# *Journal of Coastal Research* (JCR)

**Official Publication of the**
**Coastal Education and Research Foundation, Inc. (CERF)**
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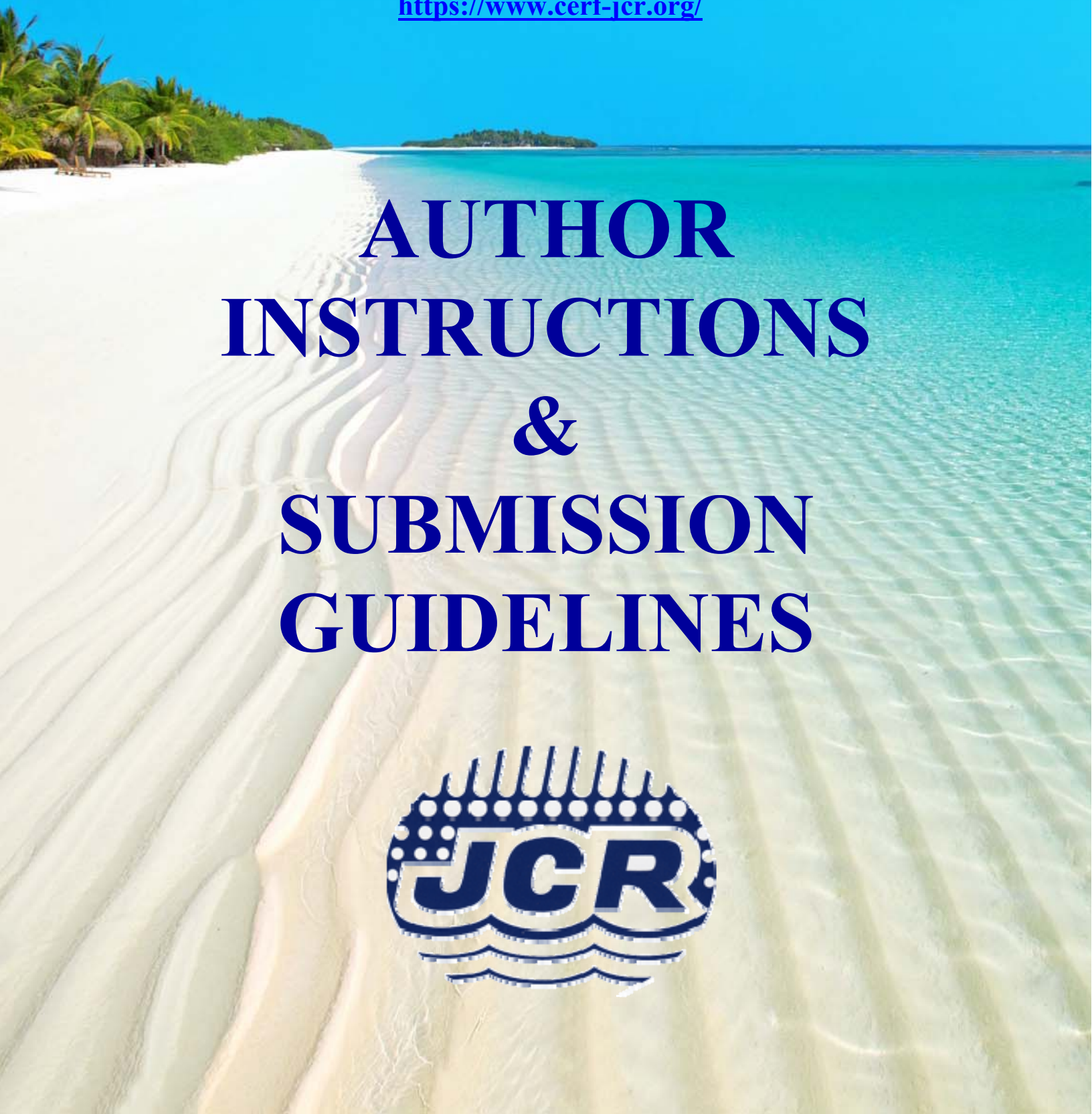
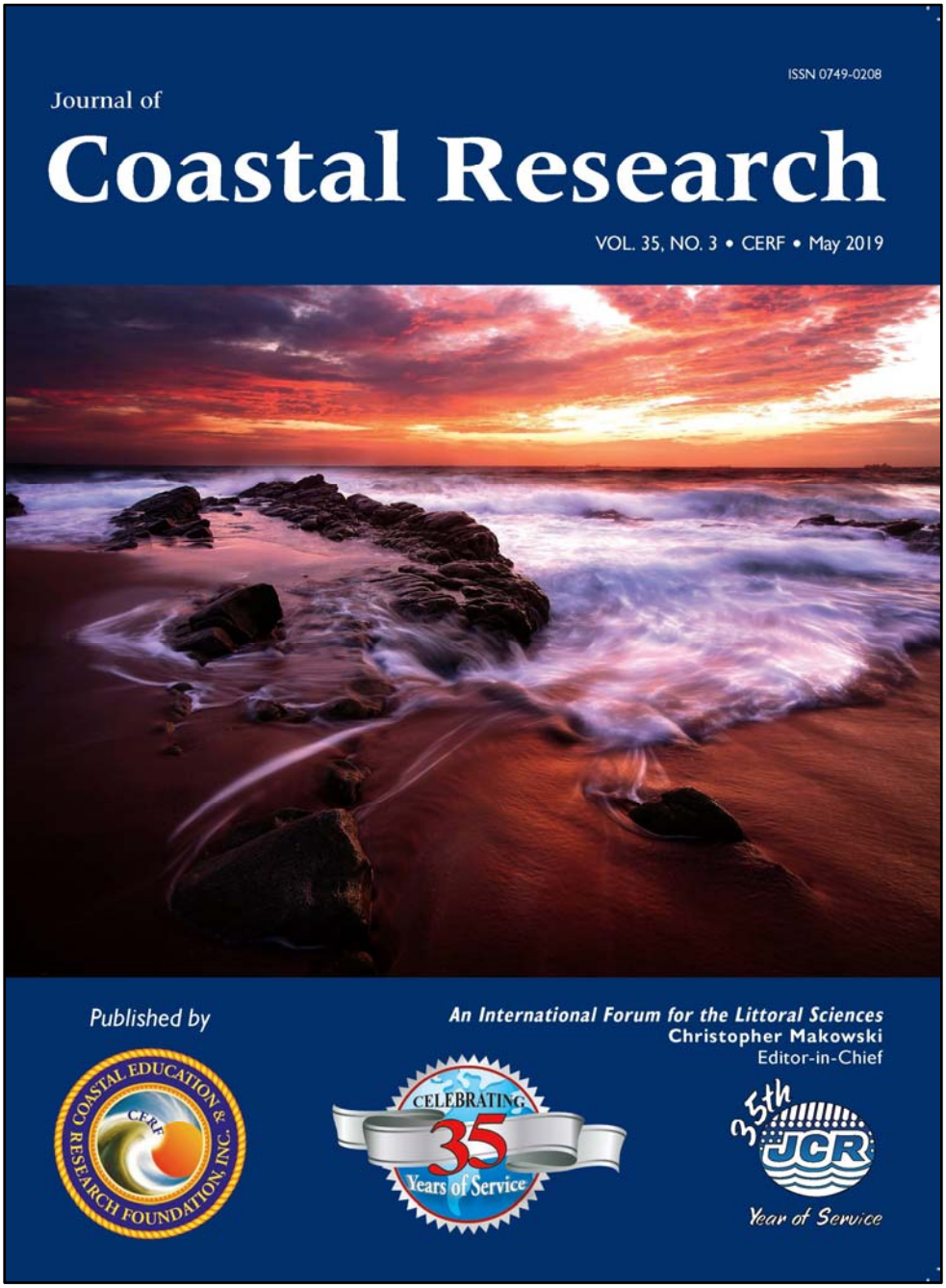


# AUTHOR INSTRUCTIONS & SUBMISSION GUIDELINES

# SCOPE OF THE JOURNAL

The ***Journal of Coastal Research*** **(JCR)** covers all fields of coastal research [*e.g.*, geology, biology, ecology, geomorphology, physical geography, climate change, littoral oceanography, hydrography, sea-level change, coastal hydraulics, environmental (resource) management (law), coastal engineering, remote sensing, *etc.*] and encompasses subjects relevant to natural and engineered coastal environments (freshwater, brackish, and marine), as well as the protection (*i.e.* management and administration) of those resources within and adjacent to coastal zones (including large lakes, rivers, and seas) around the world. The JCR broadly focuses on coasts *per se*, but also embraces those coastal environments that extend some indefinite distance inland (*i.e.* to the edge of the coastal plain) or reach seaward beyond the outer margins of the sublittoral (neritic) zone (*i.e.* to the edge of the continental shelf). Consideration is also given to zones farther out to sea if the processes or materials affect the coast.



# JCR EDITORIAL POLICY

The *Journal of Coastal Research* (JCR) is published in English by the **Coastal Education and Research Foundation, Inc. (CERF)**. Submissions fall into one of the following main departments, which are included in most JCR issues: **Research Articles (Professional Papers), Technical Communications (Methods, Procedures, Notes, or Highly-Technical Papers), Review Articles, Editorials, Letters to the Editor, Discussions and Replies, Meeting Reports, News and Announcements, Coastal Photographs, Honors and Awards, Book Reviews, Books Received, Literature Reviews, Dedications, In Memoriam, Errata (Corrigenda), *etc*. Please note that isolated Case Studies and Technical Reports are no longer accepted into the JCR.** Abstracts (in addition to a submitted abstract in English) can also be included using other native languages.

# JCR Submission Categories Include:

# RESEARCH ARTICLES

Original research papers are of primary interest to the JCR. Manuscripts dealing with coastal geology, marine biology, coastal geomorphology, physical geography, climate, ecology, sea-level change, littoral oceanography, hydrography, coastal hydraulics, environmental (resource) management (law) and policy, coastal engineering, and remote sensing are all welcome. **These professional papers should include a global context and are required to follow the standard main heading IMRAD formulation (*i.e.* INTRODUCTION, METHODS, RESULTS, ANALYSIS (if applicable), DISCUSSION, CONCLUSIONS). All other headings may serve as subheadings under these main headings. There must be text between all headings, as stacked headings are not accepted. All research article submissions are to be original works and will be peer reviewed.**

# TECHNICAL COMMUNICATIONS

Original papers dealing with new or improved techniques, procedures, notes, or methodologies may be submitted as technical communications, which are peer reviewed. These method papers, or technical contributions, may contain line drawings, photographs, and tables. Although generally shorter and more limited in scope compared to research articles, **these submissions are still required to follow the same IMRAD format with no stacked headings.** In the JCR, technical communications are usually grouped together after research and review articles in a separate department. **All technical communication submissions are to be original works and will be peer reviewed.**

# REVIEW ARTICLES

Topical reviews of coastal research subjects, analysis of natural conditions, or examinations of human interventions may be submitted as review articles that are placed in either a regional or international context. Review article submissions must first pass a test of importance and

relevancy by the JCR Editorial Staff. **These contributions, which are peer reviewed in the usual manner, must be original works** and may contain line drawings, photographs, and tables. Review articles are also expected to contain an extensive Literature Cited section. Although more limited in scope compared to research articles, they should follow the same general format; however, more flexibility with main heading titles will be granted and **these submissions do not have to follow an IMRAD format.** In the JCR, review articles are usually grouped together in a separate department after research articles and before technical communications.

## DISCUSSIONS & REPLIES

Discussions of research articles, technical communications, review articles, and letters to the editor are encouraged in the forum of the JCR for the exchange of ideas. These items should identify, in JCR format, the title and authors, as well as the volume and issue in which the paper originally appeared. Discussions will be sent to the corresponding authors of the original items by the editors so that reply items may accompany the discussions. Rejoinders and further discussions are permitted, should the author(s) or responder(s) wish to extend the dialogue. Discussions and replies should be submitted directly at: **cerf.jcr@gmail.com**

## NEWS, ANNOUNCEMENTS, HONORS, & AWARDS

News items and announcements from supporting organizations, educational institutions, and other associations with coastal themes and interests can be submitted to the JCR. Brief descriptions and photographs related to professional activities on an international, national, or regional scale are relevant here. Also included, are news features about people, honors, awards, or opportunities for fellowships, scholarships, and research funds. Any news, announcements, honors, and awards items should be submitted directly at: **cerf.jcr@gmail.com**

## LETTERS TO THE EDITOR

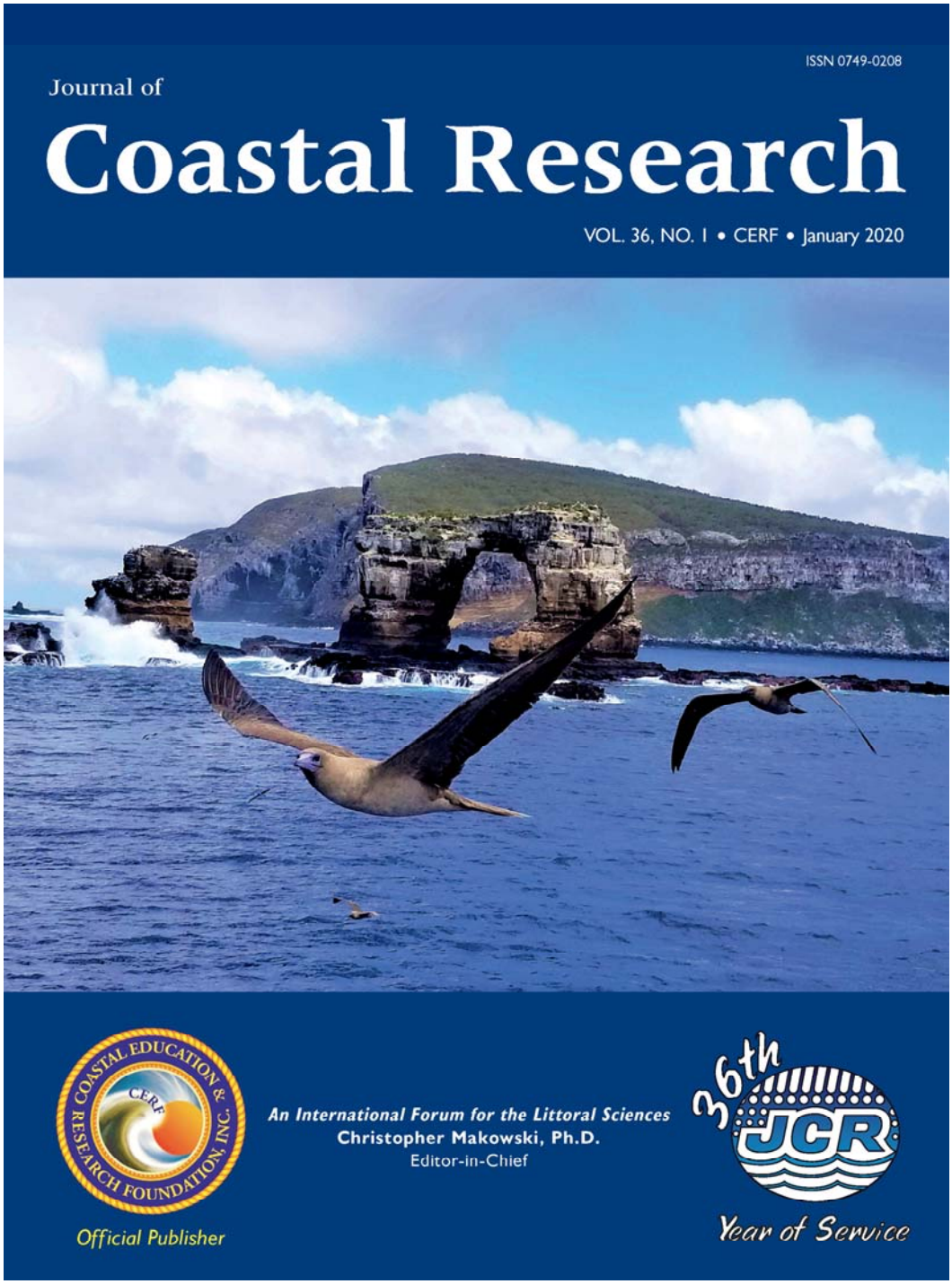
This department contains informative commentaries or opinion items on any aspect of coastal technology, research, management, or policy. Letters to the Editor submissions may be subject to peer review and their acceptance is determined by the Editor-in-Chief. Letters to the Editor should be submitted directly at: **cerf.jcr@gmail.com**

## LITERATURE REVIEWS, BOOK REVIEWS, & BOOKS RECEIVED

Topical literature reviews in specialized subjects should feature classical interpretations of contentious coastal issues, as well as modern developments. Selected book reviews and shorter listings of books received can also be submitted. These items should be submitted directly at: **cerf.jcr@gmail.com**

# COASTAL PHOTOGRAPHS

Coastal and underwater photographs can also be submitted for publication in the JCR. They are either published in color or grayscale, as full single pages, with a descriptive extended caption (the photographer's affiliation should be provided with location and date taken). Previous JCR issue front matter should be used as a guide to compose proper extended captions. **Photographs should be submitted as an image file (.jpeg or .tif) with a resolution of at least 300 dpi.** Grayscale coastal photographs are printed at no cost to the photographer. Quotes for printed/online color coastal photographs may be obtained after submission. Those submitted photographs that are deemed exceptional by the editorial staff will be considered for potential JCR front covers. Photographs should be submitted directly at: **cerf.jcr@gmail.com**



# SUBMISSION TO THE JCR

**There is a required, non-refundable manuscript submission fee for all submissions.** Current CERF-JCR members receive a reduced submission fee of USD $45 *vs.* USD $65 for non-CERF-JCR members. **This is not a publishing fee, but rather a non-refundable manuscript submission processing fee.** This fee is required to offset third-party usage and maintenance costs associated with the electronic Editorial Manager (PeerTrack) manuscript tracking and peer review system (**http://www.editorialmanager.com/jcoastres/**). **Paying the submission fee does not guarantee acceptance of your submission, otherwise, that would be a conflict of interest. Only after a thorough peer review is your submission evaluated for either acceptance or dismissal.**

Electronic submission of contributions is required; papers are no longer typeset from manual hard copies. **When preparing a manuscript, it is essential to follow these author instructions explicitly, especially the formatting checklist in this document. Contributions not following these specifications (*i.e.* fail the technical check) will be returned to the respective author(s) for proper JCR manuscript formatting. Please submit manuscripts for electronic submission tracking and processing at: http://www.editorialmanager.com/jcoastres/.**

**It is not the responsibility of the editors or peer reviewers to rewrite poorly prepared manuscripts. Submissions may be declined solely on the basis of poor English usage and grammar.** Authors who have difficulty writing with proper scientific English grammar may avail themselves by employing an English language editing service. The JCR Editorial Staff may require proof that an English language editing service was used in order to consider whether a submission is accepted or dismissed.

Research articles, technical communications, and review articles are peer reviewed in a timely manner by at least two referees. The peer review referees assist the Editor-in-Chief in obtaining comments and suggestions for improvement of the manuscripts. The Editor-in-Chief is ultimately responsible for the material published in the JCR. **At any time, the Editor-in-Chief has the ability to withdraw a submission from consideration; even after it has been formally accepted.**

# GENERAL MANUSCRIPT REQUIREMENTS

**Manuscripts must be original contributions and cannot be concurrently submitted/ considered for publication elsewhere.** The following text formats are accepted for electronic submission: **(*.doc, *.docx, and *.rtf)**. Submissions may be single- or double-spaced throughout. **Manuscripts are to be prepared using a popular font (*e.g.*, Helvetica or Times New Roman, 12 point font size) and include page and line numbers throughout**. Do not use oversize letters or fancy fonts for headings or text. Book or journal titles and foreign words and phrases (*et al*., *e.g*., *i.e*., *ca*., and *etc*.) should be italicized. Symbolization used in mathematical formulae may be accompanied by marginal notes that identify the foreign characters (first occurrence only) for the typesetter. Authors are responsible for making their submissions clear, concise, and accurate, and should consult these guidelines for proper JCR formatting. **Manuscripts not properly formatted will not pass the JCR technical check and be returned for correction.**

The following standard heading formats are set up to accommodate a majority of situations normally encountered in the JCR. Note that headings are unnumbered and their rank is normally determined by case and position on the page. **There should be a short paragraph between all headings in the text, especially between main headings and subheadings to introduce the sections that follow. Stacked headings are not accepted.**

**FIRST ORDER MAIN HEADINGS ARE BOLD TYPE IN CAPITALS AND CENTERED**

**Second Order Subheadings are Upper and Lower Case, Bold, Flush Left**

**Third Order Subheadings are Upper and Lower Case, Bold, Indented**

**Fourth Order subheadings are Upper and Lower Case, Bold, Indented as a Paragraph.** Then the text that follows is run in.

***An example of a properly formatted submission to the JCR is included as a supplement at the end of these instructions. Authors should use this as a guide. Any questions related to the preparation and submission of manuscripts should be emailed to: cerf.jcr@gmail.com***

**Below is a description of some various components when organizing your manuscript:**

# TITLES

A good title (a) briefly defines the subject, (b) indicates the purpose of the contribution, and (c) gives important, high-impact words early. Besides being descriptive, the title should be concise, usually less than 15 words except in unusual circumstances. Titles should avoid using abbreviations, excessive notations, or proprietary names; and authors should avoid using unusual or outdated terminology. **Also, isolated case studies are no longer accepted by the JCR and should not be included in the title.**

# TITLE PAGE

The first page of the manuscript should contain: (1) a concise title; (2) full name(s) of the author(s), under the title in one line; (3) affiliations (no P.O. Boxes or street addresses and one email address for the corresponding author); (4) a left running head (LRH) for authors' last names; and (5) a short right running head (RRH) of the title. Footnotes for new or present addresses may be added to this page. Other information, such as contribution numbers and financial support should be placed in the Acknowledgements. A sample of a JCR manuscript title page is shown here:

## Long-Term Equilibrium of a Wave Dominated Coastal Zone

**Patricio L. Tavares[†*], Rodrigo Garcia[‡], and Ana P. Lopez[‡]**

**[†]Coastal Consultants**
**Copenhagen 2400, Denmark**
**[*]ptavares@example.com**

**[‡]Department of Geosciences**
**University of the Atlantic**
**Pomona, FL 33931, U.S.A.**

**LRH: Tavares, Garcia, and Lopez**
**RRH: Coastal Zone Equilibrium**

# ABSTRACT

Because abstracts are viewed up to 500 times more than the full paper, an abstract should convey information in a clear and concise manner. The general format of an abstract follows the classical **IMRAD** formulation (*i.e.* introduction, methods, results, analysis (if applicable), discussion, conclusions). The abstract (not more than 3% of the text or $\leq$300 words) should fall on the second page of the manuscript and avoid using bibliographic citations, figures, tables, equations, formulas, obscure abbreviations, or acronyms. Abstracts in other native languages may be provided in addition to the English version, but are not required.

# ADDITIONAL INDEX WORDS

Please list several additional index words after the Abstract that are **not found in the title.** These words are useful to abstracting services and indexers who prepare lists for computer searches by subject. They are identified after the abstract as "**ADDITIONAL INDEX WORDS:**" and are listed in italic (scientific names are reversed italic), separated by commas, and followed by a period (full stop). Make sure these words are not overly specific, but generic in such a manner that they will help direct researchers to your paper.

# TABLES

**Tables are submitted at the end of the manuscript text file or as a separate file (or files).** They should be numbered consecutively, appropriately based, and kept as simple and short as possible. Longer tables can be submitted as supplemental appendices, which would appear at the end of the paper. Show the units for all measurements in column heads, in spanner heads, or in the field. In general, only horizontal rule lines are used: a double rule line at the top, a single rule line below the box head, and a single rule line at the bottom just over the footnotes (if any); additional horizontal rule lines may be needed under spanner heads and subheads. Vertical rule lines within tables should be avoided. Please refer to recently published JCR article tables for proper formatting. **Tables should be submitted in either .xls, .doc, or .docx formats. Table captions are italic and should be comprehensive in nature (*i.e.* should point out the most important features and indicate why the reader is viewing the table).**

# FIGURES & ILLUSTRATIONS

**ALL FIGURES MUST BE UPLOADED AS SEPARATE IMAGE FILES (that is, not embedded in a text, WORD, or EXCEL file) with a minimum resolution of 300-600 dpi.** Photographs and line drawings are numbered in Arabic numerals in a single sequence as "Figure 1," "Figure 2," *etc*., and so referred to in the manuscript text. All figures should be called out in the manuscript text as, *for example*, Figure 1 (not Fig. 1). Each figure must be clearly captioned and acknowledged when necessary. Figure captions must be included at the end of the manuscript in a "List of Figures." **All approved figures will be reduced according to JCR standards, which may be less than the width of one column (85 mm). Figure sizes are finalized at the discretion of the JCR Editorial Staff, not the authors.** Larger illustrations may be rotated sideways and printed as a turn-page (landscape view) to take advantage of maximum page size. The minimum size of a reduced letter should be about 1 mm high. For a figure that is to be reduced to 1/4 of its size (1/2 length of size), lines of 0.5 to 0.8 mm and 16 to 18 point bold are recommended. Computer-generated figures should be used. Magnifications should be given as bar lines in photographs or satellite images and defined in the caption or legend. Maps and planimetric drawings should contain scales in bar lines as well as a north arrow sign. See recently published JCR article figures and captions for proper formatting. Figure captions should be comprehensive in nature (*i.e.* includes the importance of the figure, why the reader is viewing it, and a synopsis of all the visual components).

Figures will not be placed out of numerical order. Figures are assumed to be grayscale or black and white (even if submitted in color), unless otherwise stated. If a figure is to be published in color, it must be indicated at the time of the initial submission. For charges associated with figure color production, see Publication Charges in these instructions.

***Digital Figure Guidelines:*** **Digital figure files that are allowed include: TIFF (.tif), EPS (.eps), PDF (high-quality), and JPEG (.jpg).** Some of these formats are resolution-dependent, and the file resolution required for good quality printing is much higher than is required for viewing on a computer screen. Files that are created in programs or at settings that are “low” resolution will always retain the visual characteristics of low-resolution files regardless of what is done to them later. A low-resolution file has a bitmapped (pixilated) appearance. The best file

resolution for a figure file depends on the type of figure it is and what line-screen will be used to print the figure. Using resolutions that are higher than ideal does not serve any advantage. Ideal and minimum resolutions recommended for figures are provided in Table 1 below.

**Table 1.** ***Ideal and minimally acceptable figure resolutions for the JCR.***

| Type of Figure | Ideal Resolution (dpi) | Min Resolution (dpi) |
|---|---|---|
| B/W Line Drawing | 1200 | 600 |
| Color | 600 | 300 |
| Color/Line Drawing Combination | 600 | 300 |
| Halftone | 600 | 300 |
| Line/Halftone Combination | 600 | 300 |

Digital files that require excessive time to open will be rejected. To avoid replacing a figure: crop excessive marginal white space, submit it in grayscale or bitmap mode unless it is intended to be published in color, and size the figure close to the final print size. **If a figure has several subparts, they must be merged together, resaved as one figure file, and labeled appropriately (*e.g.*, (A), (B), (C)...).** Do not exceed the ideal resolution for the specific kind of figure. **Figure file formats that are no longer allowed: MS WORD (.doc, .docx), WordPerfect, Excel (.xls), PowerPoint (.ppt), GIFF (.gif), Adobe Illustrator (.ai), Canvas, Adobe Photoshop (.psd), Quark documents, Corel Photo-Paint, PageMaker documents, Corel Draw, PictureViewer documents, Rich Text Format (.rtf,), .pic or .pcx, Metafiles, Harvard Graphics, Cricket Graph, Sigma Plot, and JNB.**

# APPENDICES & SUPPLEMENTAL MATERIALS

An Appendix, or multiple Appendices, may be submitted in the form of additional tables, figures, definitions, equations, or text. These items should be appropriately labeled and referred to in the manuscript text, as they will be printed as part of the publication. **Supplemental materials, on the other hand, can be submitted as online-only supplements that will not be typeset or copyedited (*i.e.* these items will not be printed as part of the publication).**

# UNITS OF MEASURE

The S.I. system (*le System International d' Unites*) of reporting measurements, as established by the International Organization for Standardization in 1960, is required insofar as practical. Other units may be reported in parentheses or as the primary units when it would be impossible or inconvenient to convert to the S.I. system. Equivalent units may be given in parentheses when tables, figures, and maps retain units of the English system (Customary units).

# SCIENTIFIC NAMES

Identifiers of plant and animal genera, subgenera, species, and lower taxa need to be in italic, with specific and lower epithets being written with a lower case initial letter. Nomenclature should follow the appropriate international code. Geological, ecological, and other scientific terms should follow standard usage or be defined the first time they are used in the paper.

# EQUATIONS

Equations should be numbered in order throughout the manuscript text. Please keep in mind that elaborate equations often extend over several lines with many breaks. Alternatively, it may be advantageous to group long equations into a "Table," which can run across the full width of the page, thus allowing clearer presentation.

# LITERATURE CITED

***In-Text Citations:*** Citations are generally treated according to the modified "Harvard System." In the body of the manuscript text, they are cited by naming the author(s) and indicating the year of publication. For three authors or less, all names are given **(Jones, Smith, and Andrews, 2005)**. When there are more than three authors, *et al.* is used **(Finkl *et al.*, 2005)**. Enclose the citation in parentheses if referring indirectly: *e.g.*, "**(Jones, 1988)**" or "**(Smith *et al.*, 1989)**;" or enclose the year of publication in parentheses if referring directly: *e.g.*, "**according to Jones (1988)**," or "**from data prepared by Smith *et al.* (1989)**." **Multiple citations given together should be listed in alphabetical (not chronological) order, separated by semicolons. For example: (Andrews and Stewart, 2006; Jones, 2004; Jones, Andrews, and Stewart, 2003; Smith *et al.*, 1961). For citations by the same authors with the same date, use this format: Jones (2013a,b) or (Smith, Roberts, and Cline, 2009a,b).**

***Literature Cited Section:*** Previous works cited throughout the text should be grouped together in a listed section with the heading "LITERATURE CITED" (not References or Bibliography), that is alphabetically arranged by first authors' surnames, unnumbered, and located at the end of the body of the manuscript. In this section, all authors' names and initials are required (no space between initials and no use of *et al.*), followed by the year of publication and the full title of the previous work in the appropriate case. For periodicals, the full title of the periodical is given in italic, the volume and issue number in Arabic numerals, and finally the page spread. For books, the title is given in italic, followed by the place (city and state or country) of publication and the bare name of the publisher, and finally the total number of pages in the book.


It is the responsibility of the author(s) to scrupulously check the accuracy of the LITERATURE CITED section. Responsibility for proper formatting rests solely with the author(s) and manuscripts will be returned for improper formatting. Examples of different types of citations can be found on the next few pages.

# EXAMPLES OF LITERATURE CITED FORMATS FOR THE JCR

***Single-Author Paper in a Journal*:**

Dickinson, W.R., 2000. Isostatic and tectonic influences on emergent Holocene paleoshorelines in the Mariana Islands, western Pacific Ocean. *Journal of Coastal Research*, 16(3), 735-746.

***Please note that issue numbers should be listed for all journal citations, if possible.***

Klemas, V., 2011. Remote sensing technologies for studying coastal ecosystems: An overview. *Journal of Coastal Research*, 27(1), 2-17.

***Two-Authored Paper in a Journal*:**

Fairbridge, R.W. and Teichert, C., 1948. The low isles of the Great Barrier Reef: A new analysis. *Geographical Journal*, 3(1), 67-88.

Lidz, B.H. and Hallock, P., 2000. Sedimentary petrology of a declining reef ecosystem, Florida Reef Tract (U.S.A.). *Journal of Coastal Research*, 16(3), 675-697.

***Multi-Authored Paper in a Journal*:**

Anthony, E.J.; Gardel, A.; Gratiot, N.; Proisy, C.; Allison, M.A.; Dolique, F., and Fromard, F., 2010. The Amazon-influenced muddy coast of South America: A review of mud-bank-shoreline interactions. *Earth-Science Reviews*, 103(1), 99-121.

Finkl, C.W.; Estebanell Becerra, J.; Achatz, V., and Andrews, J.L., 2008. Geomorphological mapping along the upper southeast Florida Atlantic Continental platform; I: Mapping units, symbolization and geographic information system presentation of interpreted seafloor topography. *Journal of Coastal Research,* 24(6), 1388-1417.

Martinez, J.O.; Gonzalez, J.L.; Pilkey, O.H., and Neal, W.J., 2000. Barrier island evolution on the subsiding central Pacific Coast, Colombia, South America. *Journal of Coastal Research*, 16(3), 663-674.

Tomás, A.; Méndez, F.J., and Losada, I.J., 2008. A method for spatial calibration of wave reanalysis data bases. *Continental Shelf Research*, 27(8), 952-975. doi:10.1016/j.csr.2007.09.009

***Including DOI numbers is optional when printed page numbers are not available.***

***Paper in a Journal of Coastal Research (JCR) Special Issue:***

Reed, C.W.; Brown, M.E.; Sanchez, A.; Wu, W., and Buttolph, A.M., 2010. The coastal modeling system flow model (CMS-Flow): Past and present. *In:* Rosati, J.D.; Wang, P., and Roberts, T.M. (eds.), *Proceedings, Symposium to Honor Dr. Nicholas C. Kraus*. *Journal of Coastal Research*, Special Issue No. 59, pp. 8-14.

Tillman, T. and Wunderlich, J., 2013. Barrier rollover and spit accretion due to the combined action of storm surge induced washover events and progradation: Insights from ground penetrating radar surveys and sedimentological data. *In:* Conley, D.; Masselink, G.; Russell, P., and O'Hare, T. (eds.), *Proceedings from the International Coastal Symposium (ICS) 2013* (Plymouth, United Kingdom). *Journal of Coastal Research*, Special Issue No. 65, pp. 600-605.

***Paper in a Proceedings Volume with Editors*:**

Ashton, A.D.; Murray, A.B., and Littlewood, R., 1980. The response of spit shapes to wave-angle climates. *In*: Kraus, N.C. and Rosati, J.D. (eds.), *Proceedings of the Sixth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes* (New Orleans, Louisiana), pp. 351-363.

***Paper in a Proceedings Volume with No Editor*:**

Butenko, J. and Barbot, J.P., 1980. Geological hazards related to offshore drilling and construction in the Oronoco River Delta of Venezuela. *Proceedings of the Offshore Technology Conference* (Houston, Texas), Paper 3395, pp. 323-329.

Goda, Y., 1970. The observed joint distribution of periods and heights of sea waves. *Proceedings of the 16th International Conference on Coastal Engineering* (Sydney, New South Wales, Australia), pp. 227-246.

Uda, T.; Turner, R.E., and Hashimoto, H., 1982. Description of beach changes using an empirical predictive model of beach profile changes. *Proceedings of the 18th Conference of Coastal Engineering* (Cape Town, South Africa, ASCE), pp. 1405-1418.

***Book; Commercial Publisher*:**

Darwin, C., 1842. *The Structure and Distribution of Coral Reefs*. London: Smith Elder, 214p.

Roberts, N. and Norseman, E.R., 1989. *The Holocene: An Environmental History*. Malden, Massachusetts: Blackwell, 316p.

***Book; Government*:**

Fisk, H.N., 1944. *Geological Investigations of the Alluvial Valley of the Lower Mississippi River*. Vicksburg, Mississippi: U.S. Army Corps of Engineers, Mississippi River Commission, 78p.

***Book; University Press*:**

Pilkey, O.H.; Neal, W.J.; Kelley, J.T., and Cooper, A.G., 2011. *The World's Beaches*. Berkeley, California: University of California Press, 283p.

Woodroffe, C.D., 2002. *Coasts: Form, Process and Evolution*. Cambridge: Cambridge University Press, 623p.

***Chapter in an Edited Book*:**

Oertel, G.F., 2005. Coasts, coastlines, shores, and shorelines. *In*: Schwartz, M.L. (ed.), *The Encyclopedia of Coastal Science*. Dordrecht, The Netherlands: Springer, pp. 323-327.

Wang, Y. and Healy, T., 2002. Definition, properties, and classification of muddy coasts. *In*: Healy, T.; Wang, Y., and Healy, J.A. (eds.), *Muddy Coasts of the World: Processes, Deposits and Function*. Amsterdam: Elsevier, pp. 9-18.

***Miscellaneous Reports with Specified Author:***

Farrow, D.R.G.; Arnold, F.D.; Lombardi, M.L.; Main, M.B., and Eichelberger, P.D., 1986. *The National Coastal Pollutant Discharge Inventory: Estimates for Long Island Sound*. Rockville, Maryland: National Oceanic and Atmospheric Administration, 40p.

McKee, E.D., 1989. *Sedimentary Structures and Textures of Río Orinoco Channel Sands, Venezuela and Colombia. U.S. Geological Survey Water-Supply Paper W2326-B*, pp. B1-B23.

Mehta, A.J. and Montague, C.L., 1991. *A Brief Review of Flow Circulation in The Vicinity of Natural and Jettied Inlets: Tentative Observations on Implications for Larval Transport at Oregon Inlet, N.C.* Gainesville, Florida: University of Florida, Department of Coastal and Oceanographic Engineering, *Report UFICOELIMP91/03*, 74p.

Vann, J.H., 1969. *Landforms, Vegetation, and Sea Level Change along the Coast of South America*. Buffalo, New York: State University College at Buffalo, *Technical Report No. 3*, 128p.

***Miscellaneous Reports without Specified Authors*:**

McClelland Engineering Staff, 1979. *Interpretation and Assessment of Shallow Geologic and Geotechnical Conditions*. Caracas, Venezuela: McClelland Engineering, Inc., *Orinoco Regional Survey Areas, Offshore Orinoco Delta, Venezuela*, 1, 109p.

U.S. Environmental Protection Agency Staff, 1994. *The Long Island Sound Study: Summary of the Comprehensive Conservation and Management Plan*. Washington, DC: U.S. Environmental Protection Agency Publication, *EPA 842-S-94-001*, 62p.

***Theses and Dissertations*:**

Worthy, M.C., 1980. Littoral Zone Processes at Old Woman Creek Estuary of Lake Erie. Columbus, Ohio: Ohio State University, Master's thesis, 198p.

Zarens, S.M., 1996. Aeolian Processes in the Dutch Foredunes. Amsterdam, The Netherlands: University of Amsterdam, Ph.D. dissertation, 150p.

***Maps or Charts*:**

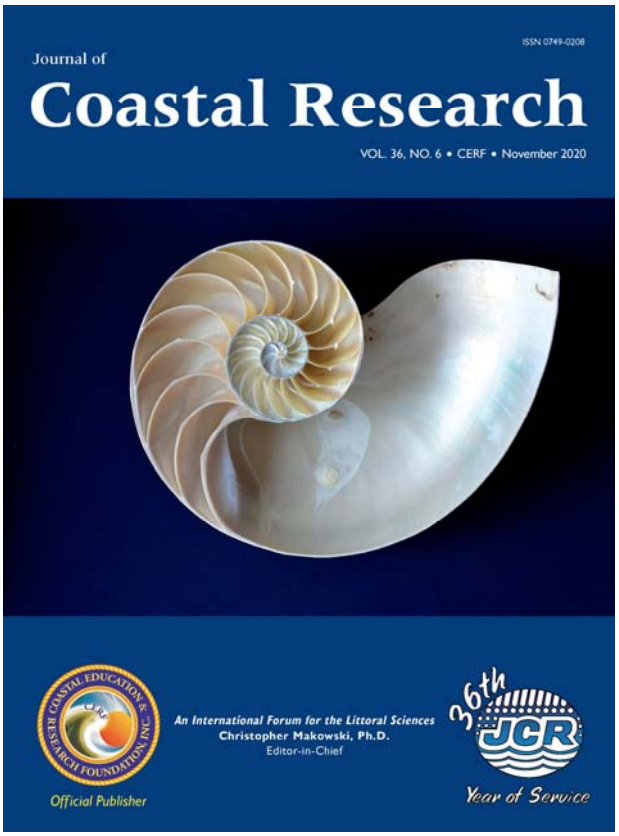
Beltran, C., 1993. *Mapa Neotectónico de Venezuela*. Caracas, Venezuela: FUNVISIS Departmento de Ciencias de la Tierra, scale 1:2,000,000, 1 sheet.

***Websites*:**

Coastal Education and Research Foundation, Inc. (CERF), 2022. https://www.cerf-jcr.org.

Turner and Townsend, 2012. *International Construction Cost Survey 2012* *http://www.turnerandtownsend.com/construction-cost-2012/_16803.html*.

United States Department of Agriculture, 1999. *The Federal Agriculture Improvement and Reform Act of 1996*. http://www.usda.gov/farmbill/title0.htm



# AUTHOR FORMATTING CHECKLIST BEFORE SUBMITTING

**We please request that the authors read the JCR Author Instructions. We kindly thank the authors for addressing these formatting requests before your submissions can be peer reviewed.**

- **Please make sure the English grammar of your submission is suitable for publication in an international journal. Submissions can be rejected solely on the basis of poor English usage.**
- **Change 'Keywords' to 'Additional Index Words.'**
- **Remove PO Boxes and street names from your affiliations. Also, the laboratory and college/department should be listed above the university.**
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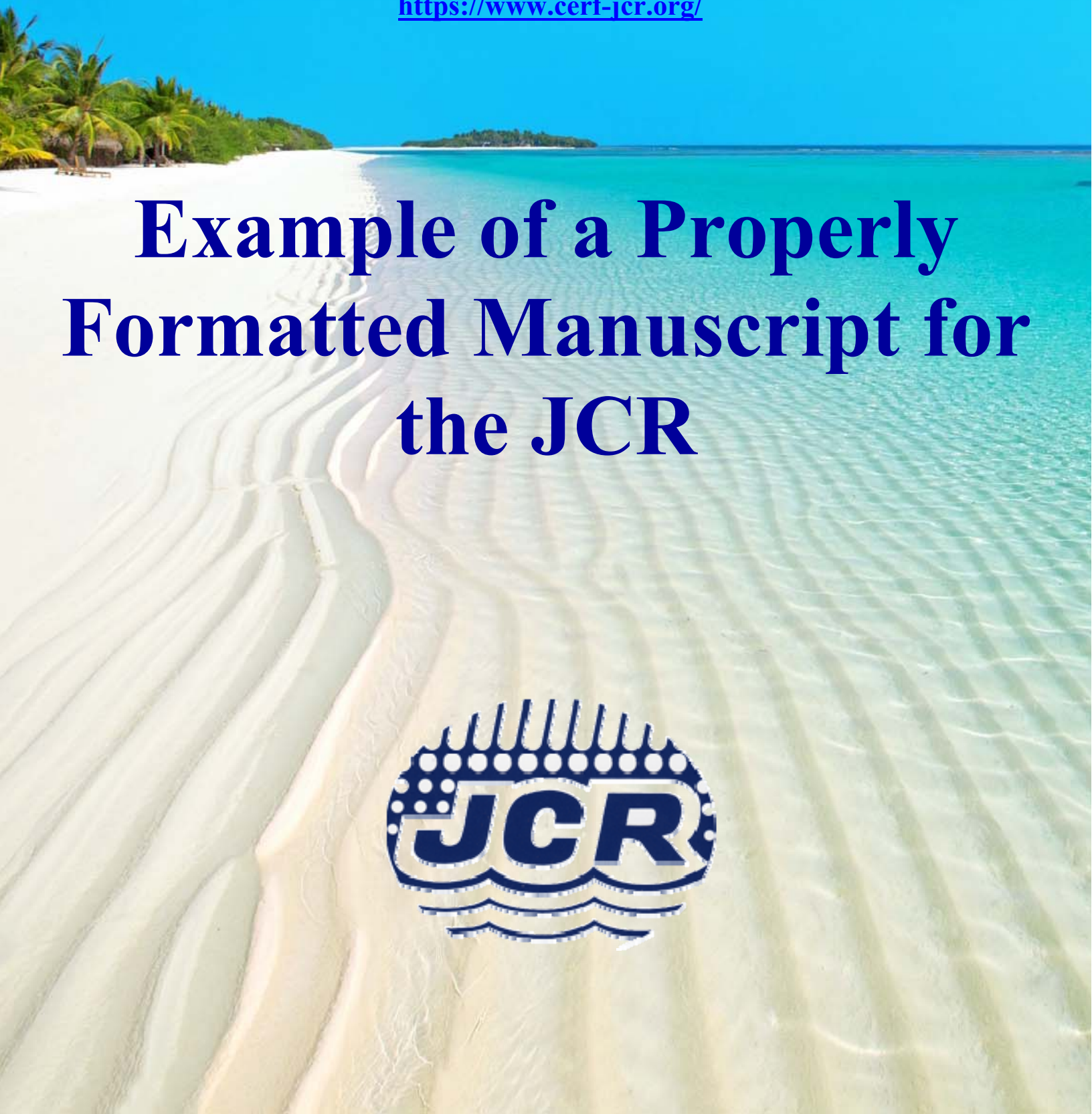

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# Cyclone Lahar and the Associated Wave Characteristics: A Numerical Modelling Approach

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**LRH (authors' last names): Xi, Lu, and Zhang**

**RRH (short running title): Numerical Modelling of Cyclone Lahar**

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## ABSTRACT

Natural hazards, especially tropical cyclones, are persistent visitors of Bay of Bengal which results in significant loss of life, damage to infrastructure, marine life, and biodiversity. This paper discusses the development of a cyclone model for the Bay of Bengal and adjoining the Andaman Sea, especially to understand the wave characteristics during cyclones of the Andaman Islands, and simulated the nearshore spectral wave characteristics of South Andaman during Cyclone Lahar, which hit the Islands from 23rd November 2013 to 26th November 2013. The spectral wave model of MIKE 21 developed by Danish Hydraulic Institute was used to simulate the wave characteristics of Bay Bengal and the Andaman Sea; whereas, the observed wave characteristics of a Wave Rider Buoy located at Port Blair, Andaman, was used for the validation of the model. A maximum simulated significant wave height of approximately 18 m was observed from the model of the cyclone and maximum simulated significant wave heights around 3.5 m were observed on the nearshore coastal waters of Port Blair, Andaman Islands.



**ADDITIONAL INDEX WORDS:** *Nearshore wave characteristics, significant waves heights, Bay of Bengal.*


## INTRODUCTION

Tropical cyclones which are mostly associated with warm and moist air and due to this reason they originate only over warm ocean waters near the equator. The favourable conditions required for the formation of cyclones are: (a) Warm sea surface temperature, (b) Large convective instability, (c) Low-level positive vorticity, (d) Weak vertical wind shear of horizontal wind, and (e) Adequate Coriolis force (Dube *et al.*, 2020; Sarker, 2018). The development of cyclonic storms is a frequent phenomenon in the Bay of Bengal, and it accounts for about 7% of the global annual total number of cyclones (Dube *et al*., 2020). The genesis of a cyclone is a regular feature in the pre-monsoon and (May) and post-monsoon (October to November) over Bay of Bengal (Patra, Mohanty, and Mishra, 2015). Timely prediction of these storms can reduce the

loss of human life and damage to infrastructure. Nateshan *et al*. (2013) have estimated the wave heights during cyclones Baaz, Fanoos, and 7B in the Bay of Bengal. Patra *et al*. (2015) developed a wave model to estimate and validate offshore wave characteristics of cyclones occurred in the Bay of Bengal from 2008 to 2009. Aboobacker *et al*. (2009) estimated the spatial characteristics of the nearshore waves of Paradeep, India during monsoons and extreme events.

This paper is concentrated on Cyclone Lahar for illustrating the application of numerical modelling tools to simulate the waves generated by cyclones and to assess the nearshore wave characteristics due to the cyclone on the coastal waters of Andaman and Nicobar Islands.

The Cyclone Lahar, which originated in the Bay of Bengal from 23rd to 28th November 2013, is categorized as a very severe cyclonic storm. It formed as depression over the Andaman Sea on 23rd November 2013 evening and intensified into cyclonic storm Lahar on 24th November 2013 near latitude 10.0°N and longitude 95.0°E. The salient feature of this particular cyclone was that it was the first severe cyclone storm to cross Andaman and Nicobar Islands after 1989. This cyclonic system crossed Andaman and Nicobar Islands near Port Blair at 0000 UTC of 25th November 2013 as a severe cyclonic storm. While moving west-northward direction over west central Bay of Bengal, this particular system weakened from 27th November afternoon and crossed Andhra Pradesh coast near to Machlipatanam around 8:30 UTC of 28th November 2018 as a deep depression i.e.it rapidly weakened over the sea from the stage of a very severe cyclonic storm to a depression in just 18 hours (IMD, 2014). The track of the cyclone is given in Table 1.

For the simulation of a cyclonic model, a large domain is required. The model covers the Bay of Bengal and its wider surroundings including Andaman and Nicobar Islands as Lahar is the only cyclone that crossed the Islands after 1989. The MIKE 21 Spectral Wave Model developed by DHI (Danish Hydraulic Institute) is used in the present study to simulate the cyclone. The assessment of nearshore wave climate of South Andaman Islands during cyclonic winds was the prime objective of the model simulation.

## METHODS

The following part describes the generation of the model. Initially, wind and pressure fields of the Cyclone Lahar were generated. The generated fields were then incorporated into the regionally-developed model and finally the model was validated.

### Wind and Pressure Field Generation

The cyclonic wind and pressure fields for Cyclone Lahar were generated by using MIKE 21 Cyclone Wind Generation tool. This tool generally computes the wind and pressure considerations due to cyclones by using different cyclonic parametric models such as Young and Sobey model, Holland-single vortex model, Holland-double vortex model and Rankine vortex model. The wind and pressure fields for Cyclone Lahar were generated by using Young and Sobey model. The cyclonic parameters used for the generation are: (a) Time, (b) Track of the cyclone, (c) The radius of the maximum wind speed, (d) Maximum wind speed, (e) Central pressure, and (f) Neutral pressure of the cyclonic system. The data required for the generation wind and pressure field was obtained from the IMD best track results. Figures 1 and 2 show an example for the wind and pressure fields of Cyclone Lahar on 23/11/2013 4:00 pm. These wind and pressure fields were used to drive the cyclonic wave model for the study.

### Regional Model Setup of Bay of Bengal

A Regional model was setup for the study based on MIKE 21 Spectral Wave model giving special considerations for Andaman and Nicobar Islands by constructing finer mesh around the Islands. Various physical phenomena like wave growth by the action of wind, non-linear wave-wave interactions, dissipation due to white capping, dissipation due to bottom friction, dissipation due to depth-induced wave breaking, wave refraction, wave shoaling and wave current-interactions were considered during the model development. The fully spectral formulation used in the model was based on wave action conservation equation, where the directional-frequency wave action spectrum is the dependable variable.

This regional wave model covers the coastlines of India including the coastlines of Andaman and Nicobar Islands, Sri Lanka, Myanmar and Indonesia (Figure 2). This model was then used to simulate the generation and propagation of cyclone waves. An unstructured flexible mesh with variable cell sizes was used in the model. The bathymetry required for the model was taken from MIKE C-Map Global Database.

**Numerical Modelling of Waves for Cyclone Lahar**

The regional wave model which was set up for the present study was based on the MIKE 21 Spectral Wave model (SW), and this particular model was employed in simulating the growth and propagation of the cyclonic waves. For this model, the fully spectral formulation with in-stationary time formulation was used. Low order numerical scheme was employed in the model. Wave diffraction, wave breaking, bottom friction and white capping were also included in the simulation of the model. With the JONSWAP fetch growth empirical formulations, the quadruplet wave interaction were also included.

The wave model for this study was driven by the wind speed and pressure field simulated, as shown in Figures 1 and 2. The entire passage of Cyclone Lahar was covered until its landfall.

**Validation of the Model**

The simulated maximum significant wave heights were compared against the maximum significant wave heights recorded by the Rider Buoy of NIOT at Port Blair (92.765°E, 11.661° N). The simulated significant wave heights from the model are in good agreement with the observed data hence proving a robust validation of the model.

## RESULTS

The Cyclone Lahar model shows that a maximum significant wave height around 18.0 m has occurred at a location of 88.243898°E, 14.718843°N on 26th November 2013 22:00:00 hours. The two-dimensional distribution of wave heights is shown in Figure 2 for this particular time

135 step. Table 1 indicates that the maximum wave heights were generated near the western coast of
136 Andhra Pradesh. The timely distribution of significant wave heights at this location is shown in
137 Figure 3 and indicates that maximum significant wave heights higher than 10 m were sustained
138 approximately more than 28 hours and wave heights more than 16 m sustained approximately
139 around 12-14 hours.
140 Further analysis was done on the wave characteristics due to Cyclone Lahar on the nearshore
141 coastal waters of Andaman and Nicobar Islands. The model shows a maximum significant wave
142 height of 3.7 m has occurred at 92.753346°E, 11.642340°N (Carbyn's Cove Beach, Port Blair)
143 on 25th November 2013 00:00:00 hours. A two-dimensional distribution of wave heights are
144 shown in Figure 3. The temporal distribution of significant wave heights at this location is shown
145 in Figure 3. The figure specifies that significant wave heights more than 3m sustained for
146 approximately 5 hours.
147
148 **DISCUSSION**
149 The model results indicate that Cyclone Lahar was a significant event which generated waves up
150 to 18 m at the height of the storm. The cyclone moved west-northwestwards over the central Bay
151 of Bengal. A better understanding of wave characteristics due to Cyclone Lahar on the near shore
152 of Andaman and Nicobar Islands were achieved from this particular study and which is very
153 important for these Islands that are vulnerable to natural disasters like tsunamis and cyclones.
154 Numerical modelling techniques can be used as a better tool for making enhanced strategies for
155 Disaster Risk Reduction and management specifically in the era of changing climate.
156
157 **CONCLUSIONS**
158 The study underlines how numerical how a robust wave model can be utilized to simulate
159 offshore and nearshore wave characteristics and impacts of cyclones over coastal developments
160 and infrastructures. The methodology used in this for modelling cyclones in the Bay of Bengal

and Andaman Sea could be applied to other sites around the world that are affected by these extreme events.


## ACKNOWLEDGEMENTS

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## Table Captions

**Table 1.** ***Simulations performed throughout the study. First column gives the acronym used for the simulation. Second column indicates if wave coupling is active or not. Third column indicates if the atmospheric pressure evolves with time (AROME) or not (constant value).***

## Figure Captions

**Figure 1. (a) Triangular grid mesh of the coupled model, and tropical cyclone COOK track (colors indicate intensity range: orange is 24–33 m/s; red is 33–44 m/s; violet is 44–55 m/s), (b) zoom on the East coast of New Caledonia grid mesh.**

**Figure 2. Maximum (a) 10-m wind speed (km/h), (b) wave height (m), (c) SSH due to inverse barometer effect (m), (d) SSH due to wave effects (m); zooms in (d): Ouvéa atoll and Poe lagoon. The yellow star offshore Poindimié indicates the position of the pressure sensor.**

**Figure 3. Evolution of Hs (m) at the Fourmi station (yellow star in Figure 3). Blue is observations from the pressure sensor, black, red, and green are modelled Hs at the closest model grid points with various depths.**


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