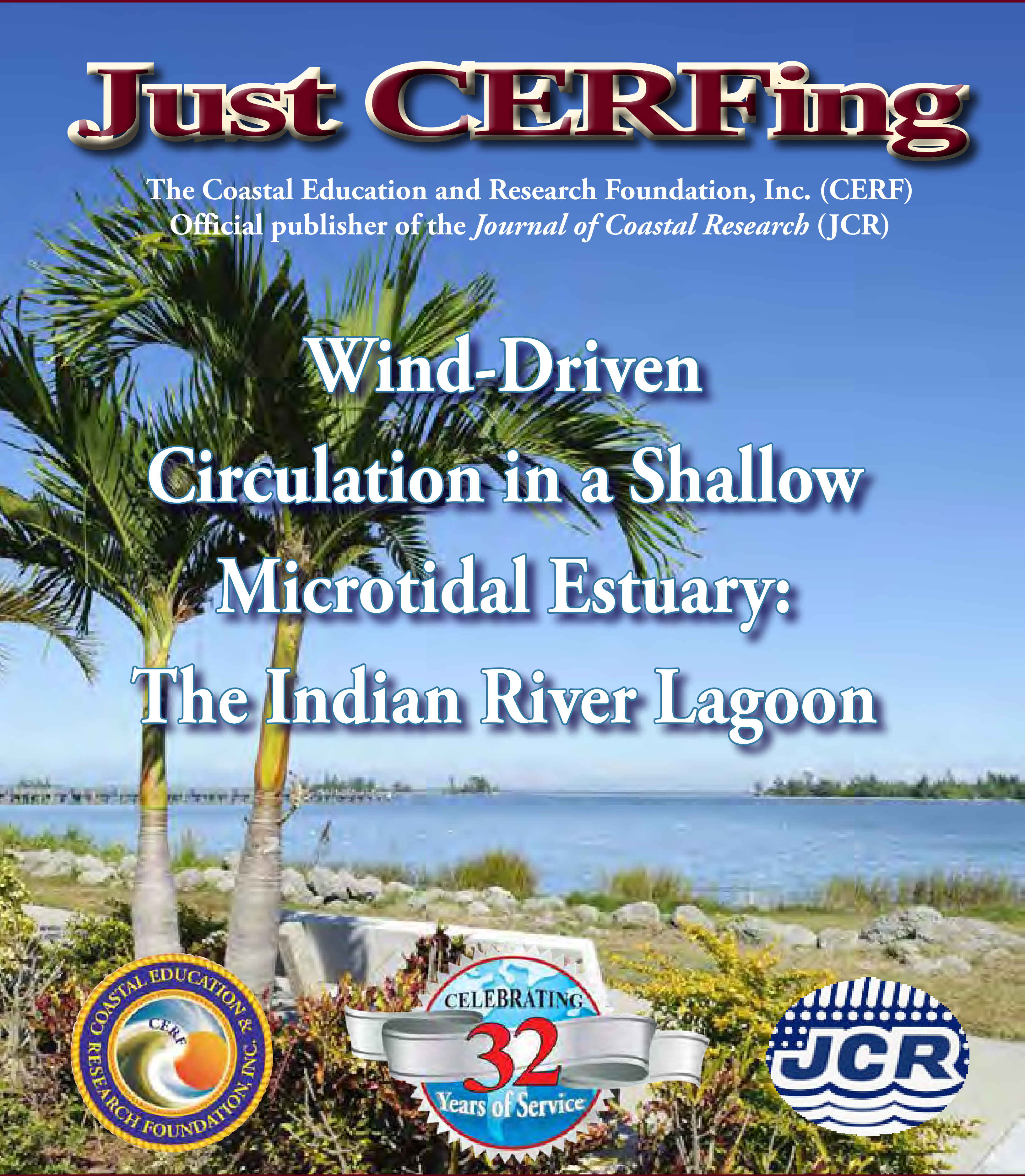

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Wind-Driven Circulation in a Shallow Microtidal Estuary: The Indian River Lagoon

CELEBRATING 32 Years of Service

In This Issue:

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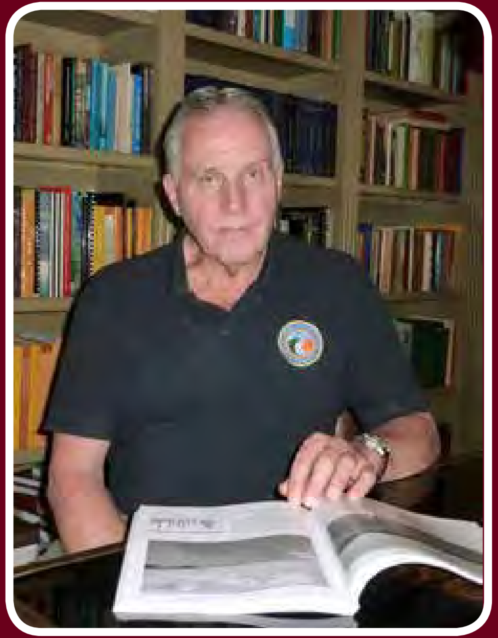

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Coastal Education and Research Foundation *[CERF]* is pleased to announce our newly appointed Regional Vice Presidents (RVP), who throughout the international scientific community continue to provide outstanding representation of our coastal research society. Please join us in honoring the following individuals for their tremendous service and support of CERF and the JCR.

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Victor V. Klemas, Ph.D.
Orrin H. Pilkey, Jr., Ph.D.

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Carlos Pereira da Silva, Ph.D.
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Marcel J.F. Stive, Ph.D.

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Kazimierz K. Furmańczyk, D.Sc.

Oceania

Charles Lemckert, Ph.D.
Vic Semeniuk, Ph.D.
Andrew D. Short, Ph.D.

CERF RVP (Southeast Asia)

Nobuo Mimura, D.Eng.

Nobuo Mimura, D.Eng., is currently serving as the President of Ibaraki University. His academic areas of expertise are global environmental engineering, coastal engineering, and adaptation policy to climate change. Dr. Mimura has also been a member of the advisory committees for Ministry of Foreign Affairs, Ministry of Infrastructure, Land and Transportation, Ministry of the Environment and Ministry of Education, Culture, Sports, and Science and Technology.

CERF RVP (North America)

James R. Houston, Ph.D.

Jim Houston, Ph.D., is Director Emeritus of the U.S. Army Engineer Research and Development Center (ERDC), which includes all the research and development laboratories of the Corps of Engineers. He managed one of the most diverse research organizations in the world – seven laboratories at four geographical sites, with over 2,000 employees and an annual program budget of $1.3 billion. Dr. Houston has published over 130 technical reports and papers and has received several honors and awards including three Presidential Rank Awards and the National Beach Advocacy Award.

Vic Klemas, Ph.D.

Vic Klemas, Ph.D., is Professor Emeritus in the University of Delaware's College of Earth, Ocean, and Environment. He directed UD's Applied Ocean Science Program from 1981-98, and he has co-directed UD's Center for Remote Sensing for more than 30 years. Dr. Klemas has served on six scientific committees of the National Research Council and received a number of awards, including, in November 2010, the Science Prize of the Republic of Lithuania. The honor recognized his lifetime achievements in applying remote sensing and other advanced techniques to study coastal ecosystems.

Orrin H. Pilkey, Jr., Ph.D.

Orrin H. Pilkey, Ph.D., is a James B. Duke Professor Emeritus of Geology within the Division of Earth and Ocean Sciences and Director Emeritus of the Program for the Study of Developed Shorelines (PSDS) in the Nicholas School of the Environment and Earth Sciences at Duke University. Since 1965, Dr. Pilkey has been at Duke University with one-year breaks with the Department of Marine Science at the University of Puerto Rico, Mayaquez, and with the U.S. Geological Survey in Woods Hole, Massachusetts. His research career started with the study of shoreline/continental shelf sedimentation, progressed to the deep sea with emphasis on abyssal plain sediments, and back to the nearshore with emphasis on coastal management. Dr. Pilkey has published more than 250 technical publications and has authored, coauthored, or edited 39 books.

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CERF RVP (South America)

Omar Defeo, D.Sc.

Omar Defeo, D.Sc., is a professor in the Marine Science Unit at the Universidad de la República in Uruguay. He is also among a select group of ecologists worldwide working on sandy beach ecosystems and how they are threatened by climate change. For the past 15 years, Prof. Defeo has also been involved in artisanal shellfisheries, ecology, and conservation of coastal marine invertebrate biodiversity research in Latin America, primarily in Mexico and Chile.

CERF RVP (Western Europe)

Carlos Pereira da Silva, Ph.D.

Carlos Pereira da Silva, Ph.D., is the Director of e-GEO within the Research Centre for Geography and Regional Planning at the Universidade Nova de Lisboa, Portugal. Dr. Pereira da Silva's research interests are mainly focused on coastal zone management, with specific emphasis in beach management, public participation studies, and carrying capacity. A long time supporter of CERF and the JCR, in April 2009, he served as the local Chair and Co-organizer of the 10th International Coastal Symposium (ICS) that took place in Lisbon, Portugal.

Michael Phillips, Ph.D.

Professor Mike R. Phillips (BSc, PGCE, MSc, PhD, MIEnvSc, FRGS) serves as Pro Vice-Chancellor of Research, Innovation, Enterprise, and Commercialization at the University of Wales Trinity Saint David (Swansea Metropolian). Professor Phillips research expertise includes coastal processes, morphological change and adaptation to climate change and sea-level rise. Consultancy includes beach replenishment issues and developing techniques to monitor underwater sediment movement to inform beach management. He is widely published and recently organized a session on Coastal Tourism and Climate Change at UNESCO Headquarters in Paris as part of his role as a member of the Climate Change Working Group of the UNEP Global Forum on Oceans, Coasts, and Islands.

Marcel J.F. Stive, Ph.D.

Until 2010, Marcel Stive, Ph.D., was Scientific Director of the Water Research Centre Delft, which is now embedded in the Delft Research Initiative Environment. He currently holds the positions of: Chair of Coastal Engineering in the Section of Hydraulic Engineering and Department Head of Hydraulic Engineering at Delft University of Technology. Dr. Stive was recently appointed Knight in the Order of the Dutch Lion in theatre the Rijswijkse Schouwburg in Rijswijk. He was presented with this award for his outstanding record as a top researcher, much consulted expert, distinguished engineer, and inspiring teacher.

CERF RVP (Eastern Europe)

Kazimierz K. Furmańczyk, D.Sc.

Kaz Furmańczyk, D.Sc., is currently Full Professor at the University of Szczecin and the Head of the Remote Sensing and Marine Cartography Unit at the Institute of Marine and Coastal Sciences. Author and co-author of over 100 scientific publications including books (2) and chapters, journal articles, abstracts, and conference papers. Contributions are mainly in the disciplines of remote sensing, coastal sciences, hydrology, and oceanography. In May 2011, he served as the local Chair and Co-organizer of the 11th International Coastal Symposium (ICS) that took place in Szczecin, Poland.

CERF RVP (Oceania)

Charles Lemckert, Ph.D.

Charles Lemckert, Ph.D., is the Head of Discipline of Civil Engineering at Griffith University's School of Engineering. He has active research interests in the fields of physical limnology, coastal systems, environmental monitoring techniques, environmental fluid dynamics, coastal zone management, and engineering education. Along with his postgraduate students and research partners, Dr. Lemckert is undertaking research studies on water treatment pond design (for recycling purposes), the dynamics of drinking water reservoirs, the study of whale migration in southeast Queensland waters, and ocean mixing dynamics. In 2007, he served as the local Chair and Co-organizer of the 9th International Coastal Symposium (ICS) along the Gold Coast of Australia.

Vic Semeniuk, Ph.D.

Vic Semeniuk, Ph.D., is a natural history research scientist, specialising in coastal, estuarine and wetland environments, and mangrove and tidal flat environments. He has 45 years experience in scientific research in Australia, Europe, Canada, the USA, Ireland, the United Kingdom, and South Africa. Dr. Semeniuk is currently the Director of the Research & Development Firm, the V & C Semeniuk Research Group, and has over 130 publications in refereed scientific journals. He also has a proactive interest in conservation and coastal management, and has published multiple scientific works directly and indirectly leading to this objective.

Andrew D. Short, Ph.D.

Andy Short, Ph.D., served as the Director of the Coastal Studies Unit at The University of Sydney and has been the National Coordinator of the Australian Beach Safety and Management Program in cooperation with Surf Life Saving Australia. Dr. Short is mainly interested in the processes and morphology of coastal systems. His present research focuses on the beach and barrier systems of Australia, as it relates to the morphodynamics of representative systems in variable wave and tide environments, and in the nature, hazards, and usage of all Australia beach systems.

Wind-Driven Circulation in a Shallow Microtidal Estuary: The Indian River Lagoon

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ABSTRACT

Studying wind-driven fluctuations in the surface elevation along the Indian River Lagoon (IRL) allows researchers to better understand the best methods for managing sustainable water quality in a microtidal estuary. Water quality has a direct effect not only on the marine life, but also on tourism. This study improves the knowledge of circulation and surge in a shallow, microtidal estuary while enabling validation of numerical modeling efforts. Two submersible pressure sensors were deployed in the IRL for 7 months. Data collected from these gauges is analyzed in conjunction with data from permanent gauges at Haulover Canal and Sebastian Inlet, with an emphasis placed on the relationship between surface elevation and meteorological forcing. A time series analysis was employed to correlate periods of harmonic oscillations with wind events. Analysis focused on the direction of the wind with respect to the along-estuary and cross-estuary orientation of the lagoon. Results indicate that the water rises or falls uniformly in the cross-estuary direction and is transported to the south during Nor'easter events, piling up at the constriction south of Sebastian Inlet. Study results will be used to provide a better understanding of circulation in shallow-water estuaries, as well as improve numerical models to better predict wind-driven circulation in the IRL.

ADDITIONAL INDEX WORDS: *Coastal lagoon, estuarine dynamics, hydrodynamics, wind-driven current, wind set-up, numerical modeling.*

INTRODUCTION

The Indian River Lagoon (IRL) is approximately 250 km in length and 2–4 km in width, located on Florida's East Coast (Figure 1). The depth typically ranges from 1 to 3 m, with an average depth of 1.2 m (Smith, 1990; Woodward-Clyde Consultants, 1994). Because of its shallow and narrow nature, this lagoon is generally identified as a restricted lagoon system (Kjerfve, 1986). Primary factors that influence water movement in general estuarine systems include freshwater discharge, tidal action, and atmospheric forcing (Reynolds-Fleming and Luettich, 2004). In coastal lagoon systems such as the IRL, the effect from tidal forcing is reduced by the morphology, orientation, and connection of the system to the ocean (Luettich *et al.*, 2002). The IRL has six inlets (Port Canaveral, Fort Pierce, Sebastian, Ponce de Leon, St. Lucie, and Jupiter Inlets), five of which allow the mixing of brackish estuarine water with ocean water. The inlet at Port Canaveral is isolated from the lagoon by a lock system that is opened on demand. Tidal forcing is an important component near all the inlets except Port Canaveral; however, the movement of water throughout most of the lagoon is driven primarily by meteorological processes (Smith, 1990). This is especially the case in the northern IRL, where the distance between inlets is on the order of 143 km, and the tidal energy entering from Ponce Inlet in the north is quickly dissipated in the Mosquito Lagoon by a series of islands and shallow channels. The energy entering from Sebastian Inlet is dissipated over a greater distance by bottom friction in the shallow lagoon. The geometry for this estuary is also unique, because it is long, narrow,

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and oriented at an angle of approximately 23° from the +*x* (east axis). This orientation is an important factor, along with the wind forcing causing a unique circulation pattern. Our research focuses on the northern portion of the IRL from Sebastian Inlet north to the Haulover Canal (Figure 2).

On the basis of previous work in the Virginia Coast Reserve (Mied *et al*., 2010) and its shared characteristics with the IRL, it is expected that the Ekman forcing is negligible. Additionally, water movement is expected to be parallel to the shoreline or alongshore rather than across-shore because of the large length-to-width ratio.

When modeling circulation in shallow lagoon systems such as the IRL, it has become commonplace to estimate flow patterns and to simulate this circulation in order to apply the model to different sized systems (Cheng, Casulli, and Gartner, 1993). Seiching due to the semidiurnal and diurnal tidal and nontidal signals observed in the IRL may be an important physical component that will be understood by performing a spectral analysis. Other studies conclude that a surface oscillation with a semidiurnal period will correspond to strong wind events that occur in small lagoon systems such as the IRL (Vilibićand Orlić, 1990). Numerical and spectral analysis will be conducted in this study to analyze the tidal, atmospheric, and seiche forcing mechanisms that are responsible for the circulation patterns. From the results of previous studies, peaks are expected in the spectrum that are consistent with the seiche wave occurring in the IRL for periodic meteorological forcing observed in the daily sea breeze cycle (Niedda and Greppi, 2007). However, when selecting key wind events with higher and more consistent wind speeds and a smaller time window, the IRL's reaction is expected to respond to that dominant signal.

Water circulation has been previously analyzed with different methodologies in the Indian River Lagoon. First, analysis of seasonal patterns of water movement in the IRL found that water was being forced into the lagoon during the summer months and would later be drawn out in the late fall and winter months (Smith, 2001). The inlets also behaved according to this seasonal flow because the central inlets responded with the strongest outflow during the summer months and the southern inlet had the largest outflow during the winter months (Smith, 2001). Second, an integrated modeling system has been developed and successfully implemented that models hydrodynamics and salinity, waves and sediments, water quality, light attenuation, and submerged aquatic vegetation (Sheng *et al*., 2001). Circulation models have also identified local river water discharge as a significant factor to understand water movement throughout the lagoon (Liu, Zarillo, and Surak, 1997).

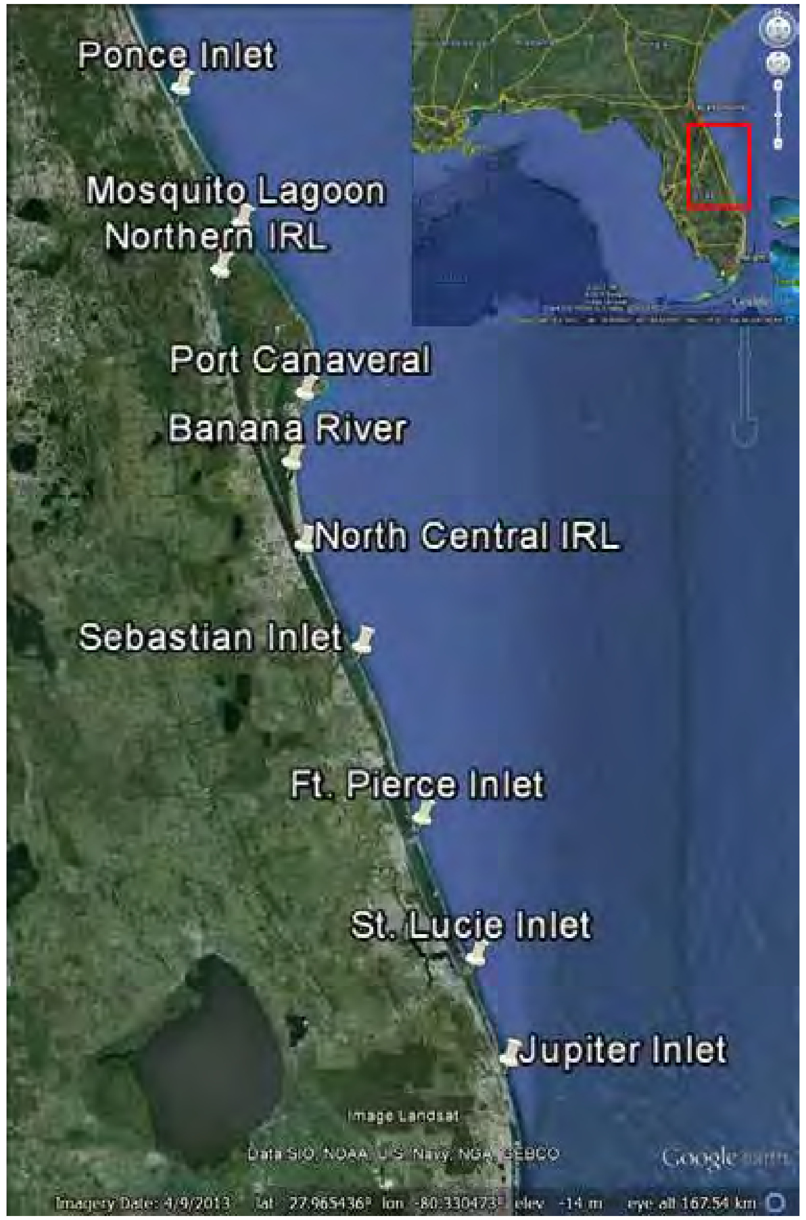

Figure 1. Map of the study area along Florida's east coast, focusing on the Indian River Lagoon, including inlet locations and identifying the Mosquito Lagoon in the northern IRL, the Banana River in the central northeast IRL, and the IRL proper extending south to Jupiter Inlet. (Source: Google™ Earth).

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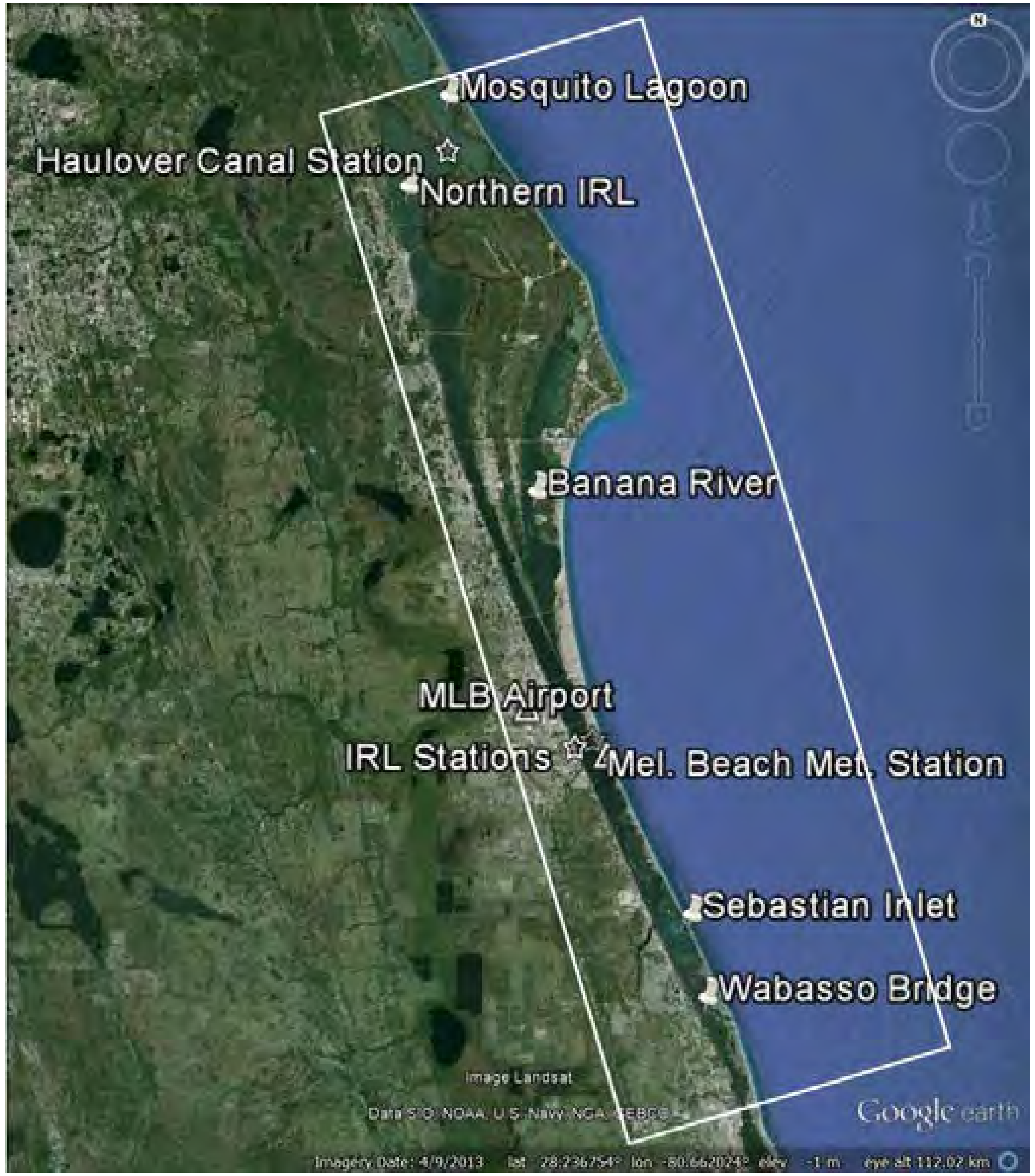

Figure 2. Map of the northern IRL system with notable locations and waterbodies identified. This image covers from Ponce Inlet in the north to Vero Beach in the south. Note the constriction south of the Wabasso bridge and the location of the north-central IRL gauges approximately 32 km (20 miles) north of Sebastian Inlet. This work focuses on the area contained within the white box. (Source: Google™ Earth).

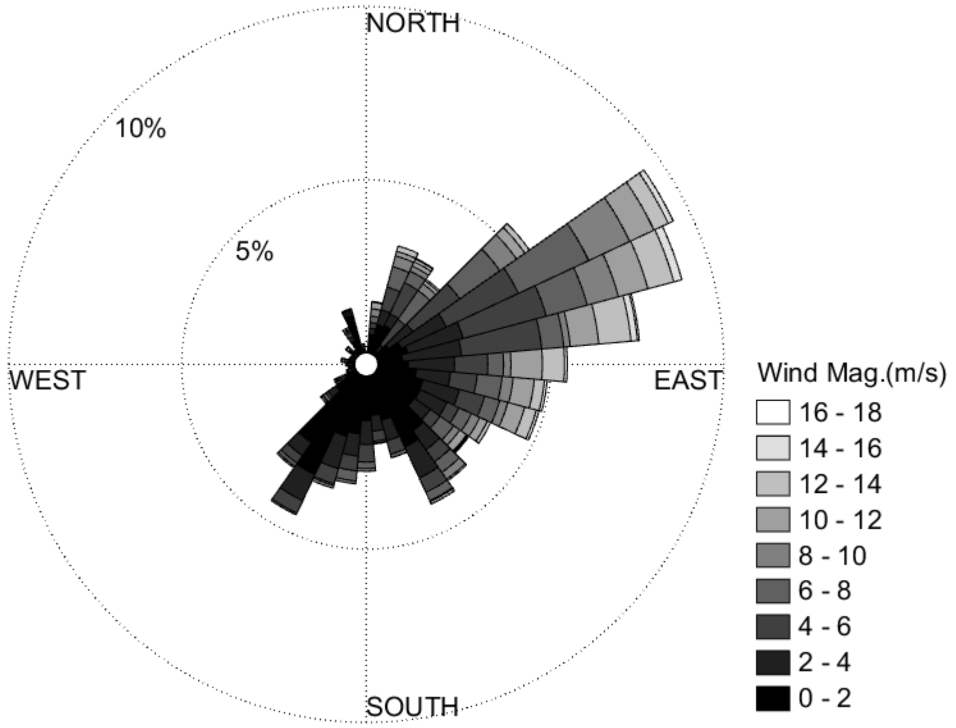

Figure 3. Hurricane Isaac: Wind rose with magnitude (m/s) contours and wedges, each indicating a 108 directional bin using meteorological wind direction convention (winds blowing from). The radial rings indicate the percentage of the total duration that the winds were coming from a particular direction. Winds are predominantly out of the east-northeast during this 11-d time period.

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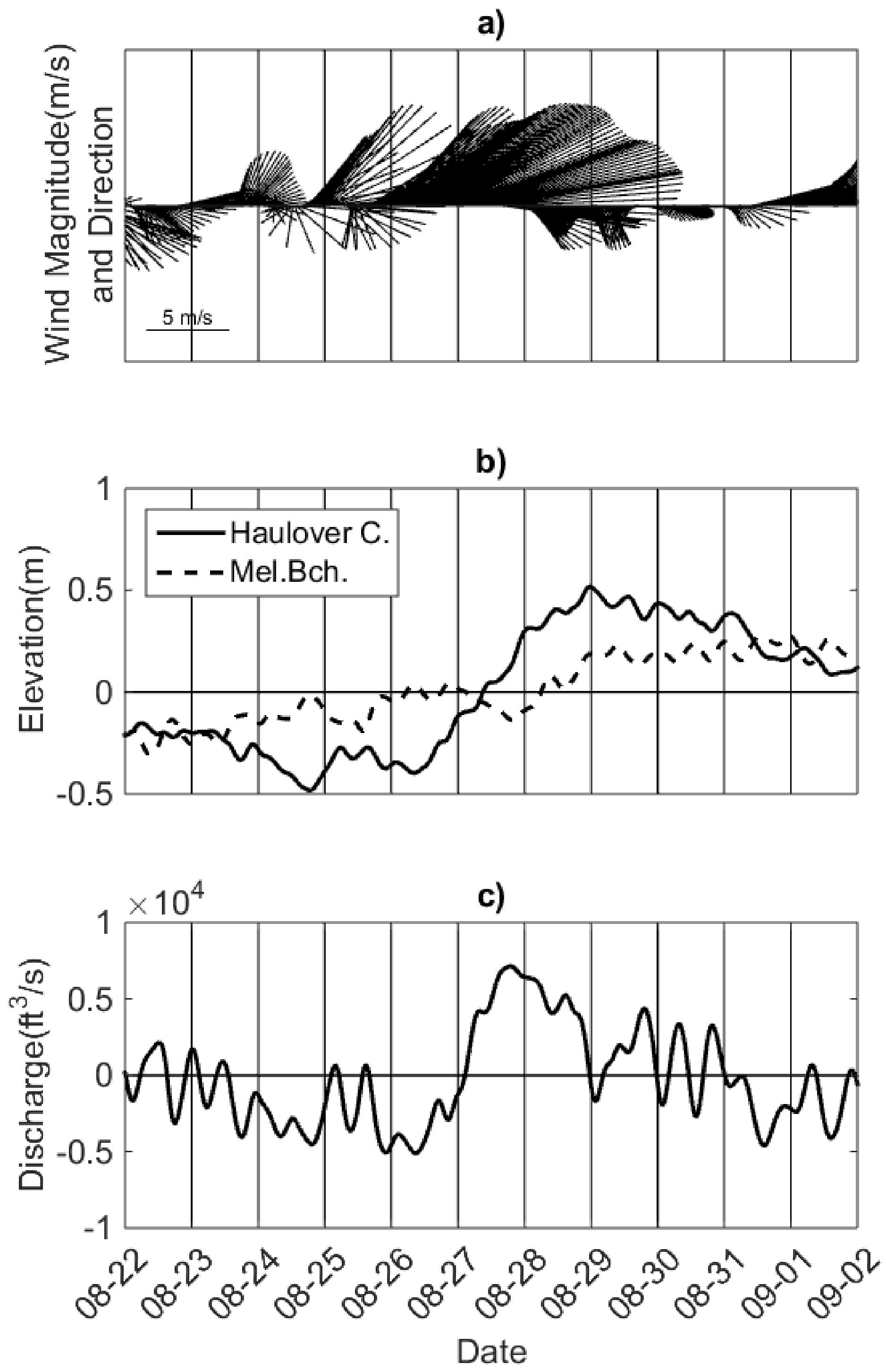

Figure 4. Hurricane Isaac: (a) wind magnitude (m/s) and direction (N–S, *y* axis; E–W, *x* axis) stick plot with horizontal bar indicating a magnitude of 5 m/s; (b) Haulover Canal and IRL Melbourne Beach Pier water levels (de-meaned); (c) recorded water discharge from the Haulover Canal (positive discharge indicating flow into the Mosquito Lagoon and negative discharge indicating flow into the IRL).

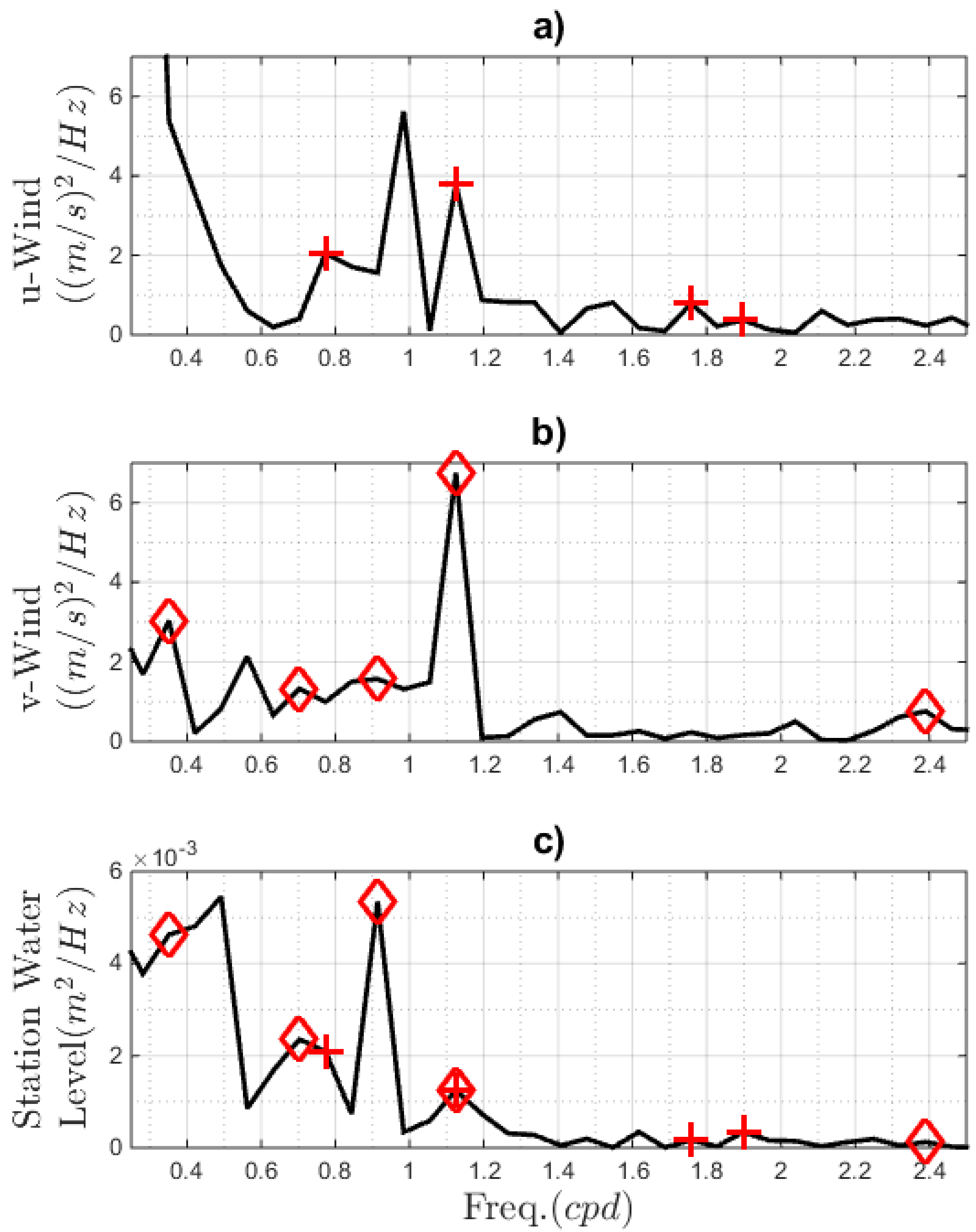

Figure 5. Hurricane Isaac: Spectral analysis of wind and water elevation with frequencies in cycles per day (cpd): (a) *u* component, (b) *v* component, and (c) IRL gauge data. The highlighted points on the graphs indicate matching frequencies between the wind spectra and the water elevation spectrum. Matched peaks between the wind components and the water level are indicated as plus marks (*u* component) or diamonds (*v* component).

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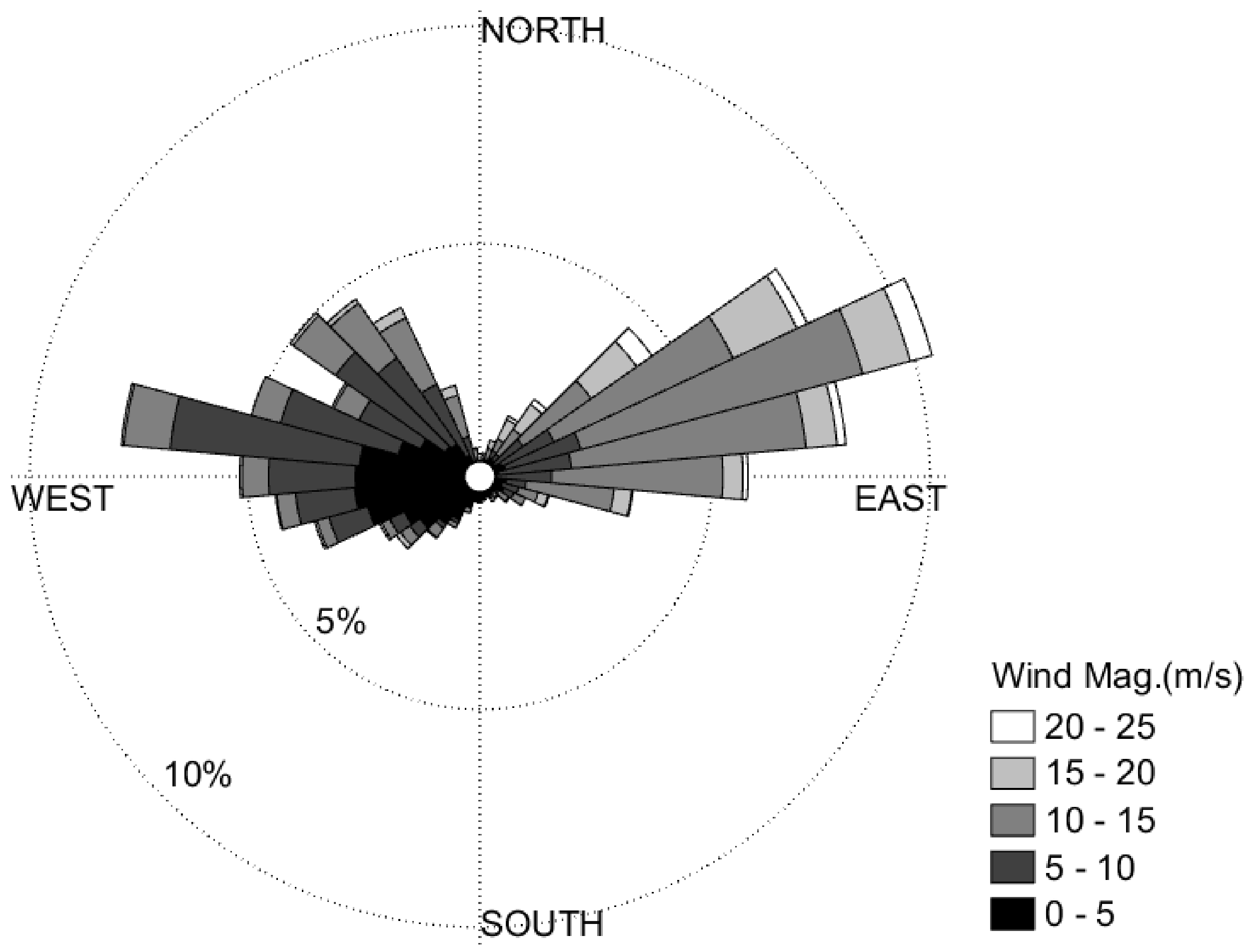

Figure 6. Hurricane Sandy: Wind rose with magnitude (m/s) contours and wedges, each indicating a 108 directional bin using meteorological wind direction convention (winds blowing from). The radial rings indicate the percentage of the total duration that the winds were coming from a particular direction. Strongest winds are predominantly out of the east-northeast during this 9-d time period. Westerlies and northwesterlies top out in the 10–15 and 15–20 m/s range with a smaller frequency of occurrence.

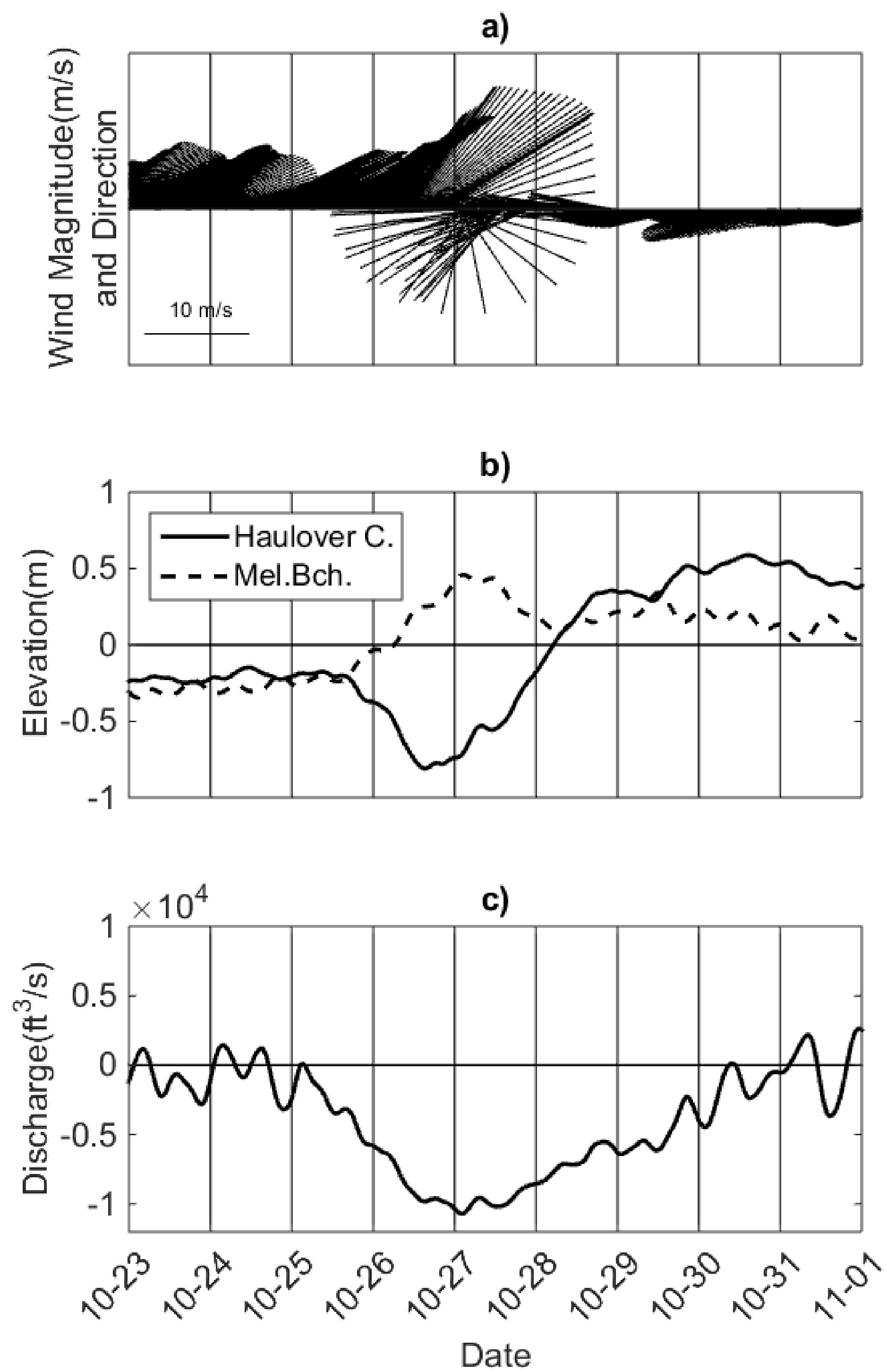

Figure 7. Hurricane Sandy: (a) Wind magnitude (m/s) and direction (N–S, *y* axis; E–W, *x* axis) stick plot with horizontal bar indicating a magnitude of 10 m/s; (b) Haulover Canal and IRL Melbourne Beach Pier water levels (de-meaned); (c) recorded water discharge from the Haulover Canal (positive discharge indicating flow into the Mosquito Lagoon and negative discharge indicating flow into the IRL). In the days leading up to Sandy, the Florida east coast was subject to NE winds.

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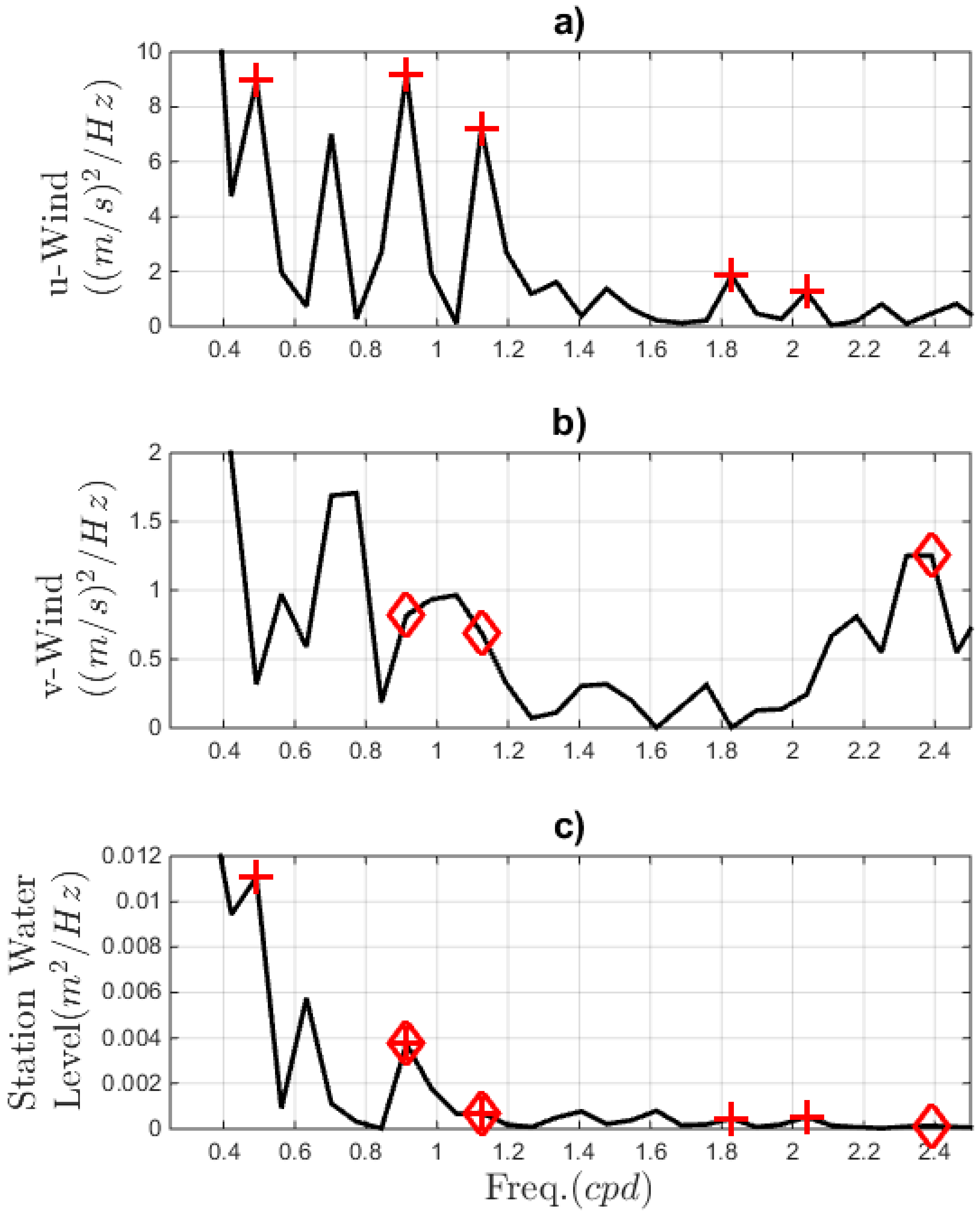

Figure 8. Hurricane Sandy: Spectral analysis of wind and water elevation with frequencies in cycles per day (cpd): (a) *u* component, (b) *v* component, and (c) IRL gauge data; the highlighted points on the graphs indicate matching frequencies between the wind spectra and the water elevation spectrum. Matched peaks between the wind components and the water level are indicated as plus marks (*u* component) or diamonds (*v* component). The circle indicates a peak in the water elevation near the calculated fundamental seiche frequency, with no matching peaks in the wind signal.

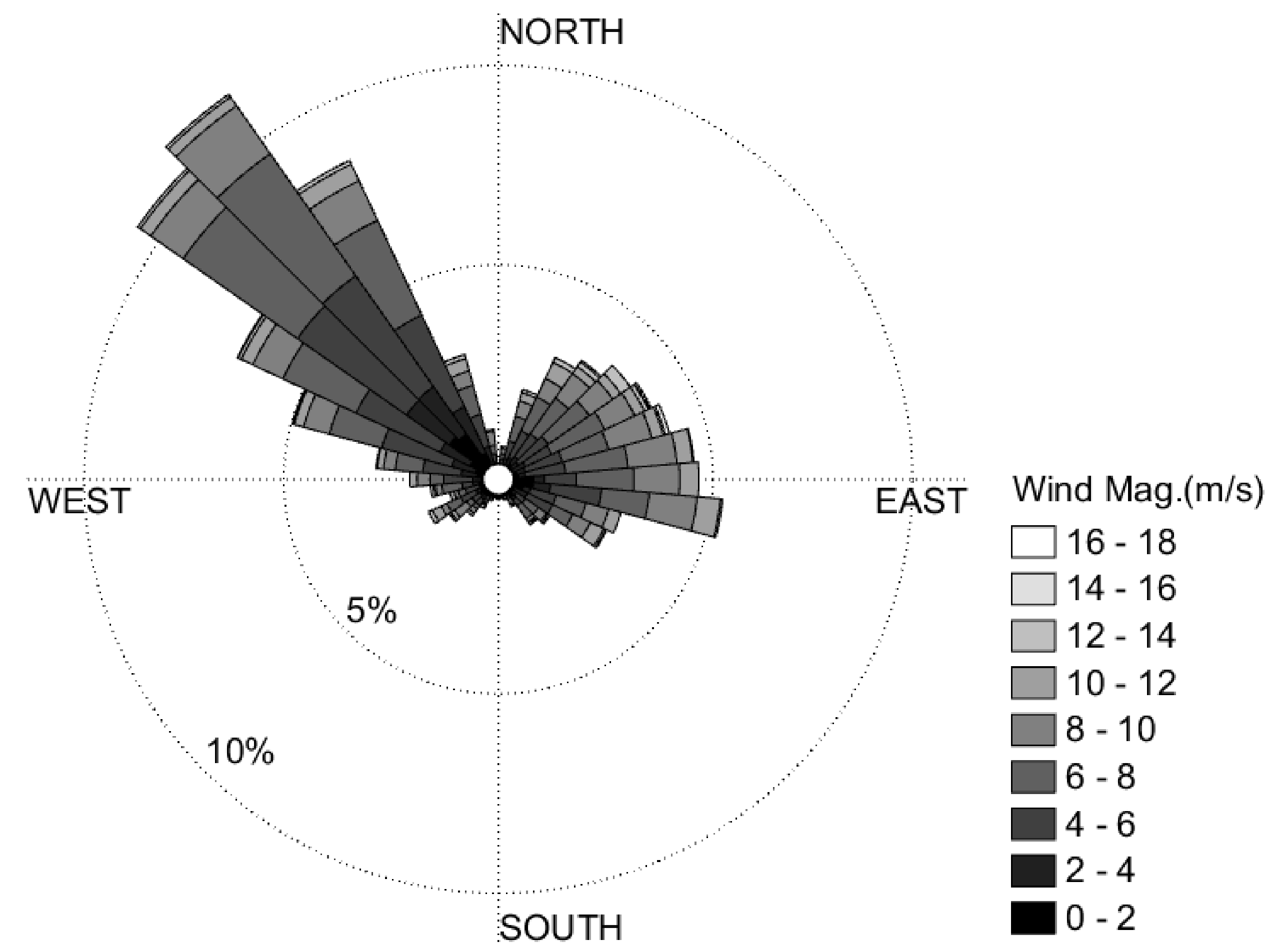

Figure 9. Nor'easter: Wind rose with magnitude (m/s) contours and wedges, each indicating a 108 directional bin using meteorological wind direction convention (winds blowing from). The radial rings indicate the percentage of the total duration that the winds were coming from a particular direction. During this 11-d time period, the strongest winds were out of the northeast; however, the winds with the highest frequencies came from the northwest.

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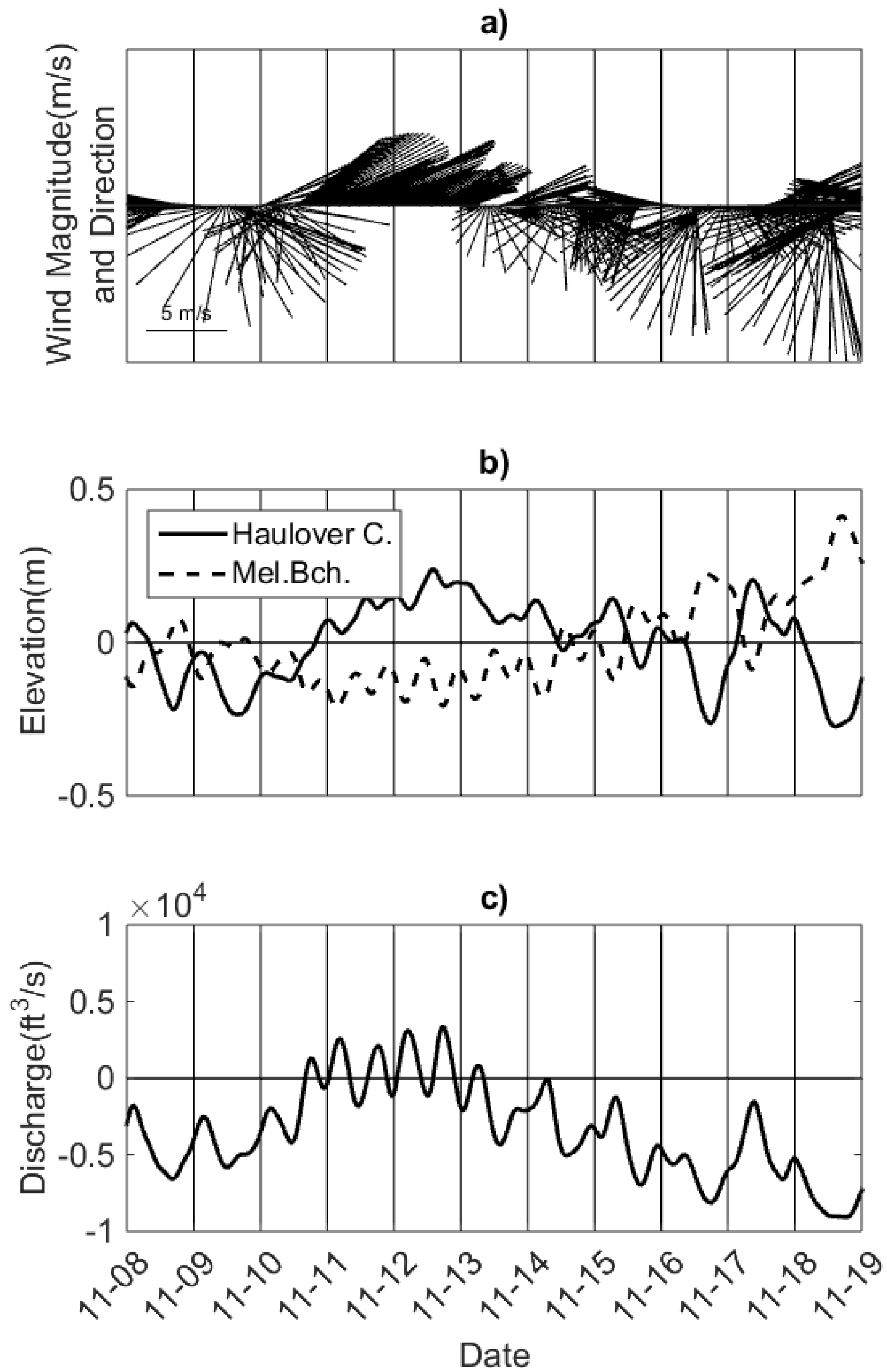

Figure 10. Nor'easter: (a) Wind magnitude (m/s) and direction (N–S, *y* axis; E–W, *x* axis) stick plot with horizontal bar indicating a magnitude of 5 m/s;(b) Haulover Canal and IRL Melbourne Beach pier water levels (de-meaned);(c) recorded water discharge from the Haulover Canal (positive discharge indicating flow into the Mosquito Lagoon and negative discharge indicating flow into the IRL). The strong consistent NE winds occur between 9 November and 13 November.

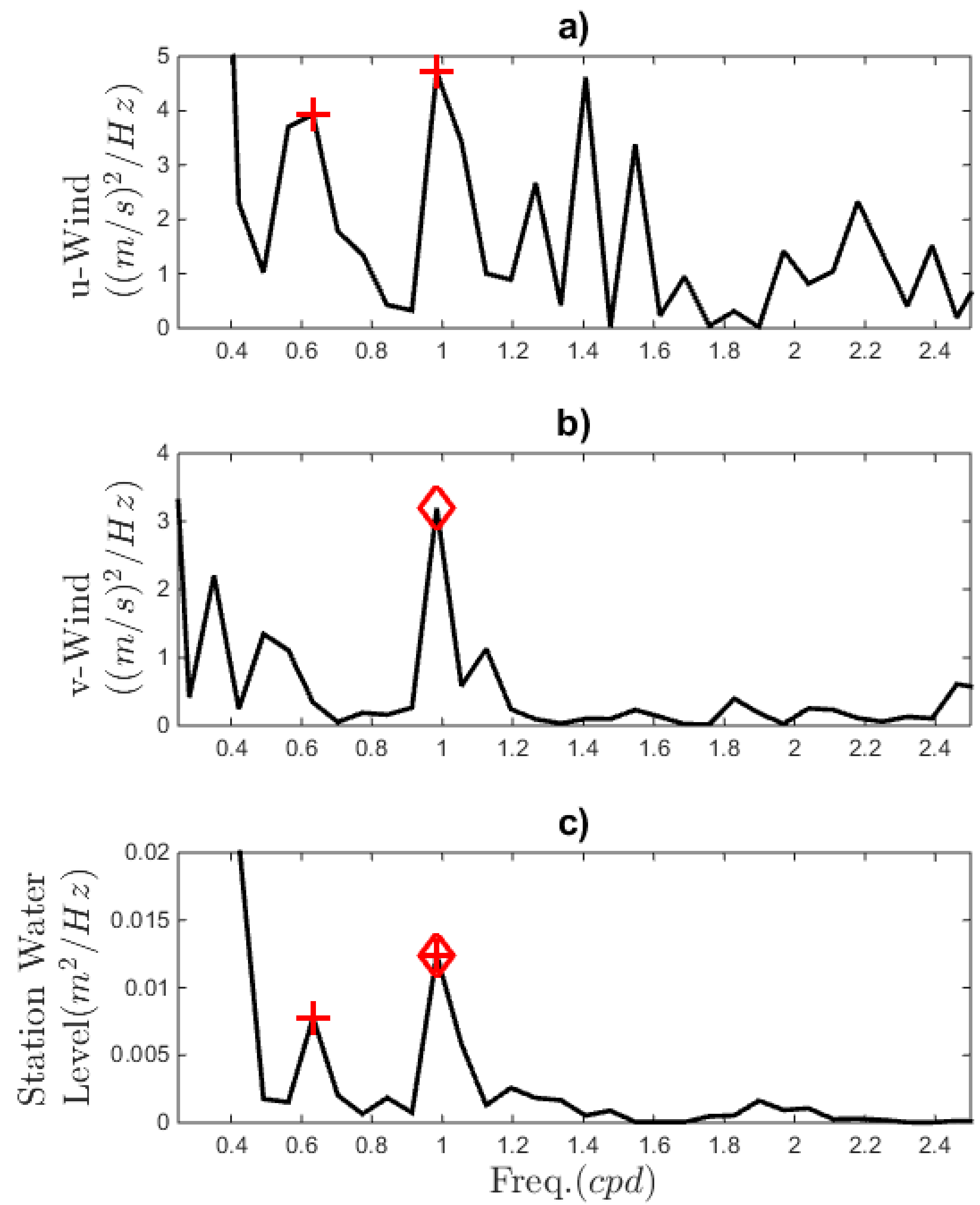

Figure 11. Nor'easter: Spectral analysis of wind and water elevation with frequencies in cycles per day (cpd): (a) *u* component, (b) *v* component, and (c) IRL gauge data; the highlighted points on the graphs indicate matching frequencies between the wind spectra and the water elevation spectrum. Matched peaks between the wind components and the water level are indicated as plus marks (*u* component) or diamonds (*v* component).

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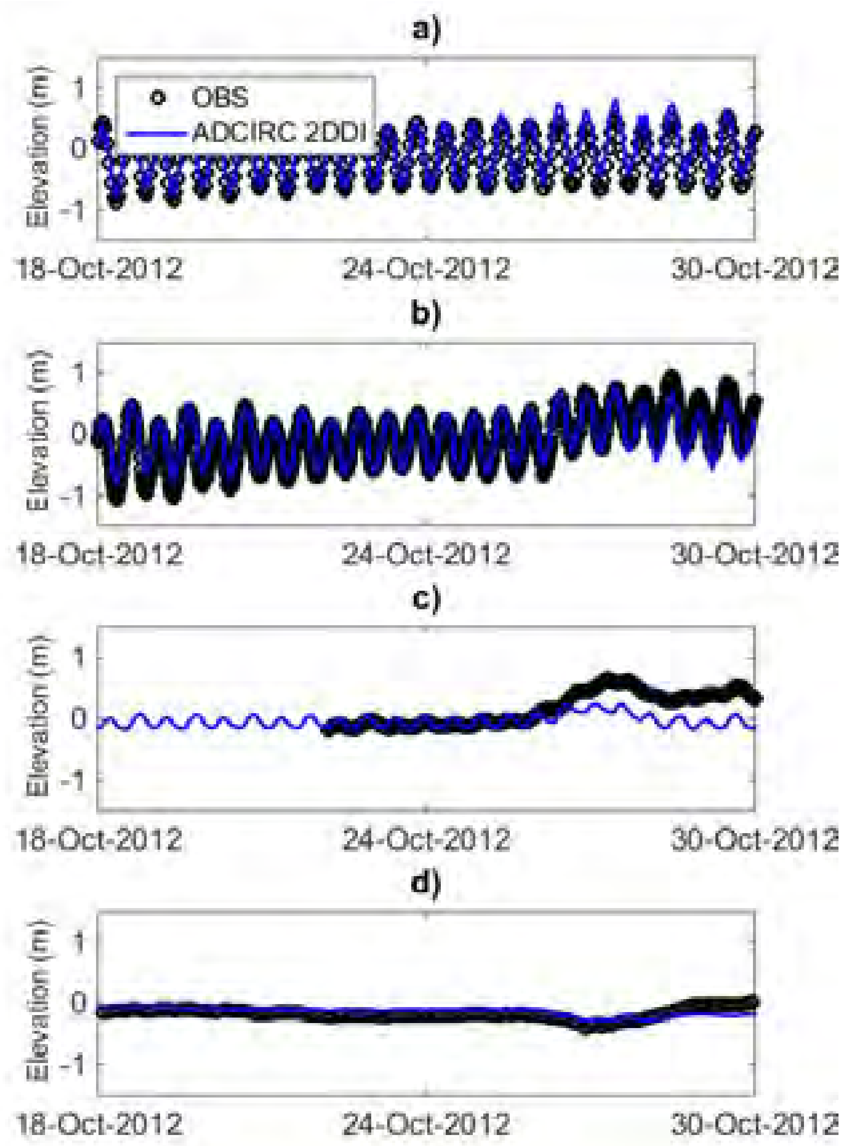

Figure 12. Model validation plots for the Sandy time period at four stations:(a) at Trident Pier outside the IRL, the model and the station match in both phase and magnitude; (b) at Sebastian Inlet, the model is in agreement with the station data in both magnitude and phasing; (c) at Melbourne Beach Pier, the model deviates from the station data and the model results underpredict the measured increase in water level; (d) at Haulover Canal, the model and the USGS station agree. Model results are sensitive to wind forcing.

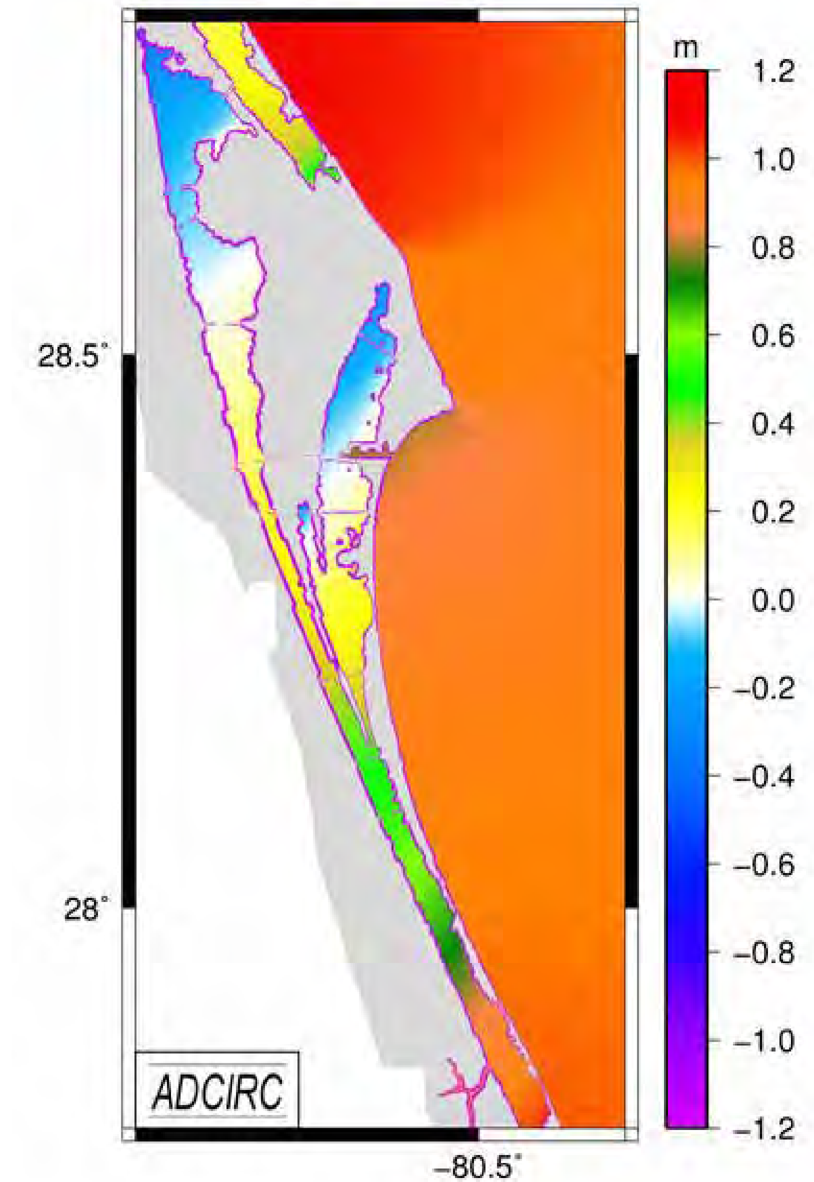

Figure 13. Water elevation (in meters NAVD88) on the afternoon of 28 October 2012 during the Sandy model simulation is contoured within the computational domain. At the southern end of each basin the water piles during the simulation. In the middle of the northern portions of the domain, a band of zero elevation change is predicted, indicating the point about which the water level is pivoting as the winds set up the water in the narrow south and blows down the water in the north.

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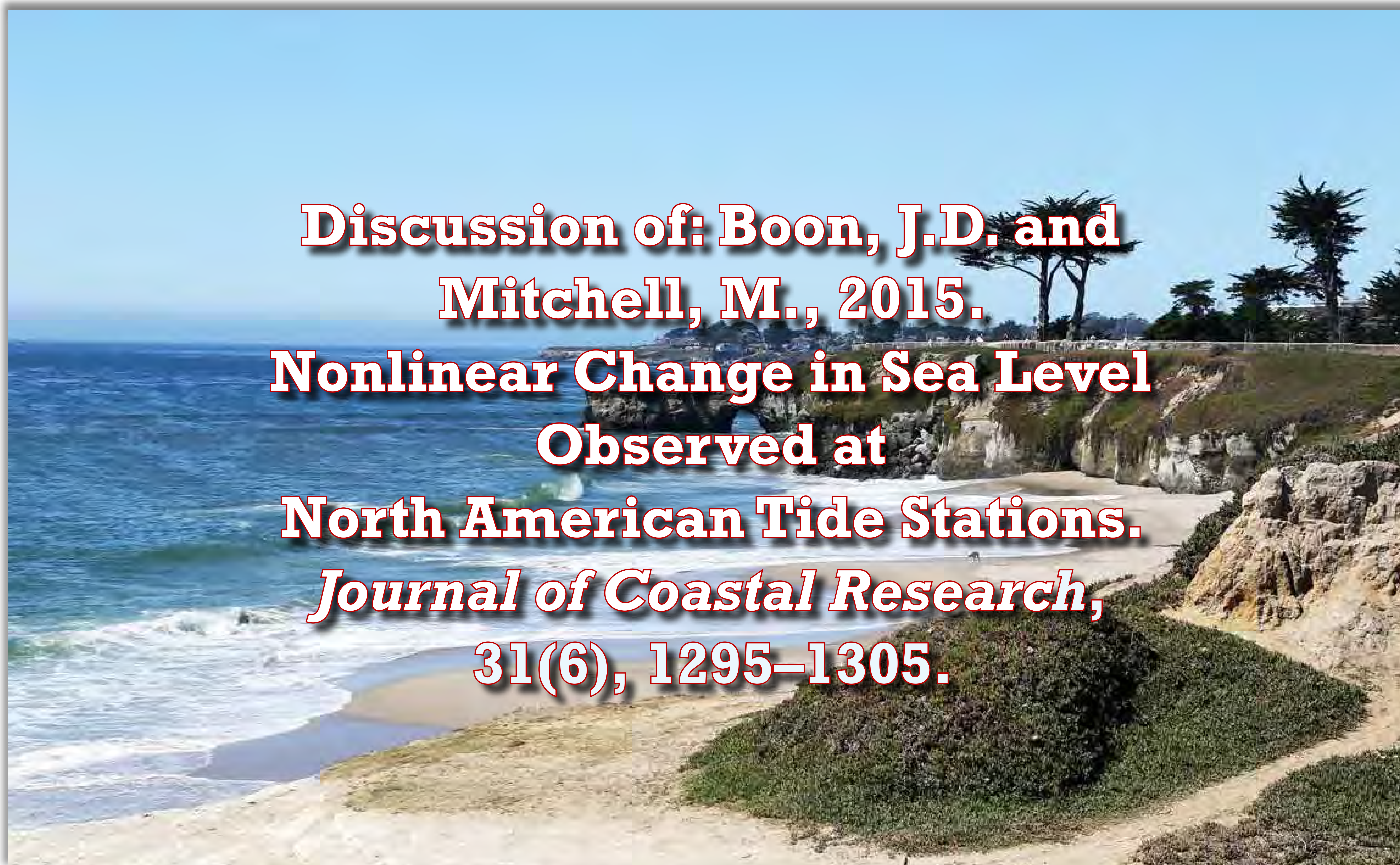

Discussion of: Boon, J.D. and Mitchell, M., 2015. Nonlinear Change in Sea Level Observed at North American Tide Stations. *Journal of Coastal Research*, 31(6), 1295–1305.

Discussion of: Boon, J.D. and Mitchell, M., 2015. Nonlinear Change in Sea Level Observed at North American Tide Stations. *Journal of Coastal Research*, 31(6), 1295–1305.

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ABSTRACT

Boon and Mitchell determined sea-level acceleration using monthly averaged relative mean sea-level data from 45 U.S. tide stations and 1 Canadian station for 1969–2014. Their methods of analyzing tide gauge data are interesting and useful. However, they then projected sea-level change for 58 years from 1992–2050 based on constant accelerations calculated from these 46-year records. Calculations of acceleration based on records as short as 40–50 years are well known to be heavily corrupted by decadal variations in sea level. For example, Boon and Mitchell showed that 3–6 year variations in record length or time period resulted in what they said were "dramatic change" in calculated acceleration. Therefore, the accelerations they calculated did not even remain constant for a few years, making long-term projections based on them untenable. Boon and Mitchell projected significant sea-level falls from 1992 to 2050 on the coasts of California, Oregon, and Washington, in stark contrast with projections of significant rises by the National Research Council. Similarly, their projections on the U.S. Atlantic and Pacific coasts differ remarkably from projections of the Intergovernmental Panel on Climate Change. Acceleration calculated from 46-year records varies significantly through time, and it is not valid to fix an acceleration value and project it into the future as if it were a constant.

INTRODUCTION

Sea-level change recorded by individual tide gauges has decadal-scale variability with quite large fluctuations of 5–15 cm or greater (Sturges, 1987). Douglas and Peltier (2002) note that these low-frequency fluctuations are coherent over large ocean regions for several decades or more. This decadal variability can significantly affect accelerations determined from tide gauge records, in particular for short record lengths. Douglas (1992, 2001) calculated accelerations for tide gauge records in the database of the Permanent Service for Mean Sea Level (PSMSL) and found that "low-frequency variations of sea level heavily corrupt the computation of an acceleration parameter for records less than about 50 years in length." Douglas (2001) recommended that tide gauge records of at least 50–60 years be used to determine acceleration and noted that Douglas (1997) found improved results using tide gauge records with lengths greater than 70 years. Houston and Dean (2013) performed the same analysis as Douglas (1992), but with 20 additional years of data, for 1123 tide gauge records in the PSMSL database, concluding that record lengths needed to be at least 75 years to determine acceleration that was not corrupted by decadal variations.

Boon and Mitchell determined sea-level trends and accelerations using monthly averaged relative mean sea-level data from 45 U.S. tide stations and 1 Canadian station for 1969–2014, centering their calculations in 1992. They were aware of Douglas (1997, 2001) and noted that Douglas argued that re-

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cords longer than 70 years were required to reliably determine acceleration. However, they determined trends and accelerations based on the 46-year records, assumed they would remain constant for 58 years, and projected sea-level rise from 1992 to 2050. This discussion will focus on their 50-percentile projections.

PROBLEMS

The problems of using short records to project future sea-level change are apparent in Boon and Mitchell. They noted (p. 1299) that "results from numerous analyses show a dramatic change after moving the 1969–2014 window back only 6 years to 1963–2008." For example, a 6-year shift in the analysis period changed trends and accelerations for Sitka, Alaska (shown in Figure 6 of their article), from −2.06 mm/y and +0.096 mm/y^2, respectively, based on the period 1963–2008, to −2.72 mm/y and −0.085 mm/y^2, respectively, based on 1969–2014. Assuming, as they do, that these trends and accelerations remain constant for 58 years results in a projected rise in sea level of +4 cm based on 1963–2008 but a fall of −30 cm based on 1969–2014. A shift of only 6 years in the analysis period changes the projected rise by −34 cm, twice the magnitude and in the opposite direction of global sea–level rise in the 20th century, which was about +17 cm (Church *et al.*, 2013). Similar large differences are shown for five other gauge locations in Figures 6 and 7 of Boon and Mitchell. If moving the 46-year window back 6 years leads to a "dramatic change" in projections, moving the window forward 6 years as the years unfold to 2020 would likely result in a similar dramatic change, making the projections completely unreliable. Accelerations based on short records simply do not remain constant for 58 years.

Boon (2012) performed the same basic analysis as Boon and Mitchell for 23 gauge locations on the U.S. Atlantic coast, but for the period 1969–2011 rather than 1969–2014. Both made projections to 2050. For example, Boon projected that Fernandina Beach, Florida, would have a fall in sea level by 2050 of–6 cm, whereas Boon and Mitchell project a rise of +11 cm using just 3 additional years of data from 2011 to 2014. A mere 3-year difference in the analysis period resulted in a sea-level rise rather than fall, with the magnitude of the difference equal to the global rise in sea level in the 20th century. Boon and Mitchell noted that adding 3 years to the analysis period analyzed by Boon changed projections along most of the U.S. Atlantic coast by 10–17 cm, sometimes lowering projected levels and sometimes raising them. Therefore, projections based on accelerations calculated from 1969 to 2017 will likely differ substantially from those based on 1969–2014, and the projections will change markedly every 3 years. Projections based on short record lengths of 40–50 years are of little value to communities, because they change significantly over short time periods.

The projection of sea-level change from 1992 to 2050 that Boon and Mitchell made for the San Francisco, California, gauge location powerfully illustrates that accelerations based on 46-year records cannot be used to validly project future sea-level change. They project a fall in sea level of–18 cm from 1992 to 2050, despite a measured rise of +18.9 cm from 1855 to 2014, including a rise of +1.6 cm from 1992 to 2014 (PSMSL, 2015). In stark contrast, the National Research Council (NRC, 2012) projected a rise in sea level at the San Francisco gauge of +28.0 ± 9.2 cm from 2000 to 2050. The average annual relative sea level at the San Francisco gauge rose +17.3 cm from 1855 to 1992 (PSMSL, 2015). Combining this actual rise to 1992 with the projection of −18 cm from 1992 to 2050 by Boon and Mitchell results in a projected net fall in relative sea level of −0.7 cm over 195 years from 1855 to 2050. Despite a rise in sea level of +18.9 cm at San Francisco from 1855 to 2014, global warming, and worldwide sea-level rise, the Boon and Mitchell projection leads to the absurd result that sea level will fall at San Francisco over 195 years from 1855 to 2050.

Boon and Mitchell projected that 9 of the 10 tide gauge locations they considered in California, Oregon, and Washington would have drops in sea level of −6 to −34 cm from 1992 to 2050. These projections completely disagree with projections by the NRC (2012) of rises of +18–48 cm on these coasts from 2000 to 2050. What is happening with sea-level change on these coasts is illustrated by the tide gauge recording at San Diego, California (Figure 1). Boon and Mitchell project 2.5- and 50-percentile drops in sea level at San Diego from 1992 to 2050 of −33 cm and −7 cm, respectively. Yet Figure 1 shows no apparent sign that sea level will drop from 1992 to 2050. Rather than just

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determining acceleration based on a single period of 1969–2014, centered in 1992, it is illustrative to consider the entire 109-year San Diego tide gauge record using a sliding 46-year window. First, the acceleration from 1906 to 1951, centered in 1929, is determined, then the acceleration from 1907 to 1952, centered in 1930, and so on thorough a record of 1969–2014, centered in 1992. Figure 2 shows that accelerations determined from 46-year portions of the San Diego gauge record oscillate as a result of decadal variations. Boone and Mitchell obtained a negative acceleration at San Diego for their analysis centered in 1992 because sea level is in a negative acceleration phase for this particular time period, as seen in Figure 2.

Bromirski *et al.* (2011) said that the negative-acceleration phase of sea-level change on the U.S. Pacific coast, including San Diego, would soon end and be followed by a positive acceleration phase in a long-term pattern of oscillations between positive and negative phases due to decadal variations, as seen in Figure 2. Boon and Mitchell acknowledged that Bromirski *et al.* might be correct, but they said that their 46-year records did not show a shift had started. Their records did not show a shift because they only considered records centered on a single year, 1992. As Figure 2 clearly shows, the negative acceleration phase reversed direction in a record from 1964 to 2009, centered in 1987, and is now rapidly moving toward a positive acceleration phase. Figure 2 supports Bromirski *et al.*, and in a handful of years San Diego will move to a positive acceleration phase.

Projections by Boon and Mitchell also disagree remarkably with projections of the Intergovernmental Panel on Climate Change (IPCC, 2013). Annex II of IPCC shows a projected global sea-level rise from 1986–2005 to 2050 of +25.0 ± 7.0 cm to +27.0 ± 7.0 cm, depending on the scenario. Local ground motion at Boston, Massachusetts, is −0.84 ± 0.08 mm/y (Zervas, Gill, and Sweet, 2013). Subtracting ground motion of −3.8 ± 0.4 cm to −5.4 ± 0.5 cm (covering the range from 1986–2005 to 2050) gives a 2050 total range of projected relative sea level rise at Boston of +28.8 ± 7.0 cm to +32.4 ± 7.0 cm. Boon and Mitchell have 2.5-, 50-, and 97.5-percentile projections of relative sea-level rise for Boston of +46 cm, +62 cm, and +80 cm. Their low projection and the IPCC high projection do not even overlap at 95% confidence intervals. Similarly, projections for San Francisco based on IPCC projections with ground motion added result in a 50-percentile global sea-level rise from 1986–2005 to 2050 of +25.0 ± 7.0 cm to +27.0 ± 7.0 cm, depending on the scenario. NRC (2012) used a different method and projected a similar rise of +28.0 + 9.2 cm from 2000 to 2050. Both sets of projections contrast remarkably with the 50-percentile fall of −18 cm projected by Boon and Mitchell.

Houston and Dean (2013) applied 40-, 50-, and 60-year moving windows described for San Diego to every long tide record in the world and found the same significant positive and negative phases of calculated acceleration that would make projections based on short records nonsensical. Figures 3–8 show examples using the moving 46-year window approach described for San Diego. Calculated accelerations do not continue at the same rate for even a year, and on a decadal scale there are large oscillations between calculated positive and negative accelerations. For example, Figures 3 and 4 for Stockholm, Sweden, and Mumbai, India, show that a shift in the analysis period of 1 year can change acceleration by more than ±0.1 mm/y^2, which, when projected for 58 years, would change sea level by about ±34 cm. The plot for New York, New York, in Figure 5 is typical of accelerations on the U.S. NE coast. Just as a negative acceleration phase has bottomed out in San Diego, a positive acceleration phase appears to be topping out in New York and heading toward a negative phase, the most recent of which lasted for about 30 years at New York. Note from Figure 6 that North Shields, Great Britain, which is in the north Atlantic, as is New York, has phase oscillations similar to New York, and it is already moving from a positive acceleration phase toward a negative. Douglas (1992) and Houston and Dean (2013) showed that about half the gauges in the world at any given time are in a positive acceleration phase and the other half in a negative acceleration phase, as seen in Figures 3–8. Phases always reverse eventually on time scales less than 58 years.

CONCLUSIONS

Houston and Dean (2013, 1071–1072) wrote, "It is not valid to project future sea-level rise based on acceleration or trend difference determined using tide gauge record lengths of only about 40 to 60 years." This conclusion

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holds for projections by Boon and Mitchell. They assumed accelerations they determined from 46-year records would be stationary in time from 1992 to 2050. However, they demonstrated accelerations were not stationary even for short periods when they noted that 6-year shifts in the periods they analyzed resulted in "dramatic" changes in accelerations and that adding 3 years to records caused similar large changes. Projections to 2050 are of little value to a community when they change greatly with the passage of a few years.

The Boon and Mitchell projections of falling sea level from 1992 to 2050 on the coasts of California, Oregon, and Washington are not valid, and they are troublesome because they support inaction in addressing sea-level rise on the U.S. Pacific coast. Why prepare for sea-level rise in San Francisco from 2014 to 2050 if Boon and Mitchell project sea level at the 50-percentile level will fall –20 cm (there was a rise of about +2 cm from 1992 to 2014) and there would be a rise of only +2 cm at the 97.5-percentile? Climate change skeptics would say that even in the worst-case scenario, sea-level rise would be negligible at San Francisco from 2014 to 2050. The same argument could be made for most of the U.S. Pacific coast and Hawaii, based on Boon and Mitchell projections.

It is best not to use acceleration determined from tide gauge records to project future sea-level change. Decadal variations heavily corrupt the computation of acceleration for short records, and accelerations computed from long records do not account for effects of increasing global temperatures on sea-level change. Instead, IPCC (2013) projections should be used to determine the global sea-level rise component of relative sea-level rise. Annex II of IPCC has global sea-level rise projections for every decade to 2100. Local ground motion should then be subtracted from IPCC projections (ground subsidence is negative and when subtracted adds to the rise). Some tide stations have GPS measurements that can be used to determine ground motion, but if not available, the approach in Zervas, Gill, and Sweet (2013) for estimating local ground motion can be used.

Boon and Mitchell present a valuable approach to analyzing tide gauge records, but it is overshadowed by their invalid projections based on 46-year records. In reply to this discussion, they should be explicit that the sea-level projections in their paper, which undercut the credibility of projections by the NRC (2012) and the IPCC (2013), should not be used.

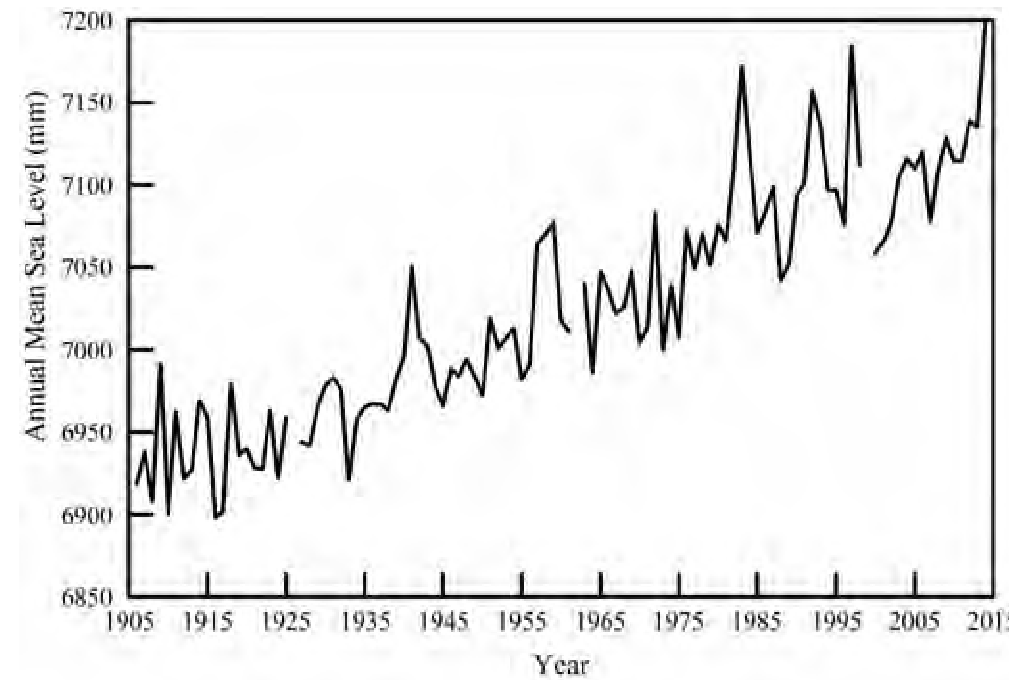

Figure 1. Tide gauge recording at San Diego from 1906 to 2014 (PSMSL, 2015; retrieved 24 December 2015). Data record missing for 1926 and 1999.

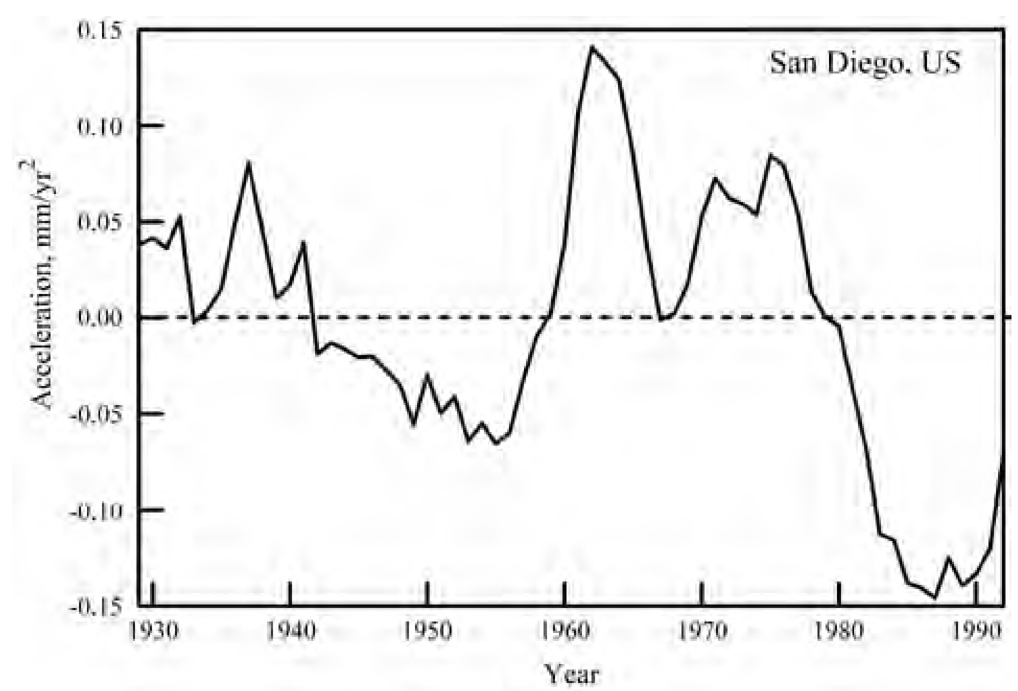

Figure 2. Sea-level acceleration at San Diego based on 46-year records centered in years 1929–1992 and representing the years 1906–2014.

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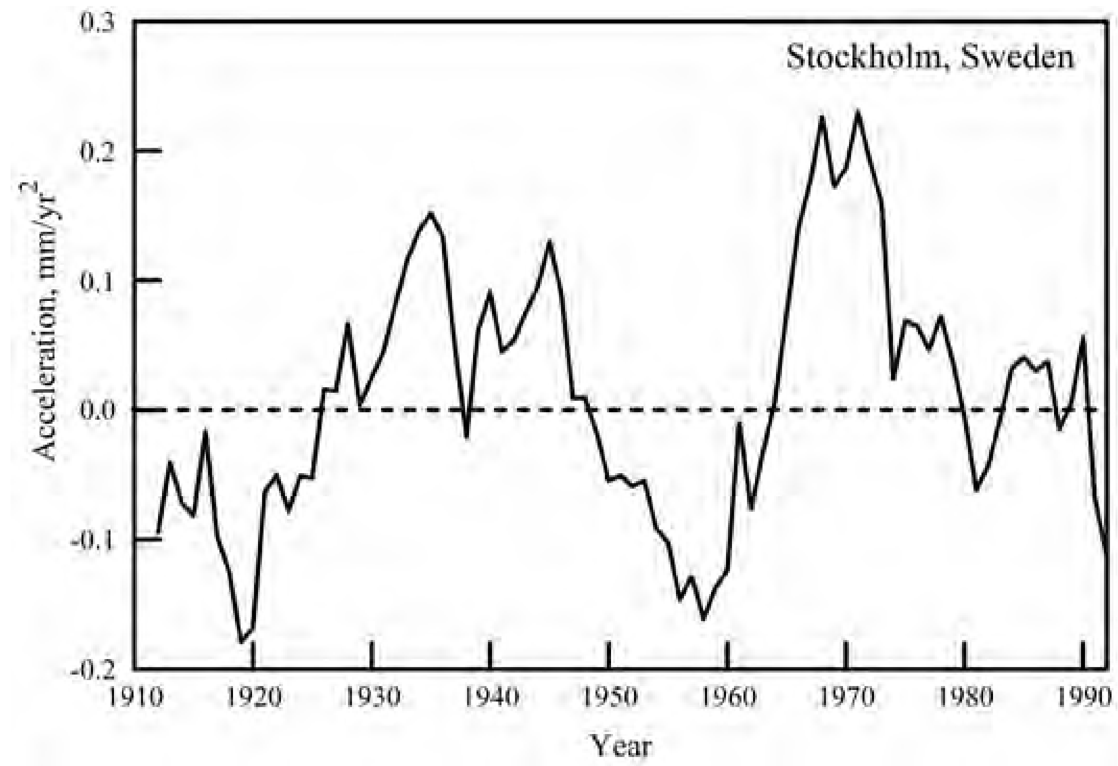

Figure 3. Sea-level acceleration at Stockholm based on 46-year records centered in years 1912–1992 and representing the years 1889–2014.

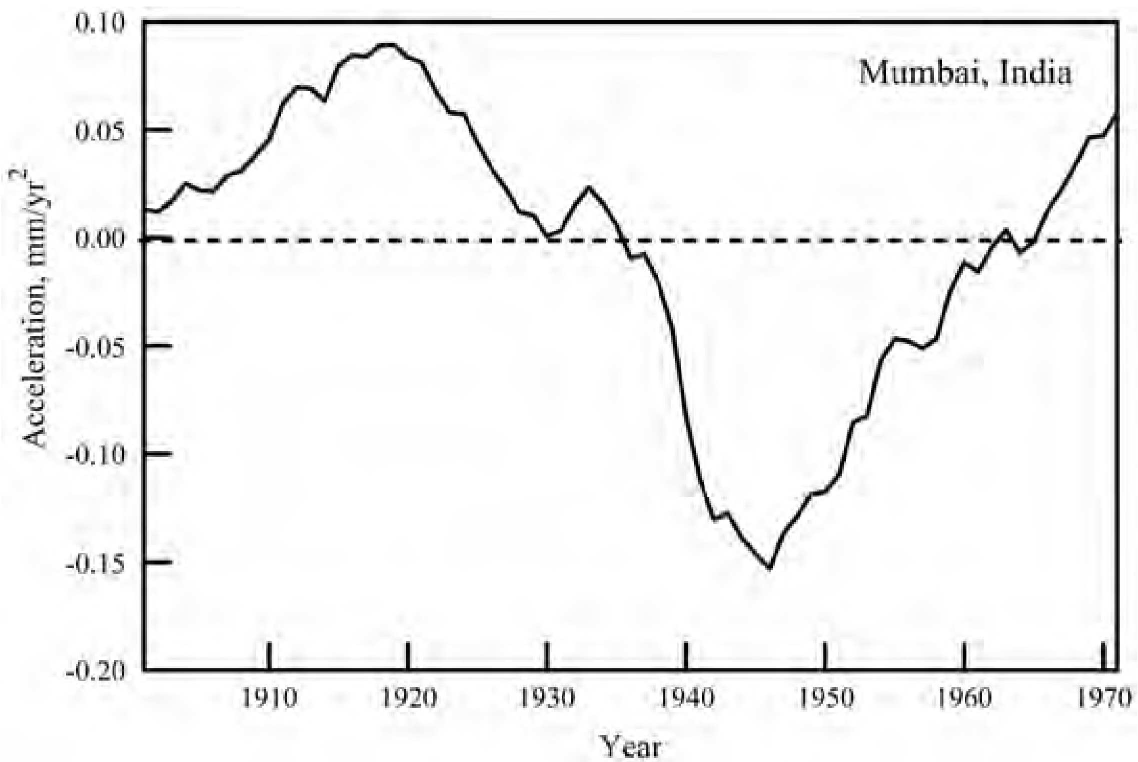

Figure 4. Sea-level acceleration at Mumbai based on 46-year records centered in years 1901–1971 and representing the years 1878–1993.

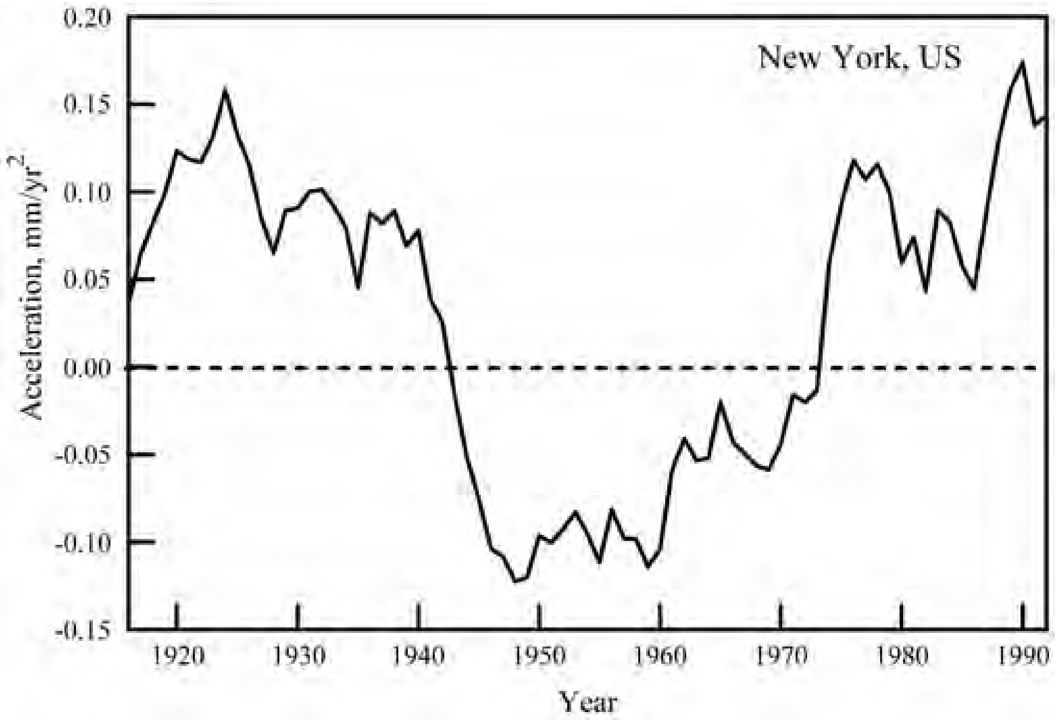

Figure 5. Sea-level acceleration at New York based on 46-year records centered in years 1916–1992 and representing the years 1893–2014.

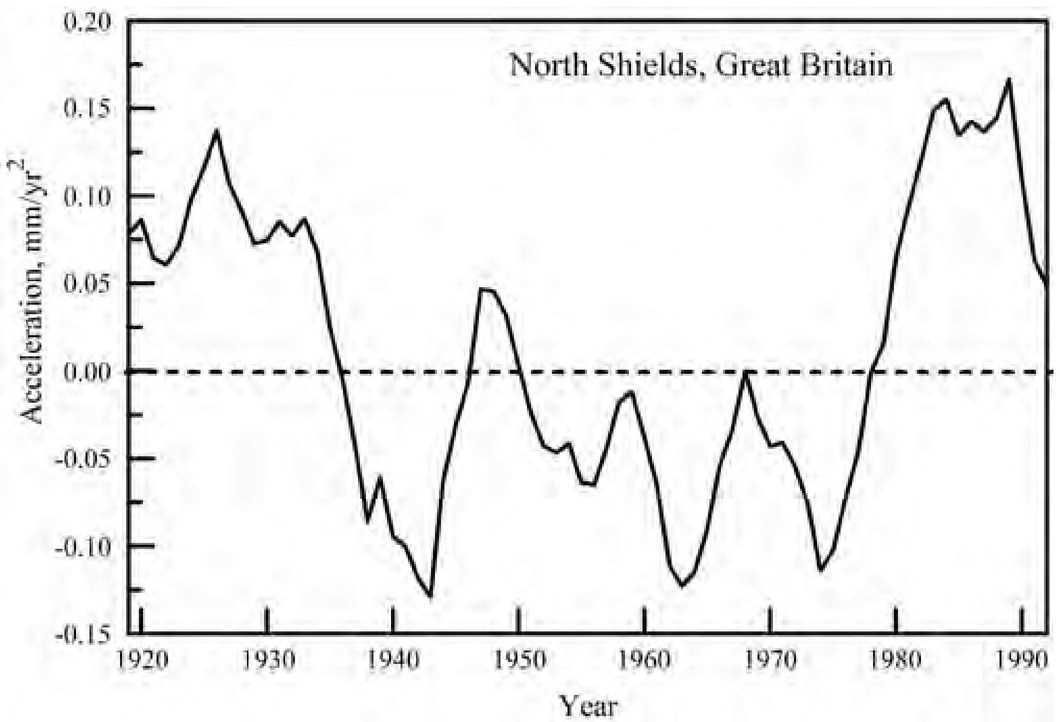

Figure 6. Sea-level acceleration at North Shields based on 46-year records centered in years 1919–1992 and representing the years 1896–2014.

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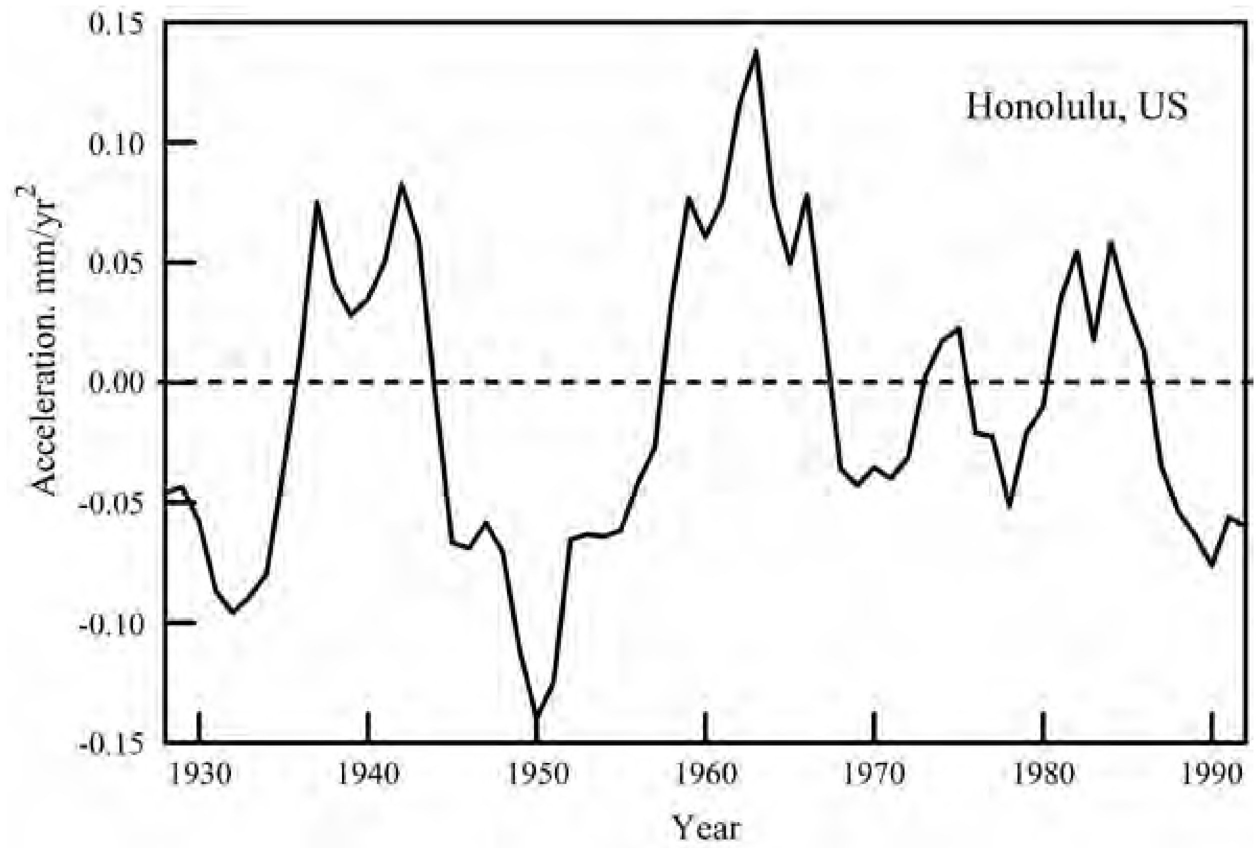

Figure 7. Sea-level acceleration at Honolulu, Hawaii, based on 46-year records centered in years 1928–1992 and representing the years 1905–2014.

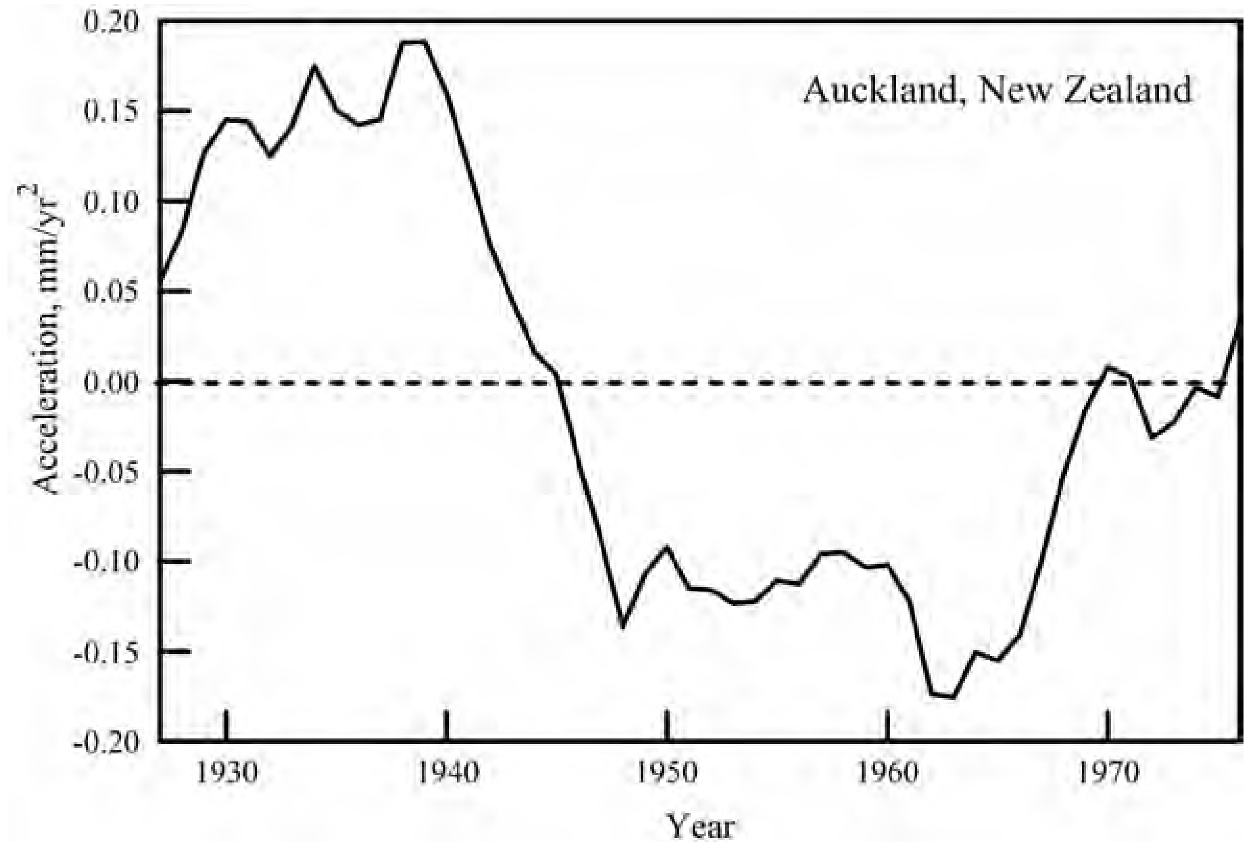

Figure 8. Sea-level acceleration at Auckland, New Zealand, based on 46-year records centered in years 1927–1976 and representing the years 1904–1998.

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Nonlinear Change in Sea Level Observed at North American Tide Stations.
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INTRODUCTION

Objections raised by J.R. Houston to relative mean sea level (RMSL) projections made by Boon and Mitchell (2015) stem from his previous work published with the late professor R.G. Dean. Houston and Dean (2011) stated that "Without sea-level acceleration, the 20th-century sea-level trend of 1.7 mm/y would produce a rise of only approximately 0.15 m from 2010 to 2100; therefore, sea-level acceleration is a critical component of projected sea-level rise" (p. 409). After applying quadratic regression to records from 57 tide stations across the United States and its territories, these authors cast considerable doubt on that same component by finding, on average, a slight deceleration. Citing work by Douglas (1992), they computed an error about their group average from the 57 residuals, rather than using the error estimates of the individual station records. Six stations that showed more than a slight acceleration were termed outliers on the basis of their "short" records of between 62 and 70 years (Houston and Dean, 2011, p. 411). Houston and Dean (2013) further asserted that decadal variations (*e.g.*, Sturges and Hong, 2001) would obscure underlying accelera-tions if record lengths for individual gauges were not greater than at least 75 years. These findings, if correct, place severe limitations on estimates of temporal and spatial variation in the rate of sea-level change as measured by tide gauges. In retrospect, it is not surprising that the underlying acceleration of −0.0014 ± 0.0161 mm/y^2 they found by smoothing across 57 locations using records lengths varying between 62 and 156 years is not statistically different from zero. We are among those who have questioned their deterministic assertions in favor of a data-driven probabilistic approach that seeks to understand trends in recent sea-level acceleration looking forward rather than backward in time. The purpose of our research is not the derivation of a globally averaged, worldwide estimate of sea-level change throughout the 21st century; we wish to know what recent observations now suggest at individual locations within the coastal zone of North America over the next few decades.

Measuring Sea-Level Acceleration

Sliding windows have been applied to detect trend behavior and acceleration in tide gauge observations by the discussant and other authors (Boon, 2012; Boon and Mitchell, 2015; Jevrejeva *et al.*, 2013; Sallenger, Doran, and Howd, 2012) along with nonparametric methods (Ezer, 2013; Ezer, Haigh, and Woodworth, 2016). In Boon (2012) and Boon and Mitchell (2015), serial trends were investigated using monthly RMSL data, with seasonal cycle removed, to detect periods of approximately linear change in the rate of sea level rise (or fall), providing evidence of constant acceleration (or deceleration). Having found such a period beginning around 1969 (Boon and Mitch-

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ell, 2015), we then applied a more rigorous statistical procedure, the moving block bootstrap (MBB; Mudelsee, 2010), which has confirmed acceleration and, in some cases, deceleration, at many U.S. and Canadian coastal locations in the post- 1969 period. In contrast, the discussant presents several figures showing acceleration widely varying between positive and negative rates at a given station, with few discernable patterns other than averaging near-zero throughout periods of record dating back to 1906. We suspect that much of the heightened variability seen in these figures is due to the small sample size employed in his determinations based on 46-year records, centered on each year across a series of years. The data therein consist of annual mean sea level, rather than monthly values, which then provides only 46 data points for each least-squares regression yielding an acceleration estimate. Error bands on the estimates are not shown, and serial correlation often present in raw times-series data is not accounted for. The MBB method used in Boon and Mitchell (2015) employs 552 random-block data points per estimate and then computes 9000 independent (serially uncorrelated) replicates to provide Bayesian probability distributions for our paired regression parameters as well as our year 2050 projections.

Our Sea-Level Projections

A *projection* here is an inference drawn from a quadratic regression model over a reasonable prediction period beyond the latest RMSL observation available. Thus, we refer to the year 2050 height percentiles in Boon and Mitchell (2015) as belonging to a 36-year projection (2014–2050), rather than 58 years (1992–2050), as the discussant has done. Monthly mean sea-level data now available for New York (NOAA National Ocean Service, 2016), with seasonal cycle removed by us, illustrate the relationship between our present 47-year (1969–2015) series of observations and the remaining 35-year projection from 2015 to 2050 (Figure 1). Although 0.40 m is projected from the single regression shown in Figure 1, our latest MBB median projection of 0.41 m is 0.06 m less than previously reported for New York (Boon and Mitchell, 2015; Table 1).

We agree that decadal variation (the magenta curve in Figure 1) is responsible for this change. However, rather than corrupting the data and rendering it unusable, the decadal signal we have examined using a third-order Butterworth filter with a 24-month cutoff instead modulates the fitted quadratic. Projections are then seen to vary in a well-defined cyclical pattern, as illustrated in Figure 2 using the New York data. A variation period of about 8 years is evident for the modulated quadratic projection (Figure 2), which is only slightly longer than the zero–up-crossing period of 6–7 years found for the decadal signal (Figure 1). In both figures, the curve representing the quadratic projection is bounded by confidence intervals that include approximately 95% of all monthly observations, the latter representing the expected range of the individual observations, as opposed to the predicted average in any given year (Draper and Smith, 1998). As expected, the confidence intervals in Figure 2 are wide at first but converge toward a fixed interval as the length of the observed time series increases. This interval will extend to 2050 and reminds us that sea-level in a given month, then as now, may be as much as 0.2 m higher or lower than the annual RMSL mean or median. Providing the decadal signal and underlying acceleration persist, a net RMSL rise of about 0.5 m above 1992 levels by 2050 now seems likely, or between two and three times the 0.19-m linear projection at New York, as seen in Figure 2. We find very similar patterns at Boston, Massachusetts; Baltimore, Maryland; and Norfolk, Virginia.

Comparison with USACE/NOAA Sea-Level Projections

Version 2015.46 of the U.S Army Corps of Engineers (USACE, 2016) online Sea-Level Change Curve Calculator provides year 2050 projections starting in 1992 by both USACE and NOAA. Figure 3 compares our 2.5%, 50%, and 97.5% probability percentile projections, given 1969–2014 observations at 45 tide stations, with the highest and lowest of four scenarios developed by NOAA for these stations. The lowest scenario is represented by a straight line based on NOAA's published linear rate of sea-level change at NOAA tide stations; the *highest* scenario is represented by a quadratic equation, $E(t) = at + bt^2$, whose quadratic coefficient (one-half acceleration) is a constant ($b = 0.156$ mm/y^2), which, when combined with the 20th century global rate ($a = 1.7$ mm/y), projects a rise of 2.0 m by 2100 (*i.e.* $t = 2100–1992 = 108$ years). One consequence of applying constant acceleration everywhere is that the range

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interval for NOAA's 2050 high–low projections (the length of the gray bars in Figure 3) is also constant at 0.52–0.53 m throughout. A second consequence results from using NOAA's published linear rates for the coefficient a. Because acceleration is assumed constant, station-to-station change in 2050 projection heights (the vertical position of the gray bars in Figure 3) is governed entirely by NOAA's historical sea-level trends. Whether these linear trends are based on records as long as 159 years (The Battery, New York) or a short as 50 years (Nantucket, Massachusetts), the NOAA 2050 high–low projections are very similar across any one region.

Information on actual acceleration or deceleration is presently absent in the USACE calculator projections, which is why we believe it is important that we offer the inferences we have made based on the recent RMSL observations available from NOAA's National Ocean Service. This is consistent with USACE policy and post-Katrina guidance requiring that "… all coastal projects be evaluated with respect to changes in sea level throughout the project life-cycle" (USACE *Sea Level Change Curve Calculator User Manual 2015*.46, p. 3). The following is a brief discussion of our principal findings by region.

U.S. Atlantic Stations

Our 2050 projections for the Atlantic stations in Figure 3 clearly show a break in accelerated rise rates decreasing south of Cape Hatteras, North Carolina, as first observed by Sallenger, Doran, and Howd (2012) in confirming recent model predictions based on ocean dynamics (Yin, Schlesinger, and Stouffer, 2009). Specific features of the North Atlantic western-boundary ocean circulation involved have been further described by Ezer (2013), Ezer *et al.* (2013), and Yin and Goddard (2013), along with additional observations by Boon (2012) and Boon and Mitchell (2015). To be sure, uncertainty exists as to how coastal sea level will respond to open-ocean processes and existing cycles as both evolve with time. Rather than an excuse not to, this is a reason for, continuing to analyze new RMSL observations as soon as they become available.

U.S. Gulf Stations

Among 2050 projections for the Gulf stations in Figure 3, most of ours are in good agreement with those by NOAA. However, the probable range [95% highest density interval (HDI)] we show for Galveston (Pier 21), Texas, is clearly lower than the high–low scenarios offered by NOAA, the latter being the highest among the 45 U.S. stations included in our analyses. The reason, we believe, is due to a substantial decline in land-subsidence rates following broad replacement of extensive ground-water mining by surface water supplies during the 1970s in the heavily industrialized Houston–Galveston region (Galloway, Jones, and Ingebritsen, 1999). Our analysis underscores the uncertainty associated with future sea-level change at Galveston before a state of equilibrium has definitely returned. In this instance, the full 108-year tide record now available at Galveston is more indicative of past rather than future sea level change.

U.S. Pacific Stations

Here, our 2050 projections in Figure 3 fall well below those by NOAA, even at Juneau and Ketchikan, Alaska, where rapid coastal emergence drives falling RMSL. We state, once again, that our analyses and projections are based on the 1969–2014 period and not on the 1855–2050 straw man the discussant erects at San Francisco, California. Bromirski *et al.* (2011) noted that both tide-gauge measurements and altimetry since 1983 indicate virtually no increase in sea level along the Pacific coast. These authors attribute the suppression of regional sea-level rise along this coast to a dramatic change in Pacific ocean-wind stress curl after a mid-1970s regime shift, which recent evidence suggests may soon revert to its previous state followed by resumption of the expected normal–accelerated–sea-level rise. That may well be the case, but the presumption here, and implicit in the USACE sea-level curve calculator, is that global sea-level acceleration in any one scenario is ubiquitous and easily downscaled to fit one location, as well as the next, anywhere, after an adjustment for the historical linear trend. We will continue to look at the latest observations.

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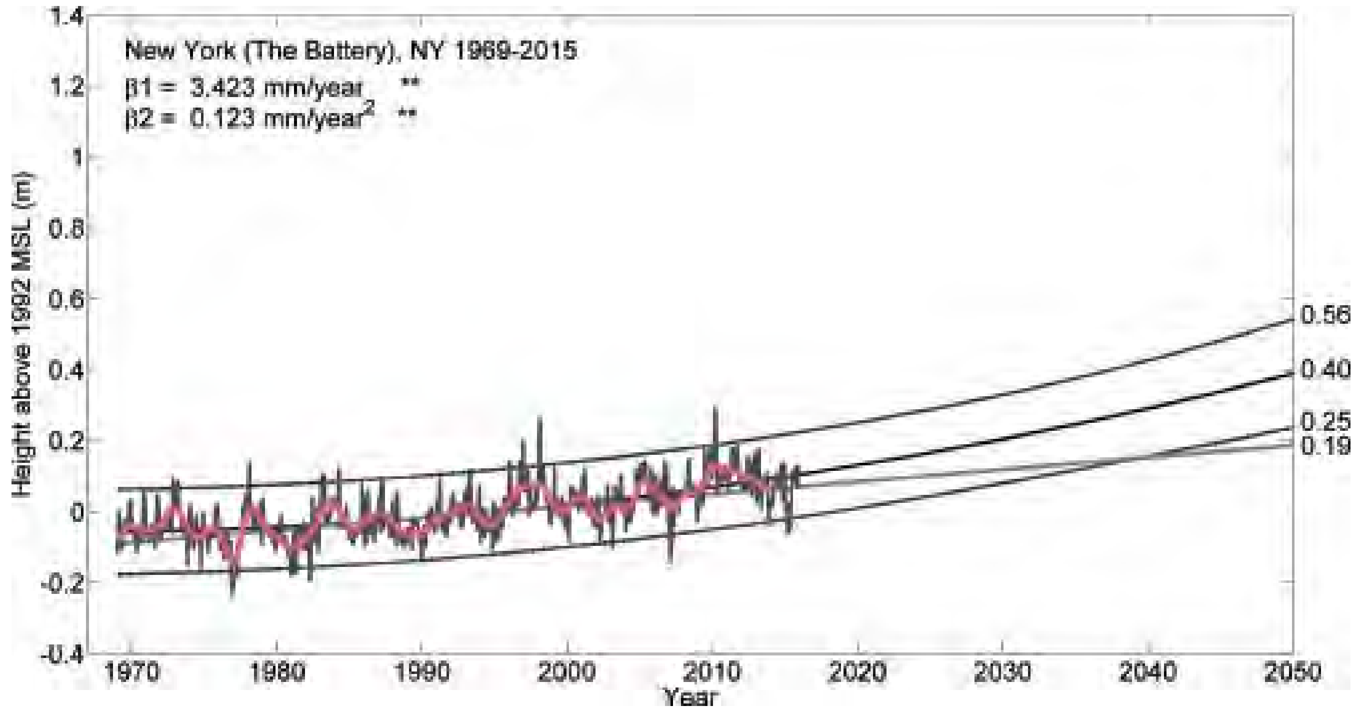

Figure 1. Quadratic regression applied to NOAA 1969–2015 monthly mean sea-level series at The Battery, New York, after removal of the seasonal cycle. Double asterisks (**) indicate derived values of rise (b1) and acceleration (b2) are significant at 99% level of confidence. Confidence bands (dotted lines) surrounding the quadratic projection to the year 2050 (solid black line) include approximately 95% of monthly observations. Linear projection to the year 2050 is shown by the solid-gray line with low-pass filtered, decadal signal (magenta) superposed on monthly observations.

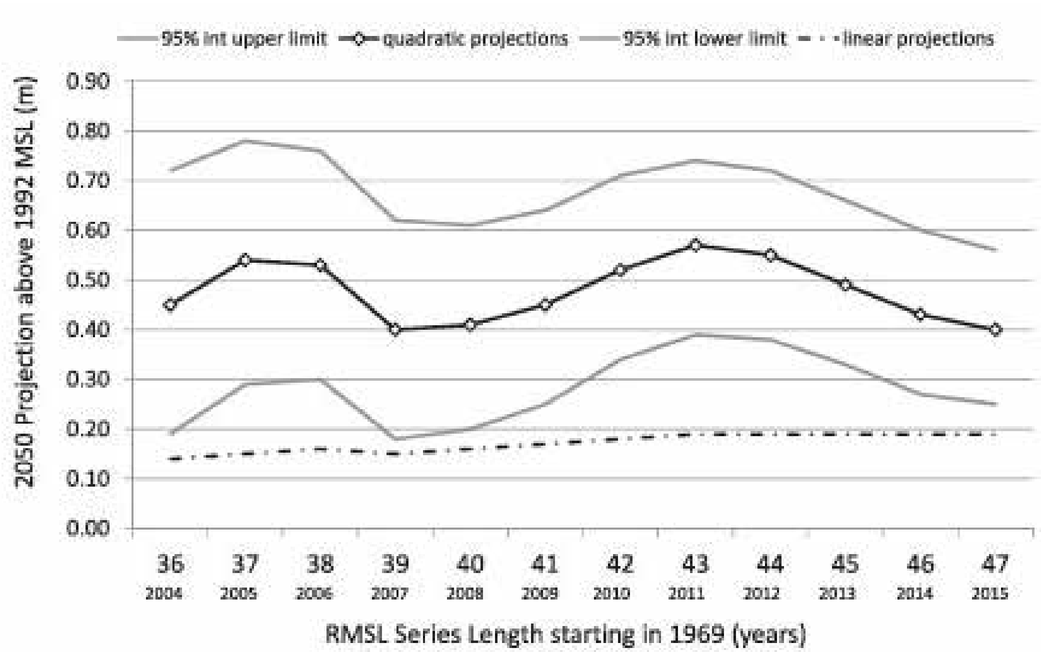

Figure 2. Plot of 2050 projections (m) above 1992 mean sea level (MSL) as a function of series length (years) since 1969 at The Battery, New York. Decadal signal modulation of quadratic projection (the solid line with the diamond markers) is apparent as an ongoing, well-defined cycle with little effect on rising linear projections (dash–dot line). Note 95% confidence bands (gray lines) converge to an expected limit of about ±0.15 m on monthly deviations from the quadratic regression.

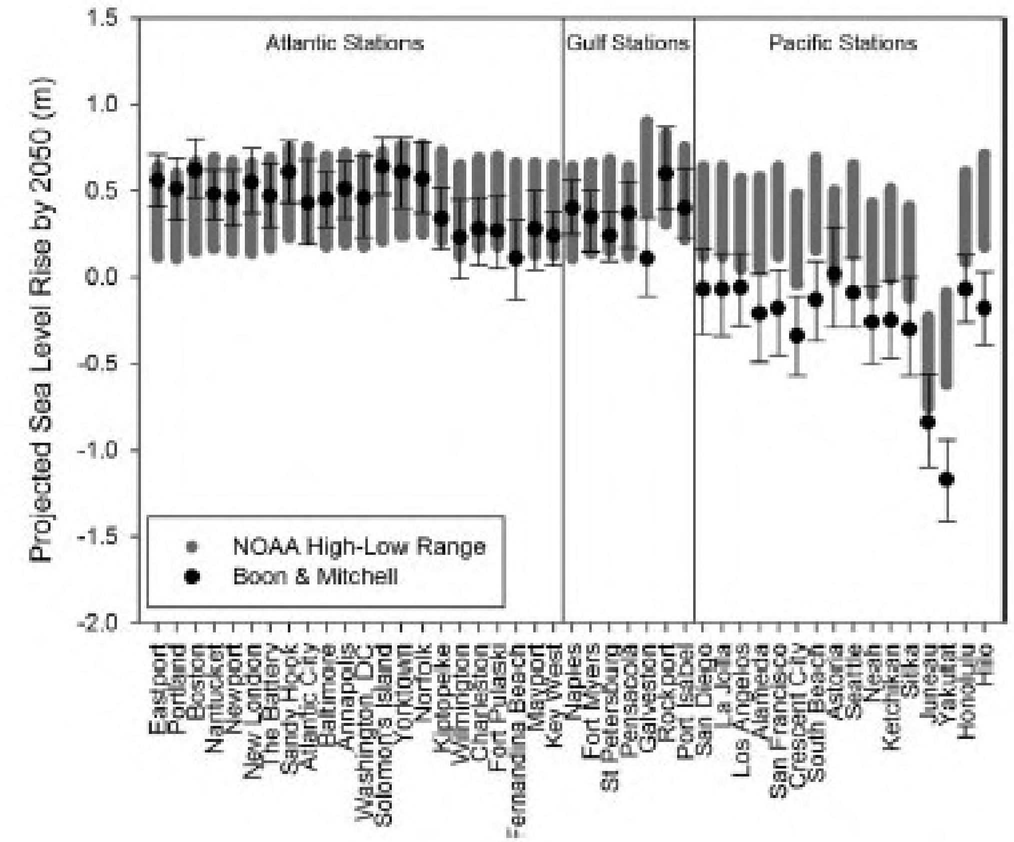

Figure 3. Comparison of year 2050 mean sea-level projections relative to 1992 mean sea level (MSL) by Boon and Mitchell (2015) with NOAA projections at 45 U.S. tide stations. Thin bars represent the 95% highest density interval (95% HDI) as described in Boon and Mitchell (2015) with the black dot indicating median probability density. Thick-gray bars represent NOAA highest and lowest 2050 projections taken from the USACE online Sea-Level Change Curve Calculator, Version 2015.46.

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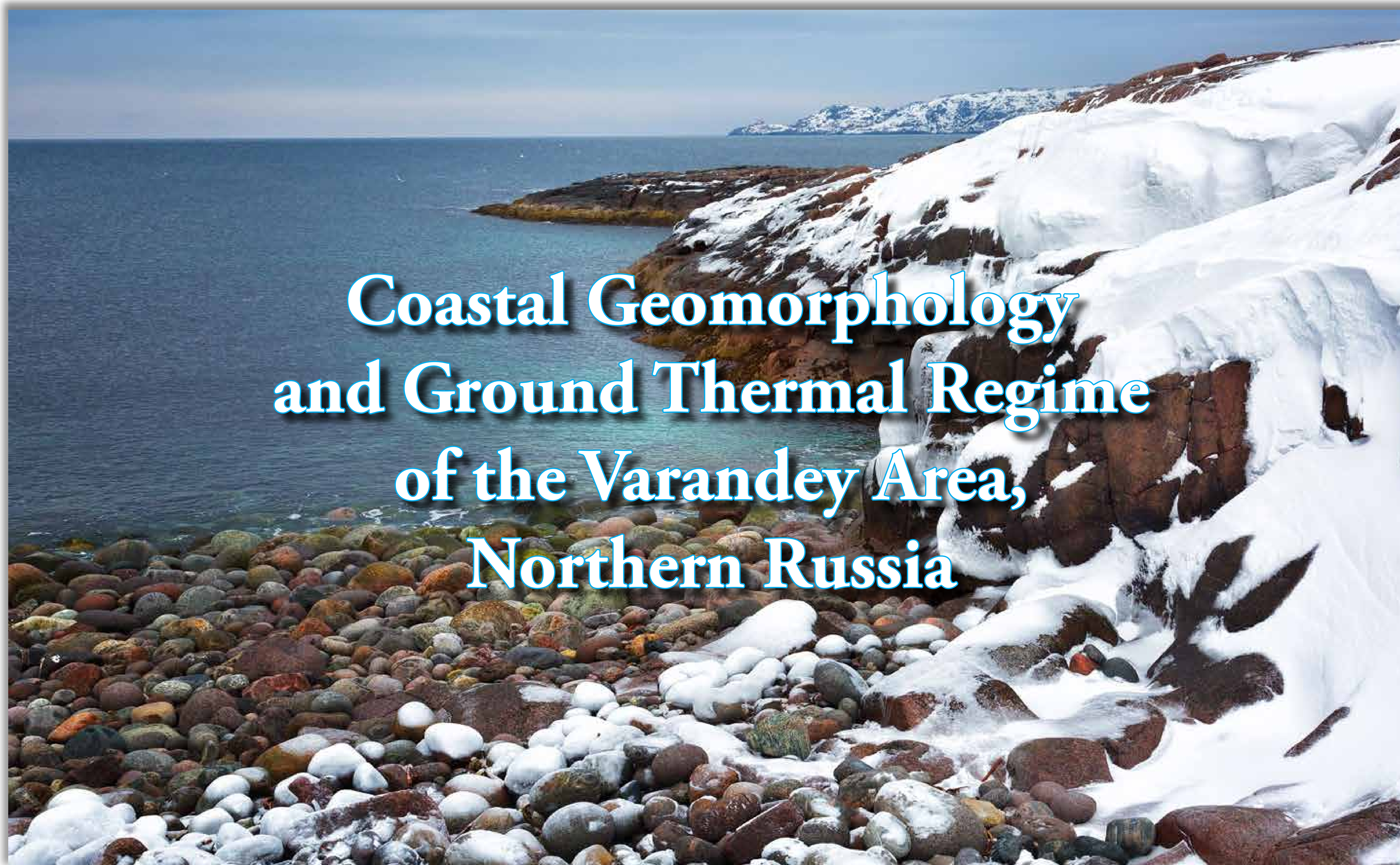

Coastal Geomorphology and Ground Thermal Regime of the Varandey Area, Northern Russia

Coastal Geomorphology and Ground Thermal Regime of the Varandey Area, Northern Russia

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ABSTRACT

This study documents a regional summary of the present geomorphology of the Varandey area coastline of northern Russia. Fieldwork was undertaken over three seasons (2011–2013) and combined with observations from 1999. The Varandey area has morphologies varying from low-gradient, wide sandy shores with dune belts that reflect stable and aggrading coasts (where sandy shore processes govern the coastal dynamics) to subvertical coastal ice-rich bluffs and narrow beaches, which reveal active coastal recession (where cohesive shore processes are dominant). In addition to these geomorphological observations, the study documents a continuous ground temperature recorded from July 2011 through August 2013 by six thermistor strings installed on a 500-m-long transect perpendicular to the coast. The thermal regime of the ground in permafrost areas controls its mechanical strength and stability, therefore influencing the coastal dynamics through a recession caused by a thawing bluff failure (thermodenudation). The ground temperature recorded along the transect varied from −1.9°C at the thermistor strings located 500 m from the shoreline to 0.3°C at the thermistor strings situated on the upper beach. The temperature measurements characterize this area as being affected by a warm permafrost near the temperature phase change (transient conditions), and the stability of the ice-rich segment of this coastline is sensitive to future variations of air temperature. The investigation did not reveal permafrost underneath the upper beach of the thermally investigated section and did identify numerous cryopegs in the inland portion.

ADDITIONAL INDEX WORDS: *Cohesive shores, permafrost.*

INTRODUCTION

A growing industrial interest in hydrocarbon in the Arctic has necessitated the construction of coastal infrastructures built on permafrost, which in turn requires a better understanding of the behavior and stability of these coastal areas. The Varandey area (also called the Bolshezemelskaya tundra) is located in the Pechora sector of the Barents Sea in northwestern Russia (Figure 1) and is a key site for hydrocarbon development in the Arctic. The 90-km-long coastline of the Varandey area is affected by permafrost (Brown *et al.*, 1997) and erosion rates up to 6.5 m/y (Novikov and Fedorova, 1989). The influence of human activity has increased the rates of coastal destruction, which has been considerably amplified in recent decades along Russian coasts in connection with the development of oil and gas resources on the shelf (Ogorodov, 2005). An old oil terminal installed on the Varandey coastline was shut down in 2006 because of

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its vulnerability to the imminent threat of an actively recessing coastal bluff. The airstrip of the Varandey settlement is also situated near the shoreline, and erosion protection, such as fences to hold sand dunes along the strip and heavy material deposited at the toe of the recessing coastal bluff, have been installed to minimize the coastal recession at this location.

Sea ice is usually present in the area from early October through late June (Sinitsyn *et al.*, 2013), thereby limiting the wave energy reaching the coast to a short summer period of ice-free water. The sea floor in the area has a smooth relief, gently tilting northward with an average depth of 20–30 m (Levitan *et al.*, 2000). Two wide river estuaries—the Varandeskaya Guba and Peschanka—divide the Varandey coastline into three geographic sectors: Pesyakov, Varandey, and Medynskiy (Figure 1).

High rates of coastal recession are common in Arctic areas, which are characterized by ice-rich soils. In addition to the coastal morphodynamic processes occurring in temperate coasts (hydrodynamic and aeolian processes), these frozen coasts are affected by zonal processes such as thermodenudation and thermoabrasion (Aré, 1988). Thermodenudation processes are primarily driven by meteorological conditions (air temperature, wind regime, and amount of precipitation) that thaw the coasts and trigger bluff failure through surface wash and various mass-wasting movements (Guégan and Christiansen, 2016). The Arctic coasts are also affected by thermoabrasion, which refers to the mechanical and thermal effects of waves on bluffs that produce erosion, primarily through the development of a thermoabrasional niche at the base of the bluff that generates block failure. Arctic coastal systems have a great spatial variation in their response to different environmental forcing agents; hence, careful considerations are needed regarding their dynamic response in the context of global climate change (Cowell *et al.*, 2006; Stive, 2004). However, in Arctic coastal areas, where winter surveys encounter logistical and accessibility challenges, a continuous monitoring of data of coastal thermal evolution is sparse and sporadic. A detailed documentation of the current geomorphological and thermal conditions of the natural (undisturbed) coastal setting conditions is needed to help track the evolution of this permafrost coast under a changing climate and increased human activity.

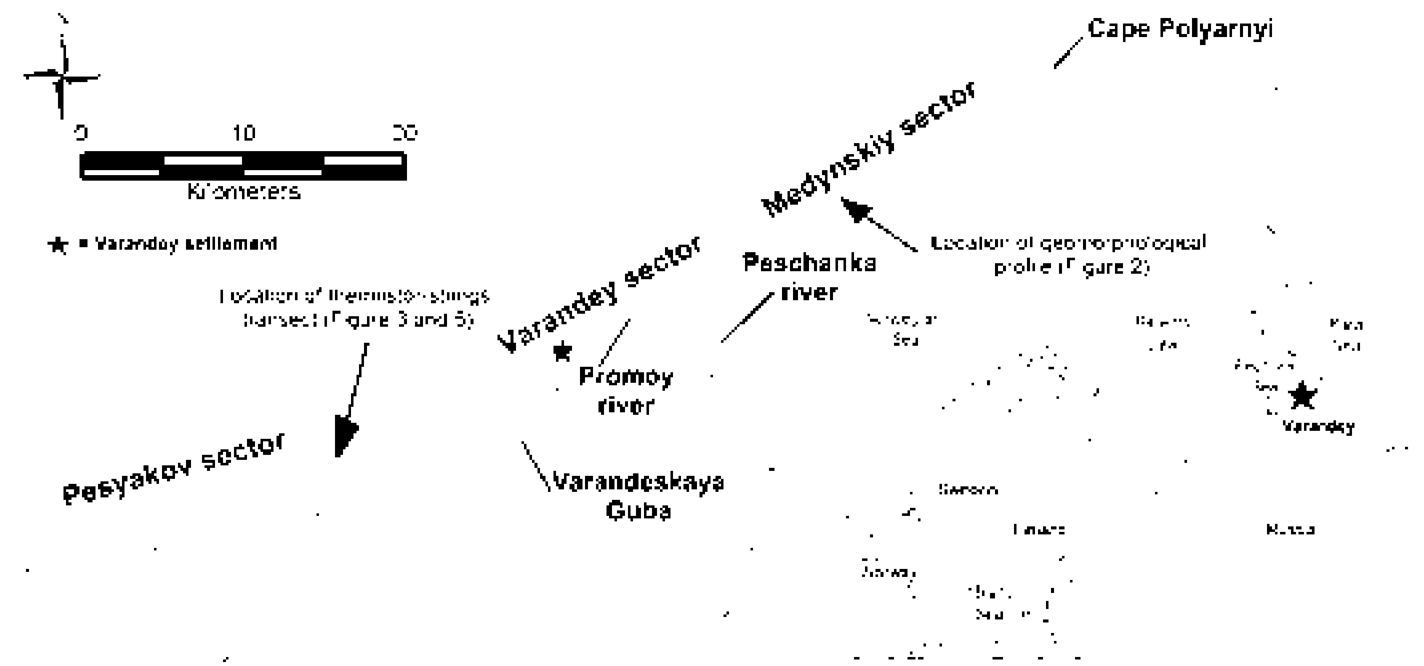

Figure 1. Location of the Varandey area in northern Russia. The 90-km-long coastline is divided into three geographic sectors: the Pesyakov, Varandey, and Medynskiy sectors. Locations of Figures 2, 3, and 5 of this paper are indicated.

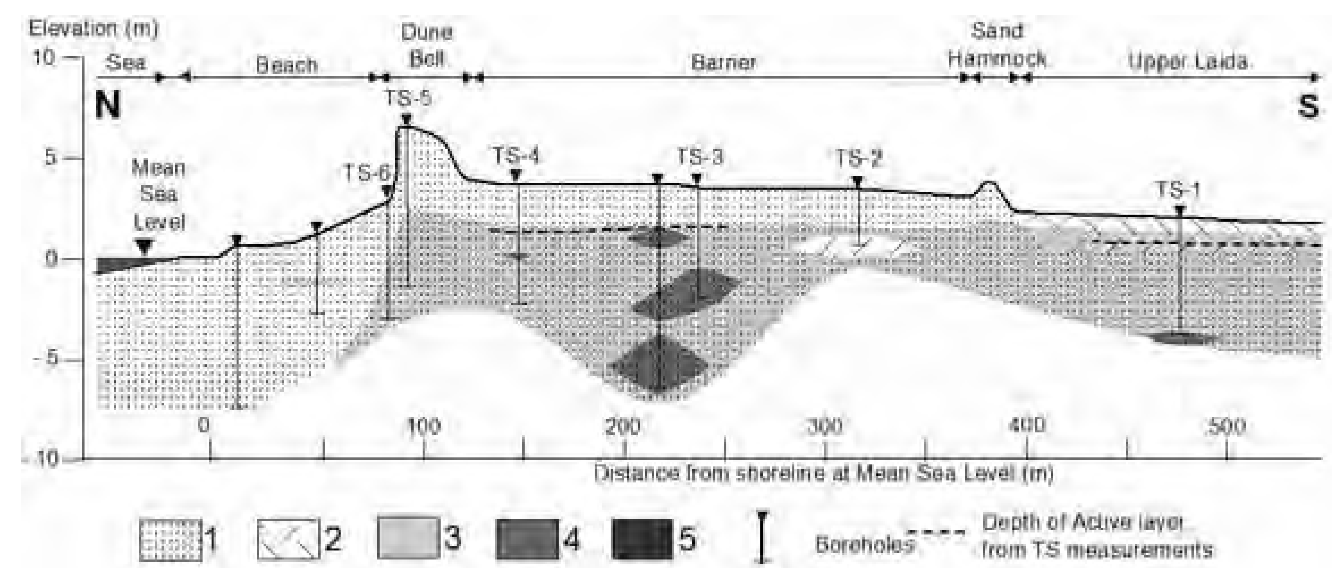

Figure 2. Geocryological profile on date of drilling in the middle part of Pesyakov Island: 1 – fine sand, 2 –sand with remains of peat, 3 – ice-bonded frozen ground, 4 – probable lenses of cryopegs, 5 – seawater; TS1 through TS6 show thermistor strings. The boundary for ice-bonded soil is drawn based on the probe results and is therefore representative of the soil condition in June 2012. The geocryology profile features the transition between a stable permafrost regime inland to warmer subsea soil (transient area), as well as a steep permafrost table underneath the upper beach.

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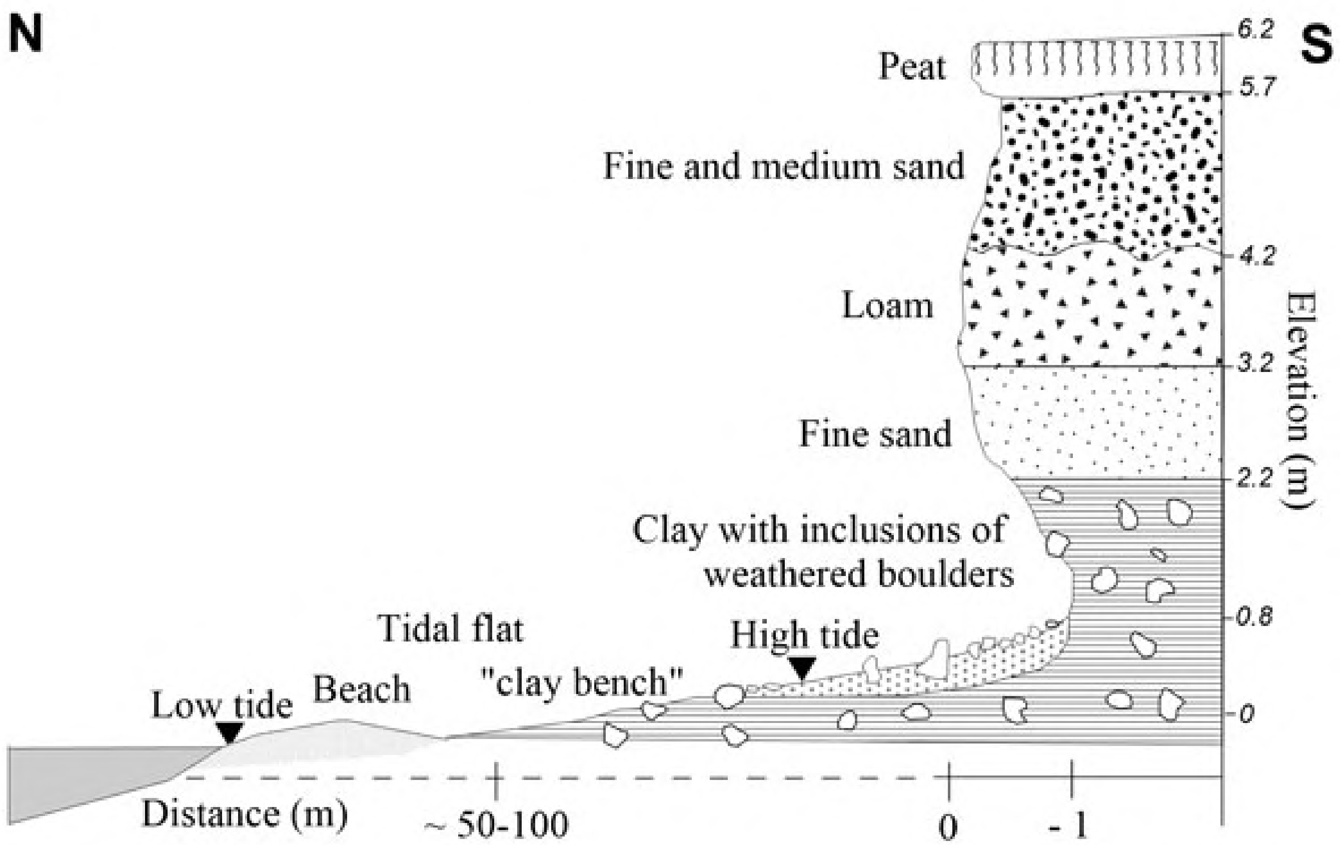

Figure 3. Geological-geomorphological profile of a coastal bluff in the Medynskiy sector in October 1999. The subvertical bluff geometry with an undercut at its base highlights the importance of wave action observed in the fall. The coastal bluff geometry and the narrow beach suggest a recessing coastal segment.

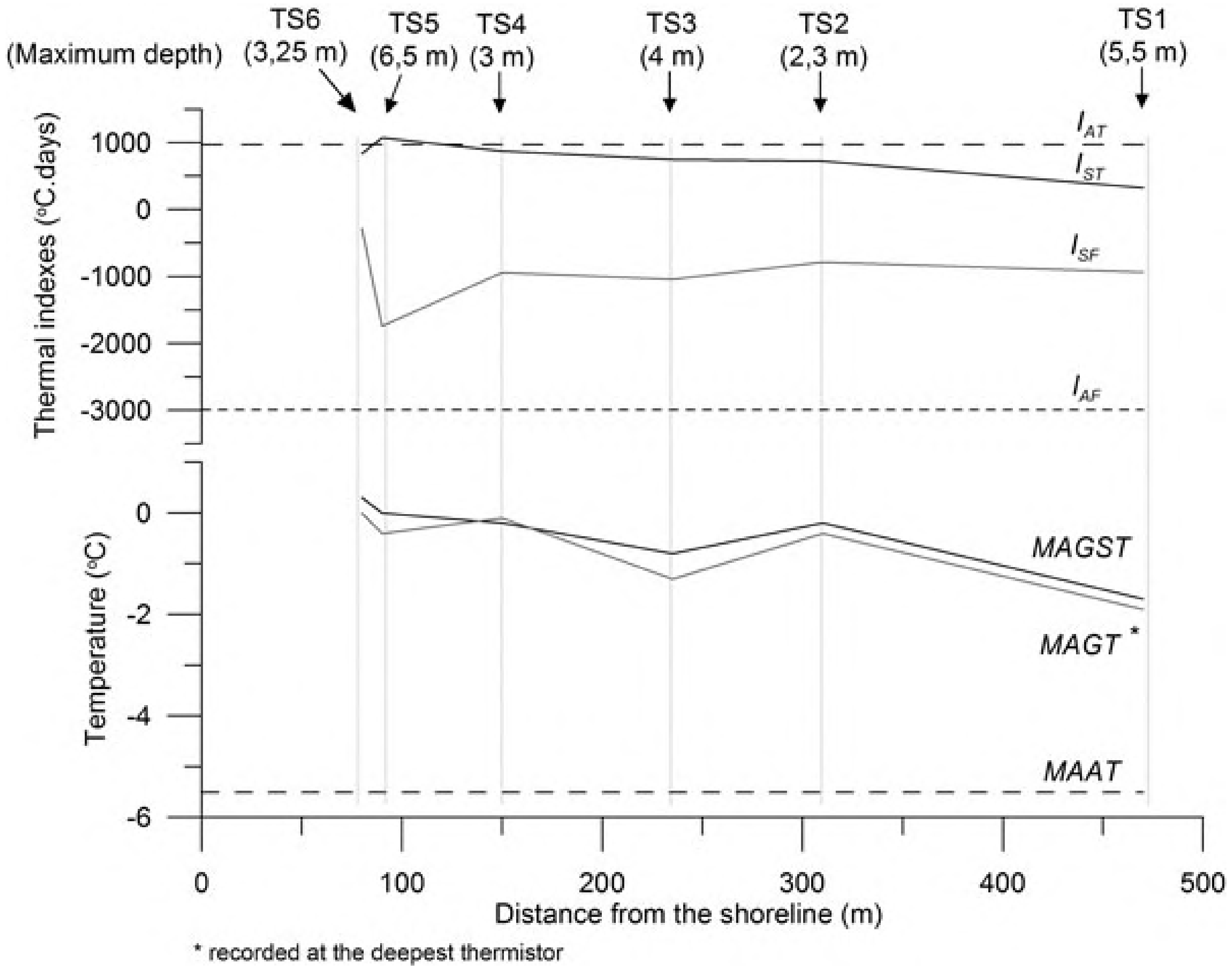

Figure 4. Ground thermal characteristics recorded at each thermistor string highlighting an increase of annual mean ground surface temperature (AMGST) and annual mean ground temperature (AMGT) toward the shoreline. AMAT is annual mean air temperature.

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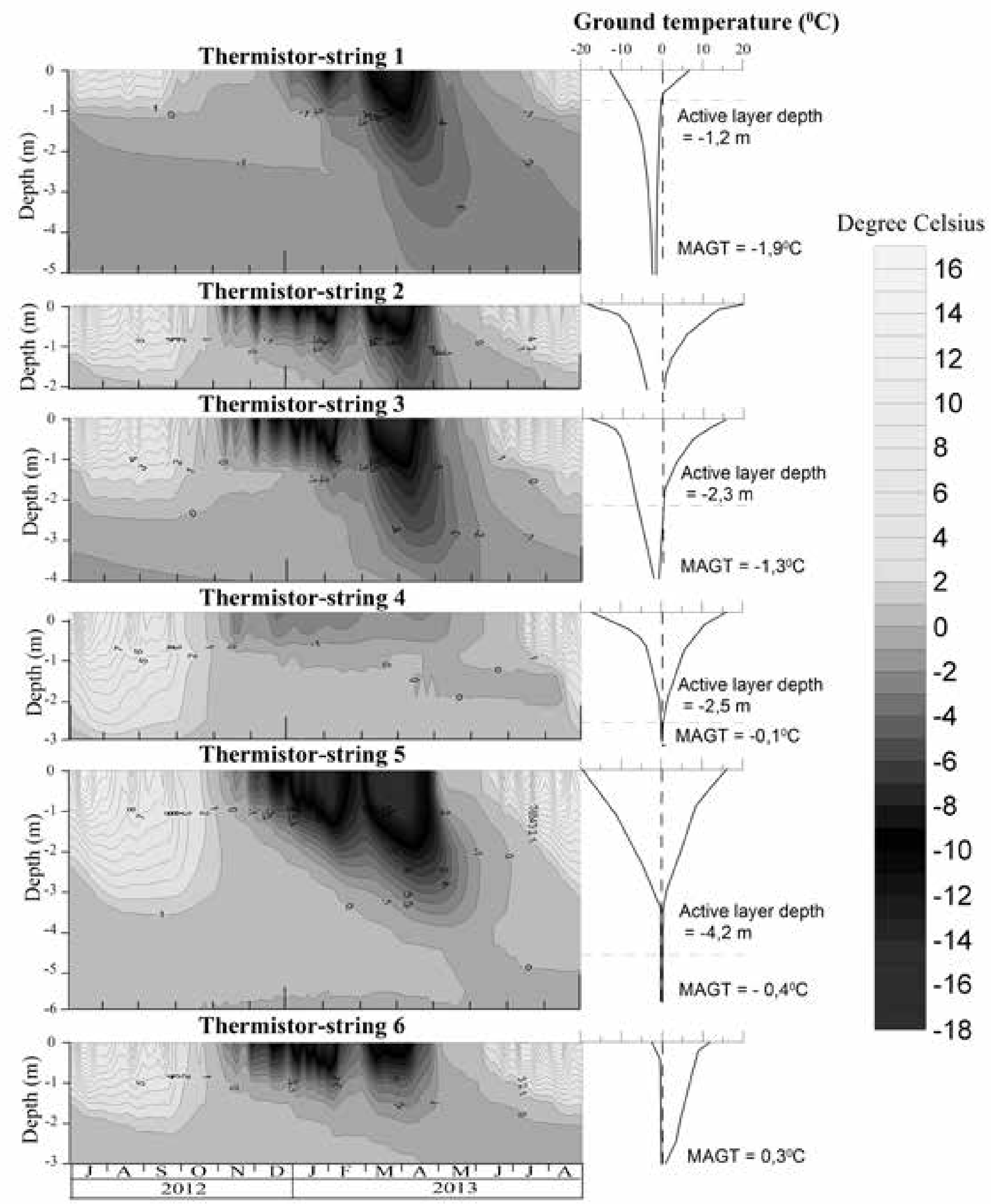

Figure 5. Minimum, maximum, and average ground temperatures at all depths from December 2012 to December 2013 for thermistor strings (TS) 1, 2, 4, 5, and 6 The deepest soil temperatures recorded are characteristic for warm permafrost areas and vary between 0.3 and -1.9°C. The extreme surface temperatures vary significantly between each thermistor string, thus showing various barren surfaces. No permafrost has been identified underneath TS6 situated in the upper beach (inhibiting the determination of the depth of active layer at that site). Furthermore, the depth of temperature record by TS2 did not reach the level of zero annual amplitude, preventing the determination of AMGT, as well as the depth of the active layer for this location.

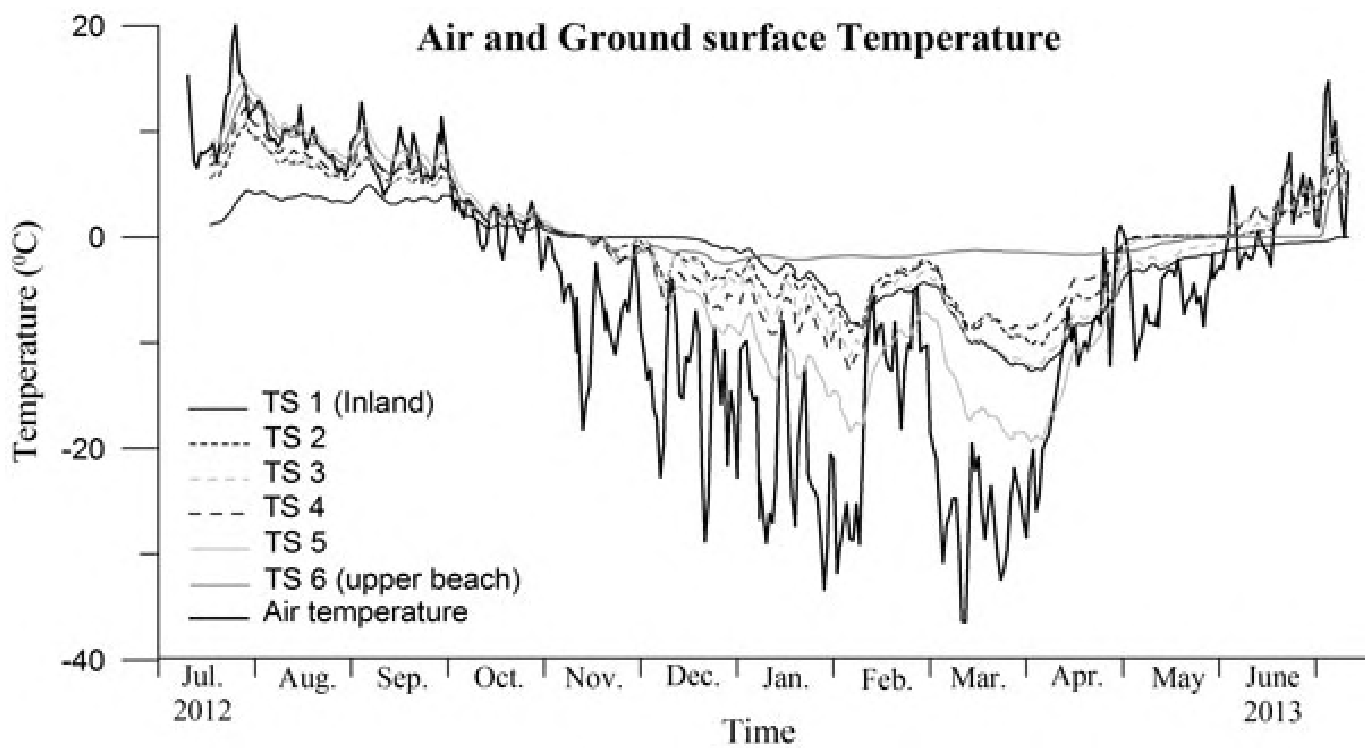

Figure 6. Annual daily near-surface temperature at each thermistor string. The variation between the different thermistor strings is characteristic of the different surface n-factors (various barren conditions). TS6 features isothermal winter temperatures around -1°C from the end of November to early May. This peculiar isothermal winter temperature suggests the presence of a significant snowbank accumulation on the lee side of the dune belt, isolating the ground from extreme cold winter temperatures.

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Orville Tyler Magoon (July 18, 1928 – March 19, 2016)

On March 19 in Santa Barbara, California, Orville Tyler Magoon passed away surrounded by his wife, Karen, and children. He was 87. Mr. Magoon was a native of Hawaii, who was born July 18, 1928. His life was one dedicated to our planet and its coastal treasures and to the people who surrounded him.

Following his graduation from Punahou School class of 1946, Orville Magoon received his under-graduate degree in Civil Engineering from the University of Hawaii in 1951 and an M.S. degree in Civil Engineering from Stanford University in 1952. After thirty years of experience in the field of coastal planning, design, construction and rehabilitation of coastal structures, Mr. Magoon retired as Chief of the Coastal Engineering Branch of the Planning Division of the US Army Corps of Engineers, South Pacific Division in July, 1983. He continued to be active in coastal zone management and coastal engineering through lectures at universities and symposia and his writing. Orville balanced his time between coastal engineering and managing Guenoc Winery and Guenoc Ranch in California where he produced award-winning wines, including the Genevieve Chardonnay named for Orville's mother and which was honored in The Wine Spectator.

After his retirement from the Army Corps of Engineers in 1983 as a coastal engineer, he continued to dedicate his life to finding solutions to coastal issues, all the time managing the family estate winery in Lake and Napa Counties, called Guenoc, and once owned by Lillie Langtry, British actress and legend. In 2004 he retired from Guenoc to San Francisco with his wife, Karen. There he continued to work for better understanding of our beaches and coastal structures.

During his years of government service, Orville Magoon served on several committees and panels, including the Permanent International Association of Navigation Congresses (PIANC) Committee on Waves, on a number of National Aeronautics and Space Administration panels involved with remote sensing and satellite imagery of coastlines and the National Academy of Engineering.

Orville served as President of the Coastal Zone Foundation as well as Vice Chair of the Coastal Engineering Research Council for forty years and still had time to serve as President of the American Shore and Beach Preservation Association for ten years. In 1978 a series of Coastal Zone conferences was initiated by Orville, seeking solutions to coastal issues and held biannually, hosting up to 1500 people. He continued to organize international, focused conferences on topics such as coastal structures, Coastlines of the World, Sand Rights, California and the World Ocean, Ocean Wave Measurement and Analysis resulting in over sixty of volumes of written proceedings.

Orville Magoon received several national and international awards during his career including the Jim Purpura National Coastal Engineering Award from FSBPA and the Murrough P. O'Brien Award from ASBPA. He also received the William Wisely, Arthur M. Wellington Prize, International Coastal Engineering Award and the Moffat-Nichol Awards from ASCE in recognition of his service to the coastal engineering and coastal zone management. His contributions to the profession were recognized with Distinguished Member of ASCE and Honorary Member of JSCE. Recognizing his devotion to students, Texas A&M University established the Orville T. Magoon Scholarship in 2003 which is given annually to one or more students who exhibit a strong interest in the field of coastal engineering and sustainability.

In recognition of his eminence in his profession, the American Society of Civil Engineers created the Orville T. Magoon Sustainable Coasts Award in 2014 which is given annually. This award is given to a leader who promotes the concept of sustainability in coastal engineering research, design, construction and management.

He is recognized by his friends and colleagues as a tireless mentor, leader, and friend to everyone. Orville loved gathering mushrooms; he loved nature and animals; cats were drawn to him as well as anyone who ever met him.

Orville Magoon is survived by his brother Eaton Harry Huha "Bob" Magoon, children Melissa, Marshall and their spouses Brian and Jena, as well as Mary and Matthew, grandson Spencer and great grandson Bradley; and Orville's wife Karen, her children Aaron and Bridget, Aaron's spouse Yvonne, and grandchildren, Uli, Matti and Mori.

Two memorial celebrations of Orville's life are planned, the first on Sunday, May 1 at 2 pm at the Unitarian Universalist church at 1187 Franklin in San Francisco, and the second on Saturday, June 18, at 1pm at the Bay Club Santa Clara, 3250 Central Expressway, Santa Clara.

In lieu of flowers, contributions can be made to the Orville T. Magoon Sustainable Coasts Award in c/o American Society of Civil Engineers, ATTN: Jane Alspach, 1801 Alexander Bell Drive, Reston, VA 20191; please mark the contribution for Permanently Restricted Fund.

Remembering Orville T. Magoon
A World Leader in Coastal Management, Education, and Engineering

Organizing committee (Orville is third from the right) of the Egypt Coastal Management of Deltas and Low Land Coastlines conference in March 2010.

This April marks the 70th anniversary of the destructive tsunami that struck Hawaii in 1946, resulting from an earthquake in the Aleutian Islands, Alaska. Orville was 17 years old living on the beach near Diamond Head and this event fascinated him and started him on a life time of interest and study of tsunamis and other forces acting on coasts.

My recollection of first meeting Orville was in the early 1970s at the Corps' Coastal Engineering Center when it was at Delcarlia, NW Washington, D.C., before CERC was moved to Ft. Belvoir, Virginia. I was fresh from graduate school and being commissioned as a Corps of Engineers 2nd Lt after being drafted. I was just starting my career at CERC as a research coastal geologist in David Duane's Geology Branch. Orville was a coastal engineer with the Corps' San Francisco District and was detailed to CERC as an advisor to the Director. I'm not sure what his specific duties were or how long he was at CERC, but it was clear to me that Orville was well respected for his expertise in coastal engineering and design.

Orville was at CERC only a short while and then returned to San Francisco, eventually moving to the Corps' North Pacific Division office. CERC relocated to new facilities at Ft. Belvoir about 1978 and over the years, I would occasionally see Orville at review meetings of the Coastal Engineering Research Board when we would report status of our projects. In 1983, when the decision was made to move CERC south to Vicksburg, Mississippi and merge with the Water Ways Experiment Station, I decided not to relocate and instead accepted a position with the U.S. Geological Survey/Office of Marine Geology in Reston, Virginia.

My next connection with Orville was in his organizing, starting in 1984, the Coastal Zone conferences, bringing together scientists, engineers, managers, and students. These conferences were sponsored by the Coastal Zone Foundation that Orville founded in 1984. My initial involvement was presenting papers and suggesting session topics, but eventually when I became a project leader in the late 80s and director of the Survey's Coastal and Marine Geology Program from 1996 to 2000, I also supported several CZ conferences with grant funds. I found the CZ conferences to be among the best in bringing together coastal professions from around the world.

I always looked forward to attending CZ organizing committee meetings led by Orville. When the business of organizing the conference was done, he would bring out an assortment of his excellent Guenoc wines. The Coastal Zone conferences were Orville's vision of bringing together the various coastal disciplines from around the world and present the information in ways that were meaningful and useful to coastal managers; and, I always thought the conferences were successful in combining talks, field trips, and opportunities to learn and establish partnerships. My research focus was on coastal processes, sand inventory and sediment movement along coastal and nearshore regions,

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and climate change impacts such as sea level rise and storm effects. Orville had similar interests and we exchanged papers, review comments, and ideas over the years.

As a trained engineer, Orville had questions on geology and longer-term thinking of how coasts evolve, how coral reefs contribute to carbonate sand beaches, and the upper limits of sea level rise with continued global warming. Orville was always positive in his outlook and willingness to learn new information. Orville was passionate about the need to preserve coasts and resources (*e.g.*, wetlands, coral reefs) in sustainable ways, well before others became aware of the need to do. As the science of global warming and climate change began to mature in the 1990s and 2000s and we understood it was a reality caused by human activities, Orville was enthusiastic about including impacts of climate change in engineering design and management. As one example, this resulted in a paper, authored by Orville, me and others, in 2004 presented at the International Coastal Engineering Conference in Portugal on the economic impacts of human activities on U.S. coasts.

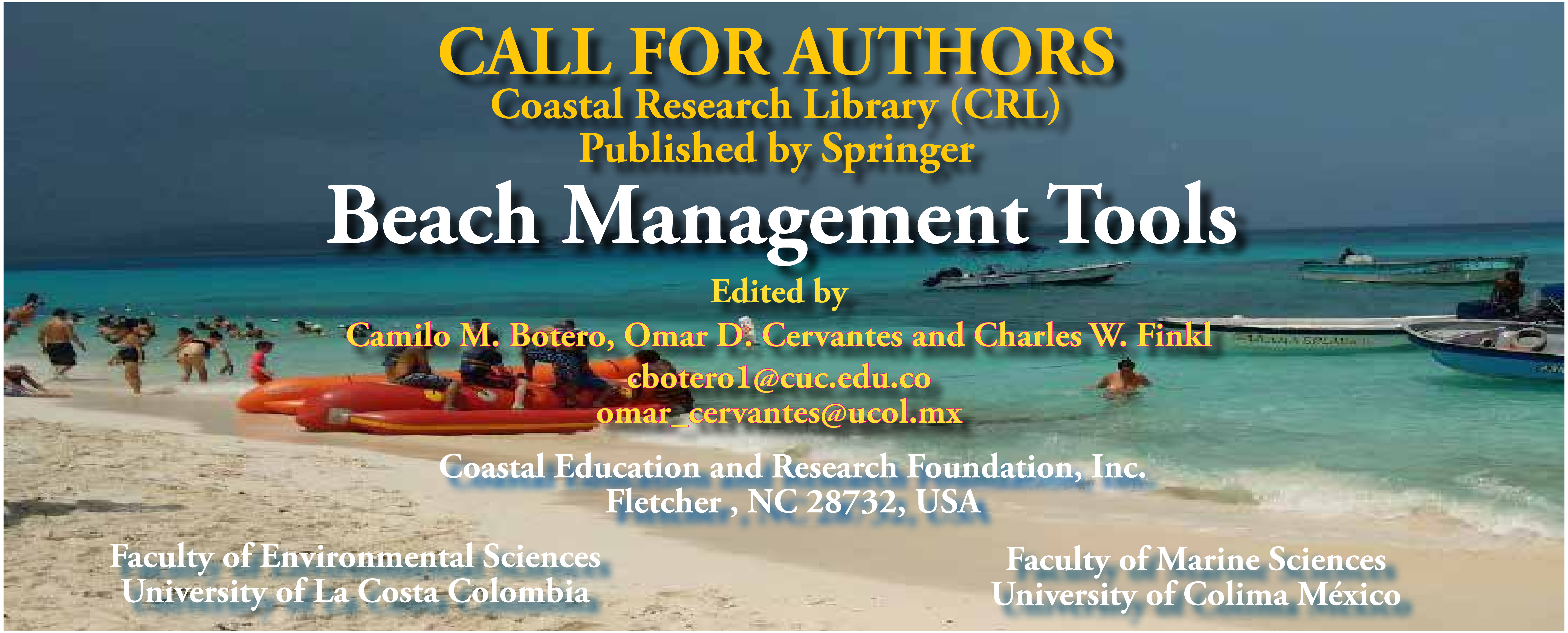
This paper was the result of our discussions and sharing ideas the year before, including a memorable visit in 2003 to the Langtry Estate in Middletown, California. My wife Rebecca and I were fortunate to spend several days enjoying the hospitality of Orville and wife Karen, going to hill tops in his 22 thousand acre vineyard estate, with Orville driving the rutted roads in an old Chevy carryall, him dressed in faded jeans and heavy work boots, to enjoy sunsets and of course a sampling of fine Guenoc wines. And, of course, also getting lessons from Orville on the local geology and microclimates of the region and their importance to growing the best grapes.

Over the next decade, Orville and I remained colleagues and friends. I often visited him and Karen when in San Francisco for AGU conferences or on business trips to the USGS center in Santa Cruz. I was especially pleased and grateful in 2009 to learn from Orville and Billy Edge that I was elected to receive the Coastal Zone Foundation Career Achievement Award at an ASCE conference in St Johns, Newfoundland. In 2010, just as I was retiring from USGS in Woods Hole, MA, I was asked to serve on the organizing committee with Orville, Nabil Ismail and others for the 1st Coastal Management of Deltas and Low Land Coastlines to be held in Alexandria, Egypt in March 2010. The conference was a total success resulting in a published proceedings volume of papers presented. Following the conference, Orville, Karen, Lesley Ewing and I spent a week travelling south to Cairo and tour sites and the High Aswan Dam via trains, Nile River cruises, and airplanes. The pictures above are from this memorable 2-week trip to Egypt with Orville and Karen.

Later, in 2013, I was spending winter months in Kailua, Hawaii and was able to meet up and enjoy a dinner with Orville and Karen in Honolulu on one of their visits back to Orville's favorite island. Hawaii is where he was born and started his keen interest and enthusiasm for coasts, sandy beaches, and waves and currents at the triple- point of land-ocean-atmosphere interaction.

Orville Magoon, by all measures, was indeed an authority and world leader in the coastal profession, but as important he was a wise and generous and decent man, always willing to share and discuss ideas with others. Orville was a valued friend whom I will remember with many memories from over the past 45 years.

S. Jeffress Williams
North Falmouth, Massachusetts, U.S.A.



We are planning an edited volume in the Coastal Research Library (CRL) series that deals with an overview of beach management tools, such as carrying capacity, beach nourishment, environmental and tourism awards (like Blue Flag or others), bathing water quality, zoning, beach typologies, quality index, user's perception, interdisciplinary beach monitoring, coastal legislation, shore protection, social and economic indicators, ecosystem services, coastal governance (applied in beach's case studies), among others.

Beaches are among of the most intensely used coastal ecosystems and are responsible for more than a half of tourism incomes in the world. Therefore, this book will help to inform beach managers about state of the art of tools to combat beach challenges, such as coastal erosion, tourist development, urban growth, coastal policy and management, just to define some of them.

Authors must send contributions that are only focused on the various tools applied to beach management, preferably with examples on recent local and regional case studies around the world. These suggested chapters, if accepted, would then be compiled as part of the multi-volume set which is the CRL series.

The publisher for the CRL series is Springer Science in Dordrecht, The Netherlands.

We invite your suggestions for contributed chapters or other ideas that we may have missed.

Please send your proposals and questions to Dr. Camilo M. Botero (cbotero1@cuc.edu.co) and Dr. Omar D. Cervantes (omar_cervantes@ucol.mx) so we may consider your chapter submission for this volume.

The Perceived Value of a Scuba Diving Experience

The Perceived Value of a Scuba Diving Experience

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ABSTRACT

Tourists today are more value conscious, which creates challenges for tourism products to keep up with what tourists want and how they perceive certain experiences. Perceived tourism value can be seen as the value that tourists experience and can be defined from separate perspectives, such as money, quality, benefits, and social aspects. The purpose of this study is to determine the perceived value of a scuba diving experience. A survey was conducted at Sodwana Bay, where 402 divers participated by means of stratified sampling. The factor analysis revealed five values, namely perceived emotional value, perceived risk value, perceived functional value, perceived social value, and perceived epistemic value. This insight can assist role players in the marine environment to adapt their scuba diving product where needed and can also assist in the improvement of diver satisfaction, the diving experience, and marketing initiatives.

ADDITIONAL INDEX WORDS: *Perceived tourism value, marine tourism, tourism marketing, Sodwana Bay,.*

INTRODUCTION

Marine tourism has become the focus of tourist attention, and therefore countries with coral reefs attract millions of scuba divers (Cesar, Burke, and Pet-Soede, 2003; Higham and Lück, 2008). The contribution of scuba diving to the marine tourism environment is significant and considered one of the world's fastest growing recreational sports, developing globally into a multibillion dollar industry (Ong and Musa, 2012). The number of certified scuba divers has increased significantly worldwide, with a total of 20.3 million divers in 2011, compared with the 2.5 million divers registered in 1988 (PADI, 2012). With the increase in the number of scuba divers on the one hand and the pressure being imposed on marine protected environments to limit the number of scuba divers on the other hand, business competition levels are high, and conflicting interests make it difficult for small scuba diving companies to survive in marine tourism environments such as Sodwana Bay (Ray the Fisherman, 2012).

Sodwana Bay, in Maputaland, KwaZulu-Natal, has been rated as the 16th best dive site in the world (Bremmer, 2012), with 59,553 dives conducted by 15,780 divers (Dicken, 2014). This area lies within the Greater St. Lucia Wetland Park (iSimangaliso) (SA-Venues, 2012) and was listed as South Africa's first World Heritage site in December 1999 (iSimangaliso Wetland Park, 2015). It is therefore a very popular dive site, rich in plant and animal life, which contributes to the growth of the tourism industry.

The tourism experience is a mix of tangible and intangible elements, with the latter being difficult to manage and measure. Intangibility has been defined as something that cannot be seen, touched, or felt (Page and Connell, 2009), and this experience might differ from person to person. These elements create uncertainty about providing the right product to the right market and making

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sure that customers are so satisfied with the experience that they will return again. However, to overcome the effect of intangibility, the value of tourism products can be enhanced by adding sensations such as emotions, functionality, and risk (Page and Connell, 2009).

Although there have been studies conducted on the perceived value of tourism, no such study has been conducted in the marine environment, for scuba diving tourists, or within the South African context. Knowing the value that scuba divers receive from a diving experience will assist dive operators and sites in becoming more sustainable and delivering experiences according to the needs of the divers. Such knowledge will assist in product development, enhancement of customer satisfaction, improvement of the diving experience, and improvement of marketing initiatives and ultimately will assist in giving the destination a competitive advantage. The purpose of this research is therefore to determine the perceived value of a scuba diving experience at a marine destination, namely Sodwana Bay.

This section elaborates on an in-depth analysis of previous research completed in relation to the objectives of this study and serves as the theoretical framework for the empirical study.

Overview of Previous Scuba Diving Research

Research concerning scuba diving and divers is not new, but the type of studies, location of studies, and study themes differ significantly. The focus of these studies can be categorised as follows: management of scuba divers/diving, the impacts of scuba diving, and the profile and travel motives of the scuba market. Firstly, management studies include that of Ku and Chen (2013), who analysed a management process to better control the effects of scuba diving on coral reefs. Hunt *et al.*(2013), on the other hand, conducted research that formed part of Green Fins, aimed at the development of a Code of Conduct as a management tool for the protection of marine ecosystems. Johansen and Koster (2012) also focused on the development of environmental codes of conduct as part of diving certification courses. Other management studies in this field of research include the work of Aswani and Hamilton (2004), Lück (2007), and Pomeroy, Mascia, and Pollnac (2005). Research conducted by Wongthong and Harvey (2014) analysed the sustainable management of dive tourism based on integrated coastal management (ICM) and sustainable tourism management (STD) frameworks. This topic has also been addressed by Musa, Kadir, and Lee (2006) and Uyarra, Watkinson, and Cote (2009).

Second, closer to the scuba divers themselves and their effects on the environment, Camp and Fraser (2012) and Lamb *et al.* (2014) studied the effects of scuba divers on coral reefs. Research conducted by Toyoshima and Nadaoka (2015) addressed the importance of environmental briefing and buoyancy control as methods for reducing the negative effects of scuba diving on coral reefs. In a South African study, Lucrezi, Saayman, and Van der Merwe (2013) determined the perceived effects of diving at Sodwana Bay. A socioeconomic impact study of diving in Sodwana Bay was done by Dicken (2014). Zhang and Chung (2015) took a different approach by assessing the social carrying capacity of diving sites in Mabul Island, Malaysia. This type of study has also been conducted by Rouphael and Hanafy (2007) and Zakai and Chadwick-Furman (2002). Third, Geldenhuys, Van der Merwe, and Slabbert (2014) researched the travel motives and profile of scuba divers visiting Sodwana Bay, South Africa. Kler and Tribe (2012) analysed the pursuit of dive experiences, whilst Edney (2012) focused on diver characteristics, motivations, and attitudes. The economic contribution of scuba divers has also been analysed by several researchers (Asafu-Adjaye and Tapsuwan, 2008; Pendleton and Rooke, 2006; Saayman and Saayman, 2014; Stoeckl *et al.*, 2010). Research in this field of study is ample, but the perceived value of the scuba diving experience is under-researched even though the creation of a valued experience can lead to return visits.

Overview of Perceived Value

Perceived value was labelled the "new marketing mania" and the way to sell in the 1990s (Sinha and De Sarbo, 1998) and has proved to be of continuing importance in the 21st century (Sweeney and Soutar, 2001). Marketing facilitates the exchange process between organisations and customers, resulting in a mutually rewarding transaction (Ali, 2007). Value is created through this process, which leaves both parties better off than before the exchange occurred (Bowie and Buttle, 2004). A common ideal shared by Hightower, Brady, and

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Baker (2002), Holbrook (1999), Kuo, Wu, and Deng, (2009), Woodruff (1997), and Zeithaml (1988) is that the consumer is a key factor in gaining a competitive advantage. Hartnett (1998) noted that when retailers satisfy the basic needs of people, they are delivering value, which places them in a much stronger position in the long term.

Rekeach (1973) defines perceived value as enduring beliefs that particular end states of existence are personally or socially preferable to other states. According to Holbrook (1999) and Zeithaml (1998), this concept value is old and endemic to consumer behaviour, but the intangibility thereof creates challenges in terms of understanding and measuring this important concept. This is also true for tourism products consisting of product, service, and experience elements, with all three elements potentially contributing to the perceived value.

Kuo, Wu, and Deng (2009) state that the customer's perceived value can be defined from various perspectives. Zeithaml (1988) defines perceived value as the consumer's overall assessment of the utility of a product based on the perception of what is received and what is offered. Sánchez *et al.* (2006) have a slightly different view and define perceived value as a dynamic variable experienced before purchase, at the moment of purchase, at the time of use, and after use. Boksberger and Melsen (2011) assert that the perceived value of services is a combined assessment of consumers' perceptions of benefits and sacrifices, including quality and price. Original behavioural intentions and customer satisfaction also play a role in the overall evaluation. Perceived value can therefore be viewed as the overall assessment, perceptions, mental estimates, interpretation of information or enduring beliefs of product attributes, attribute performances, and consequences of the cognitive trade-off or value received between consumers, the product source, and the benefits received.

Creating a perception of value is not an easy task (Zeithaml, 1988), because these experiences tend to be complex. Therefore, various models have been adapted by marketing researchers to test the manner in which consumers perceive value. In 1994, Holbrook defined perceived value as an "interactive relativistic preference experience." Extrinsic value relates to a product or consumption experience that serves instrumentally or functionally as a means to some further end, and intrinsic value is where the consumption experience is appreciated for its own sake as well as the sake of a self-justifying end in itself (see Table 1).

A self-orientated value occurs when a consumer prizes some product or consumption experience for his/her own sake, because of how he/she responds to it, or by virtue of the effect it has on him/her. Another orientated value occurs when a consumer prizes a product or consumption experience for the sake of others, because of how he/she responds to it, or by virtue of the effect it has on him/her. In Holbrook's typology, economic value refers to an instance in which a product or consumption experience serves as a means to achieve a consumer's own objectives, whereas social value occurs when one's own consumption behaviour serves as a means to shape the responses of others. Hedonic value arises from a person's own pleasure in consumption experiences that are appreciated for their own sake, as ends in themselves, whereas altruistic value is about the effect a person's own consumption behaviour has on others.

Sheth, Newman, and Gross (1991) presented a theory of consumption values to determine why consumers make the choices they do. Four consumption values are identified in this theory, namely functional value, social value, emotional value, and conditional value (see Table 2).

Sweeney and Soutar (2001) developed a perceived value (PERVAL) scale based on the consumption values identified by Sheth, Newman, and Gross (1991). Sweeney and Soutar (2001) used this PERVAL scale to assess customers' perceptions of the value of consumer durable goods at the brand level. The measure was developed for use in a retail purchase situation to determine what consumption values drive purchase attitude and behaviour. Five value dimensions emerged from this study, namely emotional value, social (acceptability) value, functional (price/value for money) value, functional (performance/quality) value, and functional (versatility) value, as presented in Table 3.

The identification of these value dimensions assisted in explaining the attitudes and behaviour of consumers. Research conducted by Sweeney and Soutar (2001) indicates that multiple value dimensions explain consumer choice better, both statistically and qualitatively, than does a single "value for money" item and therefore produce superior results when investigating consumption

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value. They conclude that the PERVAL scale (see Table 3) has a variety of potential applications and can serve as a framework for further empirical research (Sweeney and Soutar, 2001).

Hall, Robertson, and Shaw (2001) built on the model of Sweeney and Soutar (2001) and argue that to understand perceived value thoroughly, the model needs to be applied to a large number of products. In their study, the model was therefore tested on a nondurable product, namely wine. Hall, Robertson, and Shaw (2001) revealed that perceived risk value should be added to Sweeney's model and can be defined as the utility derived from those factors that reduce risk and are also highly sought after.

Perceived Value and Its Importance in a Tourism Environment

The foundation of tourism is people and their experiences, and therefore it needs to be value driven. There is a need to determine what value tourism experiences hold and what benefits they create for the tourism industry and tourists alike, because consumers are becoming even more value conscious than they were in the past (Sweeney and Soutar, 2001), and the role of value has become of major and increasing concern to marketers. Indeed, Albrecht (1992) argues that the only thing that matters in the world of quality is delivering consumer value.

As previously indicated, unlike retail industries, tourism is an intangible service that is delivered to tourists as an experience. Consequently, careful analysis and a different approach are required when it comes to creating and measuring perceived value in the tourism industry. Hartnett (1998) notes that when retailers (also diving companies and destinations) satisfy people's basic needs, they are adding value. This places them in a much stronger position over the long term when compared with their competitors. Because perceived value has been noted as a key factor in gaining a competitive advantage, the tourism industry has an opportunity to use this value to their advantage; for if utilised properly, the advantages of the perceived value could be endless (Hartnett, 1998).

The intangibility of its services is what makes the tourism experience unique, because the tourism product carries the characteristics of service products, together with characteristics that are unique to the tourism industry. This makes the tourism product very different from physical (tangible) goods. The intangibility of tourism products implies a large amount of risk and uncertainty concerning customer value. For example, a scuba diver who books a diving holiday package does not know with certainty what he or she can expect and how he or she will eventually perceive the quality experienced while on holiday. Therefore, setting up a quality criterion creates confidence and reduces the risks for the consumer (Weiermair, 2003). Moreover, adding sensations to the tourism product such as emotional, social, perceived risk, or functional sensations will create more certainty for tourists. The perceived value of the "tourism experience" will be enhanced by such product changes (Weiermair, 2003).

An experience is not a snapshot, but rather a complex process that involves multiple parties, and evolves over time and retains value far into the future. People want to buy products because they want the experience-bringing services that they hope the product will render (Abbott, 1955). Therefore, tourists (*e.g.*, scuba divers) who are seeking to obtain an experience must actually – physically and emotionally – experience the activity before gaining the full value of that experience. Page and Connell (2009) argue that tourism experiences are based on a notion of fun, pleasure, and emotional responses, which are assuming growing importance in seeking to understand tourist behaviour. These responses (fun, pleasure, and emotions) can be used to create certain values, thereby creating a fuller experience and ensuring that tourists are satisfied.

Certain studies that focus on determining perceived value have been undertaken in the tourism industry. Kashyap and Bojanic (2000) investigated the relationships between tourists' perceptions of value, quality, and price and their influence on tourists' ratings of similar hotels and revisit intentions. They found that value played a pivotal role in tourists' decision making, emphasising the need to refocus efforts from managing quality alone to managing customer value. Differences in the value perceptions of business and leisure tourists emphasise the need to develop segment-based strategies to manage price and quality (Kashyap and Bojanic, 2000).

Babin and Kim (2001) conducted a study to explore the satisfiers of inter-

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national student travel behaviour as well as to introduce a specific multidimensional value conceptualisation to travel literature. A structural model was explored that indicated how characteristics such as perceived safety, fun, and educational benefits create travel satisfaction through their effect on personal hedonic and utilitarian travel value perceptions (Babin and Kim, 2001). Babin *et al.* (2005) suggest that hedonic values capture the affective qualities, whereas utilitarian values capture the functional qualities of services.

Petrick, Morais, and Norman (2001) explored the determinants of the intentions of entertainment vacationers to revisit and also investigated their perceived value. The results suggest that perceived value is a good predictor of the intentions of entertainment vacationers to revisit a destination, which emphasises its importance and influence. Petrick and Backman (2002) analysed the satisfaction of golf travellers and their perceived value, loyalty, and intentions to revisit. In this study, perceived value was measured against loyalty and satisfaction, which, according to Petrick and Backman (2002), are all derived from an experience. The findings revealed that perceived value aided in explaining the intention of golf travellers to revisit and that satisfaction was an antecedent to perceived value in the prediction of intentions to revisit.

Oh (2003) conducted a study on price fairness and the asymmetric effects thereof on overall price, quality, and value judgements in a hotel. The results indicate that the hypothesised asymmetric effects between positive (*i.e.*gain) and negative (*i.e.* loss) price deviations exist in buyers' judgments of quality and value, although this is not the case in overall price perceptions (Oh, 2003). Al-Sabbathy, Ekinci, and Riley (2004) conducted a study in the hospitality industry, in which they investigated perceived value dimen-sions and the implications for hospitality research. The study applied a two-dimensional value scale developed by Grewal, Monroe, and Krishnan (1998) to hospitality services, hotels, and restaurants. Although the scale was found to be reliable, there were some concerns about its validity across the two studies. In particular, although the dimension of acquisition value was found to be valid, transaction value indicated poor validity. The conclusion suggests that a new conceptualisation of transaction value and a better scale should be developed for the evaluation of hospitality services (Al-Sabbathy, Ekinci, and Riley, 2004).

Gallarza and Soura (2006) investigated the travel behaviour of university students focusing on value dimensions, perceived value, satisfaction, and loyalty. In this study, the value dimensions tested were efficiency, service quality, social value, play, aesthetics, perceived monetary costs, perceived risk, time and effort, and loyalty that were adapted from the Holbrook typology. Gallarza and Soura (2006) indicate that the results confirm the existence of a quality-value-satisfaction-loyalty chain and illustrate the complexity of value dimensions that were revealed to be highly sensitive to the tourism experience.

Gallarza and Soura (2008) analysed tourism experiences by exploring the concept of value and its dimensions. They found the value dimensions to be efficiency, quality, play, aesthetics, and social value, and a measure of the overall perceived value was tested to be personal (*i.e.* they vary across people), comparative (with differences among objects), and situational (specific to the context). Table 4 summarises the values measured and the dimensions of value specifically measured in the tourism industry.

It is evident from Table 4 that most studies focus on price (Al-Sabbathy, Ekinci, and Riley, 2004; Gallarza and Soura, 2006; Kashyap and Bojanic, 2000; Oh, 2003) or quality (Gallarza and Soura, 2006; Kashyap and Bonjanic, 2000; Oh, 2003) as value dimensions. Other aspects that were also evaluated in these studies are hedonic value and utilitarian value (Babin and Kim, 2001), as well as acquisition and transaction value (Petrick and Backman, 2002).

None of the studies listed in Table 4 focused on the perceived value experienced at a marine destination, nor did any of these studies focus on the perceived value of scuba diving as a tourism experience. Therefore, an opportunity for new research exists in the literature and practice that will lead to a better understanding of the perceived tourism values experienced at a marine destination. It is therefore the purpose of this study to determine the perceived value of a tourism experience at a marine activity, namely scuba diving.

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Interannual Feature of Summer
Upwelling around the
Zhoushan Islands
in the East China Sea

Interannual Feature of Summer Upwelling around the Zhoushan Islands in the East China Sea

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ABSTRACT

The interannual feature of summer upwelling around the Zhoushan Islands off the Zhejiang coast over the East China Sea (ECS) shelf has been investigated using multiscale ultrahigh resolution (-1 km) sea surface temperature (SST) data during the period from 2003 to 2014 and an auxiliary Pathfinder SST data set with a relatively low resolution of 0.05° × 0.05° during 1985–2002. Coastal upwelling usually occurs during April to June, reaches its peak intensity in July and August, and starts to decay in September. It has not strengthened or weakened obviously during the past 30 years. The influence of sea winds on the interannual variation of the summer upwelling is analyzed using the National Oceanic and Atmospheric Administration/National Climatic Data Center blended sea surface wind data. Results demonstrate that the sea wind over the ECS, which is part of the East Asian summer monsoon (EASM) system, plays a dominant role in determining the changes in upwelling intensity, and the southeasterly wind is favorable for the formation of the summer upwelling around the Zhoushan Islands. The El Niño–Southern Oscillation (ENSO) modulation of the interannual variability of the upwelling intensity is complex because of the unstable correlation between the EASM and the ENSO cycle.

ADDITIONAL INDEX WORDS: *Sea surface temperature, sea surface wind, ENSO.*

INTRODUCTION

Coastal upwelling is closely related to human activities. Most of the productive fishing grounds are in the upwelling regions, which account for only 0.1% of the area of the oceans but contribute to about 50% of fishery production in the world (Ryther, 1969). Because of the ecological and economic importance of these regions, changes in upwelling intensity and timing have attracted considerable scientific interest in recent years (Varela *et al.*, 2015).

One of the most outstanding features in the East China Sea (ECS; see Figure 1a) is coastal upwelling (Lee and Chao, 2003; Wang and Wu, 2009). The ECS is situated in the typical monsoon regime, its climate a part of the East Asian monsoon system. Forced by the intense monsoon, strong upwelling centers have been frequently reported during summer in the ECS (Liu and Gan, 2014). In particular, the upwelling around the Zhoushan Islands (hereafter called Zhoushan upwelling) of Zhejiang province (see Figure 1b), where the largest fishery field of China is located, has attracted many investigations, most of which focused on its generation mechanism. It was found that wind forcing and topography both contribute to the Zhoushan upwelling (Liu and Su, 1991; Luo and Yu, 1998). The upwelling is also associated with intensified cross-shore transport of the northeastward-flowing Taiwan Warm Current (TWC) (Yuan *et al.*, 1986). More recently, Lü *et al.* (2006) suggested that tidal mixing plays a predominant role in inducing Zhoushan upwelling,

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which was later discussed by Liu and Gan (2014). However, the temporal and spatial characteristics of the coastal upwelling are still not very clear. Does the sea wind, or the El Niño–Southern Oscillation (ENSO) cycle have a significant influence on the long-term changes of the upwelling? The question remains to be resolved.

This study investigates the interannual feature of the Zhoushan coastal upwelling and the effect of sea wind and ENSO using 12 years (2003–2014) of high-resolution (0.01°× 0.01°) sea surface temperature (SST) data, supplemented by relatively low resolution (0.05° × 0.05°) SST data during 1985–2002. The data and methods used to determine the temporal changes in the upwelling intensity are introduced in the following section.

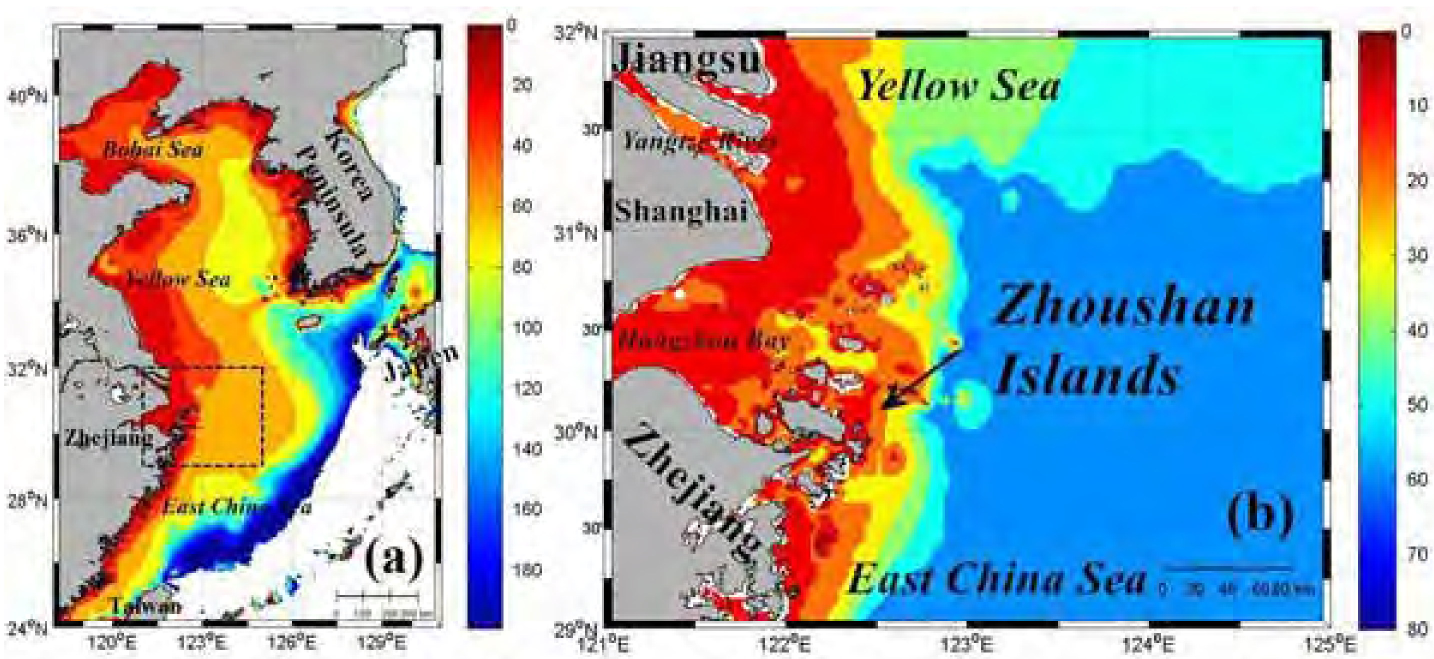

Figure 1. (a) Bathymetry (m) of the ECS and (b) the zoomed area of the study area (*i.e.* Zhejiang coastal regions) boarded by dashed lines in panel (a), from which one can see the distribution of the water depth of the coastal upwelling region. The bathymetry data are from ETOPO2 (National Centers for Environmental Information, 2006).

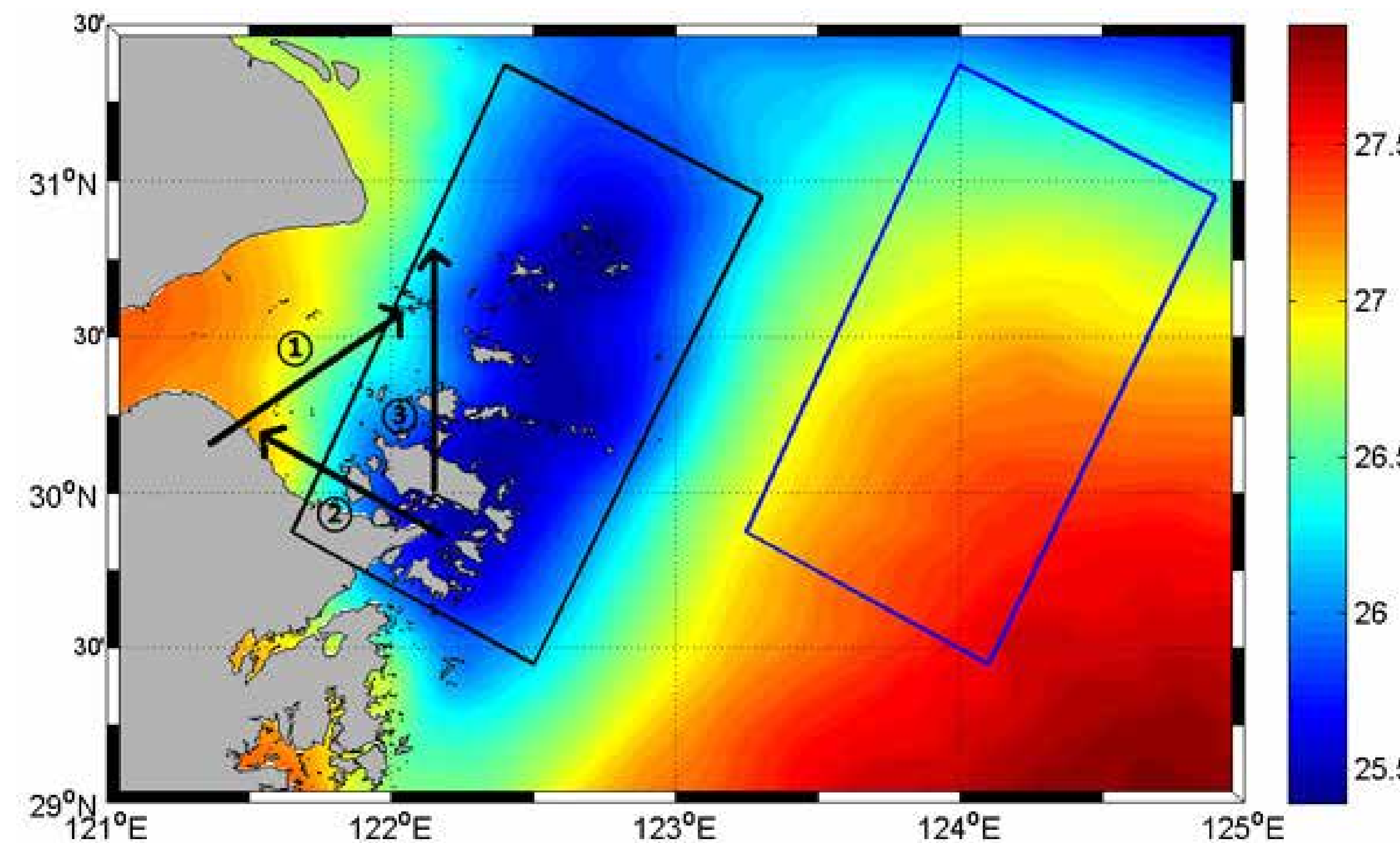

Figure 2. Locations of upwelling waters (dashed rectangular) and reference waters (dotted rectangular) offshore of the Zhoushan Islands overlaid on climatological SST (8C) map in July. The SST upwelling intensity is defined as the temperature difference between the reference waters and upwelling waters [see Equation (1)]. The black arrows denote the three possible upwelling-favorable wind directions considered in this study.

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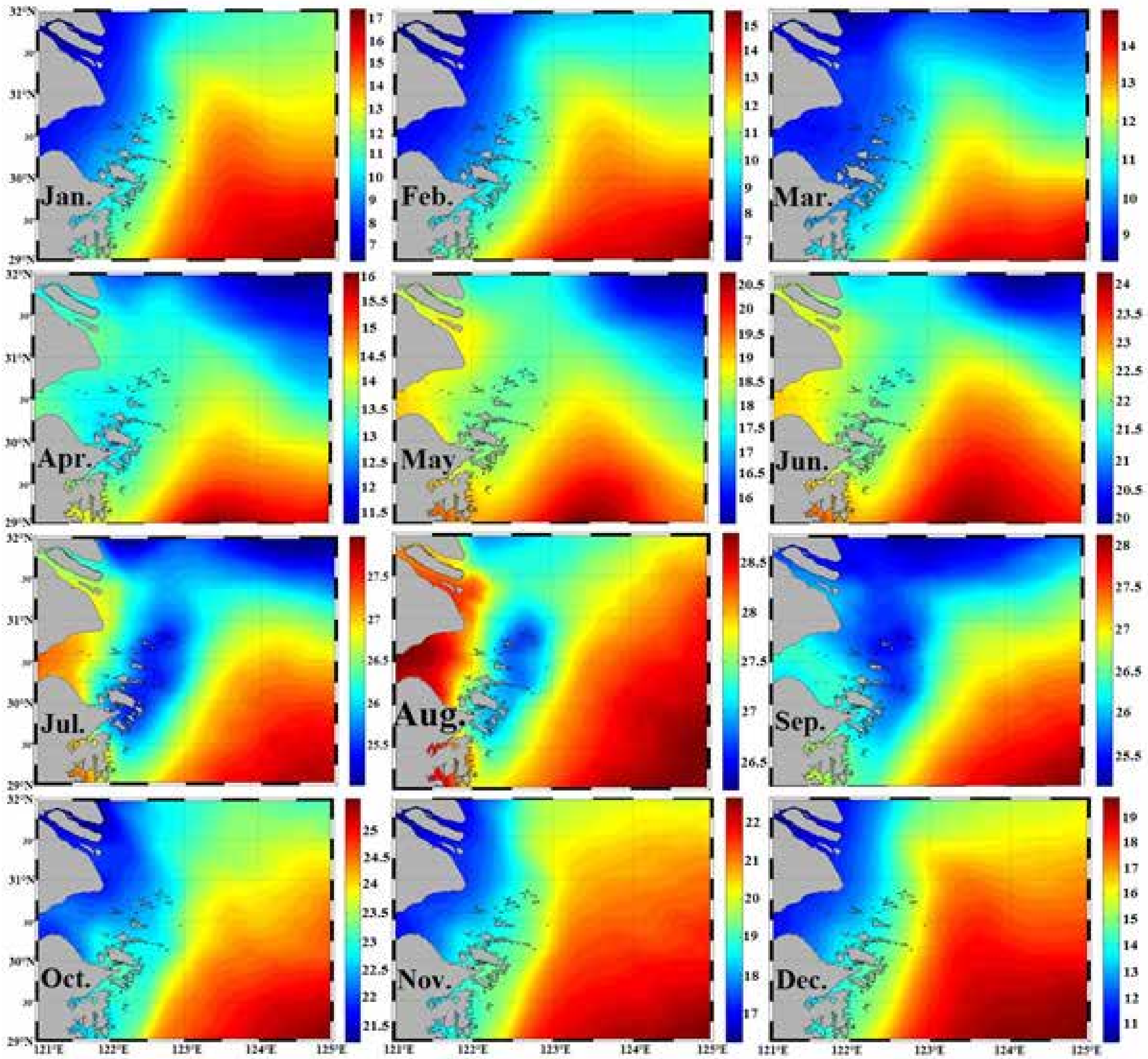

Figure 3. Monthly climatological SST (8C) averaged from MUR SST data (2003–2014) in the study area, which shows spatial and temporal variation of the coastal upwelling around the Zhoushan Islands.

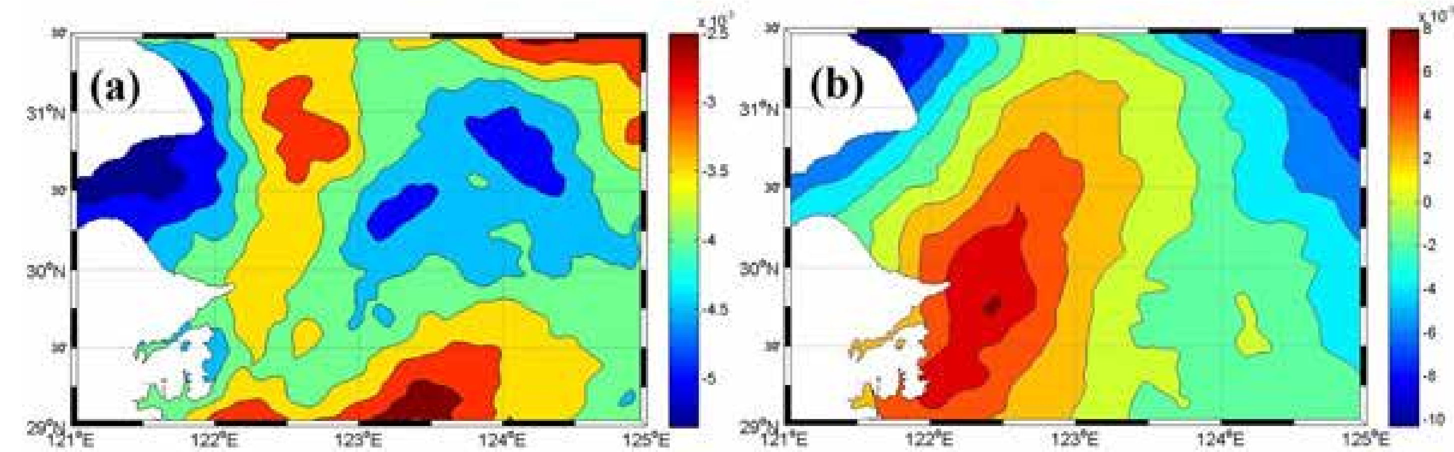

Figure 4. (a) The first EOF mode of the SST anomaly in July, which represents the influence of river runoff (*e.g.*, the Yangtze River and Qiantangjiang River) and ocean currents (*e.g.*, TWC, Yellow Sea coastal current, *etc.*) on SST. (b) The second EOF mode, which represents the state of the study area under the influence of coastal upwelling. The area with positive values corresponds to the upwelling region.

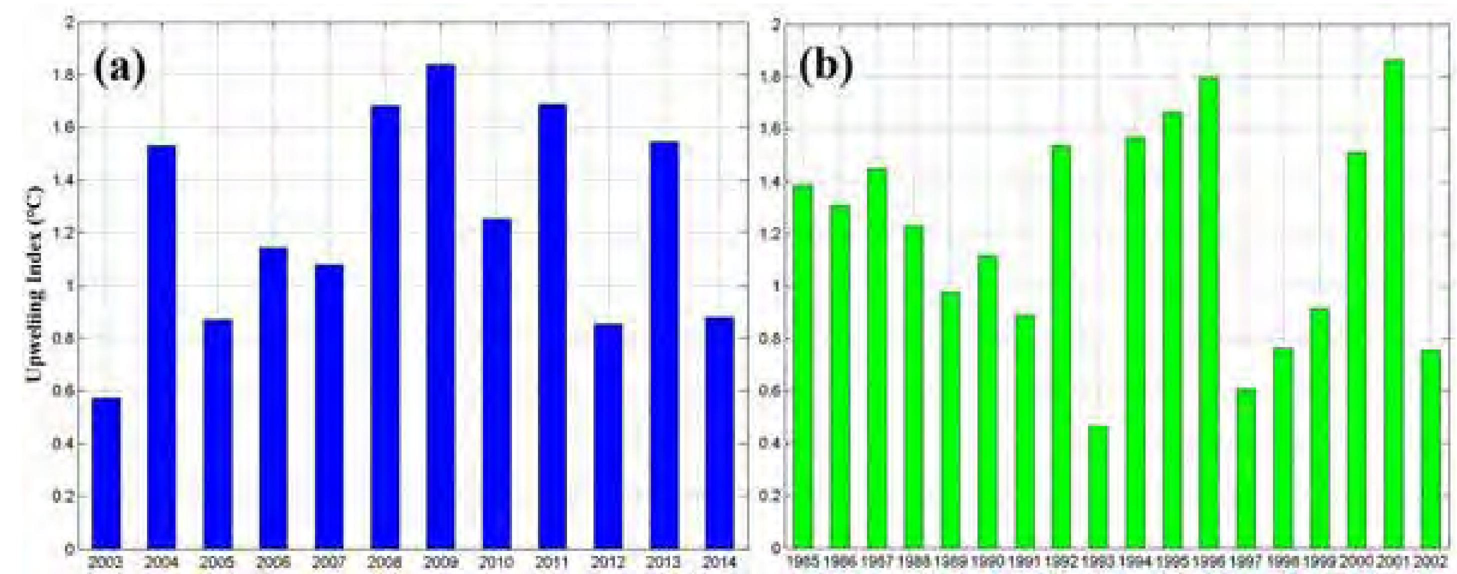

Figure 5. The SST upwelling index of the Zhoushan upwelling calculated from (a) high-resolution MUR SST data during 2003–2014 and (b) relatively low resolution Pathfinder SST data during 1985–2002. Both figures show the interannual variability of the upwelling intensity.

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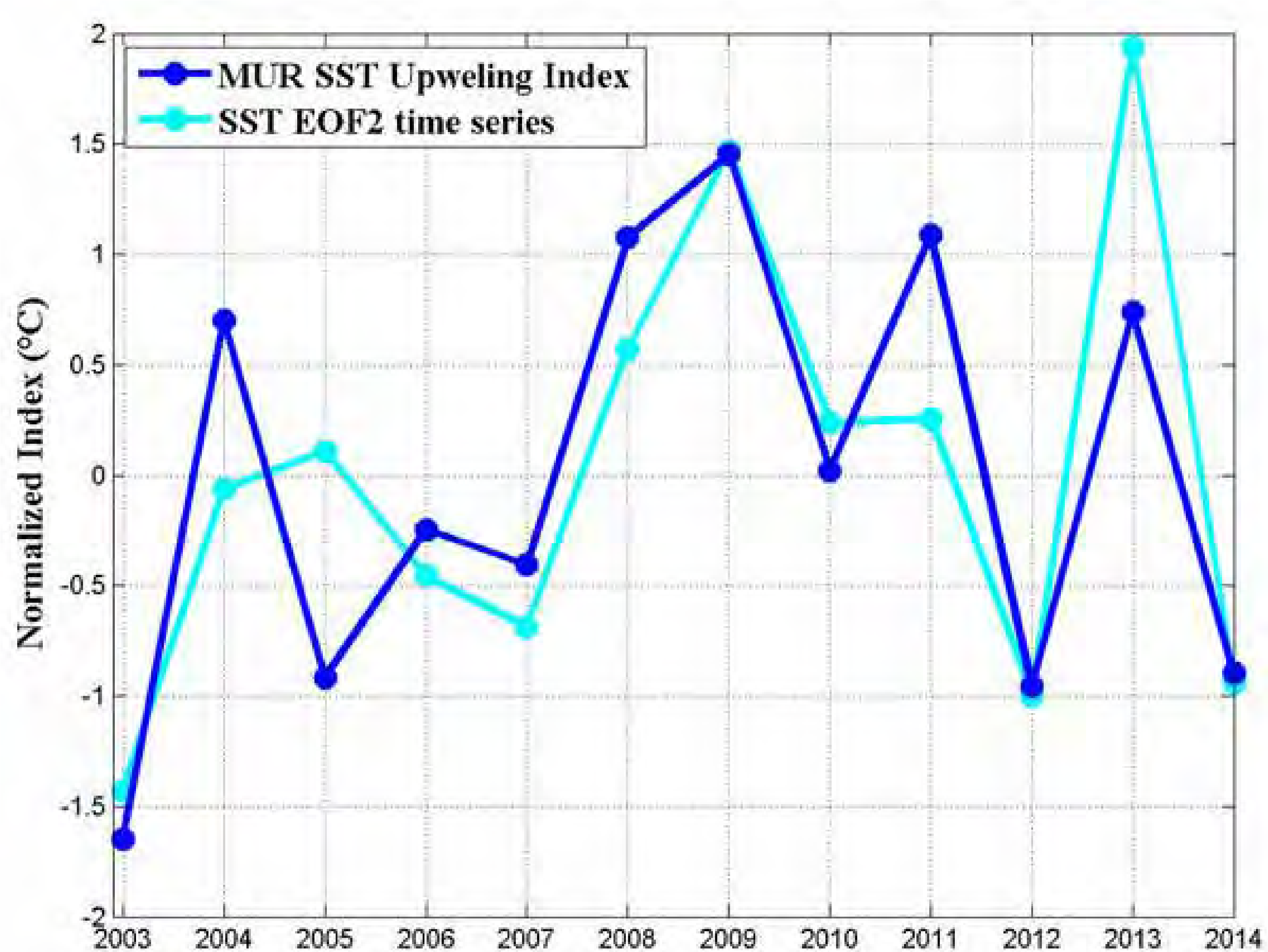

Figure 6. Comparison between the normalized SST upwelling index and time series of the EOF-2 mode of the SST anomaly. The correlation coefficient is 0.81, indicating that the SST upwelling index is a good indicator of upwelling intensity.

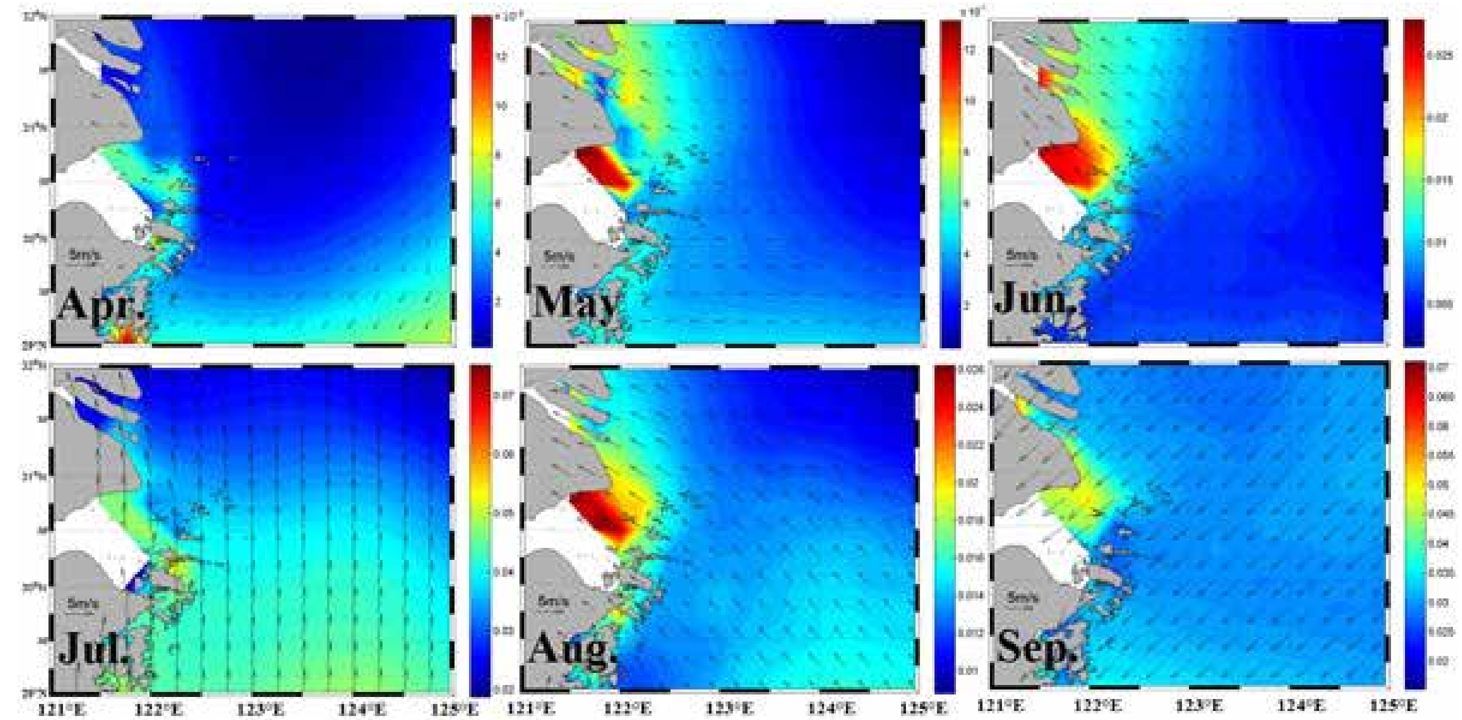

Figure 7. Monthly climatological sea surface wind field (2003–2014) overlaid on the wind stress (N/m^2) map, showing that the wind plays an important role in the generation and evolution of summer upwelling by Ekman transport.

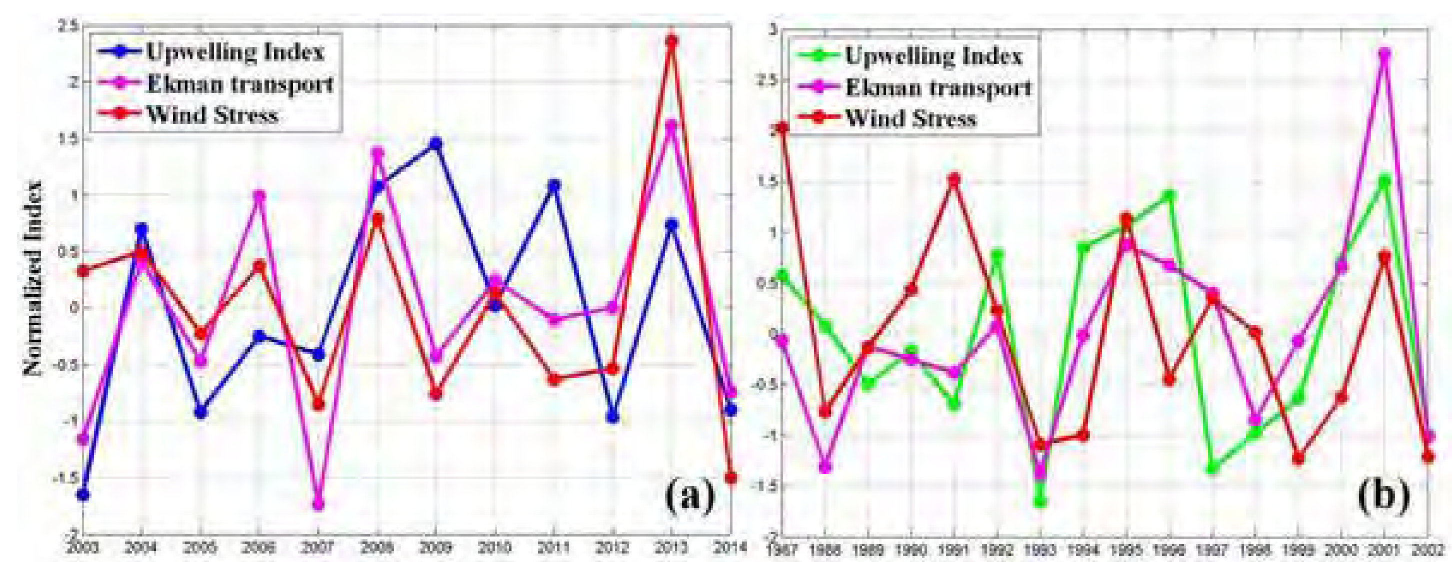

Figure 8. The relationship between the normalized SST upwelling index, wind stress, and Ekman transport in July under the favorable southeasterly wind (for case 2) during 2003–2014 (a) and 1985–2002 (b). Both wind stress and Ekman transport show strong interannual variability similar to that of the upwelling index, indicating that the wind plays a dominant role in determining the intensity of summer upwelling.

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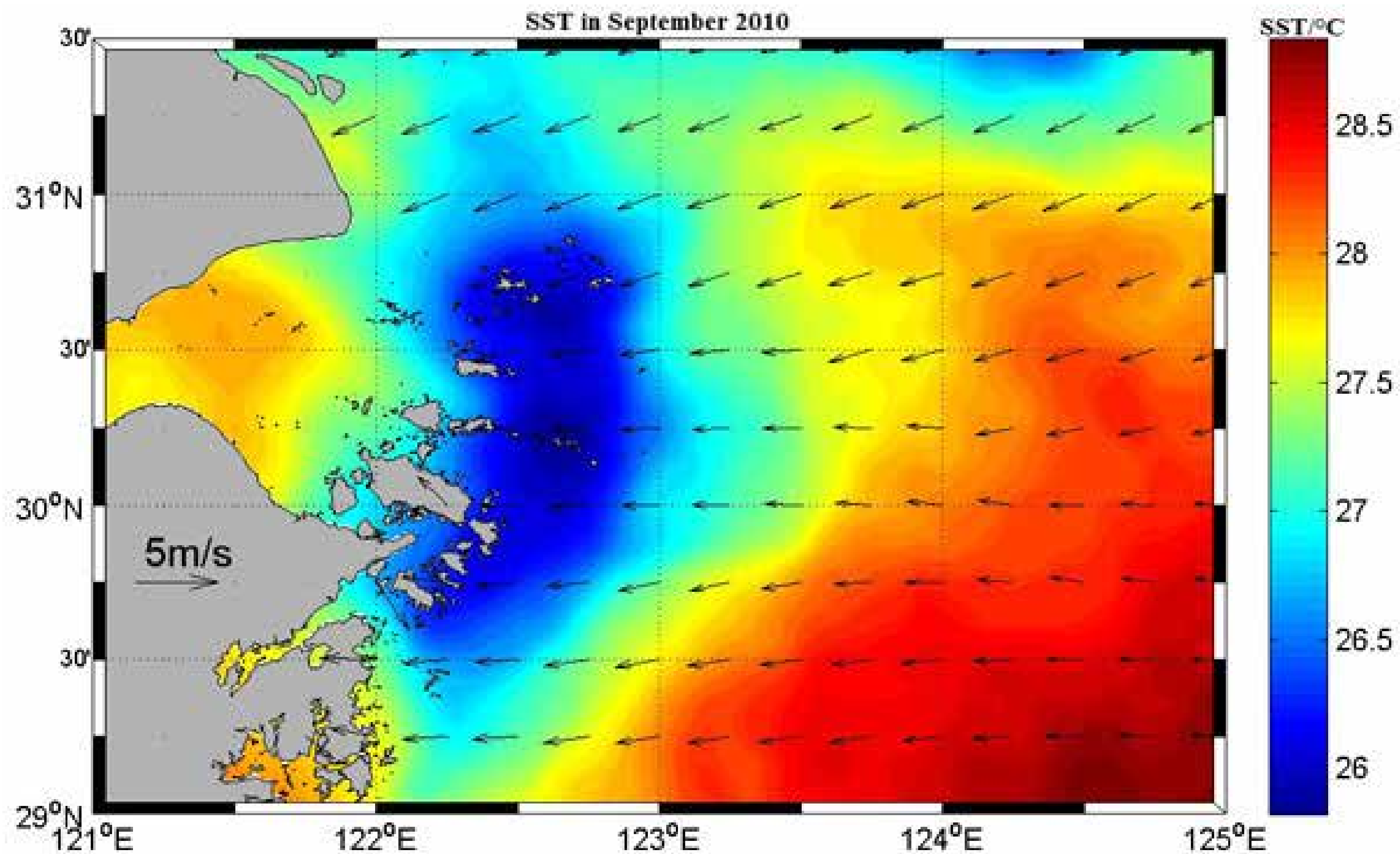

Figure 9. SST and the sea surface wind field in September 2010, which shows an intense upwelling driven by a strong upwelling-favorable easterly wind, whereas in the other years, the upwelling almost disappears in September when the northeasterly wind prevails.

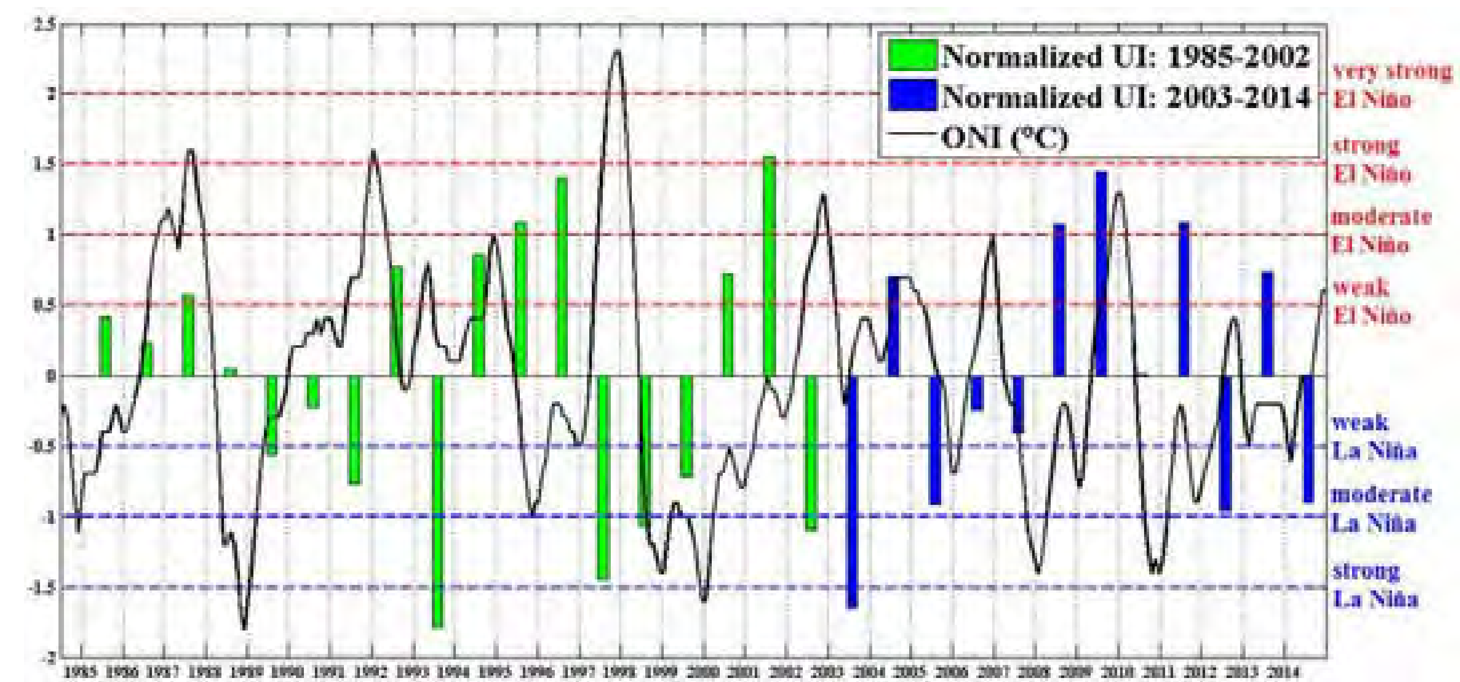

Figure 10. The normalized SST upwelling index (in July) and the ONI during 2003–2014 (black bars) and 1985–2002 (slash bars). The upwelling indexes during the two periods are normalized separately. The unstable correlation between the two indexes suggests that modulation of ENSO on upwelling intensity is complex.

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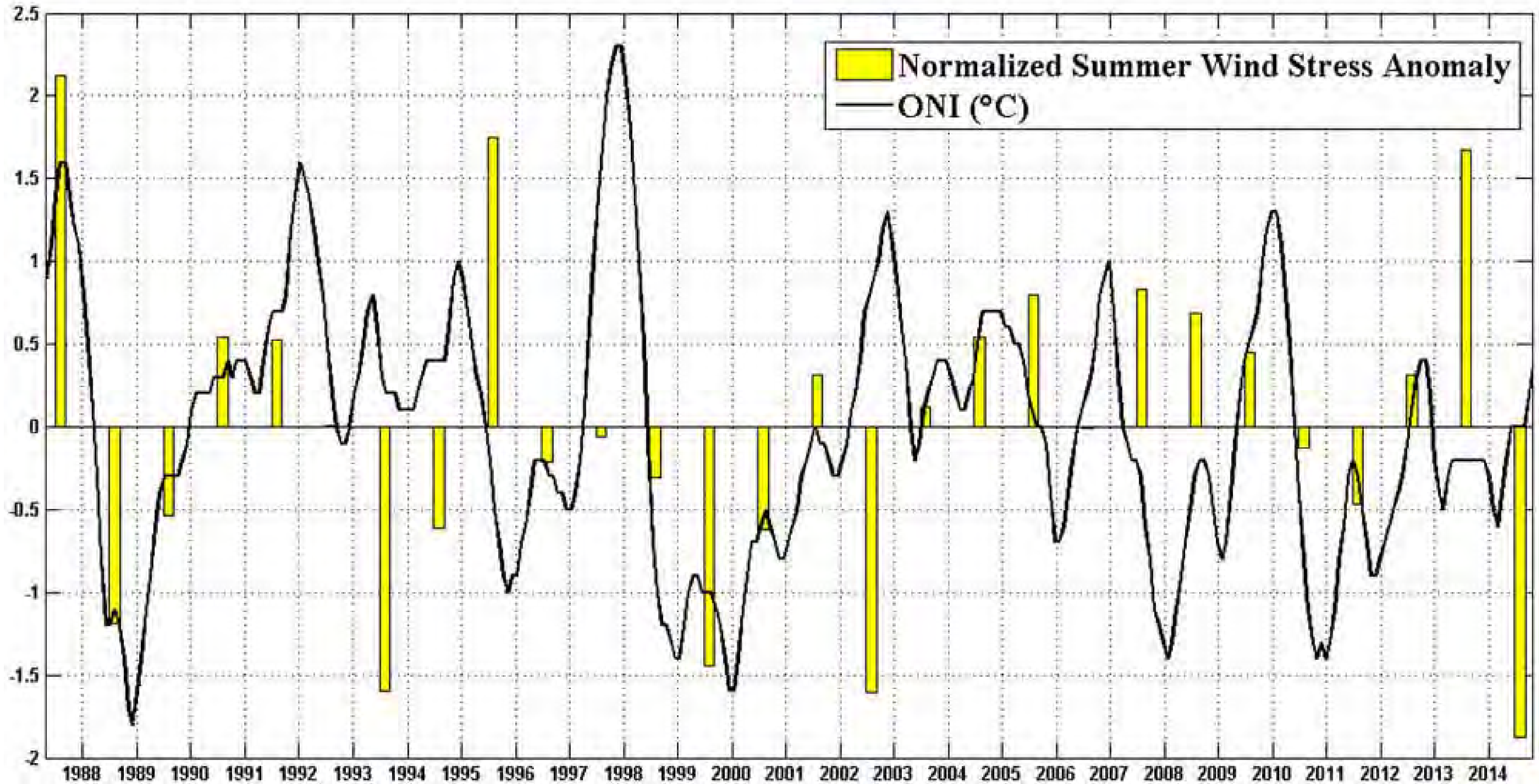

Figure 11. The normalized summer (June, July, and August) wind stress anomaly (white bars) and the ONI (black line) during 1987–2014. The correlation between the sea wind in the study area, which is part of the EASM and ENSO, is unstable because of the variation in the ENSO–EASM relationship.

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Recently Published

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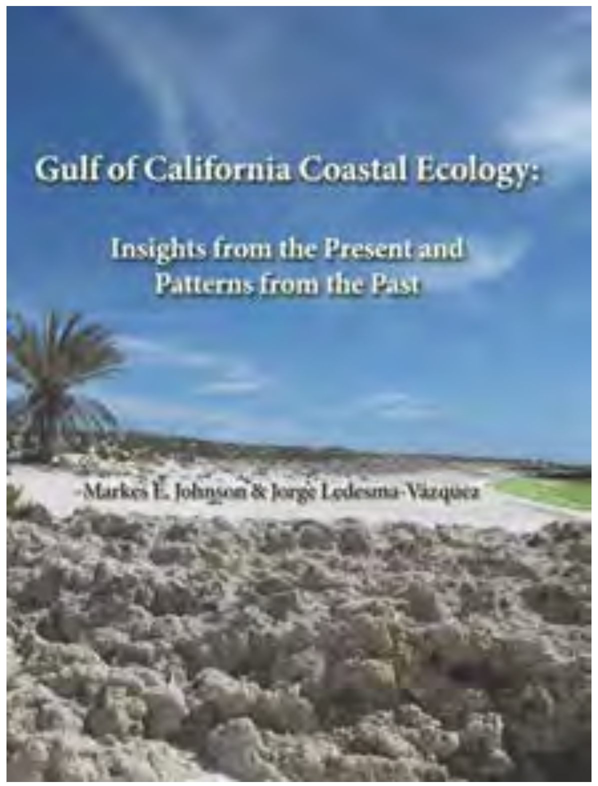
by Markes E. Johnson and Jorge Ledesma-Vázquez



Co-authored by geologist Jorge Ledesma-Vázquez, this handbook on ecology and paleoecology is infused with insights on the origins and development of Mexico's Sea of Cortés during a span of more than 12 million years. It makes the connection between a beautiful shell washed onto a beach with the discovery of the same or a similar fossil shell from a nearby limestone cliff. The concept of natural history appears less often in increasingly specialized literature, nowadays, failing to draw a connection between the present and the distant past. This book makes the connection and brings the past alive. It deals with multiple and interlocking ecosystems and their fossil counterparts, providing a holistic overview on geography, ecology, and geology. Students, scholars, and outdoor enthusiasts of all kinds will find this guide an indispensable resource for exploration of virtually any stretch of coastline on the Gulf of California.

Markes E. Johnson is the Charles L. MacMillan Professor of Natural Science, Emeritus, at Williams College in Williamstown, Massachusetts, where he taught courses in historical geology, paleontology, and stratigraphy in the Geosciences Department over a 35-year career. Professor Johnson also currently serves as an Editorial Board Member for the *Journal of Coastal Research* (JCR). His undergraduate education in geology concluded with a BA degree (1971) from the University of Iowa and his advanced training in paleoecology culminated with a Ph.D. degree (1977) through the Department of Geophysical Sciences at the University of Chicago. With 25 years of field experience in Baja California, Johnson has been a semi-annual visitor to the frontier states of Mexico where he habitually led field courses and supervised thesis projects for students from Williams College. He is an authority on the geology of ancient shorelines and the evolution of inter-tidal life through geologic time based on studies conducted around the world from Western Australia to China's Inner Mongolia to the fringe of Arctic lands across Siberia, Norway, and Canada, as well as comparatively young island groups such as the Seychelles in the Indian Ocean and the Cape Verdes in the North Atlantic. Whether on explorations near or far away, this traveler has always been drawn back to the wild islands in the western Gulf of California and their associated peninsular shores. The author lives with his spouse, Gudveig Baarli, in Williamstown, Massachusetts, where they maintain an active and mutually supportive schedule of ongoing research and writing projects.

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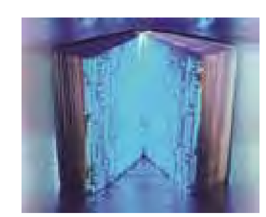

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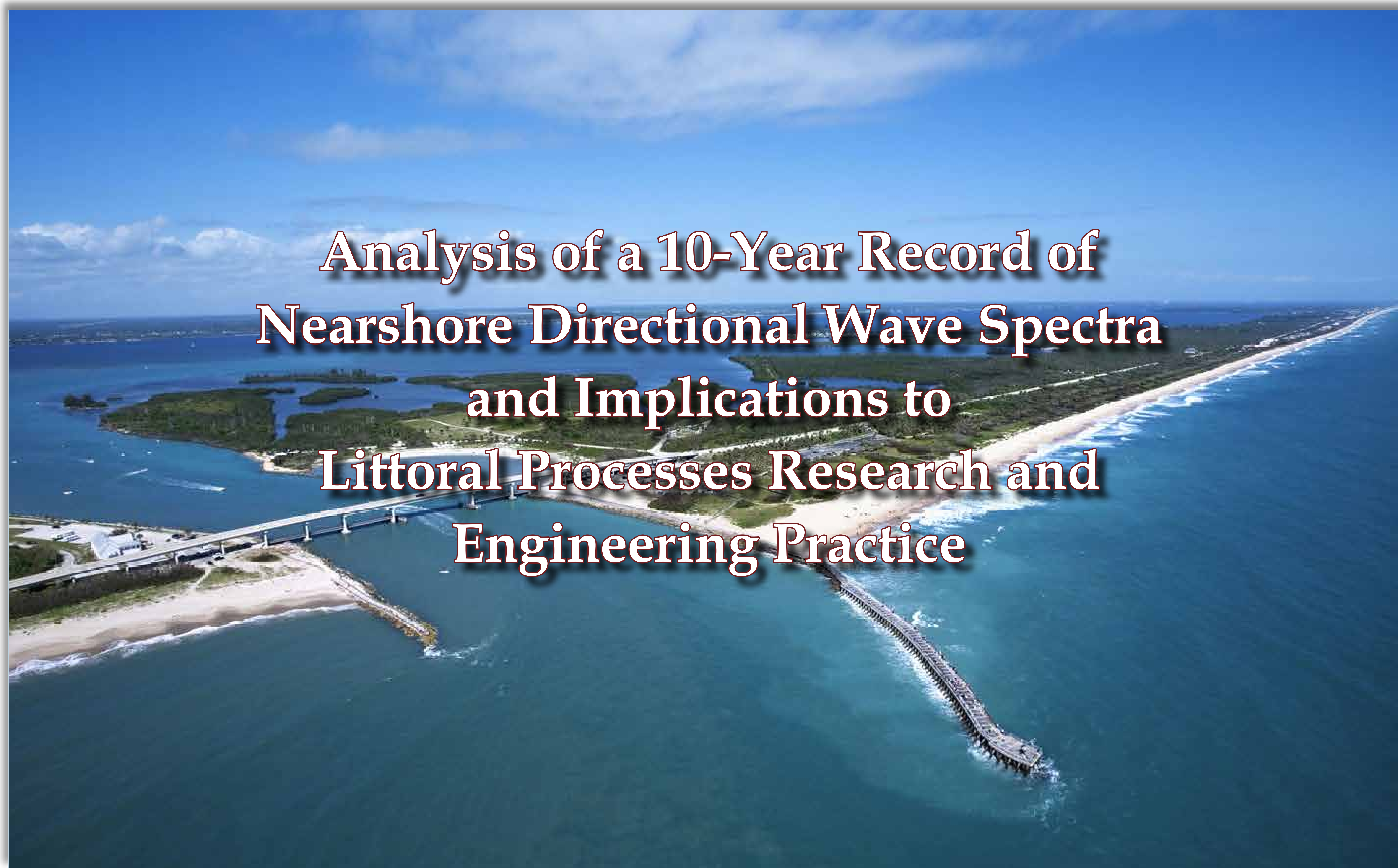

Analysis of a 10-Year Record of Nearshore Directional Wave Spectra and Implications to Littoral Processes Research and Engineering Practice

Analysis of a 10-Year Record of Nearshore Directional Wave Spectra and Implications to Littoral Processes Research and Engineering Practice

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ABSTRACT

Slightly more than 10 years (August 28, 2001, to October 28, 2011) of high-resolution directional wave spectra were measured by an Acoustic Doppler Current Profiler installed in the nearshore at Spessard Holland North Beach Park in Melbourne Beach, Florida. Analysis of the record yields an average wave power of 17.6 MW/m of shoreline but with a standard deviation of 22.5 MW/m. Cumulative annual wave power ranged from 43,455 to 93,722 MWh/m, and the annual storm count was between 3 and 14. The mean spectrum for the entire record shows an almost symmetric directional distribution of wave energy centered on the shore-normal direction, which is somewhat unexpected considering that the net longshore transport in the region is definitively N-S. Partitioning the data into shore-normal, NE, and SE windows shows that most wave energy approaches from the SE, again contrary to expectations. The rigorously integrated mean longshore forcing of wave radiation stress, S_{xy}, is slightly N-S (7.2 N/m) but has a standard deviation of 77.2 N/m. Computing a cumulative average through the record indicates that it takes between 4 and 5 years for the net magnitude and direction of S_{xy} to be conclusively revealed. Using significant wave height, peak wave period, and mean wave direction to estimate S_{xy} yields values nominally 42% greater than the integrated results, confirming that fully directional spectra should be used in both study of littoral processes and coastal engineering practice. Finally, the supposition that the wind plays an important role in driving longshore currents and consequently longshore transport is tested. However, analysis of more than 4 years of wind data collected at the site reveals a mean longshore wind stress that is essentially balanced (*i.e.* nil).

ADDITIONAL INDEX WORDS: *Nearshore wave climate, wave power, radiation stress, Acoustic Doppler Current Profiler measurements.*

INTRODUCTION

Although wave buoy data have been collected for several decades by the National Data Buoy Center (NDBC, 2015) and others, the buoys are generally located far offshore in deep water. As such, their data are consequently of little direct use in coastal science and engineering applications because of the processes that affect waves as they enter shallow water, most notably refraction and energy losses due to bottom friction (*e.g.*, Herbers, Hendrickson, and O'Reilly, 2000). Spectral wave modeling, calibrated for bottom friction losses, can be used to transform the deepwater waves to the nearshore (*e.g.*, Ardhuin, Herbers, and O'Reilly, 2008; Padilla-Hernandez and Monbaliu, 2001); however, many of the buoys are nondirectional. Those that have directional capabilities yield only coarse directional distributions and cannot fully resolve wave fields from multiple sources (Strong, Brumley, and Terray, 2001). As illustrated later, full resolution of the directional distribution of wave energy in shallow water is critical for reliable computation of nearshore radiation stress (Battjes, 1972; Ruessink *et al.*, 2001) and consequently the forcing of long-

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shore currents and ultimately longshore transport of sediment.

Long-term (*i.e.* decadal) records of high-resolution directional wave measurements in shallow water are rare. Herein, "shallow water" is taken to be less than approximately 10 m depth but deep enough to be outside the surf zone during storm events. One early effort to measure nearshore waves long term was that of the Florida Coastal Data Network (Howell, 1980). At one time, the network consisted of as many as eight bottom-mounted pressure transducer wave gauges, with six deployed at nominally 80-km intervals along the Atlantic coast of Florida and two deployed on the Gulf coast. The gauges were cabled to shore, with data transfer and gauge programming performed over telephone lines. The system was active to varying degrees for nearly 13 years (1978–91). However, wave direction was measured at only two sites using a pressure gauge and biaxial electromagnetic current meter, which has the same directional resolution shortcomings as a directional buoy (Strong, Brumley, and Terray, 2001).

Perhaps the most notable record of directional wave measurements in shallow water is that collected by the "8-meter array" at the U.S. Army Corps of Engineers (USACE) Field Research Facility (FRF) located in Duck, North Carolina (Long and Oltman-Shay, 1991). Originally installed in September 1986 and brought online in January 1987, it was kept in operation until February 2012, except for a major gap between December 1987 and August 1988. Analysis of the raw data from this array of bottom-mounted pressure transducers used the iterative maximum likelihood estimator method (IMLM) developed by Pawka (1983) to construct detailed, high-resolution directional wave spectra from 2-hour, 16-minute records every 6 hours for approximately 23 years. During storm events, defined as times when the energy-based significant wave height exceeded 2 m, data were recorded every 3 hours. Long (1994) presents an analysis of the evolution of the directional spectra during 29 storms that occurred between 1986 and 1991. Although wave spectral parameters documented by the 8-meter array at the FRF have been included in a series of monthly data reports, thus far there does not appear to have been an effort to analyze the entire record of directional spectra to examine seasonal behavior or long-term trends.

Lastly, a system of three nearshore wave gauges and meteorological instruments was operated along the coast of New Jersey by the Stevens Institute of Technology from 1999 until 2007 (Herrington, Bruno, and Rankin, 2000). The wave gauges were precision pressure transducers (nondirectional), each cabled to shore, with wave statistics reported hourly. The instrument stations were located in Belmar (northern), Long Beach Township (central), and Avalon (southern), New Jersey, and initially were extremely rugged, measuring conditions during Hurricanes Dennis and Floyd in 1999.

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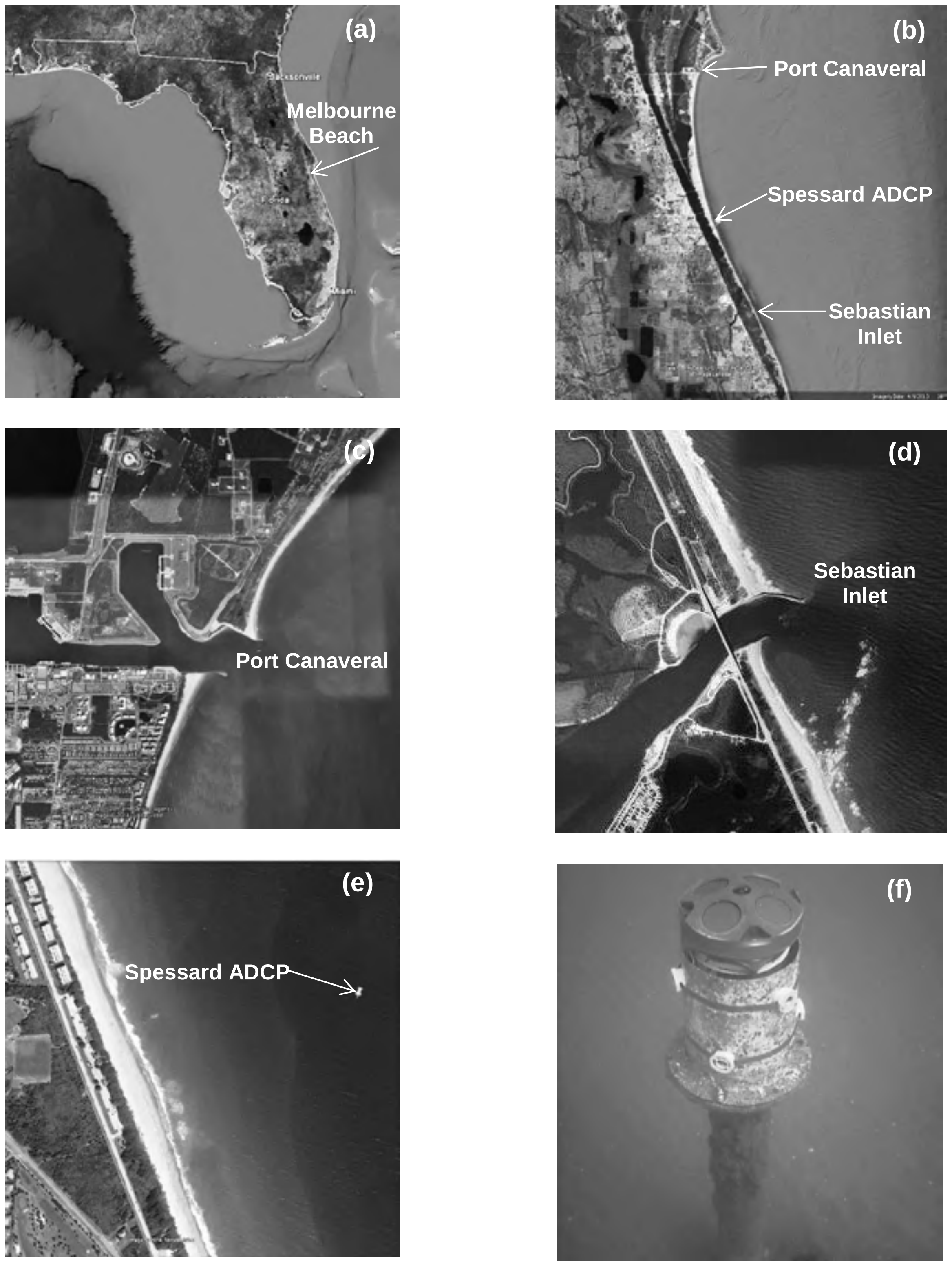

Figure 1. (a) Florida Peninsula showing the location of Melbourne Beach and (b) the locations of Port Canaveral, the Spessard ADCP, and Sebastian Inlet. (c) Aerial of Port Canaveral showing its N-S offset. (d) Aerial of Sebastian Inlet showing its N-S offset. (e) Close-up of the location of the Spessard ADCP. (f) The ADCP attached to its jetted-pipe mooring.

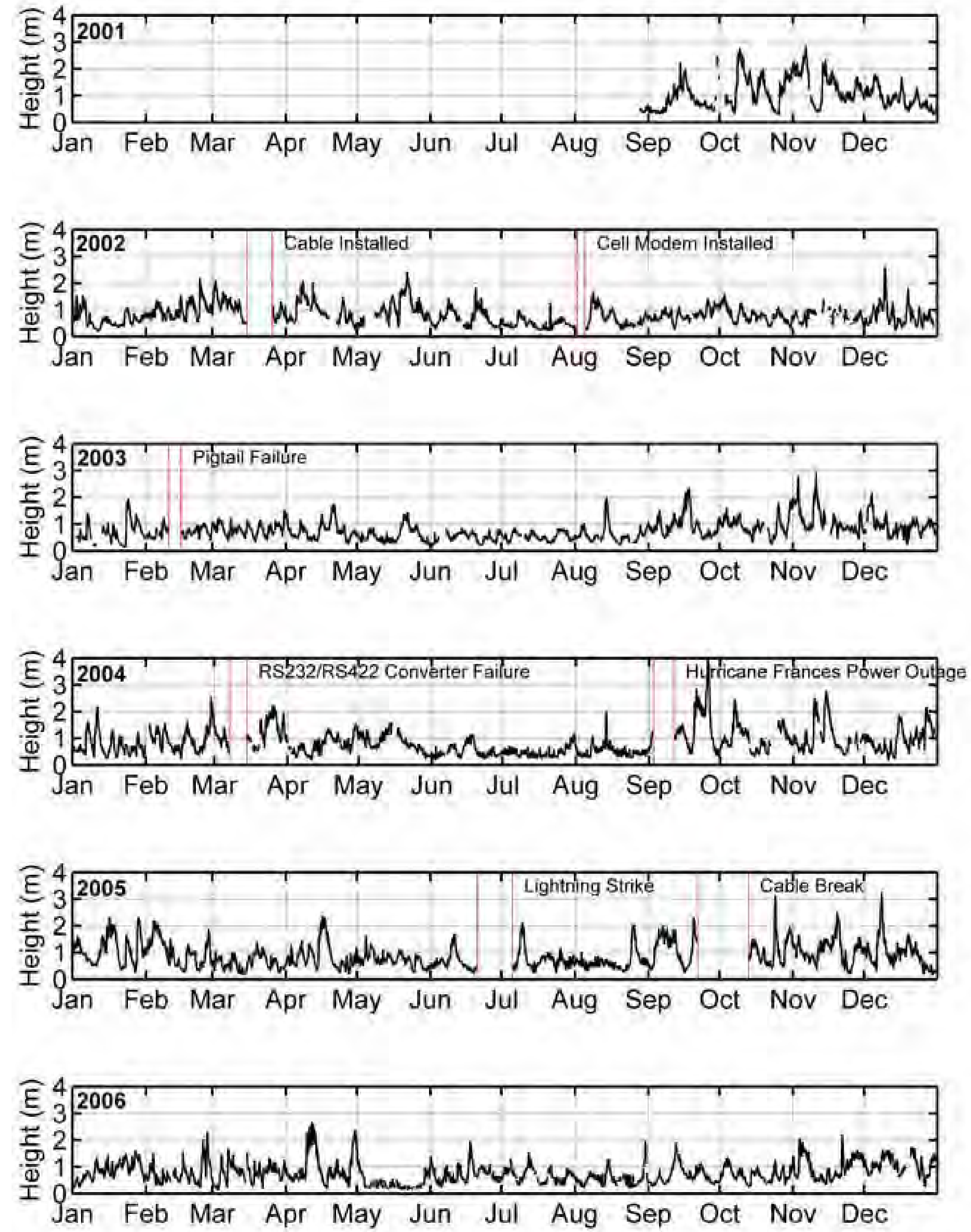

Figure 2. Record of energy-based significant wave height (H_{mo}) from the Spessard ADCP for 2001–06. Data were collected in 20-minute bursts every 2 hours. Causes of gaps in the record are noted.

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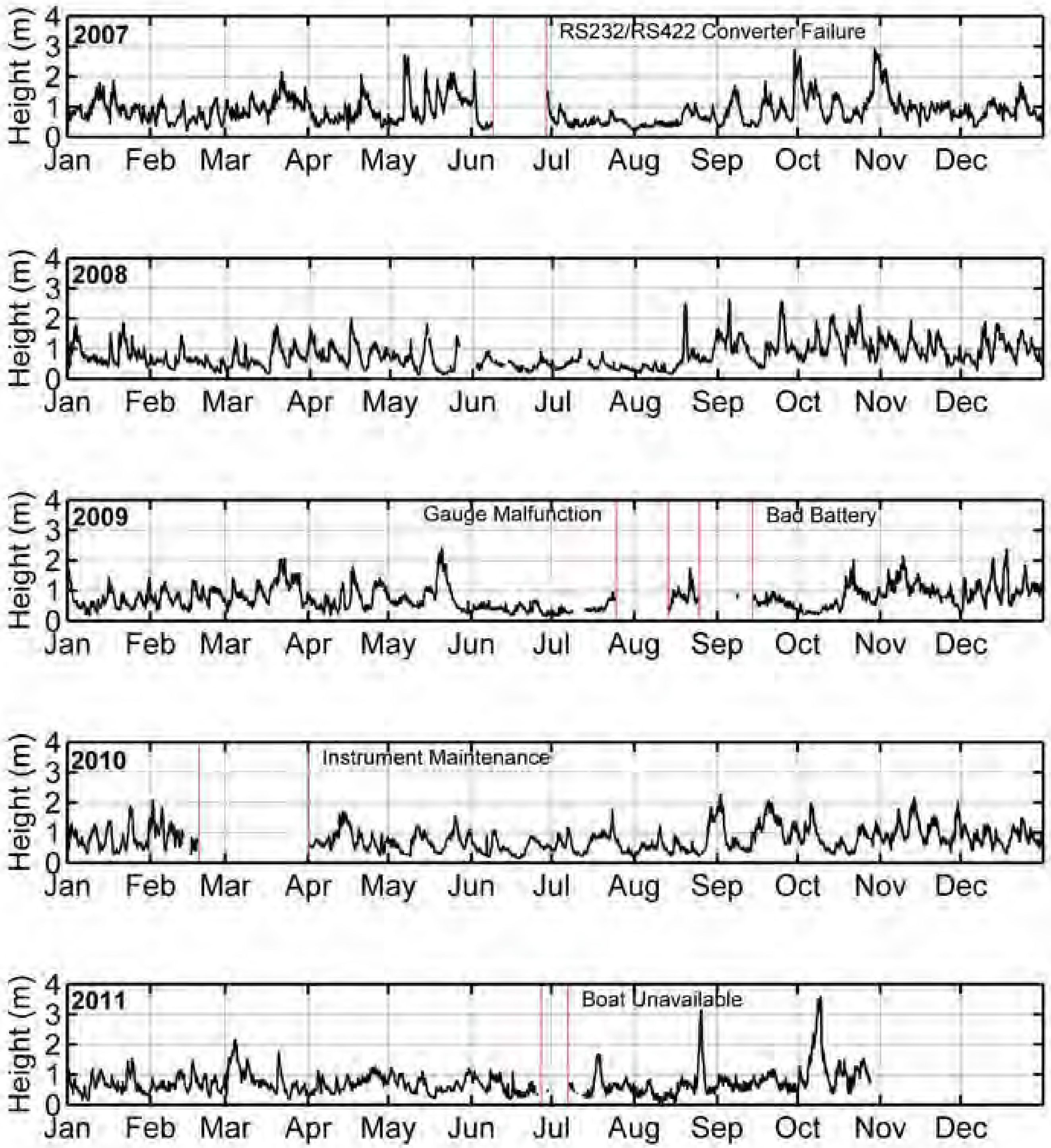

Figure 3. Record of energy-based significant wave height (H_{mo}) from the Spessard ADCP for 2007–11. Data were collected in 20-minute bursts every 2 hours. Causes of gaps in the record are noted.

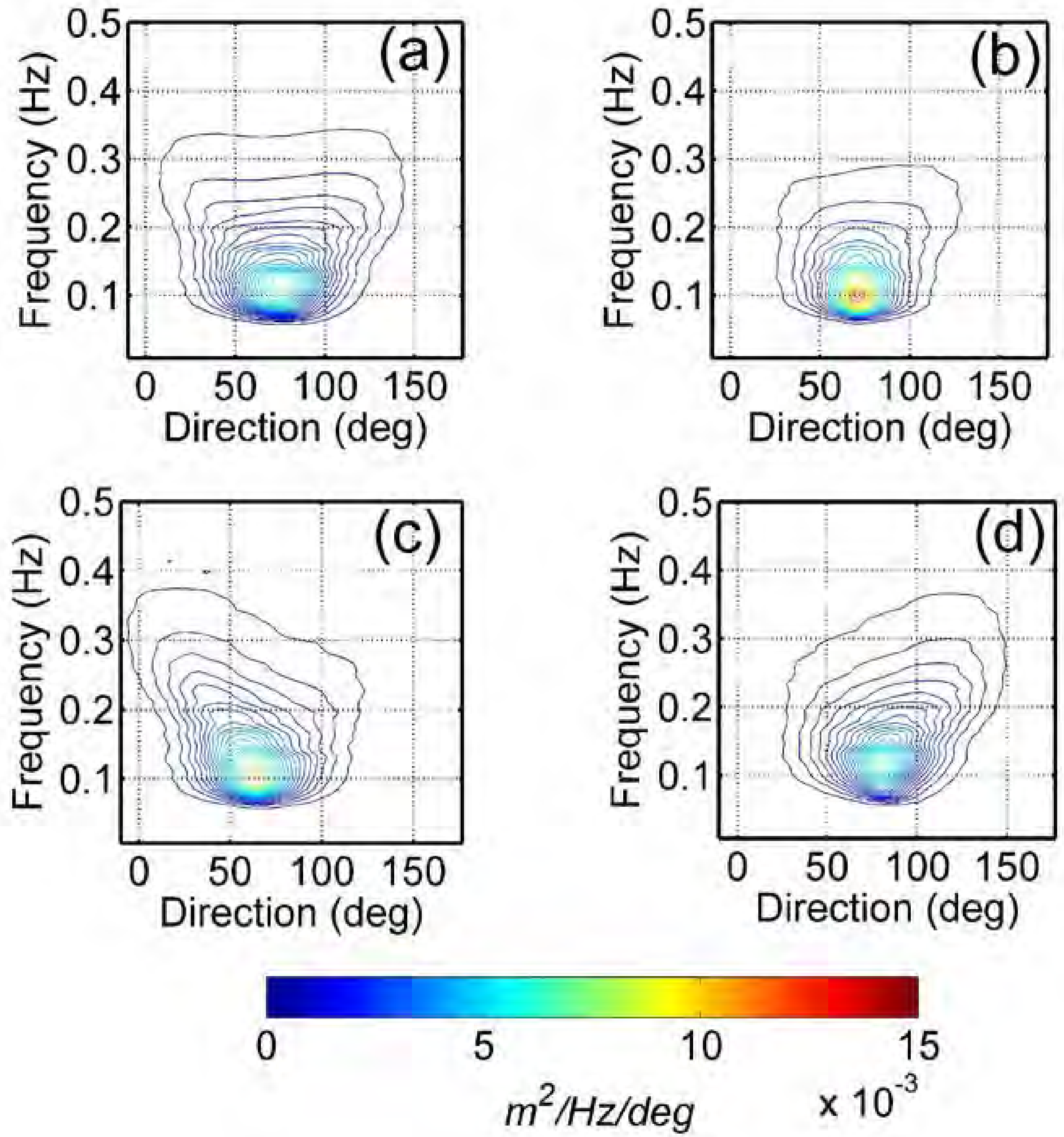

Figure 4. (a) Average of all 39,759 directional spectra from the Spessard record, showing a nearly symmetric distribution of energy centered on 74°, *i.e.* essentially the shore-normal direction (73°). (b) Average of 8151 directional spectra from the shore-normal window (69°<θ_p < 77°), showing peak energy at the shore-normal direction but with a slight bias of higher-frequency energy from the south. (c) Average of 10,716 directional spectra from the NE window (θ_p < 69°), with a peak at 61°and a high-frequency tail from the NE. (d) Average of 20,892 directional spectra from the SE window (θ_p < 77°), with a peak at 81° and a high-frequency tail from the SE.

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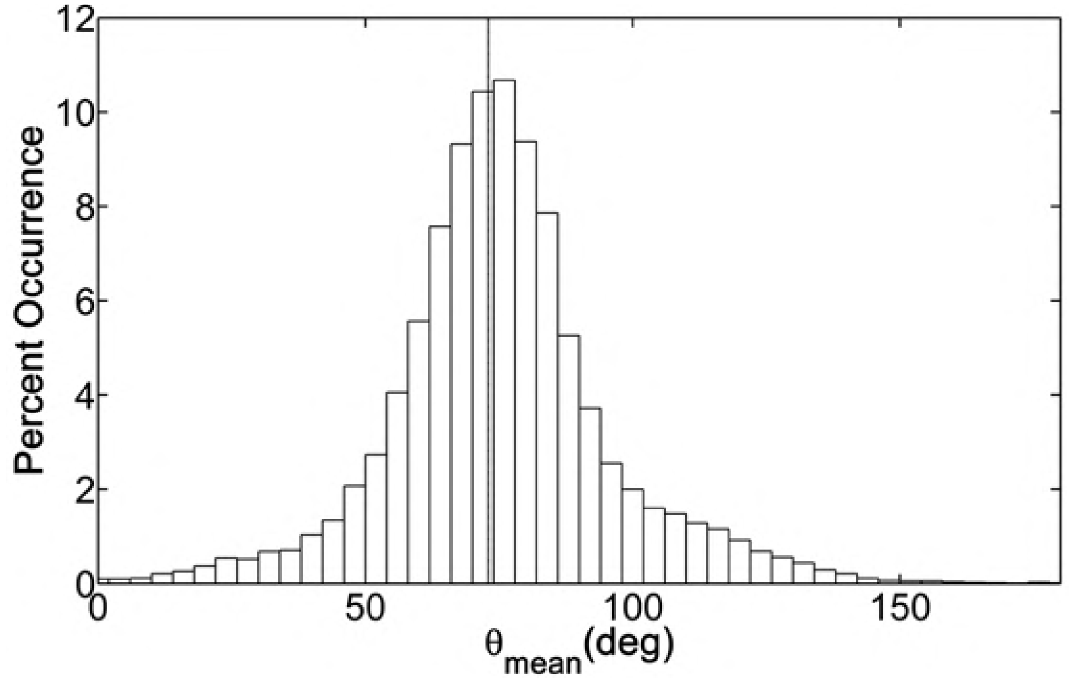

Figure 6. Directional distribution of wave energy from the Spessard ADCP for all waves and for each directional window (NE, SE, and shore normal), showing that waves from the SE dominate, contrary to expectations. Vertical line denotes the shore-normal direction.

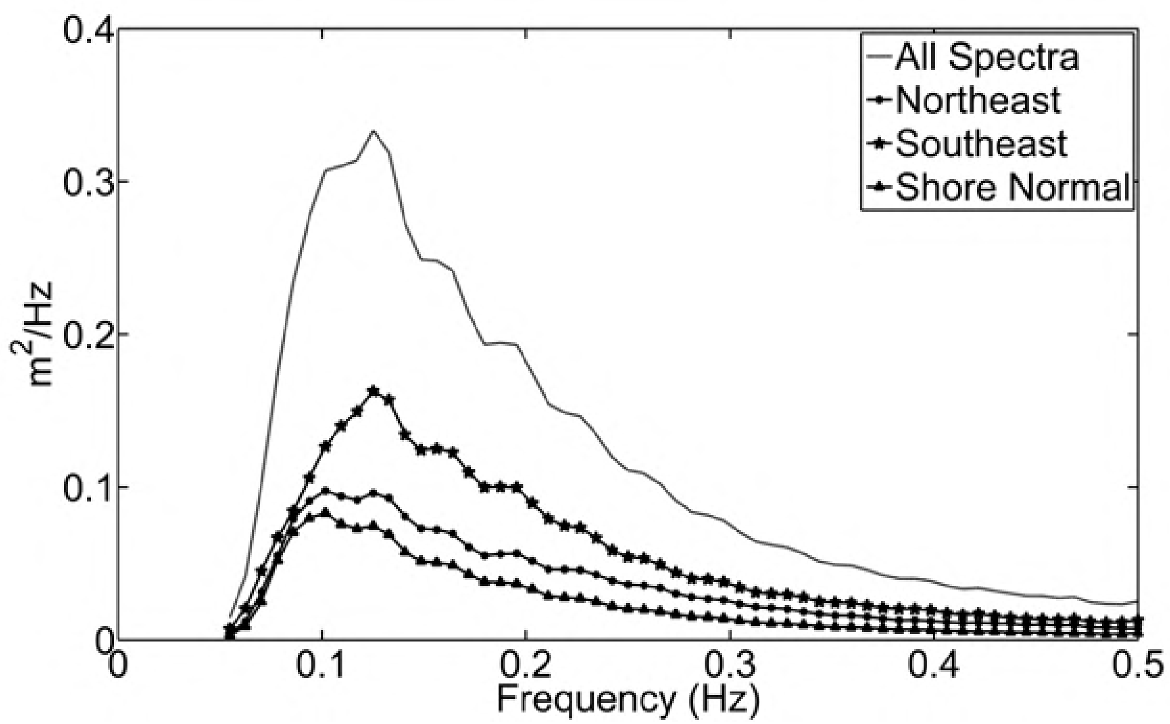

Figure 7. Average frequency spectra from the Spessard ADCP and for each directional window (NE, SE, and shore normal), showing substantially more higher-frequency energy from the SE window.

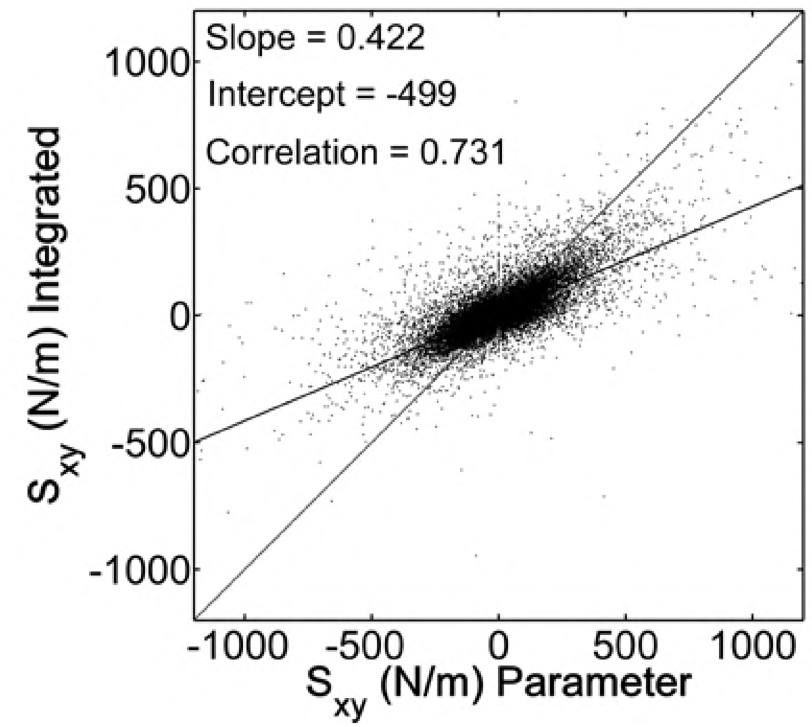

Figure 8. Scatter plot of integration-based *vs.* parameter-based estimates using Equation (2) *vs.* Equation (3) of radiation stress (S_{xy}) at Spessard. The parameter-based results are nominally 42% higher than those from integration.

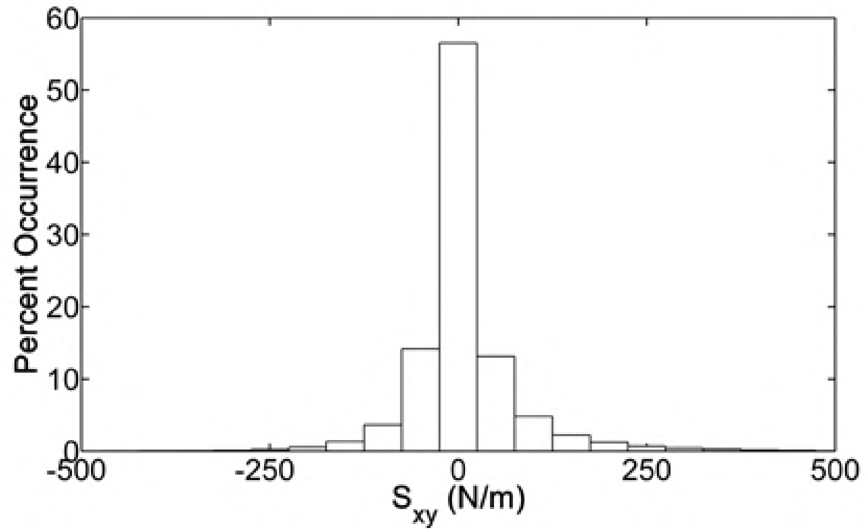

Figure 9. Histogram of integration-based radiation stress (S_{xy}) estimates at Spessard, displaying a nearly symmetric distribution about zero. There were 0.1% occurrences of S_{xy} >500 N/m and 0.04% occurrences of S_{xy} <–500 N/m.

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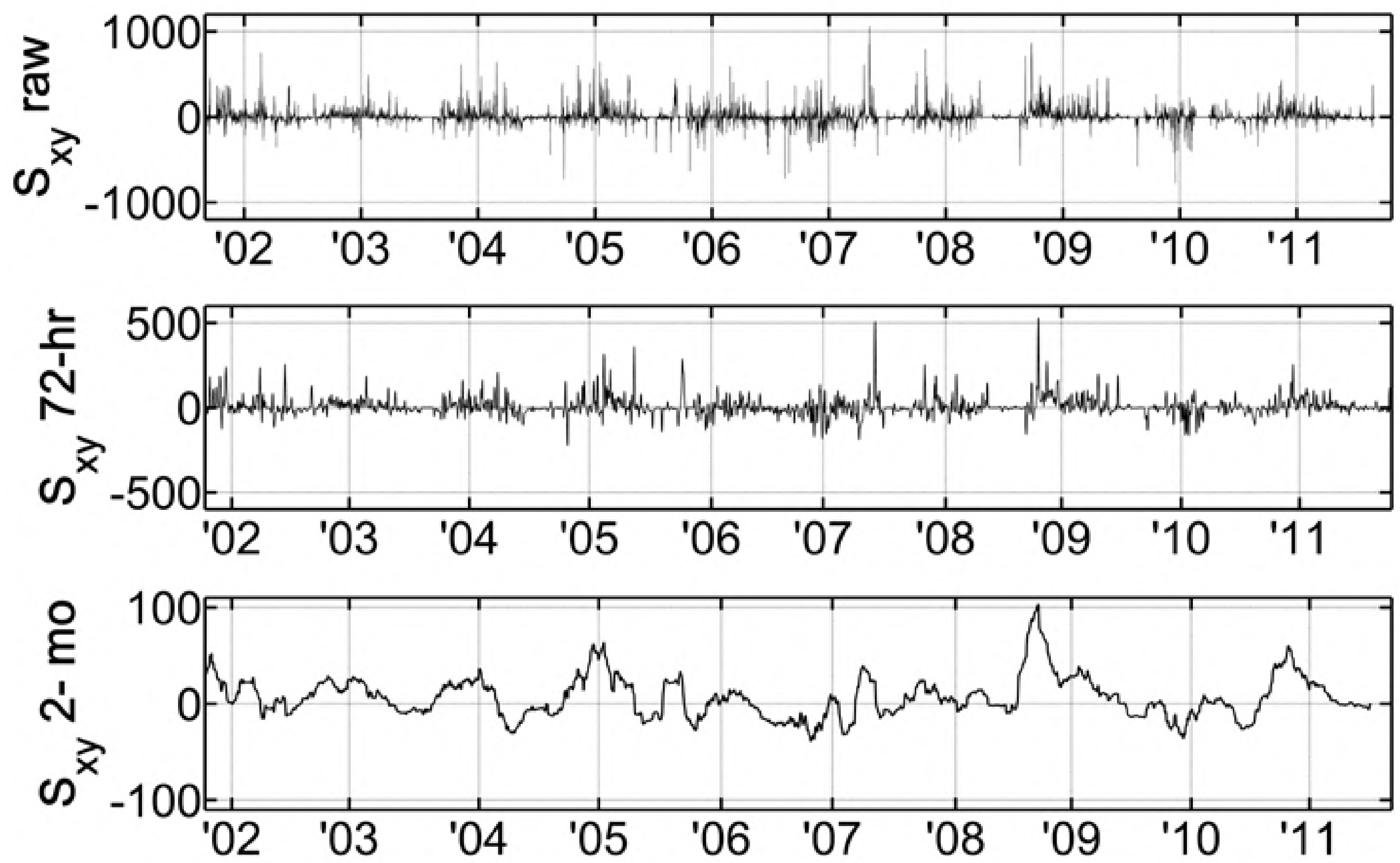

Figure 10. Time series of radiation stress (S_{xy}) from the 10-year record (upper panel), a 72-hour centered-boxcar running average (middle panel), and a 2-month centered-boxcar running average (lower panel). Periods of positive (N-S) forcing are characterized by sequences of moderate storms punctuated by one or more major events, whereas periods of negative forcing are characterized by sustained times of mild-to-moderate conditions. Note the absence of clear seasonality mid-2005–08 and during 2009–10.

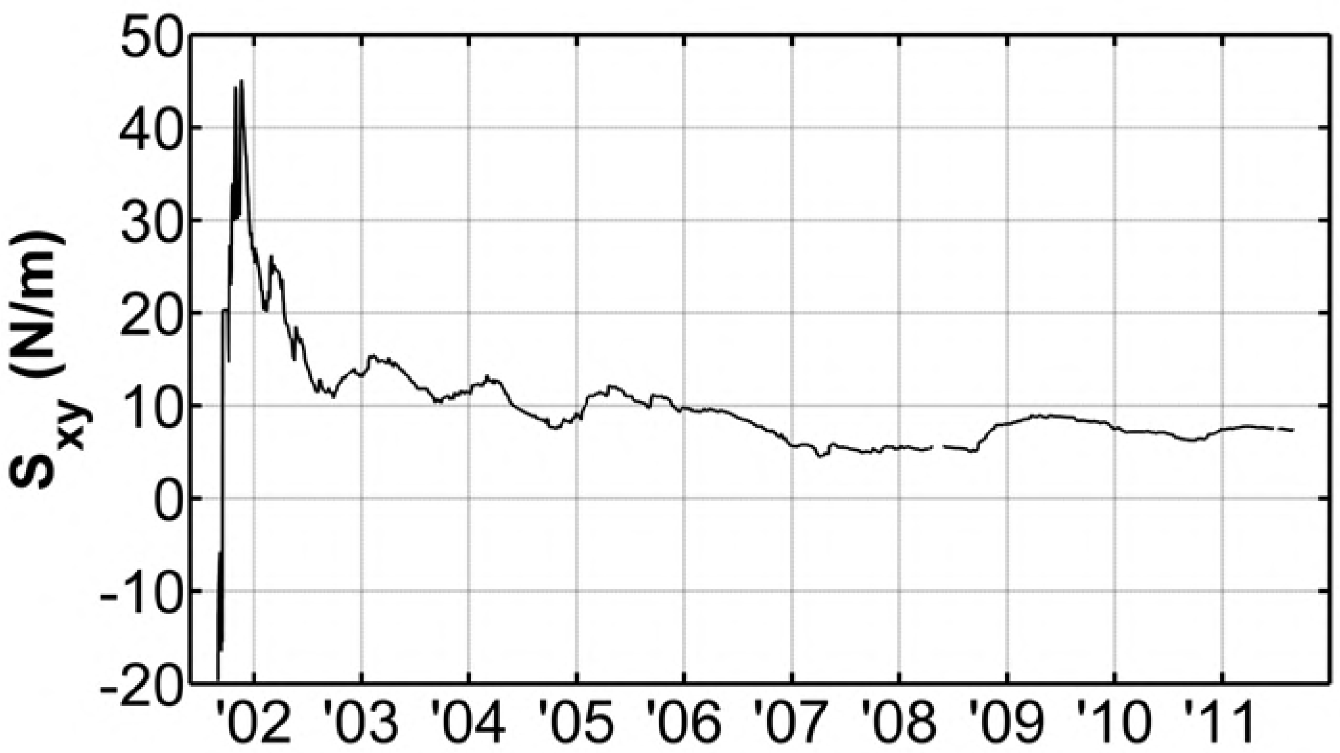

Figure 11. Cumulative average of radiation stress (S_{xy}) starting at the beginning of the Spessard record (August 28, 2001), indicating that it requires 4 to 5 years of data before the net magnitude and direction of longshore wave forcing conclusively reveal themselves.

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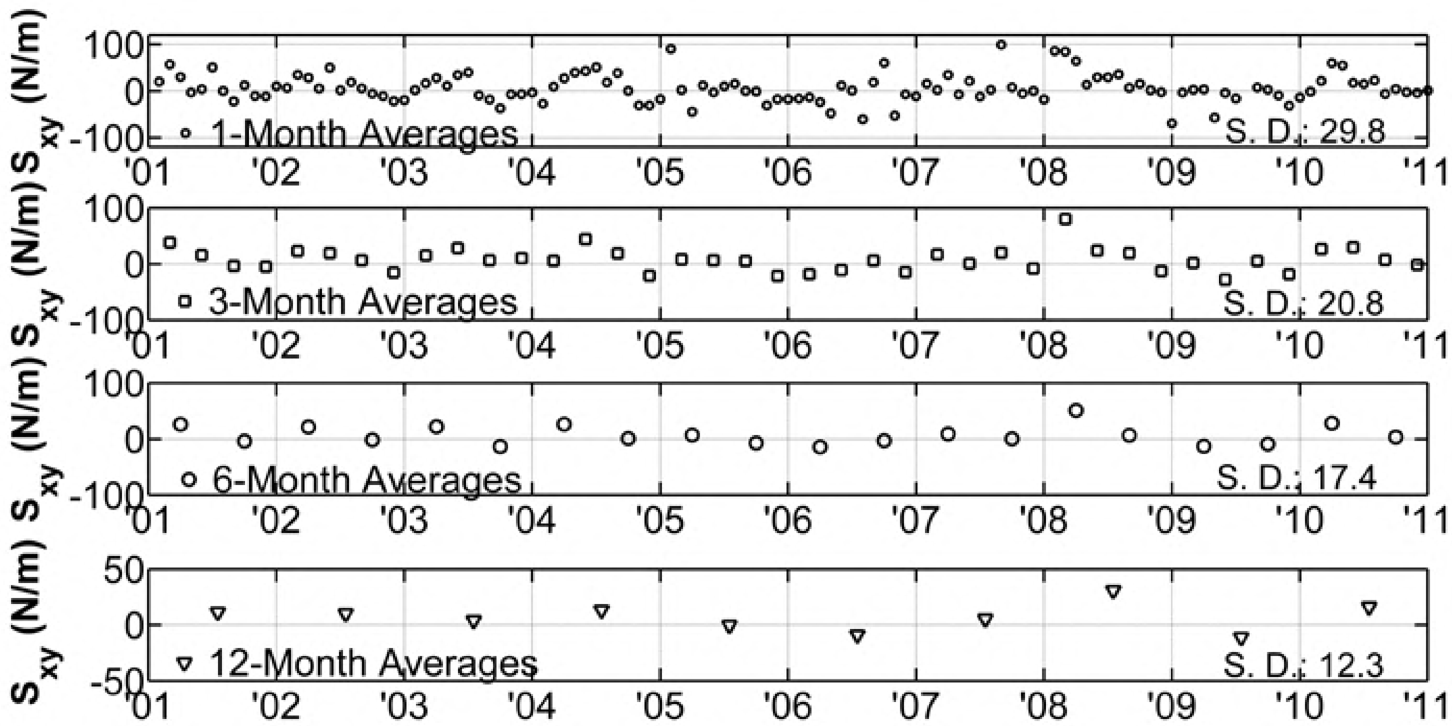

Figure 12. Comparison of centered-block averages of radiation stress (S_{xy}) for different timescales. Each block starts on October 1. Shortening the block length increases the chances of mistaking the dominant direction of longshore forcing.

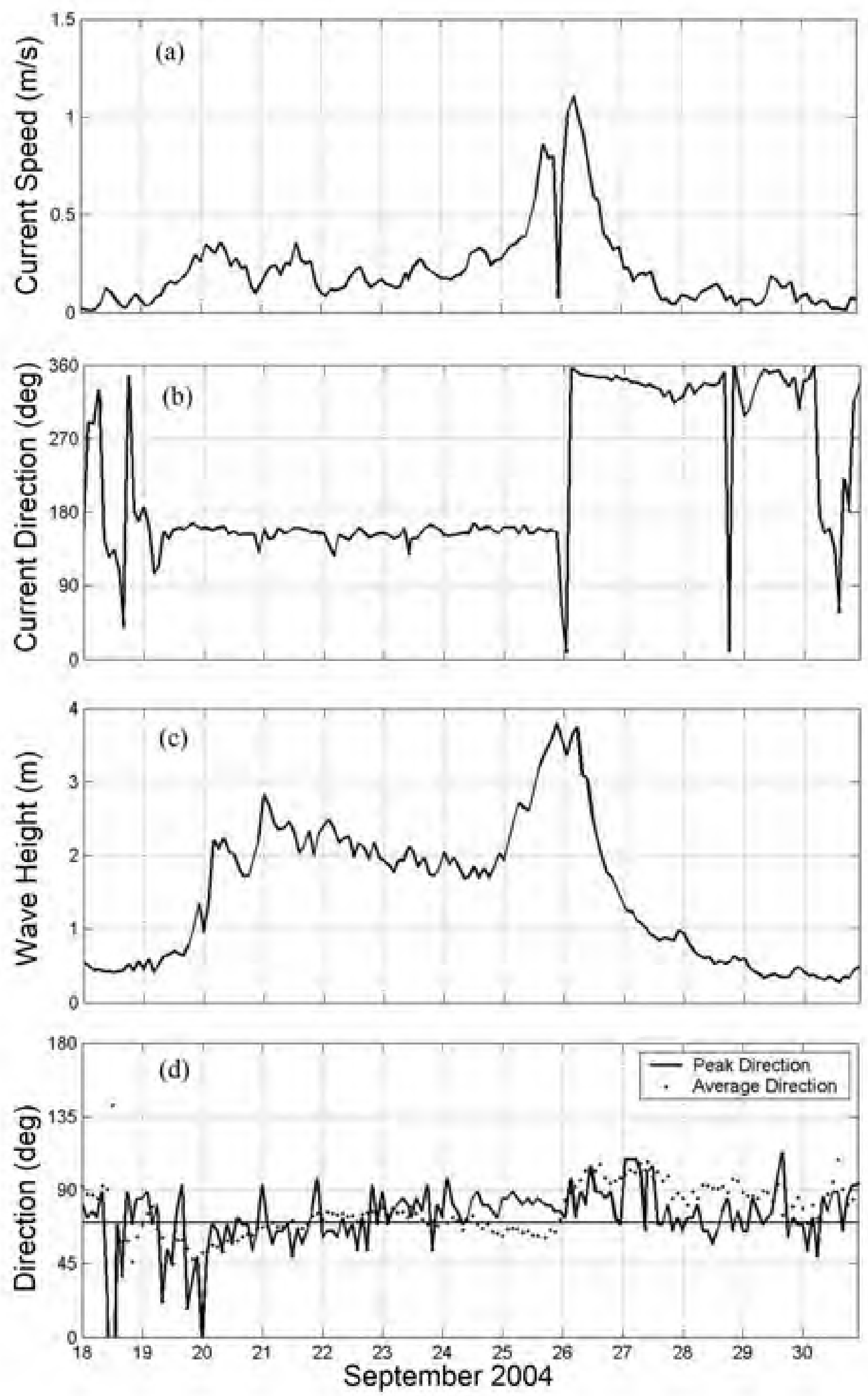

Figure 13. Observations made by the ADCP during Hurricane Jeanne, which made landfall at Ft. Pierce, 90 km south of Spessard, on the morning of September 26, 2004. (a) Depth-averaged current speed, (b) mean current direction (to which), (c) energy-based significant wave height, and (d) peak and average wave direction. Bacopoulos *et al.* (2012) demonstrated that the currents at the ADCP were predominantly wind driven during the storm, supporting the premise that the wind, particularly during nor'easters, is likely a major contributor to the net N-S sediment transport in the region.

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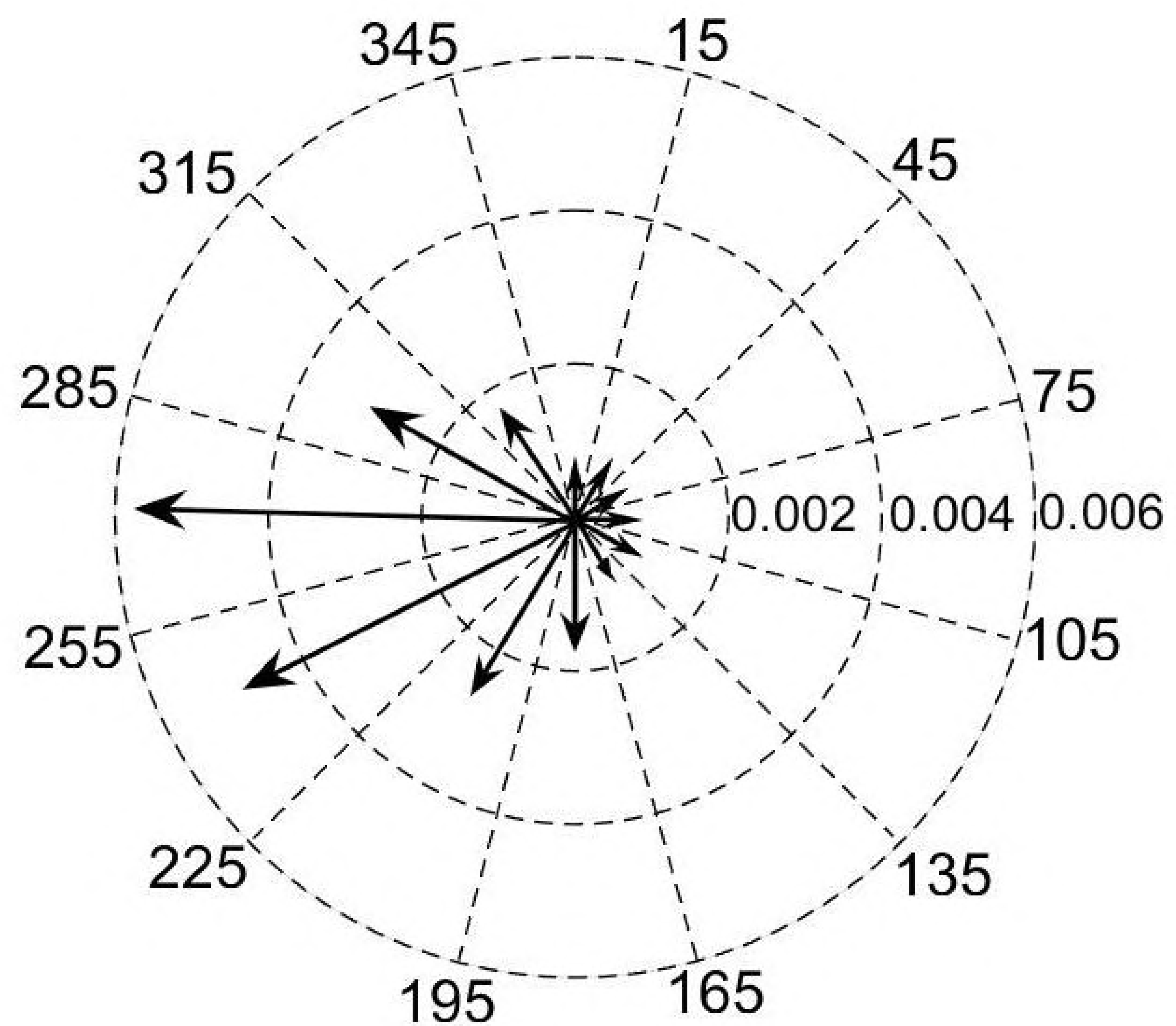

Figure 14. Wind stress climate from the anemometer at Spessard from September 13, 2002, to December 31, 2006. Each vector represents the mean wind stress for that directional sector, weighted by the percent occurrence of winds in that sector. Seaward normal to the shoreline at Spessard is nominally 73°. The averaged resultant wind vector is essentially directed onshore; *i.e.* there is almost no net longshore wind stress.

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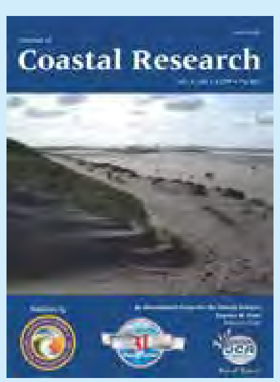

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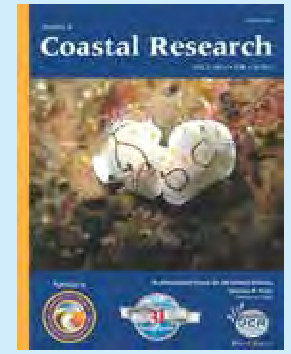

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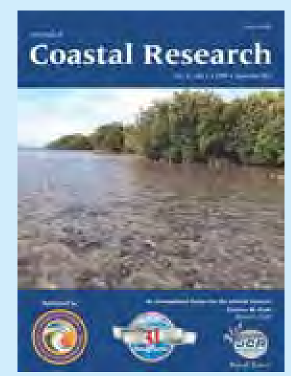

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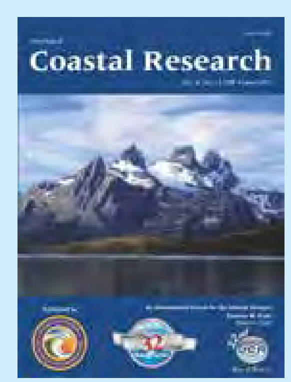

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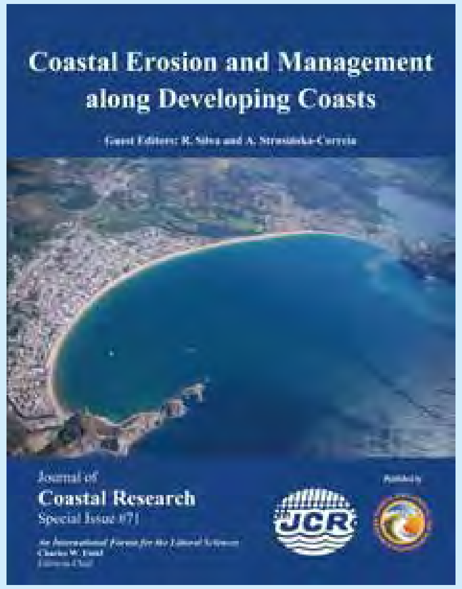

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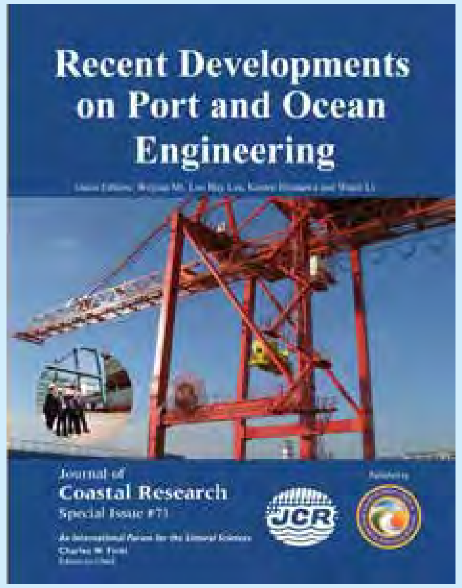

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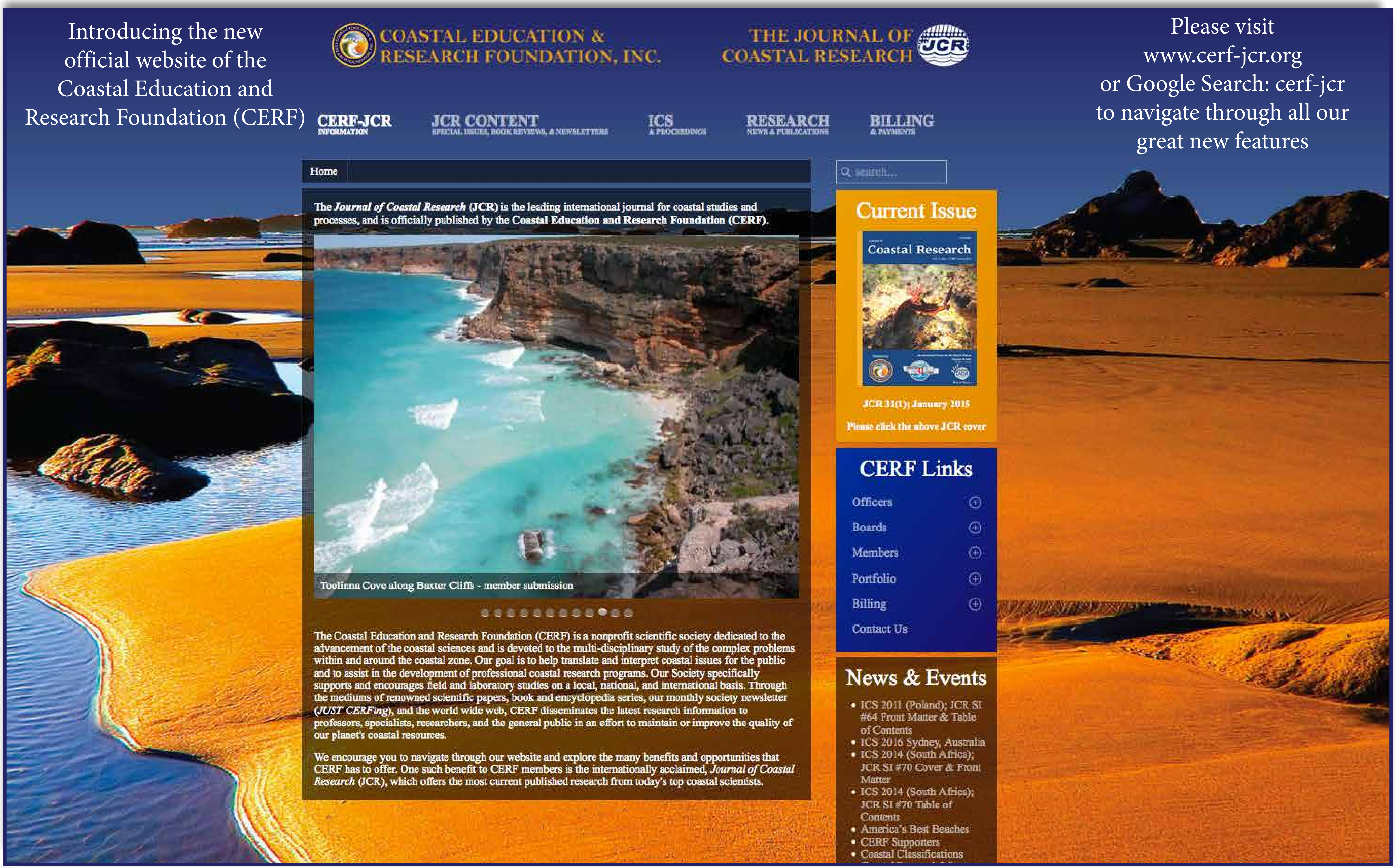
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CERF Lifetime Member

We are proud to acknowledge Associate Professor Dr. Charles Lemckert as the Coastal Education & Research Foundation's first ever Lifetime Member. Dr. Lemckert has always showed great support for CERF and the JCR, and even served as the Chair and Organizer of the 9th International Coastal Symposium (ICS) at Griffith University (Queensland, Australia) in 2007. We are honored to have Dr. Lemckert as a Lifetime Member and warmly recognize his devotion to our coastal research society.

Associate Professor Lemckert has active research interests in the fields of physical limnology, coastal systems, environmental monitoring techniques, environmental fluid dynamics, coastal zone management and engineering education. Along with his postgraduate students and research partners he is undertaking research studies on water treatment pond design (for recycling purposes), the dynamics of drinking water reservoirs, the study of whale migration in South East Queensland Waters, end ocean mixing dynamics.

Selected Publications:

Ali, A.; Lemckert, C.J.; Zhang, H., and Dunn, R.J.K., 2014. Sediment dynamics of a very shallow subtropical estuarine lake. *Journal of Coastal Research*, 30(2), 351-361.

Dunn, R.J.K.; Lemckert, C.J.; Teasdale, P.R., and Welsh, D.T., 2013. Macroinfauna Dynamics and Sediment Parameters of a Subtropical Estuarine Lake—Coombabah Lake (Southern Moreton Bay, Australia). *Journal of Coastal Research*, 29(6A), 156-167.

Ali, A.; Lemckert, C.J., and Dunn, R.J.K., 2010. Salt fluxes within a very shallow subtropical estuary. *Journal of Coastal Research*, 26(3), 436-443.

Brushett, B.A.; King, B., and Lemckert, C.J., 2011. Evaluation of met-ocean forecast data effectiveness for tracking drifters deployed during operational oil spill response in Australian waters. *Journal of Coastal Research*, 64, 991-994.

Lemckert, C.J.; Zier, J., and Gustafson, J., 2009. Tides in Torres Strait. *Journal of Coastal Research*, 56, 524-52.

For a complete list of Dr. Lemckert's publications or
his contact information, please visit:
http://www.griffith.edu.au/engineering-information-technology/griffith-school-engineering/staff/associate-professor-charles-lemckert

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A Special Acknowledgement To:

Professor Yong-Sik Cho
CERF Lifetime Member

We are proud to acknowledge Professor Yong-Sik Cho as a Lifetime Member of the Coastal Education & Research Foundation. Professor Cho, Yong-Sik received his bachelors and masters degrees from Hanyang University in February 1981 and August 1988 respectively, and his Ph.D. from the School of Civil and Environmental Engineering of Cornell University in January, 1995. The title of the thesis is "Numerical Simulations of Tsunami Propagation and Run-up" (Advisor: Professor Philip L.-F. Liu).

He had continuously worked at Cornell University as a Post-Doctoral Associate after graduation. From March of 1997, he had been employed as an Assistant Professor at the Department of Civil and Environmental Engineering at Sejong University and then moved to Hanyang University in March, 2000. From February 2003 to January 2005, he had served as the Chair of the Department of Civil and Environmental Engineering at Hanyang University. Professor Cho has served as the Director of Innovative Global Construction Leader Education Center, a government enterprises sponsored by the Ministry of Education, Science and Technology, and the Chair of Graduate Studies of the Department of Civil and Environmental Engineering since 2006.

Professor Cho has published 52 journal papers in prominent international journals registered in Science Citation Index such as *Coastal Engineering*, the *Journal of Coastal Research*, the *Journal of Fluid Mechanics*, the *Journal of Hydraulic Research*, *Physics of Fluids*, the *Journal of Geophysical Research*, the *Journal of Engineering Mechanics, and Ocean Engineering*. He has also published 120 papers in domestic journals and about 360 proceedings in international and domestic conferences. Professor Cho has also registered eight patents.

Selected Publications:

Kim, Y.-C.; Choi, M., and Cho, Y.-S., 2012. Tsunami hazard area predicted by probability distribution tendency. *Journal of Coastal Research*, 29(5), 1027-1038.

Cho, Y.-S., 2012. Numerical study for spreading of a pollutant material in coastal environment. *Energy Sources*, Part A, 34(16), 1459-1470.

Cho, Y.-S.; Kim, T.-K.; Jeong, W.-C., and Ha, T.-M., 2012. Numerical simulation of oil spill in ocean. *Journal of Applied Mathematics*, 2012, 1-15.

For a complete list of Professor Cho's publications or his contact information, please visit: http://civil.hanyang.ac.kr/coast/

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A Special Acknowledgement To:

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DEGREES AND DIPLOMA

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July, 1997: M.Sc. (Coastal Geomorphology and Sedimentology), Department of Geography, Nanjing Normal University (China)
July, 1994: B.Sc. (Geomorphology and Quaternary Geology), Department of Geo-Ocean Sciences, Nanjing University (China)

RESEARCH INTERESTS

Marine Sediment Dynamics; Benthic Boundary Layer Processes; Estuarine and Coastal Morphodynamics

RESEARCH PROGRAMMES (PI)

Monitoring and Development of support system on seabed topographical changes in Pearl River Estuary and Taiwan Shoal. Ocean special funds for scientific research on public causes (No. 201105001-2). 2011-2014. RMB 1,570,000 (about USD240,000).

Simulation on the evolution and realignment of North branch, Changjiang Estuary (No. BK2010050). Jiangsu Key NSF. 2010-2012. RMB 250,000 (about USD38,000).

Physical processes near bottom boundary layer in shallow seas with strong tides and high turbid water. China NSF (No. 40876043). 2009-2011. RMB 500,000 (about USD77,000).

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Sediment dynamics and associated environment response in intertidal area and estuary. Program for New Century Excellent Talents in University(No. NCET-06-0446). 2007-2009. RMB 500,000 (about USD77,000).

Wave-current dynamic processes and tidal basin system evolution over tidal flats. China NSF (No. 40576040). 2006-2008. RMB 380,000 (about USD58,000).

The estuary evolution by human activity impacts and associated hazards potential analysis. Jiangsu NSF (No. BK2006131). 2006-2008. RMB 75,000 (about USD12,000).

Siltation hazard and strategy on major embayment and estuary. National Comprehensive Survey and Evaluation Program of China Coastal Ocean (No. 908-02-03-08). 2005-2009. RMB 250,000 (about USD38,000).

Physical oceanography and marine meteorological survey in Jiangsu coastal sea. National Comprehensive Survey and Evaluation Program of China Coastal Ocean (No. JS-908-01-01). 2005-2009. RMB 921,000 (about USD140,000).

SELECT PUBLICATIONS; Refereed Publications (English papers only)

Huang, H; Wang, Y.P.; Gao, S.; Chen, J.; Yang, Y., and Gao J., 2012. Extraction of morphometric bedform characteristics from profiling sonar datasets recorded in shallow coastal waters of China. *China Ocean Engineering*, 26(3), 469-482.

Yunling Liu, Y.; Wang, Y.P.; Li, Y.; Gao, J.; Jia, J.; Xia, X., and Gao, S., 2012. Coastal embayment long-term erosion/siltation associated with P-A relationships: A case study from Jiaozhou Bay, China. *Journal of Coastal Research*, 28(5), 1236-1246.

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A Special Acknowledgement To:
Professor Nicholas K. Coch, Ph.D., C.P.G
CERF Lifetime Member

We are proud to acknowledge Professor Dr. Nicholas K. Coch as a Lifetime Member of the Coastal Education & Research Foundation. Dr. Coch received his Ph.D. in 1965 from Yale University with a specialization in sedimentology and coastal geology. In 1967, he joined the faculty at Queens College of the City University of New York (CUNY). He is now a Professor of Geology in the School of Earth and Environmental Sciences at Queens College of C.U.N.Y. and a member of the Doctoral Faculty of CUNY at the Graduate Center. He has co-authored two college geology textbooks (PHYSICAL GEOLOGY) and is the author of GEOHAZARDS (Pearson). In 2008, he received the President's Award for Teaching Excellence at Queens College and the John Moss Award For Excellence in College Teaching from the National Association of Geology Teachers. His research studies since 1967 have included sedimentation on the Moon, as a Principal Investigator in NASA's Lunar Sample Study Program, and shipboard studies of continental shelf, coastal and estuarine areas in the Northeast, as well as ground and aerial studies of the effects of hurricanes on coasts and urban centers.

His recent research deals with the effects of hurricanes on coasts, urban centers and inland areas, in predicting hurricane damage and in critically analyzing our coastal management policies in a time of sea level rise. He has carried out ground and aerial studies of most recent hurricanes as well as forensic studies of older (16th-20th century) hurricanes.

He is a Fellow of the Geological Society of America and a Member of The American Meteorological Society, Society of Sedimentary Geologists, National Association of Geology Teachers, American Association of Petroleum Geologists and is a Certified Professional Geologist.

Dr. Coch is an expert on Northern Hurricanes and has been a consultant to the N.Y. City Emergency Management Organization and the N.Y.S. Office of Emergency Management. He has presented hurricane seminars to emergency management and government officials in every county in southern New York as well as insurance, reinsurance and risk management groups nationwide. In 2003, he was chosen as a Sigma Xi Distinguished Lecturer for 2004-2007, and presented lectures on his research at educational and research facilities in the U.S. and Canada.

Programs including aspects of his hurricane research have aired on the CNN, PBS, Weather, Discovery, History and National Geographic Channels, and in local, national and international news programs and periodicals.

Selected Publications:

Coch, N.K., 2015. Unique vulnerability of the New York-New Jersey Metropolitan Area to Hurricane Destruction. *Journal of Coastal Research*, 31(1), 196-212.

Coch, N.K., 2013. A field course in tropical coastal geology. *Journal of Coastal Research*, 29(6A), 214-225.

Coch, N.K., 2006. The unique vulnerability of the Northeast U.S. to hurricane damage. Geologic Society of America, Abstract with programs, National G.S.A. Meeting (Philadelphia, Pennsylvania).

For a complete list of Dr. Coch's publications or his contact information, please visit:

http://www.qc.cuny.edu/Academics/Degrees/DMNS/sees/People/Pages/FacultyResearch.aspx?ItemID=23

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A Special Acknowledgement To:

Hany Elwany, Ph.D.
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President, Coastal Environments
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We are proud to acknowledge Dr. Hany Elwany as a Lifetime Member of the Coastal Education & Research Foundation. Dr. Elwany received a B.S. degree in Engineering from Alexandria University in 1971. In 1977, he completed his Ph.D. at the University of Dundee, United Kingdom. He obtained an additional B.S. degree in Mathematics and Statistics at Alexandria University in 1980. Dr. Elwany has extensive experience with nearshore oceanography, coastal processes, coastal engineering, and estuarine dynamics. He was the principal investigator for the physical oceanographic program of one of the largest environmental studies ever conducted on the U.S. west coast (at San Onofre). He has conducted in-depth studies of Nile Delta erosion, particularly since the construction of the Aswan Dam. His experience also includes projects involving optimization, numerical modeling, structural dynamic analysis, design of offshore structures, and data analyses, simulation, and dynamic modeling of ocean and coastal conditions. As an educator, both at Liverpool and Alexandria Universities, he taught courses in dynamics, statistics, numerical analysis, computer applications, and maritime engineering.

Dr. Elwany also serves as the President of Coastal Environments, a unique multi-disciplinary oceanographic, coastal engineering, and environmental consulting firm. Coastal Environments, founded in 1988, is comprised of over 30 professional associates, all experts in their respective fields. Technical specialties include coastal and ocean engineering, engineering geology, oceanography, marine biology and geology, environmental analysis, economics, statistics, and computer programming/modeling.

For more information about Dr. Elwany and Coastal Environments, please visit:

http://coastalenvironments.com/

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A Special Acknowledgement To:

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We are proud to acknowledge Dr. Björn Kjerfve as a Lifetime Member of the Coastal Education & Research Foundation. He is the former Dean of the College of Geosciences and was a Professor of Oceanography at Texas A&M University, 2004-2009. While at Texas A&M, he oversaw four academic departments, the Texas Sea Grant Program, and the Integrated Ocean Drilling Program (IODP), including the 475'ocean sciences drilling vessel, D/V JOIDES Resolution. Kjerfve was previously Professor of Marine and Geological Sciences at the University of South Carolina, 1973-2004, and served as the Director of the Marine Science Program, 2000-2004. He received Ph.D., M.S., and B.A. degrees from Louisiana State University (Marine Sciences), University of Washington (Oceanography), and Georgia Southern University (Mathematics), respectively.

Professor Kjerfve's expertise is coastal and estuarine physical oceanography. He has published some 12 books and 250 scientific journal papers, book chapters, and reports; has supervised 14 Ph.D. dissertations and 24 M.S. theses, and taught more than 6,000 oceanography students. His research includes problem-solving in estuarine and coastal waters as well as climate change and has attracted $20 million in research funding for 90 projects. Dr. Kjerfve's field research has taken place along the East and Gulf coasts of the USA, the Caribbean, Brazil, Mexico, Colombia, Chile, Thailand, Malaysia, the Persian Gulf, Papua New Guinea, and Australia. Dr. Kjerfve was elected as a corresponding member of the Academia Brasileira de Ciências, the Brazilian Academy of Sciences in 2012. Dr. Kjerfve has served as the President of the World Maritime University from 2009 to 2014. He now has the great honor of serving as the fourth Chancellor of the American University of Sharjah in the UAE.

Selected Publications:

Cavalcante, G.H.; Kjerfve, B.; Bauman, A.D., and Usseglio, P., 2011. Water currents and water budget in a costal mega-structure, Palm Jumeirah Lagoon, Dubai, UAE. *Journal of Coastal Research*, 27(2), 384-393.

Cavalcante, G.H.; Kjerfve, B.; Knoppers, B., and Feary, D.A., 2010. Coastal currents adjacent to the Caeté Estuary, Pará Region, North Brazil. *Estuarine Coastal and Shelf Science*, 88(1), 84-90.

Medeiros, C. and Kjerfve, B., 2005. Longitudinal salt and sediment fluxes in a tropical estuary: Itamaracá Brazil. *Journal of Coastal Research*, 21(4), 751-758.

Perillo, G.M.E. and Kjerfve, B., 2005. Regional estuarine and coastal systems of the Americas: An introduction. *Journal of Coastal Research,* 21(4), 729-730.

For a complete list of Dr. Kjerfve's publications or
his contact information, please visit: http://www.aus.edu

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A Special Acknowledgement To:

Associate Professor Wei Zhang, Ph.D.
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Dr. Wei Zhang works as an associate professor of Harbor, Coastal, and Offshore Engineering in State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Hohai University. He focuses on the tidal current, sediment and salinity movement and transportation laws of estuaries and coasts. Dr. Zhang has published over 20 papers in recent years, including five papers indexed by SCI and EI. He took part in one Key Project of National Nature Science Foundation of China, one 95th Year Key Science and Technology Project for the Ministry of Transport, and two Science and Technology Research Projects of Guangdong Province. He has also led youth projects for the National Nature Science Foundation.

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A Special Acknowledgement To:

Charles Thibault
CERF Lifetime Member

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Chuck Thibault is currently a Ph.D. candidate at the University of Memphis and a Geologist for EarthCon, Inc. Mr. Thibault received his M.S. from the University of Washington (Geology) and a B.S. from the University of Memphis (Geology). His research interests include coastal and environmental hydrogeology and coastal geomorphology. His current research investigates the movement of storm surge generated saline water plumes through coastal surficial aquifers. Mr. Thibault's field research has taken place along the U.S. coasts of Mississippi, Louisiana, and Washington, and on the eastern coast of Kamchatka, Russia.

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A Special Acknowledgement To:
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We are proud to acknowledge Dr. Erik Van Wellen as a Lifetime Member of the Coastal Education and Research Foundation. Dr. Van Wellen received M.Sc. degrees from both the Artesis Antwerpen (Civil Engineering) and the University of Liverpool (Maritime Civil Engineering). In 1999 he subsequently received his Ph.D. from the University of Plymouth with a specialization in sediment transport modeling. He has authored several papers in prominent international journals and conference proceedings.

He has research interests in the fields of natural marine sediment dynamics and mechanically driven sediment transport, renewable energy, carbon-economics, operational optimization, data analyses and mathematical simulations. During his time on the EuDA (European Dredging Association) Environment Committee he fostered a keen interest in Integrated Coastal Zone Management strategies and how to best balance the competing interests of developments such as harbor facilities, coastal defenses, tourism infrastructures and coastal environment conservation; including how best to strike a balance with mitigation and compensation.

He has previously worked as a commercial diver; and since 1999 has worked for the DEME Group (Dredging, Environmental and Marine Engineering) where he has held several operational, technical and commercial roles in a worldwide setting and is currently employed as an international Project Director.

He is a Fellow of the Institution of Civil Engineers and a Fellow of the Royal Geographical Society, a Member of the Chartered Institute of Arbitrators and a Member of the CEntral Dredging Association. Dr. Van Wellen is a Registered Professional Engineer in continental Europe (EUR ING), the UK (CEng) and internationally IntPE(UK). He is considered an expert in such matters as Civil Engineering, Maritime Construction and Dredging; and has considerable knowledge in the field of contract law and alternative dispute resolution. He also has several patents related to aforementioned technical fields registered to his name.

When not working on engineering or maritime construction projects he can be found teaching diving as a Staff Instructor for the Professional Association of Diving Instructors or actively involved in conservation work such as Dive Against Debris or Project AWARE Shark Conservation. His outstanding underwater photographs have graced the cover of the *Journal of Coastal Research* (JCR) more than once.

For a complete list of publications and more information, please contact Dr. Van Wellen via Skype on: vanwellenerik.

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A Special Acknowledgement To:

Frédéric Bouchette Ph.D.
CERF Lifetime Member

Associate Professor of Littoral Dynamics
Geosciences Montpellier
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Following a M.Sc. in physics and mechanics, Fred Bouchette received his Ph.D in March 2001 from the University of Montpellier, South of France. The title of the thesis is "Wave/Seabottom Interaction: The Liquefaction Process" (free translation from French; advisor: Professor M. Séguret). After his Ph.D., Fred had been employed at the University of Montpellier as an associate professor in the department of Geosciences. From 2008 to early 2011, he had moved to the Institute of mathematics and modeling of Montpellier for a three years long stay. Then, until 2012, he has been hosted as an invited professor in the METOS laboratory at the University of Oslo, Norway. He is now back to the University of Montpellier in the same department of Geosciences.

From 2002, Fred was asked to build a scientific staff on littoral hydro-morphodynamics called GLADYS (www.gladys-littoral.org). From that time, the group GLADYS has grown progressively. At now, Fred co-leads the group GLADYS, which rallies most of the scientists working on littoral hydro-morphodynamics along the French Mediterranean Coast, with distinct approaches ranging from applied mathematics to geosciences.

The scientific activity of Fred Bouchette concerns the development of concepts and methods in relation with the dynamics of shallow water environments. He studies the domain that extends from a few tens of meters of water depth at sea to the coastal watershed onshore, with a strong emphasis on the littoral area and the shoreline itself. He has worked in Spain, Taiwan, Canada, Norway, Chad, Italy, Greece, Switzerland, Tunisia, in the French Alps and in the Gulf of Lions (Mediterranean Sea). As testified by his publications, his research combines various points of view from geophysics to geology, including applied mathematics, civil engineering, quantitative geomorphology, with a strong connection to coastal archeology and the analysis of littoral hazards. Nevertheless, his heart's passion still lies with geophysics and applied mathematics.

Presently, Fred Bouchette actively works on the conceptualization of the growth of long term shoreline instabilities such as cuspates or sand spits. On that topic, his last contribution for the *Journal of Coastal Research* (JCR) is the following proceeding:

Bouchette, F.; Manna, M.; Montalvo, P.; Nutz., A.; Schuster, M., and Ghienne, J.-F., 2014. Growth of cuspate spits. *In*: Green, A. and Cooper, J.A.G. (eds.), *Proceedings from the International Coastal Symposium (ICS) 2014 (Durban, South Africa)*. *Journal of Coastal Research*, Special Issue No. 70, pp. 47-52.

Fred Bouchette has published>50 papers and short papers in international journals such as *Coastal Engineering*, *Journal of Coastal Research*, *Discrete and Discontinuous Dynamical Systems*, *Journal of Geophysical Research*, *Sedimentology*, *Continental Shelf Research*, *Quaternary Research*, *Ocean Engineering*, *Marine Geology*, *and Climate Research*. Most of his works were performed with and for students. He has contributed to more than 80 proceedings in international or domestic conferences. Fred Bouchette also heads the scientific development of a HPC numerical platform for coastal engineering (www.mirmidon.org).

For a complete list of publications and more information, please visit: www.bouchette.org

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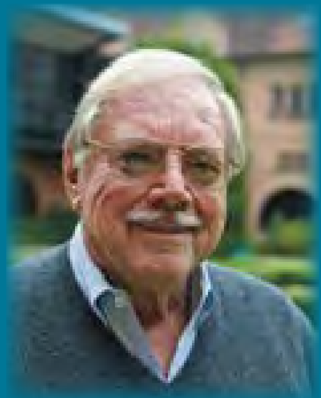

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COVER PHOTOGRAPH: Fore dunes along the North Sea's Delfland Coast, The Netherlands

Fore dunes along the North Sea's Delfland Coast, The Netherlands. An interesting geomorphologic landscape feature is shown above as a dynamic fore dune complex that resulted from the interplay between wind, sand, and vegetation after a few stormy days. Prevailing winds from the North Sea have blown large amounts of sand from the beach, which then becomes trapped by a narrow line of Marram grass (Ammophila spp). About 50-75 cm of sand was accumulated in only a few days, even so much that the grass itself is almost buried. Along the lee-side embankment behind these grasses, a kind of cuesta-shaped sand body is formed. The windward slope is gentle and rising, while the leeward slope is steep (ca. 60°) and caused by the gravity fall of dry sand grains (particle size is about 250-300 µ). This sand body is approximately 5-10 m wide and several 100 m in length, following the Marram that was planted here along the beach in long rows. Re-enforced dunes afford better protection against coastal erosion and flooding and Marram is noted for its ability to trap sand and build up dunes in a natural way. The fresh dune sand is exploited by new tapering roots of Marram for nutrients. Older, lower, sand layers in the fore dunes are infested by root-feeding nematodes and pathogenic microbes. They decrease the nutrient and water uptake capacity of the Marram roots. Plant species that naturally succeed Marram grass, such as Fescue and Sand sedge, are tolerant of the pathogens of Marram. However, in due time, they also develop such soil-borne pathogens. This ecologic chain of plant-soil feedback interactions and consequences for succession in the fore dunes was demonstrated in The Netherlands by Van der Putten, Van Dijk, and Troelstra (1988) and Van der Putten, Van Dijk, and Peters (1993), stimulating new developments in ecologic theory. (Photograph taken 20 August 2014 by Frank van der Meulen, Frank van der Meulen Consultancy, frank.vandermeulen@hetnet.nl, The Netherlands.)

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The Coastal Education & Research Foundation *[CERF]* graciously thanks you for your membership and involvement in our international society. We hope that you have enjoyed this latest edition of *Just CERFing*, our society's official newsletter. As mentioned previously, we encourage the worldwide communication of our members through the *Just CERFing* newsletter. If you have any news or announcements that you would like to promote, please send your request or questions directly to Dr. Charles W. Finkl at cfinkl@cerf-jcr.com CERF continues to provide our members with the most up-to-date, professional features of the society. We encourage you to please visit our Foundation's website at http://www.cerf-jcr.org to see all the new content that has been added.

Next Issue of *Just CERFing* coming May 2016.

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