



INDIANA UNIVERSITY UNDERWATER SCIENCE

***Muskegon (12LE0381) 3D Photogrammetry
and Underwater Museum Interpretation***

2018 Lake Michigan Coastal Program Grant CZ540

Funding for this program was provided in part by the National Oceanic
and Atmospheric Administration and the Indiana Department of
Natural Resources Lake Michigan Coastal Program

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Executive Summary

Indiana University Center for Underwater Science conducted underwater archaeological investigation of the historic shipwreck *Muskegon* to produce an accurate 3D photogrammetric model, which will help to identify significant remaining features and their respective sensitivity. The results of this investigation and computer vision photogrammetry can be used for baseline monitoring and management, as well as an interpretive model for outreach and education.

Built in 1872 as the *Peerless*, the *Muskegon* was a steamship that operated on the Great Lakes until it was abandoned in 1911. Having functioned as a passenger freighter, a lumber-hooker, and a sand-sucker during its service, the *Muskegon* represents important innovations in engineering, commerce, transportation, and industry. Following former Indiana State Archaeologist Gary Ellis' initial 1987 documentation of the shipwreck, the *Muskegon* became the first shipwreck in the state of Indiana accepted to the National Register of Historic Places for its significance in late 19th/ early 20th century Great Lakes naval history. Since 2016, Indiana University has been conducting ongoing direct diver and photogrammetric surveys to assist with the management decisions and support public outreach with funding from the Indiana Department of Natural Resources Lake Michigan Coastal Program and the National Oceanic and Atmospheric Administration. This report presents the methodology and results of this ongoing assessment, discussing management strategies to develop the shipwreck as a marine protected area and underwater preserve appropriate for public interpretation.



UNDERWATER SCIENCE

INDIANA UNIVERSITY

School of Public Health
Bloomington

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UNIVERSITY

CENTER FOR
UNDERWATER
SCIENCE

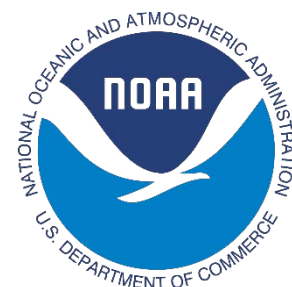


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Fully Signed Grant Agreement

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY
School of Public Health
Bloomington



**Purchase Order
Grant
State of Indiana**

Approved by Encompass Leadership Team - 2011

Order #	Date	Required Date	Page
0017556405	05/04/2017	06/03/2017	1 of 3
Requisition Number: 0000086885			
Vendor ID:		000004796 REMIT001	
Agency: 00300 Natural Resources			
Pay Terms: 35 Days in Arrears			
Fund/Object/Center: 61610/ 571300/ 231000			

Vendor 0000004796 REMIT001 71

Remit to
INDIANA UNIV
IU FINANCIAL MGMT SUPPORT
DEPT 78867 PO BOX 78000
DETROIT MI 48278

Ship To
IDNR, Lake MI Coastal Program
Indiana Dunes State Park
1600 N 25 E
CHESTERTON IN 46304

Vendor Name Address
INDIANA UNIV
IU FINANCIAL MGMT SUPPORT
400 EAST SEVENTH STREET
BLOOMINGTON IN 47405-3085

Bill To
Natural Resources
IDNR, Lake MI Coastal Program
Indiana Dunes State Park
1600 N 25 E
CHESTERTON IN 46304

Vendor Contact
Name:
eMail:
Phone:

Buyer
Name: Griffin, Shelia-300
eMail: SGriffin@dnr.IN.gov

Purchase Order Instructions & Comments

This purchase order is intended for use only as an instrument to encumber the funds necessary to satisfy the State's payment obligations and to order those items listed herein.

Purchase Order Line Details

Item No	Description	(FOB Destination)	Qty Ordered	Qty Recd	UOM	Unit Price	Extended Amt
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1- 1	Indiana University for Underwater Science will conduct an underwater Archaeological Investigation of the Muskegon historic shipwreck to produce an accurate 3D photogrammetric model.		1.0000		SVR	16,816.0000	16,816.00
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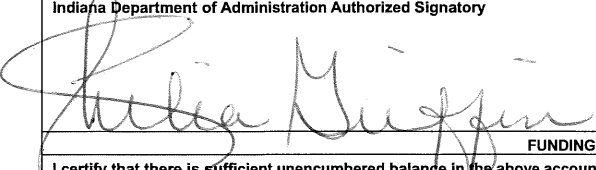
Contract ID: 0000000000000000000019560 Open Item Contract Release: 1
Contract Dates: 5/4/2017-6/30/2018

Units of Measure, Handling, Totals, Signatures

The following UN/CEFACT Unit of Measure Common Codes are used in this document:
SVR Service

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Total PO Amt. \$ 16,816.00

Indiana Department of Administration Authorized Signatory 	CONFIRMATION OF RECEIPT	
	I certify that the items listed above were received. All commodities appeared to conform to specifications and showed no patent defects, except as otherwise noted. Signature of State Employee Receiver	Date Signed(Month/Day/Year)
FUNDING ENCUMBERED BY THE AUDITOR OF STATE		
I certify that there is sufficient unencumbered balance in the above account to cover the amount of this order, and that funds have been set aside for payment thereof.		



00300 0017556405

Grant Agreement
Lake Michigan Coastal Program
Contract #0000000000000000000019560

This Grant Agreement (this "Grant Agreement"), entered into by and between the Indiana Department of Natural Resources (the "State") and THE TRUSTEES OF INDIANA UNIVERSITY (the "Grantee"), is executed pursuant to the terms and conditions set forth herein. In consideration of those mutual undertakings and covenants, the parties agree as follows:

1. Purpose of this Grant Agreement; Grant Funds

The purpose of this Grant Agreement is to enable the State to award a grant of \$16,816.00 to the Grantee for eligible costs of the services or project (the "Project") described in Exhibits A and B of this Grant Agreement, which are incorporated fully by reference. The funds shall be used exclusively in accordance with the provisions contained in this Grant Agreement, the authority to make this Grant, as well as any rules adopted thereunder. The funds received by the Grantee pursuant to this Grant Agreement shall be used only to implement the Project or provide the services in conformance with this Grant Agreement and for no other purpose.

2. Representations and Warranties of the Grantee

- A. The Grantee expressly represents and warrants to the State that it is statutorily eligible to receive these Grant funds and that the information set forth in its grant application is true, complete and accurate. The Grantee expressly agrees to promptly repay all funds paid to it under this Grant Agreement should it be determined either that it was ineligible to receive the funds, or it made any material misrepresentation on its grant application.
- B. The Grantee certifies by entering into this Grant Agreement that neither it nor its principals are presently debarred, suspended, proposed for debarment, declared ineligible or voluntarily excluded from entering into this Grant Agreement by any federal or state department or agency. The term "principal" for purposes of this Grant Agreement is defined as an officer, director, owner, partner, key employee or other person with primary management or supervisory responsibilities, or a person who has a critical influence on or substantive control over the operations of the Grantee.

3. Implementation of and Reporting on the Project

- A. The Grantee shall implement and complete the Project in accordance with Exhibit A and with the plans and specifications contained in its Grant Application, which is on file with the State and is incorporated by reference. Modification of the Project shall require prior written approval of the State.
- B. The Grantee agrees to complete the Project in accordance with the Coastal Zone Management Act of 1972, as amended (16 U.S.C. §1451 et seq.), which is incorporated herein.
- C. Reserved.(deleted by mutual agreement).
- D. The Grantee shall cause to be erected at the site of any construction project, and maintained during the construction, signs satisfactory to the DNR, that identify the Project and indicate that the Project is being funded under the Coastal Zone Management Act by the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and

Coastal Resource Management (OCRM) and the Indiana Department of Natural Resources Lake Michigan Coastal Program. The Grantee also shall maintain a permanent plaque or sign at the Project site with the same information.

- E. The Grantee must acknowledge the support of the National Oceanic and Atmospheric Administration and the Indiana Department of Natural Resources Lake Michigan Coastal Program on the title page of any publication written or published under this Grant Agreement. Correct examples of acknowledgement of support are: "This publication was made possible by a grant from the National Oceanic and Atmospheric Administration and the Indiana Department of Natural Resources, Lake Michigan Coastal Program." Or "Funding for this program was provided in part by the National Oceanic and Atmospheric Administration and the Indiana Department of Natural Resources, Lake Michigan Coastal Program."

4. Term

This Grant Agreement commences on the date of last required State signature, and shall remain in effect through June 30, 2018. Unless otherwise provided herein, it may be extended or renewed upon the written agreement of the parties and in conformance with IC §5-22-17-4, and as permitted by the state or federal law governing this Grant.

5. Grant Funding

- A. The State shall fund this grant in the amount of \$16,816.00. The approved Project Budget is set forth as Exhibit B of this Grant Agreement, attached hereto and incorporated herein. The Grantee shall not spend more than the amount for each line item in the Project Budget without the prior written consent of the State, nor shall the Project costs funded by this Grant Agreement and those funded by any local and/or private share be changed or modified without the prior written consent of the State.
- B. Reserved. (deleted by mutual agreement).

6. Payment of Grant Funds by the DNR

- A. Unless otherwise authorized by statute and agreed to in this Grant Agreement, all payments shall be made 35 days in arrears in conformance with State fiscal policies and procedures and, as required by IC §4-13-2-14.8, by electronic funds transfer to the financial institution designated by the Grantee in writing. If advance payment of a portion of the grant funds is permitted by statute, and the State agrees to provide such advance payment, it shall be made only upon submission of a proper claim setting out the intended purposes of those funds. After such funds have been expended, Grantee shall provide State with a reconciliation of those expenditures.
- a. Unless authorized by statute, all payments will be made in arrears only upon presentation of an approved and signed invoice from Grantee detailing disbursements of state, local and/or private funds by Project budget line items as set forth in Exhibit B using the format provided in the Lake Michigan Coastal Program (LMCP) Grants Manual, which is incorporated herein by reference.

- B. Requests for payment will be processed only upon presentation of Financial Report Form in the form designated by the State. Such Financial Report Forms must be submitted with the budget expenditure report detailing disbursements of state, local and/or private funds by project budget line items.
- C. The State may require evidence furnished by the Grantee that substantial progress has been made toward completion of the Project prior to making the first payment under this Grant. All payments are subject to the State's determination that the Grantee's performance to date conforms with the Project as approved, notwithstanding any other provision of this Grant Agreement.
- D. Claims shall be submitted to the State within 30 calendar days following the end of the quarter in which work on or for the Project was performed. The State has the discretion, and reserves the right, to NOT pay any claims submitted later than 60 calendar days following the end of the quarter in which the services were provided. All final claims and reports must be submitted to the State within 60 calendar days after the expiration or termination of this agreement. Payment for claims submitted after that time may, at the discretion of the State, be denied. Claims may be submitted on a quarterly basis only.
- E. Matching funds in excess of the required 1:1 match requirement may not be applied as matching funds to other grant projects receiving funds from LMCP.
- F. Claims must be submitted with accompanying supportive documentation as designated by the State. Claims submitted without supportive documentation will be returned to the Grantee and not processed for payment. Failure to comply with the provisions of this Grant Agreement may result in the denial of a claim for payment.
- G. Grantee must observe the closeout procedures provided by the Lake Michigan Coastal Program within 60 days after the expiration or termination date of this Grant Agreement. The Grantee is responsible for submitting to DNR a Final Report using the format provided in the Lake Michigan Coastal Program (LMCP) Grants Manual, which is incorporated herein by reference, within 60 days after the expiration of this Grant Agreement. Funds may only be expended beyond the expiration date for activities such as the preparation of the final reports and other documents directly associated with closeout of the grant, and for obligations properly created prior to the expiration date. When the DNR determines that all required reports have been submitted, the DNR will send a letter advising the Grantee that closeout has been completed. The letter will also advise the recipient regarding records retention requirements. If closeout action results in a debt to the DNR, Grantee must pay the debt within a reasonable period, not to exceed sixty (60) days.
- H. The Grantee is responsible for submitting to the DNR on a quarterly basis, both a Progress Report and a Financial Report until the completion of the Project. Quarters consist of a three (3) month period as follows: January through March; April through June; July through September; and October through December. DNR must receive reports no later than fourteen (14) days following the end of each quarter (i.e., April 14th, July 14th, October 14th, and January 14th) regardless of when the project officially starts. These reports should provide a detailed explanation of what was accomplished under each task during the quarter. The Progress Report should be organized in the same format as the Project description and timeline in the original grant application and include the following:

- a. Status of tasks within each Project phase, organized by task title (e.g. meetings held, work products completed, contracts completed, difficulties that may impede timely completion).
 - b. Status of objectives due during the quarter.
 - c. Status of special grant conditions, if any, due during the quarter.
 - d. Financial reports should conform to the format provided by the Lake Michigan Coastal Program and detail progress made on each budget item in Exhibit B.
 - e. LMCP Performance Indicators Checklist.
- I. If this Grant Agreement is terminated by either party prior to the Expiration Date of this Grant Agreement, the DNR may promptly conduct an on-site monitoring of the Project and complete a Project monitoring report.
- J. Failure to complete the Project and expend state, local and/or private funds in accordance with this Grant Agreement may be considered a material breach of the agreement and may entitle the DNR to impose sanctions against the Grantee including, but not limited to, suspension of all grant payments until such time as all material breaches are cured to the DNR's satisfaction. Sanctions may also include repayment of all DNR funds expended for activities that are not in the scope of the Project as set forth in Exhibits A and B.
- K. Grantee must comply with the federal policies and regulations in Exhibit D, attached hereto and incorporated herein.
- L. The payment of this Grant by the DNR to the Grantee shall also be made in accordance with the following schedule and conditions: (i.) This Grant Agreement must be fully executed, (ii.) All of the evidentiary materials required by Exhibit C., attached hereto and incorporated herein, must be submitted to and approved by the DNR.

7. Project Monitoring by the State

The State may conduct on-site or off-site monitoring reviews of the Project during the term of this Grant Agreement and for up to ninety (90) days after it expires or is otherwise terminated. The Grantee shall extend its full cooperation and give full access to the Project site and to relevant documentation to the State or its authorized designees for the purpose of determining, among other things:

- A. whether Project activities are consistent with those set forth in **Exhibit A**, the grant application, and the terms and conditions of the Grant Agreement;
- B. the actual expenditure of state, local and/or private funds expended to date on the Project is in conformity with the amounts for each Budget line item as set forth in **Exhibit B** and that unpaid costs have been properly accrued;

- C. that Grantee is making timely progress with the Project, and that its project management, financial management and control systems, procurement systems and methods, and overall performance are in conformance with the requirements set forth in this Grant Agreement and are fully and accurately reflected in Project reports submitted to the State.

8. Audits and Maintenance of Records

Grantee acknowledges that it may be required to submit to an audit of funds paid through this Agreement. Any such audit shall be conducted in accordance with IC 5-11-1, et. seq. and audit guidelines specified by the State and all applicable provisions of 2 C.F.R. 200. Grantee shall make all books, accounting records and other documents available at all reasonable times during the term of this Grant Agreement and for a period of three (3) years after final payment for inspection by the State or its authorized designee. Copies shall be furnished to the State at no cost.

- A. Reserved. (deleted by mutual agreement).

9. Compliance with Laws

- A. The Grantee shall comply with all applicable federal, state and local laws, rules, regulations and ordinances, and all provisions required thereby to be included herein are hereby incorporated by reference. The enactment or modification of any applicable state or federal statute or the promulgation of rules or regulations thereunder after execution of this Grant Agreement shall be reviewed by the State and the Grantee to determine whether the provisions of this Grant Agreement require formal modification.
- B. The Grantee and its agents shall abide by all ethical requirements that apply to persons who have a business relationship with the State as set forth in IC §4-2-6, et seq., IC §4-2-7, et seq., the regulations promulgated thereunder. **If the Grantee has knowledge, or would have acquired knowledge with reasonable inquiry, that at state officer, employee, or special state appointee, as those terms are defined in IC 4-2-6-1, has a financial interest in the Grant, the Grantee shall comply with the disclosure requirements in IC 4-2-6-10.5 prior to execution of this Grant.** If the Grantee is not familiar with these ethical requirements, the Grantee should refer any questions to the Indiana State Ethics Commission, or visit the Inspector General's website at <http://www.in.gov/ig/>. If the Grantee or its agents violate any applicable ethical standards, the State may, in its sole discretion, terminate this Grant immediately upon notice to the Grantee. In addition, the Grantee may be subject to penalties under IC §§ 4-2-6, 4-2-7, 35-44.1-1-4, and under other applicable laws.
- C. The Grantee certifies by entering into this Grant Agreement that neither it nor its principal(s) is presently in arrears in payment of taxes, permit fees or other statutory, regulatory or judicially required payments to the State. The Grantee agrees that any payments currently due to the State may be withheld from payments due to the Grantee. Additionally, payments may be withheld, delayed, or denied and/or this Grant suspended until the Grantee is current in its payments and has submitted proof of such payment to the State.
- D. The Grantee warrants that it has no current, pending or outstanding criminal, civil, or enforcement actions initiated by the State, and agrees that it will immediately notify the State of any such actions. During the term of such actions, the Grantee agrees that the State may suspend funding for the Project. If a valid dispute exists as to the Grantee's liability or guilt in any action initiated by the State or its agencies, and the State decides to suspend funding to the Grantee, the Grantee may submit, in writing, a request for review to the Indiana Department of Administration (IDOA). A determination by IDOA shall be binding on the parties. Any disbursements that the State may delay, withhold, deny, or apply under this section shall not be subject to penalty or interest.

- E. The Grantee warrants that the Grantee and any contractors performing work in connection with the Project shall obtain and maintain all required permits, licenses, registrations, and approvals, and shall comply with all health, safety, and environmental statutes, rules, or regulations in the performance of work activities for the State. Failure to do so may be deemed a material breach of this Grant Agreement and grounds for immediate termination and denial of grant opportunities with the State.
- F. The Grantee affirms that, if it is an entity described in IC Title 23, it is properly registered and owes no outstanding reports to the Indiana Secretary of State.
- G. As required by IC §5-22-3-7:

(1) The Grantee and any principals of the Grantee certify that:

(A) the Grantee, except for de minimis and nonsystematic violations, has not violated the terms of:

- (i) IC §24-4.7 [Telephone Solicitation Of Consumers];
- (ii) I C §24-5-12 [Telephone Solicitations]; or
- (iii) IC §24-5-14 [Regulation of Automatic Dialing Machines]; In the previous three hundred sixty-five (365) days, even if IC 24-4.7 is preempted by federal law; and

(B) the Grantee will not violate the terms of IC §24-4.7 for the duration of this Grant Agreement, even if IC §24-4.7 is preempted by federal law.

(2) The Grantee and any principals of the Grantee certify that an affiliate or principal of the Grantee and any agent acting on behalf of the Grantee or on behalf of an affiliate or principal of the Grantee, except for de minimis and nonsystematic violations,

(A) has not violated the terms of IC §24-4.7 in the previous three hundred sixty-five (365) days, even if IC §24-4.7 is preempted by federal law; and

(B) will not violate the terms of IC §24-4.7 for the duration of this Grant Agreement even if IC §24-4.7 is preempted by federal law.

10. Drug-Free Workplace Certification

This clause is required by Executive Order 90-5 and applies to all individuals and private legal entities who receive grants or contracts from State agencies. This clause was modified in 2005 to apply only to Contractor's employees within the State of Indiana and cannot be further modified, altered or changed.

As required by Executive Order No. 90-5, April 12, 1990, issued by the Governor of Indiana, the Grantee hereby covenants and agrees to make a good faith effort to provide and maintain a drug-free workplace. Grantee will give written notice to the State within ten (10) days after receiving actual notice that the Grantee, or an employee of the Grantee in the State of Indiana, has been convicted of a criminal drug violation occurring in the workplace. False certification or violation of the certification may result in sanctions including, but not limited to, suspension of grant payments, termination of the Grant and/or debarment of grant opportunities with the State of Indiana for up to three (3) years.

In addition to the provisions of the above paragraphs, if the total amount set forth in this Grant Agreement is in excess of \$25,000.00, the Grantee certifies and agrees that it will provide a drug-free workplace by:

- A. Publishing and providing to all of its employees a statement notifying them that the unlawful manufacture, distribution, dispensing, possession or use of a controlled

substance is prohibited in the Grantee's workplace and specifying the actions that will be taken against employees for violations of such prohibition; and

- B. Establishing a drug-free awareness program to inform its employees of (1) the dangers of drug abuse in the workplace; (2) the Grantee's policy of maintaining a drug-free workplace; (3) any available drug counseling, rehabilitation, and employee assistance programs; and (4) the penalties that may be imposed upon an employee for drug abuse violations occurring in the workplace; and
- C. Notifying all employees in the statement required by subparagraph (A) above that as a condition of continued employment the employee will (1) abide by the terms of the statement; and (2) notify the Grantee of any criminal drug statute conviction for a violation occurring in the workplace no later than five (5) days after such conviction; and
- D. Notifying in writing the State within ten (10) days after receiving notice from an employee under subdivision (C)(2) above, or otherwise receiving actual notice of such conviction; and
- E. Within thirty (30) days after receiving notice under subdivision (C)(2) above of a conviction, imposing the following sanctions or remedial measures on any employee who is convicted of drug abuse violations occurring in the workplace: (1) take appropriate personnel action against the employee, up to and including termination; or (2) require such employee to satisfactorily participate in a drug abuse assistance or rehabilitation program approved for such purposes by a federal, state or local health, law enforcement, or other appropriate agency; and
- F. Making a good faith effort to maintain a drug-free workplace through the implementation of subparagraphs (A) through (E) above.

11. Employment Eligibility Verification (deleted; not applicable)

12. Funding Cancellation

When the Director of the State Budget Agency makes a written determination that funds are not appropriated or otherwise available to support continuation of performance of this Grant Agreement, it shall be canceled. A determination by the Director of State Budget Agency that funds are not appropriated or otherwise available to support continuation of performance shall be final and conclusive.

13. Governing Law

This Grant Agreement shall be governed, construed, and enforced in accordance with the laws of the State of Indiana, without regard to its conflict of laws rules. Suit, if any, must be brought in the State of Indiana.

14. Information Technology Accessibility Standards

Any information technology related products or services purchased, used or maintained through this Grant must be compatible with the principles and goals contained in the Electronic and Information Technology Accessibility Standards adopted by the Architectural and Transportation

Barriers Compliance Board under Section 508 of the federal Rehabilitation Act of 1973 (29 U.S.C. §794d), as amended. The federal Electronic and Information Technology Accessibility Standards can be found at: <http://www.access-board.gov/508.htm>.

15. Nondiscrimination

Pursuant to the Indiana Civil Rights Law, specifically including IC §22-9-1-10, and in keeping with the purposes of the federal Civil Rights Act of 1964, the Age Discrimination in Employment Act, and the Americans with Disabilities Act, the Grantee covenants that it shall not discriminate against any employee or applicant for employment relating to this Grant with respect to the hire, tenure, terms, conditions or privileges of employment or any matter directly or indirectly related to employment, because of the employee or applicant's: race, color, national origin, religion, sex, age, disability, ancestry, status as a veteran, or any other characteristic protected by federal, state, or local law ("Protected Characteristics"). Furthermore, Grantee certifies compliance with applicable federal laws, regulations, and executive orders prohibiting discrimination based on the Protected Characteristics in the provision of services.

The Grantee understands that the State is a recipient of federal funds, and therefore, where applicable, Grantee and any subcontractors shall comply with requisite affirmative action requirements, including reporting, pursuant to 41 CFR Chapter 60, as amended, and Section 202 of Executive Order 11246 as amended by Executive Order 13672.

16. Notice to Parties

Whenever any notice, statement or other communication is required under this Grant, it shall be sent by first class mail or via an established courier / delivery service to the following addresses, unless otherwise specifically advised.

- A. Notices to the State shall be sent to: (Include contact name and/or title, name of agency & address)

Maggie Byrne, Grant Specialist
Lake Michigan Coastal Program
Indiana Department of Natural Resources
Indiana Dunes State Park Annex Office
1600 North 25 East
Chesterton, Indiana 46304
mbyrne@dnr.in.gov
219-983-9912

- B. Notices to the Grantee shall be sent to: (Include contact name and/or title, name of grantee & address)

Steven A. Martin, Associate Vice President
Office of Research Administration
Indiana University
509 E. Third St
Bloomington, IN 47401
rugs@indiana.edu
812-855-0516

- C. As required by IC §4-13-2-14.8, payments to the Grantee shall be made via electronic funds transfer in accordance with instructions filed by the Grantee with the Indiana Auditor of State.

17. Order of Precedence

Any inconsistency or ambiguity in this Grant Agreement shall be resolved by giving precedence in the following order: (1) requirements imposed by applicable federal law or other controlling document described in paragraph 20, below; (2) this Grant Agreement, (3) exhibits prepared by the State, (4) exhibits prepared by Grantee; (5) Invitation to Apply for Grant; and (6) the Grant Application.

18. Termination for Breach

- A. Failure to complete the Project and expend State, local and/or private funds in accordance with this Grant Agreement may be considered a material breach, and shall entitle the State to suspend grant payments, and suspend the Grantee's participation in State grant programs until such time as all material breaches are cured to the State's satisfaction.

- B. The expenditure of State or federal funds other than in conformance with the Project or the Budget may be deemed a breach. The Grantee explicitly covenants that it shall promptly repay to the State all funds not spent in conformance with this Grant Agreement.

19. Termination for Convenience

Unless prohibited by a statute or regulation relating to the award of the grant, this Grant Agreement may be terminated, in whole or in part, by the State whenever, for any reason, the State determines that such termination is in the best interest of the State. Termination shall be effected by delivery to the Grantee of a Termination Notice, specifying the extent to which such termination becomes effective. The Grantee shall be compensated for completion of the Project properly done prior to the effective date of termination. The State will not be liable for work on the Project performed after the effective date of termination. In no case shall total payment made to the Grantee exceed the original grant.

20. Federal and State Third-Party Contract Provisions

If part of this Grant involves the payment of federal funds, the Grantee and, if applicable, its contractors shall comply with the federal grant / contract provisions attached as Exhibit(s) D and incorporated fully herein.

21. State Boilerplate Affirmation Clause

I swear or affirm under the penalties of perjury that I have not altered, modified or changed the State's Boilerplate clauses (as defined in the 2015 OAG/DOA Professional Services Contract Manual) in any way except for the following clauses: #3: Implementation of and Reporting on the Project; #4: Term; #6: Payment of Grant Funds by the DNR; #22: Public Record-added.

22. Public Record

Unless an Access to Public Record Act exception applies, this Grant agreement will not be treated as confidential and will be posted on the State's website as required by Executive Order 05-07. Use by the public of information contained in this Grant shall not be considered an act of the State.

[Remainder of page intentionally left blank]

Non-Collusion and Acceptance

The undersigned attests, subject to the penalties for perjury, that the undersigned is the Grantee, or that the undersigned is the properly authorized representative, agent, member or officer of the Grantee. Further, to the undersigned's knowledge, neither the undersigned nor any other member, employee, representative, agent or officer of the Grantee, directly or indirectly, has entered into or been offered any sum of money or other consideration for the execution of this Agreement other than that which appears upon the face hereof. **Furthermore, if the undersigned has knowledge that a state officer, employee, or special state appointee, as those terms are defined in IC 4-2-6-1, has a financial interest in the Contract, the Contractor attests to compliance with the disclosure requirements in IC 4-2-6-10.5.**

Agreement to Use Electronic Signatures

I agree, and it is my intent, to sign this Contract by accessing State of Indiana Supplier Portal using the secure password assigned to me and by electronically submitting this Contract to the State of Indiana. I understand that my signing and submitting this Contract in this fashion is the legal equivalent of having placed my handwritten signature on the submitted Contract and this affirmation. I understand and agree that by electronically signing and submitting this Contract in this fashion I am affirming to the truth of the information contained therein. I understand that this Contract will not become binding on the State until it has been approved by the Department of Administration, the State Budget Agency, and the Office of the Attorney General, which approvals will be posted on the Active Contracts Database:

https://hr85.qmis.in.gov/psp/pa91prd/EMPLOYEE/EMPL/h/?tab=PAPP_GUEST

In Witness Whereof, Grantee and the State have, through their duly authorized representatives, entered into this Grant Agreement. The parties, having read and understood the foregoing terms of this Grant Agreement do, by their respective signatures dated below, hereby agree to the terms hereof.

THE TRUSTEES OF INDIANA UNIVERSITY

Indiana Department of Natural Resources

By: **Trisha Adams**
 Title: **Adams**
 Date:

Trisha Adams
 cn=Trisha Adams, o=Office of Research Administration, ou=Research Contracting, email=trdadams@iu.edu, c=US
 2017.04.28 08:56:05 -04'00'

By: **Michael J. Smith**
 Title: **J. Smith**
 Date:

Digitally signed by Michael J. Smith
 DN: cn=Michael J. Smith, o=Indiana Department of Natural Resources, ou=Deputy Administrative Director, email=msmith@dnr.in.gov, c=US
 Date: 2017.05.01 11:45:16 -04'00'

Approved by: Indiana Office of Technology By: N/A (for) Dewand Neely, Chief Information Officer <i>Refer to Electronic Approval History found after the final page of the Executed Contract for details.</i>	Electronically Approved by: Department of Administration By: (for) Jessica Robertson, Commissioner <i>Refer to Electronic Approval History found after the final page of the Executed Contract for details.</i>
Electronically Approved by: State Budget Agency By: (for) Jason D. Dudich, Director <i>Refer to Electronic Approval History found after the final page of the Executed Contract for details.</i>	Approved as to Form and Legality: Office of the Attorney General <i>Form approval has been granted by the Office of the Attorney General pursuant to IC 4-13-2-14.3(e) on July 13, 2016 FA 16-19</i>

Exhibit A – Timeline**Indiana Lake Michigan Coastal Grants Program
Project Number: CZ 540**

Applicant: The Trustees of Indiana University

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Timeline: May 2017 – June 2018

Summary: Indiana University Center for Underwater Science will conduct underwater archaeological investigation of the *Muskegon* historic shipwreck to produce an accurate 3D photogrammetric model which will identify significant remaining features and their respective sensitivity. The results of this investigation and computer vision photogrammetry will be utilized for baseline monitoring and management, as well as an interpretive model for outreach and education.

TASK ONE: Project Planning

May 2017

1. Apply for necessary permits and permission for archaeological investigation
2. Organize and secure equipment for field work
3. Coordinate travel and diving logistics (boats, hotels, etc)
4. Coordinate photogrammetric data collection strategy

TASK TWO: Project Implementation

July 2017

1. Conduct photogrammetric survey of *Muskegon*
2. Collect supplementary data using traditional methods
3. Identify key artifacts and features for interpretation and/or conservation
4. Create database for the storage of data collected for this project

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan
2. Draft final report of photogrammetric survey with recommendations for potential future development as an underwater park
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database.

TASK THREE: Public Outreach and Education

September 2017 – June 2018

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration

May 2017 – June 2018

1. Track and record the hours of volunteers and professionals whose work will be counted as match

2. Track and record the hours of staff whose work will be charged to the grant

Work Products:

1. A report detailing the methodology used and the recommendations for protecting the site.
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource
3. All photos, processing data, and metadata collected during the project

Exhibit B – Budget**Indiana Lake Michigan Coastal Grants Program
Project Number: CZ 540****Applicant:** Indiana University**Project Title:** Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Category	LMCP Request	Match: Cash	Match: In-Kind	Total
Personnel	\$6,204		\$10,392	\$16,596
Fringe	\$1,035		\$2,723	\$3,758
Travel	\$3,000			
Supplies	\$2,500			
Contractual	0			
Indirect rate = 32 %	\$4,077		\$4,197	\$8,274
Totals	\$16,816		\$17,312	\$34,128

Exhibit C

Grantee agrees to the following special conditions:

- A. The DNR Lake Michigan Coastal Program will fund up to 50% of the project cost using the Department of Commerce, National Oceanic and Atmospheric Administration funds, not to exceed the total grant amount. The grantee will be responsible for providing cash and/or donated goods and services sufficient to complete the project. The matching share will not consist of funds from the federal government. Costs paid for with locally provided matching funds, or in-kind services, must be accounted for in the same manner as costs to be reimbursed with grant funds.
- B. The project must be conducted in accordance with: *Coastal Zone Management Act Section 306A Guidance* and the *Lake Michigan Coastal Program Grants Manual*.
- C. Grantee will not cut or remove any trees equal to or greater than three (3) inches in diameter at breast height (dbh) between April 1 and September 30 and all mechanical cutting activity must be restricted to times when the ground is frozen.
- D. Grantee will submit to the DNR, Lake Michigan Coastal Program for review a list of all plant species to be planted as part of this grant project.
- E. Grantee will comply with the requirements of the Indiana State Historic Preservation Office (Indiana SHPO).
- F. The grantee must submit plans, specifications, or other predevelopment information, to the DNR, Lake Michigan Coastal Program for review. No construction work can begin on the project until written approval is received from the DNR, Lake Michigan Coastal Program.
- G. The grantee may not enter into any contracts for any aspects of the project work without the prior written approval of the DNR, Lake Michigan Coastal Program. Federal regulations require a competitive procurement process in the selection of all professional services that are connected with a federally funded project. See the *Lake Michigan Coastal Program Grants Manual* for more information on procurement.
- H. Grantee agrees to obtain all necessary local, state, and federal permits for any work conducted under this grant agreement. Grantee will submit a copy of all permits to the DNR, Lake Michigan Coastal Program.
- I. The grantee will submit to the DNR, Lake Michigan Coastal Program a draft project report a minimum of 30 days prior to the expiration of this grant agreement. Before closeout of this grant agreement, the grantee shall submit to the DNR, Lake Michigan Coastal Program one hard copy, and one electronic copy of the final project report with, as applicable, photo documentation of the completed work.
- J. The DNR will retain 15% of the total grant amount until the DNR Lake Michigan Coastal Program, has reviewed the final products and has found them to be in compliance with applicable requirements in this grant agreement. When all work has been completed and accepted, and all required financial documentation has been submitted to the DNR Lake Michigan Coastal Program, the 15% retention, or the balance of approved grant expenditures will be released for payment.
- K. In the event there are title discrepancies or encumbrances that the DNR deems interfere with the purpose for which grant funds were granted, or if DNR determines that the

project or property is no longer used for its original purpose, the grantee shall reimburse the DNR for the federal funds received for the project. The grantee will maintain the project in perpetuity, or at a minimum, twenty (20) years.

- L. Grantee is required to retain all financial records, supporting documents, and other records and papers related to this grant for a period of three years after the expiration date of this grant agreement. Subgrantees must likewise retain such records for a three-year period.
- M. The State Board of Accounts, or its designee, will have the right to conduct financial audits of the grantee in accordance with established guidelines. Grantee agrees to comply with all reporting requirements prescribed by the State Board of Accounts. When a grantee is audited for the period of time that grant funds were being expended, a copy of the audit report must be provided to the DNR Lake Michigan Coastal Program. If the term of the grant covers more than one audit period, all applicable audit reports must be provided to the DNR Lake Michigan Coastal Program. All local government units must ensure that the federal funds in this grant are included in the Single Audit conducted on their governmental agency by the State Board of Accounts.
- N. Requests for time extensions must be submitted to the DNR Lake Michigan Coastal Program in writing and be fully justified. Requests for extensions must be received by the DNR Lake Michigan Coastal Program 60 days before the expiration of the grant agreement. The DNR reserves the right to deny any request for extension.

Exhibit D

Grantee agrees to the following federal terms and conditions set forth herein:

- A. Grantee must comply, as applicable, with the following: (1) 2 CFR Part 200: Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments; (2) Financial management standards as prescribed in 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101; (3) Cost Principles in 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101.
- B. For any projects involving the collection or production of geospatial data (i.e. GIS data), the Grantee will comply to the maximum extent practicable with Executive Order 12906 "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure" Federal Register Vol. 59, Number 71, pp. 17671-17674, the Grantee shall document all new geospatial data it collects or produces using the standard developed by the Federal Geographic Data Committee (FGDC), and make that standardized documentation electronically accessible to the State. The standard can be found at <http://fgdc.gov/standards/standards.html>
- C. Grantee must comply with Part III of Executive Order 11246 (30 F.R. 12319, September 25, 1965) as amended by Executive Order 11375 (32 F.R. 14303, October 17, 1967) requiring federally assisted construction contracts to include the provisions of Section 203 of the Executive Order for Equal Employment Opportunity. Grantee must also comply with Department of Labor regulations implementing the Executive Order. These are found at 41 CFR 60-1.4 (b).
- D. Grantee is, for any construction activities funded through this grant, required to include, in contracts in excess of \$10,000, a provision requiring compliance with Executive Order 11246, concerning equal employment opportunity, as amended by Executive Order 11375 and supplemented in Department of Labor regulations (41 CFR Chapter 60). Grantee must observe all applicable requirements of the Orders and regulations and include in their nonexempt (see the supplementing regulation) construction contracts the specific clauses prescribed by 41 CFR 60-1.4 (b) and, if applicable, 41 CFR 60-4.3.
- E. The Grantee is prohibited from expending grant funds or in-kind goods or services for purposes of providing transportation, travel, and any other expenses for any Federal employee.
- F. The Grantee and any subrecipients or contractors shall not sub-grant or subcontract any part of the approved project to any federal agency.
- G. The Grantee shall include a statement in all lower tier covered transactions (Subgrants, contracts, and subcontracts), that the grant is subject to Executive Order 12549, "Debarment and Suspension" and Department of Commerce implementing regulations published at 15 CFR Part 26, Subparts A through E, "Governmentwide Debarment and Suspension (Nonprocurement).
- H. If appraisal of real property is required by an independent appraiser, Grantee must comply with the procedures for establishing the fair market value of land or a building or the fair rental rate of land or space in a building are governed by 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101.

- I. Grantee shall be alert to organizational conflicts of interest as well as other practices among subrecipients that may restrict or eliminate competition. In order to ensure objective subrecipient performance and eliminate unfair competitive advantage, subrecipients that develop draft work requirements, statements of work, or requests for proposals shall be excluded from competing for such subgrants.
- J. The Grantee shall maintain written standards of conduct governing the performance of its employees engaged in the grant and administration of subgrants. No employee, officer, or agent shall participate in the selection, award, or administration of a subgrant under this grant agreement if a real or apparent conflict of interest would be involved. Such a conflict would arise when the employee, officer, or agent, any member of his or her immediate family, his or her partner, or an organization which employs or is about to employ any of the parties mentioned in this section, has a financial interest or other interest in the organization selected for a subgrant. The officers, employees, and agents of the Grantee shall neither solicit nor accept anything of monetary value from subrecipients. However, the Grantee may set standards for situations in which the financial interest is not substantial or the gift is an unsolicited item of nominal value. The standards of conduct shall provide for disciplinary actions to be applied for violations of such standards by officers, employees, or agents of the Grantee.
- K. The Grantee must retain and provide access to financial and programmatic records, statistical records, supporting document, and all other records associated with a grant project according to 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101. Grantee must also require any sub-recipients to comply with this provision. In general, records must be retained for three (3) years from the date the Grantee submits its last expenditure report for the grant period. If any litigation, claim, negotiation, audit or other action involving the records has been started before the expiration of the three-year period, the records must be retained until completion of the action and resolution of all issues which arise from it, or until the end of the regular three-year period, whichever is later.
- L. Grantee must comply with the requirements for retaining records of cost sharing or matching contributions as prescribed by 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101. Complete records on matching costs should be kept and maintained by the Grantee. Records of cost-sharing or matching contributions are subject to audit in the same manner and to the same extent as records dealing with the use of federal grant funds.
- M. The Grantee is accountable to the State for any grant related income as prescribed in 2 CFR Part 200, Uniform Administrative Requirements, Cost Principles, and Audit Requirements as Adopted Pursuant to 2 CFR § 1327.101. Grant and sub-grant related income refers to: (1) interest and other investment income earned on advances of grant funds; and (2) program income.
- N. When applicable, Grantee must sign and comply with the assurances and certifications of Standard Forms 424D: "Assurances – Construction Programs", CD-511: "Certification Regarding Lobbying," and CD-512: "Certifications Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion – Lower Tier Covered Transactions and Lobbying."

Document Approval Status

SetID: STIND Contract ID: 0000000000000000000019560
Vendor: INDIANA UNIV

▼ Review/Edit Approvers

Agency Fiscal Approval

▼ :Approved

Agency Fiscal Approval

Approved

Burke,Chari-300
Agency Fiscal Approval for SCM
05/03/17 - 7:02 PM

IDOA Approval

▼ :Approved

IDOA Legal Approval

Approved

Redding,Sandra-061-Procc
IDOA Legal Approval for SCM
05/04/17 - 9:41 AM

SBA Approval

▼ :Approved

SBA Approval

Approved

Potter,Joshue-057
SBA Analyst Approval for SCM
05/04/17 - 10:03 AM

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Pre-Proposal

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY
School of Public Health
Bloomington



2017 FUNDING CYCLE PRE-PROPOSAL

State Form 54757 (R5 / 6-16)
 INDIANA LAKE MICHIGAN COASTAL PROGRAM
 COASTAL GRANTS PROGRAM



LMCP USE ONLY
 R I NR

- INSTRUCTIONS:**
1. Read the Pre-Proposal guidance before completing this form.
 2. You **MUST** limit your application to the three (3) pages of this form, plus the three (3) one-page attachments as described in question #18.
 3. **E-mail** an electronic copy of the completed application by 5:00pm (CDT) September 16, 2016 to mbyrne@dnr.in.gov

1. Title of Project: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation	
2. Organization Applying: Center for Underwater Science, Indiana University Bloomington	
3. Type of Organization: State Colleges or University	
4. County: <input type="checkbox"/> Lake <input type="checkbox"/> Porter <input checked="" type="checkbox"/> LaPorte	
5. Check ONLY one box: first choose Project Category, then choose one priority within the category. Red indicates top funding priority	
<p>(§306a) Low Cost Construction</p> <p><input type="checkbox"/> Projects to increase public access that also implement priorities identified in these LMCP documents/plans</p> <p>Historic Public Access Study (2015)</p> <p>Public Access Needs Assessment - Report</p> <p><input type="checkbox"/> Other</p> <p>(§306a) Acquisition</p> <p><input type="checkbox"/> Lands identified as priority protection areas or critical areas in watershed management plans</p> <p><input type="checkbox"/> Other</p> <p>(§306) Planning / Coordination / Management</p> <p><input checked="" type="checkbox"/> Development of long-term, natural resource management plans</p> <p><input type="checkbox"/> Other</p>	<p>(§306) Education / Outreach</p> <p><input type="checkbox"/> Lake Michigan water safety education and outreach</p> <p><input type="checkbox"/> Other</p> <p>(§306) Applied Research</p> <p><input type="checkbox"/> Study of stormwater BMP placement, and evaluation of effectiveness</p> <p><input type="checkbox"/> Other</p> <p>(§306) Emerging Issues</p> <p><input type="checkbox"/> Shoreline dynamics primer for local officials (<i>Check one box below.</i>)</p> <p><input type="checkbox"/> Planning/Coordination/Management</p> <p><input type="checkbox"/> Education/Outreach <input type="checkbox"/> Applied Research</p> <p><input type="checkbox"/> Other</p>
6. Project Manager	7. Grant Administrator
Name: Charles D Beeker	Name: Office of Research Administration
Title: Director, IU Center Underwater Science	Title: Contract Officer _ Amy Hoover
Address, City, State, ZIP: 1025 E. 7th St. Bloomington IN 47405	Address, City, State, ZIP: 509 E. 3rd St, Bloomington IN 47401
Telephone: 812 855 5748	Telephone: 812 855 0250
Fax: 812 855 3193	Fax: 812 855 9943
Email: cbeeker@indiana.edu	Email: hoovera@iu.edu
8. Project Cost Total:	9. Watershed Location: Hydrologic Unit Code (HUC). To find your HUC code, click on this link:
LMCP Share: 19,245.60	http://inwater.agriculture.purdue.edu/huc_group/
Applicant Share: 20,600	10-Digit HUC: 0406020001
	12-Digit HUC: 040602000100

<p>10. Describe the activities your organization will accomplish with both the requested LMCP grant funds and the matching funds.</p>
<p>Indiana University Center for Underwater Science will conduct underwater archaeological investigation of the Muskegon historic shipwreck to produce an accurate 3D photogrammetric model which will identify significant remaining features and their respective sensitivity, and can be utilized for for baseline monitoring and management, as well as an interpretive model for public outreach and education. Previous IU investigation of the Muskegon identified some important disarticulated features of the site, including the solid brass steam receiver pipe used to connect the double steam boilers. The Muskegon receiver pipe is very similar in size to the IU permitted recovery of the SS Pomona receiver pipe for California State Parks, conserved by IU and now on display at Fort Ross Cove State Park. With appropriate permit, IU Underwater Science would recover the Muskegon receiver pipe, conserve in our conservation lab and prepare for long term exhibit or storage. Other portable artifacts would be specifically identified and documented in situ, with no recovery in the scope of this project.</p>
<p>11. Identify the target population for the project you are proposing. Please be specific.</p>
<p>Recognizing the significance of the Muskegon as listed on the National Register of Historic Places, producing an accurate 3D model which identifies sensitive areas, as well as points of interpretative value for a 19th century Great Lakes steamer, will be beneficial to Indiana residents and visitors either to the site, or accessing through internet or future land based exhibit. The site is an underwater museum, accessible by diving population, but through modern technology, can be appreciated by 3D modeling.</p>
<p>12. Identify the project partners who will be involved with the project you are proposing. Please describe their roles in this project, in detail.</p>
<p>IU Center for Underwater Science- QP Archaeologist and scientific divers for field investigation, 3D modeling production with identified areas of sensitivity and interpretation, conservation lab for receiver pipe and preparation for long term storage/exhibit. Indiana Department Natural Resources- Division of Historic Preservation- permit for archaeological recovery of receiver pipe Indiana Department Natural Resources- Fisheries/Conservation- location and dive operation assistance.</p>
<p>13. Describe the outreach strategy you will use to inform your target population of your proposed project.</p>
<p>This project is intended to use 21st century technology to provide Indiana DNR baseline 3D monitoring and interpretive information useful for current management and future public outreach. The steamship Muskegon remaining components will be identified and interpreted, with sensitive components documented, and the portable brass receiver pipe recovered and conserved for the State.</p>
<p>14. Identify at least two (2) Plan documents that best support the high priority needs to be addressed by your proposed project. Be sure to provide a website location for the Plan, as well as page number where it may be found within the Plan.</p>
<p>1988 National Register of Historic Places, Gary Ellis, on file DHPA, Indianapolis, IN-Section 8: Page 4 http://www.nationalregisterofhistoricplaces.com/in/La+Porte/state.html 2000 Beeker et al. Assessment and Management Recommendations for Historic Shipwrecks Located in Indiana Territorial Waters of Southern Lake Michigan. In Coastal Recreation Study of Lake Michigan-Page 11,19 (Ref. Ellis 1989)</p>
<p>15. Describe how your proposed project addresses the high priority needs of the Plans you identified in question 14.</p>
<p>Successfully nominated to the National Register of Historic Places, Ellis in 1988, and Beeker in 2000, recognized the significant attributes of the Muskegon, representative of 19th century iron hulled, steam powered, propeller driven, passenger ferry boat, built and used on the Great Lakes. As with surrounding States and coastal regions, historic shipwrecks are of increasing interest to both the diving and non diving public. Utilizing 21st Century technology, the 19th century site will have accurate and detailed baseline monitoring documentation, with sensitive areas documented for appropriate management of the site. Removal and conservation of the portable brass receiver pipe is appropriate for protection and future exhibit. Other sensitive components will be documented for best practices for Indiana long term management of the site.</p>

16. Preliminary Project Budget

Provide an estimated breakdown of the proposed project budget using the following table.

Category	LMCP Request	Match: Cash	Match: In-Kind	Total
Personnel	8,000		11,000	19,000
Fringe	2,080		2,850	4,930
Travel	4,500			4,500
Supplies		750	6,000	6,750
Contractual				
Indirect rate = xx %	32	4,665.60		4,665.60
Totals	19,245.60	750	19,850	39,845.60

17. Budget Description

a. Describe project activities that will be funded with LMCP FEDERAL funds.

Project activities will include summer salary for staff and graduate students to participate on the on site documentation, subsequent computer lab model creation, and conservation treatment of the recovered receiver pipe (estimated 6 months to complete conservation and preparation for long term storage and/or exhibit. Funds will provide travel for 5 days to access the Muskegon. Weather permitting and with access assistance of Fisheries, three days on site, with travel days for a total of 5 days. Travel to include transportation and mileage, accommodations, and per diem, Indirect negotiated rate for state and federal off campus 32% covered by LMCP Federal funds.

b. Describe the source of NONFEDERAL matching funds. What project activities will be funded with matching funds?

Matching funds from Indiana University will include all research and diving equipment for on site documentation (scuba gear, photographic cameras, scale target markers, portable compressor for air fills), Match will enable use of IU computers and software to develop 3D model for baseline of site. IU Conservation laboratory will provide electrolytic equipment chemical supplies, and space for 6 months to conserve the brass receiver pipe. Underwater Science director, QP qualified, will use match of time on site and directing staff and students for 3D photogrammetry and conservation technical support.

18. Attachments: You may provide a MAXIMUM of three (3) single-page attachments. Each attachment may be a maximum of 8 ½ by 11 in size. These attachments may be photos, maps, letters of support, or other supporting documentation.

19. Has your organization received a LMCP grant in the past?

No

20. Acceptance of the terms of the Grant Guidance

"I have read and accept the terms of the Lake Michigan Coastal Grants Program 2017 Funding Cycle Pre-Proposal Guidance document." Type your name in the space below.

Name Charles D Beeker,	Date (month, day, year) September 16, 2016
---------------------------	---

Full Proposal

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY
School of Public Health
Bloomington



INSTRUCTIONS:

1. Read the 2016 Funding Cycle Application Guidance before completing this form.
2. **Deadline for Submission: 5:00 p.m. C.S.T Friday, December 18th, 2015**
Proposals may be submitted at ANY time before the deadline.
3. Required for Submission:
 - 1 complete electronic copy, submitted via either e-mail or CD – Preferred in MS Word format, or pdf that can be copied (**no scanned copies, please**).
 - The electronic copy may be e-mailed to mbyrne@dnr.in.gov if it is smaller than 24 MB. ****Do not submit a hard copy.****

Grant applications may be e-mailed or hand delivered to:

Maggie Byrne, Grant Specialist
mbyrne@dnr.in.gov
 Lake Michigan Coastal Program
 Indiana Dunes State Park Annex
 1600 North 25 East
 Chesterton, IN 46304
 Ph: 219-983-9912
Office Hours are 9:00 am-5:00 pm

1. Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation	
2. Organization Applying: Indiana University Center for Underwater Science	
3. Type of Organization: State college or university	
4. County: <input type="checkbox"/> Lake <input type="checkbox"/> Porter <input checked="" type="checkbox"/> LaPorte	
5. Project Manager	6. Grant Administrator
Name: Charles D. Beeker	Name: Steven A. Martin
Title: Director, Center for Underwater Science	Title: Associate Vice President, Office of Research Administration
Address, City, State, Zip: 1025 E 7th St, Bloomington, IN, 47405	Address, City, State, Zip: 509 E Third St, Bloomington, IN, 47401
Phone: 812-855-5748	Phone: 812-855-0516
Email: cbeeker@indiana.edu	Email: rugs@indiana.edu

Name of individual authorized to sign Grant Agreement: Steven A. Martin

7. CHOOSE ONE PROJECT TYPE FIRST choose ONE color-coded project CATEGORY SECOND choose priority or "Other" WITHIN that category ***check only <u>ONE</u> box***	
(§306a) Low Cost Construction <input type="checkbox"/> Projects to increase public access that also implement priorities identified in these LMCP documents/plans Historic Public Access Study (2015) Public Access Needs Assessment - Report <input type="checkbox"/> Other	(§306) Education / Outreach <input type="checkbox"/> Lake Michigan water safety education & outreach <input type="checkbox"/> Other
(§306a) Acquisition <input type="checkbox"/> Lands identified as priority protection areas or critical areas in watershed management plans <input type="checkbox"/> Other	(§306) Applied Research <input type="checkbox"/> Study of stormwater BMP placement, and evaluation of effectiveness <input type="checkbox"/> Other
(§306) Planning / Coordination / Management <input type="checkbox"/> Development of long-term, natural resource management plans <input checked="" type="checkbox"/> Other	(§306) Emerging Issues (check two boxes) <input type="checkbox"/> Shoreline dynamics primer for local officials (check one box below) <input type="checkbox"/> Planning/Coordination/Management <input type="checkbox"/> Education/Outreach <input type="checkbox"/> Applied Research
8. Project Cost	
LMCP Share: \$15,495	
Applicant Share: \$17,865	
TOTAL: \$33,360	
9. Watershed Location: Hydrologic Unit Code (HUC). To find your HUC code, paste this link into your browser: http://in.gov/idem/cleanwater/pages/huc/	
10-Digit HUC: 0406020001	12-Digit HUC: 040602000100

10. BRIEF SUMMARY OF PROJECT
All project categories

Use this space to write a **SHORT, ONE- OR TWO- SENTENCE PARAGRAPH** that summarizes your project:

Indiana University Center for Underwater Science will conduct underwater archaeological investigation of the Muskegon historic shipwreck to produce an accurate 3D photogrammetric model which will identify significant remaining features and their respective sensitivity. The results of this investigation and computer vision photogrammetry will be utilized for baseline monitoring and management, as well as an interpretive model for outreach and education.

11. ADDRESSING THE PROBLEM AND MEASURES OF SUCCESS

All project categories

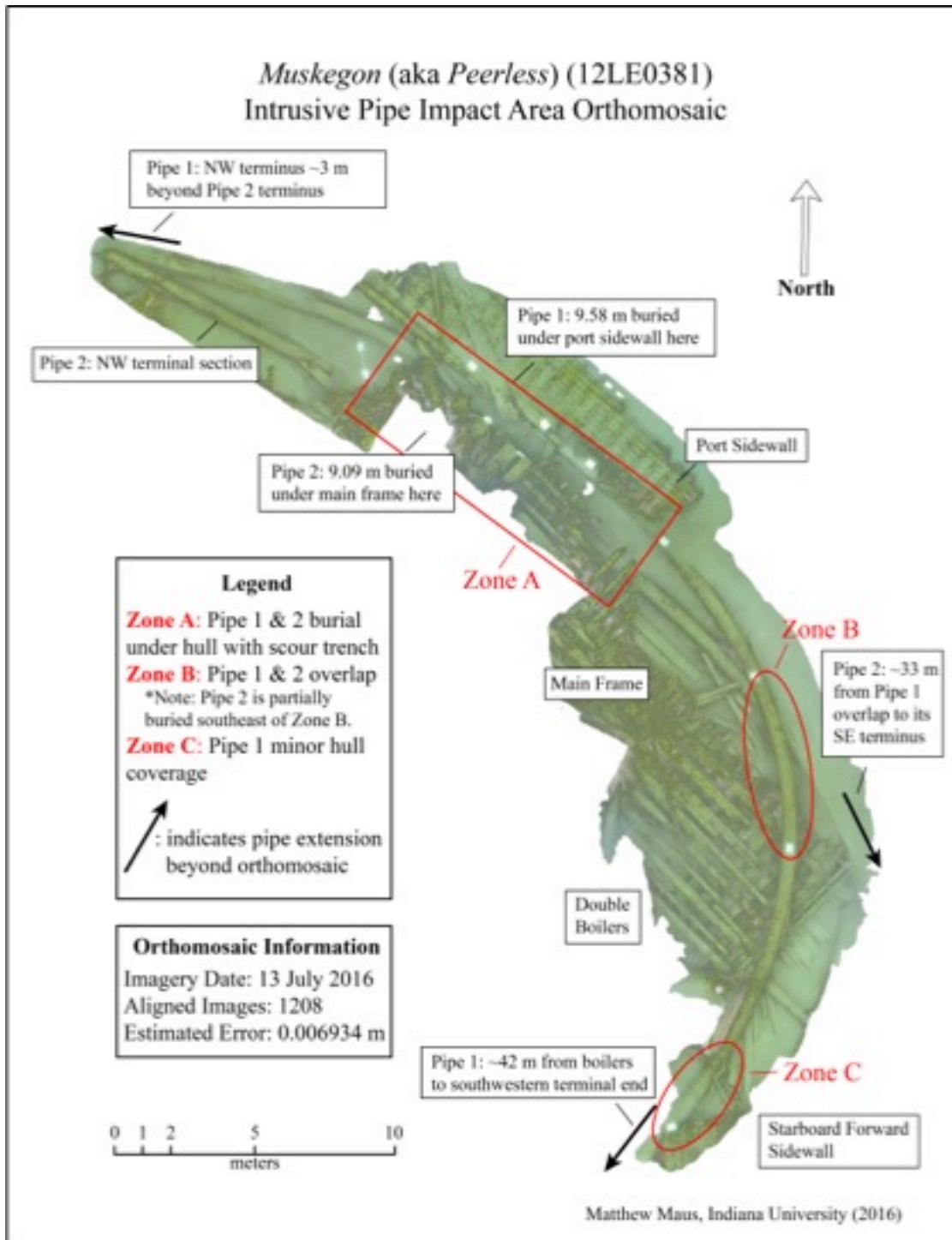
Briefly and concisely state the problem or issue that this proposal addresses, how the public has been involved in either identifying the problem or developing the project, and how the project will address the problem. Include important background information. Discuss project goals, outcomes and how you will measure success.

The need for a highly accurate, textured model is apparent and the primary way to prevent future damage is through the creation of baseline monitoring to develop an immediate protection strategy. This modeling project will aim to increase resource stewardship through public education and outreach, which will ultimately lead to much-needed resource protection and management, while providing accurate, reproducible 3D visual documentation of the shipwreck.

The Muskegon (site 12LE03811) was initially surveyed in the 1980s by Gary Ellis, Indiana's first State Archaeologist, who directed twenty five project dives over a three-year period providing the first archaeological reporting of Indiana's historic shipwrecks in the Great Lakes. Recognizing the historical significance of the 211 foot, steam powered, single propeller, passenger ferry, built in 1872 and originally named the Peerless, in 1990 Ellis successfully nominated the Muskegon to the National Register of Historic Places. The site retains wooden hull construction integrity including the Bishop Arch, 19th century steam boilers, engine cylinder, drive shaft, and three-bladed propeller (<http://www.in.gov/dnr/lakemich/images/lm-muskegonbig.jpg>).

As a part of ongoing public outreach and education, this proposal seeks to establish a new monitoring baseline composed of photogrammetric models and orthomosaics to ensure the protection and conservation of the historic Muskegon shipwreck. In 2000, the Indiana University (IU) survey of the Muskegon documented many of the features noted by the Ellis surveys of the 1980s, as well as damage to the shipwreck and associated cultural resources caused by an intrusive modern hydraulic sand dredge pipe that had been placed across the ship remains after the initial surveys. The IU 2016 survey report "Muskegon Intrusive Modern Pipe Assessment" submitted to the Indiana Department of Natural Resources' Lake Michigan Coastal Program, identified nearly 500 feet of dredge pipe on and around the shipwreck, including two sections that had scoured beneath the hull since the 2000 IU report.

Comprehensive documentation of the shipwreck is a high priority for the successful management and public interpretation of the Muskegon. The central data collection technique for this project is structure-from-motion photogrammetric imagery acquisition, which will be accomplished by IU scientific divers using SCUBA and cameras to collect thousands of images and/or video while swimming transects of delineated site sections. The ultimate objective of image acquisition is to collect sufficient overlapping imagery of the entire site in order to align images and generate a three-dimensional model and orthomosaic using computer vision photogrammetry. The specific software programs to be used for this purpose include Agisoft Photoscan and Adobe Lightroom. Additional data for this project--such as measurements for establishing model scale and estimating error--will be collected by IU scientific divers on SCUBA employing direct diver survey methodology with measuring reels, compasses, writing slates, cameras, and photobars. As a proof of concept, IU successfully implemented this photogrammetry methodology to document part of the Muskegon shipwreck associated with the intrusive modern pipe impact area on the Muskegon as described in the 2016 report submitted to the Indiana DNR. The final 3D model and orthomosaic produced by this project will be highly detailed and accurate, and will serve as invaluable monitoring tools for ongoing management of the Muskegon shipwreck. They will be of use to researchers and resource managers for identifying archaeological components and sensitive areas for long term management and interpretation of the site. Additionally, the 3D model can be easily embedded on an Indiana DNR website allowing the public to digitally visit the shipwreck in greater detail than currently available. This project will be non-invasive and will not involve excavation, collection, or any other impact to the site.



12. PROJECT DESCRIPTION

Address all of the issues listed below as they relate to your project. All project categories must answer questions a-f. The rest are color-coded according to category.

- a. Describe the project location. Include street address, and latitude and longitude coordinates, where applicable. The Muskegon currently rests in 31 feet of water 0.28 miles offshore from Mount Baldy of the Indiana Dunes National Lakeshore (GPS -86.9348, 41.7132)
- b. Describe what natural or cultural resources will potentially be affected.
No natural or cultural resources will be affected by the archaeological investigation of the Muskegon. The investigation and creation of the 3D photogrammetric model will be entirely non-invasive.
- c. Does the project require the use, lease, or purchase of land?
No
- d. List all contracts that will be charged to the grant. Describe the scope of services for each contract.
N/A
- e. List all of the partner organizations that will be involved in the project. Describe their roles in the project. Please be sure to attach letters of support for this project from each of the major partner organizations.
Indiana University Center for Underwater Science: QP archaeologist and scientific divers for field investigation and 3D modeling production with identified areas of sensitivity and interpretation
Indiana DNR Division of Historic Preservation: Permit for archaeological survey and investigation
Indiana DNR Fisheries: Location and dive operation assistance
- f. All LMCP grant projects are required to do some form of education and/or outreach, so that the public will be made aware of the project. Please describe how the public will be informed about this project.
This project is intended to use 21st century technology (computer vision photogrammetry) to provide Indiana DNR baseline 3D monitoring and interpretive information for public outreach and education. The Muskegon is an underwater museum, accessible by the diving population, that with advances in 3D modeling technology can be appreciated by the wider public via websites such as sketchfab.com or the Indiana DNR website.
- g. For Low Cost Construction and Land Acquisition category projects, NOAA requires maintenance for a minimum of 20 years. Describe how the project will be monitored/maintained for 20 years, who will be responsible for monitoring/maintenance, and the expected life of the project.
- h. Describe the project's plan for public outreach/public access that protects the resource from unauthorized use.

- i. **For Low Cost Construction and Acquisition Projects ONLY**, if the project is located a flood zone as depicted on a National Flood Insurance Rate Map, identify the specific flood zone(s) (e.g., V1-30 zone, A1-30 zone)
- j. **For Low Cost Construction and Acquisition Projects ONLY**, describe the broad and lasting public benefit that will result. Please explain how this project will benefit many different user groups of people, and how it will benefit those people for at least 20 years.
- k. **For Low Cost Construction and Acquisition Projects ONLY**, describe how the project meets requirements of the Americans with Disabilities Act.
- l. **For Low Cost Construction Projects ONLY**, list all permits that may be required to undertake the proposed project.
- m. **For Low Cost Construction Projects ONLY**, describe the type of construction materials, and the type of construction methods to be used.
- n. **For Low Cost Construction Projects ONLY**, describe the best management practices which will be used both during and after construction to avoid, minimize, or mitigate any significant impacts, such as erosion and storm water pollution.
- o. **For Natural Area Restoration Projects ONLY**, identify the restoration goals for the project area, discuss past work completed in the project area, if applicable.
- p. **For stormwater quality BMP projects:**
 - Discuss the potential pollutants the BMP will address, and the sources of those pollutants
 - Provide a map that shows the location and approximate dimensions of the BMPs
 - Provide seeding/planting specifications
 - Provide operation and maintenance guidelines for each BMP

- q. **For Applied Research Projects ONLY**, describe the end use of the research data and how your project partner will utilize the data/information.
- r. **For Education/Outreach Projects ONLY**, describe the target audience, and explain how the project meets State of Indiana Academic Standards.

**13. IMPACT ON COASTAL RESOURCES – FOR LAND ACQUISITION AND
LOW COST CONSTRUCTION PROJECTS ONLY**

**How does the project address an Area of Particular Concern
for the Lake Michigan Coastal Program (check all that apply):**

- Areas of unique, scarce, fragile or vulnerable habitats**
- Habitat of endangered or threatened plant or animal species
 - Natural areas that contain high quality natural communities, and usually contain species of plants or animals considered endangered, threatened or rare
 - Areas that contain assemblages of rare species including one or more species of plant or animal considered rare, special concern, or watch list
 - Areas that contain natural community types that are rare in the State of Indiana (see Table 8.1)
 - Dedicated state nature preserves
 - Streams classified as natural, scenic, or recreational rivers
- Areas of historical significance, cultural value, or substantial recreational value or opportunity**
- Site, district, object, and building significant in the development of Indiana, local history, architecture, archaeology, and culture that possesses integrity of location, design, setting, materials, and workmanship
 - Properties rated as “Outstanding” or “Notable” in the Indiana Historic Sites and Structures Inventory
 - Property achieving historical significance within the past 50 years
 - Archaeological sites whose contextual integrity has not been significantly altered by natural sources or human activities
 - Existing public access sites to lakes, fishing along the shoreline and boat ramp facilities
 - Areas along the Lake Michigan shoreline and salmonid streams that are suitable to provide public fishing access, are not presently providing access, and would not interfere with other areas of concern
 - Areas which are conducive to the expansion of interpretive and educational facilities
 - Marshes, bogs, and swamps of significant recreational value for sport fishing, hunting, and or wildlife viewing
 - Areas suitable to trail opportunities for walking, hiking, bicycling, horseback riding, and cross country skiing
 - Public lands managed by the Division of State Parks or the Division of Fish and Wildlife
 - Offshore shipwrecks
- Areas of high natural productivity or essential habitat for living resources, including fish, wildlife, endangered species, and the various trophic levels in the food web critical to their well-being**
- Sites designated as Salmonid streams and tributaries required for spawning and release sites
 - Isolated marshes, bogs, and swamps including those not regulated by federal and state laws
 - Offshore waters used by migratory waterfowl
 - Stopover habitat used by migratory birds
 - Public lands managed by the Division of Fish and Wildlife: Fish and Wildlife Areas or Wetland Conservation Area
 - Shoreline waters required for the reproduction of fish species other than salmonids

- Riparian corridors and in-stream habitat
- Wetlands including marshes, bogs, fens, mesic and wet prairie, and swamps as identified by the U.S. Fish and Wildlife Service National Wetlands Inventory

Areas needed to protect, maintain, or replenish coastal lands or resources including coastal flood plains, aquifers and their recharge areas, sand dunes, and offshore sand deposits

- Areas eligible as filter strips under the Filter Strip Act
- Undeveloped flood plains
- Wetlands as identified by the U.S. Fish and Wildlife Service National Wetlands Inventory
- Recharge areas mapped in the Atlas of Hydrogeologic Terrains and Settings of Indiana
- Sand dunes
- Offshore sand deposits

14. CONSISTENCY WITH, AND IMPLEMENTATION OF, AREA PLANNING EFFORTS

All project categories must answer all questions

- a. Describe how this project addresses a high priority need as identified in state/regional recognized plans, **local planning efforts, or your organization/agency's strategic plan**. Please identify the Plan, where this project specifically appears in the Plan (page number), and provide the link to the web page where it may be found. If it is not online, then provide a photocopy of the pages of the plan to which you refer.

As identified in the 2016 Muskegon Intrusive Modern Pipe Assessment (pages 7-8 attached) submitted to the Indiana Department of Natural Resources' Lake Michigan Coastal Program, comprehensive documentation of the shipwreck is a high priority for the successful management of the Muskegon. As with surrounding states and coastal regions, historic shipwrecks are of increasing interest to the diving and non-diving public and the Muskegon is the first shipwreck in Indiana on the National Registry of Historic Places. Indiana University recommend that creating a full photogrammetric model of the entire shipwreck could be used as a "detailed, accurate, and cost-effective monitoring baseline, and if made available online, as a tool for interactive public outreach by the INDNR" (Maus, Haskell, 2016, p. 7). Previous photogrammetry conducted by Indiana University focused only on the impact of an intrusive modern pipe. This project would encompass the entirety of the ship, creating a baseline for annual rapid assessment protocol conducted by divers under the direction of a qualified archaeologist (Maus, Haskell, 2016, p. 8).

- b. for Planning/Coordination/Management category projects ONLY, describe how this project fulfills a planning **need** identified by a community or organization

Kira Kaufmann identifies future conservation strategies including designation of site as a Marine Protected Area, conducting additional survey, and monitoring the site at regular intervals (Kaufmann 2013:3-6). This project will include additional survey and establishing a baseline monitoring system in order to monitor the site at regular intervals.

- c. Will this project result in an application to the Regional Development Authority (RDA) or is connected to an existing RDA application or project? YES NO

15. HAS YOUR ORGANIZATION RECEIVED A LMCP GRANT IN THE PAST?

All project categories

YES NO

caused by natural forces. Therefore, it is recommended that all exposed pipe sections on and around the *Muskegon* shipwreck be removed from the site in such a way as to avoid any further damage to cultural resources.

The only exception to this recommendation are the sections of Pipes 1 and 2 that are pinned beneath the hull main frame and port sidewall (see Appendix A *Muskegon* Orthomosaic, Zone A), as removing these buried sections would cause serious and irreversible damage to the shipwreck. Instead, Pipes 1 and 2 should be cut where they emerge from under the hull, and the remaining pieces pinned beneath the hull left *in situ* and permanently capped to prevent scour formation caused by water movement through the pipes.

In order to remove the pipes, INDNR should contract a qualified commercial diving firm with experience in the recovery of large objects from sensitive archaeological contexts (see Appendix F). At all times, a qualified, diving archaeologist should be on site to supervise and, in communication with the recovery firm, plan pipe removal to avoid damage to cultural resources. Pipes should be cut strategically to avoid any possible hull damage and separated into sections no longer than 6 meters. This maximum length permits extraction of the section of Pipe 1 that crosses the hull main frame by only cutting the pipe where it does not overlay the hull (see Image 7). This is anticipated to be the only section with a 5 – 6 m distance between acceptable cuts that do not risk impacting underlying cultural resources. Once separated, pipe sections should be lifted with their long axis parallel to the lake bottom to avoid damage to the shipwreck during extraction. The section of Pipe 1 which is partially under, but not pinned by, the edge of the starboard forward sidewall (see Appendix A *Muskegon* Orthomosaic, Zone C) should be cut, moved out from under the overhanging structure, and lifted. According to these recommendations, the total length of pipe to be extracted would be about 128.79 m (422.54 ft) with 18.67 m (62.5 ft) of buried pipe left *in situ*.

Long-term Management: Within three months after pipe mitigation, the *Muskegon* should be comprehensively documented by a qualified archaeologist. While other recording methodologies are also appropriate, an updated photogrammetric model of the shipwreck could be used as a detailed, accurate, and cost-effective monitoring baseline and, if made available online, as a tool for interactive public outreach by the INDNR. In the long term, the *Muskegon* should be monitored according to an annual rapid assessment protocol conducted by divers under the

guidance of a qualified archaeologist. Any loose, portable artifacts scattered on the lake bottom on and around the shipwreck—especially those of commercial value such as brass objects—should be recovered, conserved, and exhibited to prevent their loss to looting and to contribute to public education of the maritime heritage of Indiana (see Image 8).

At this time, it is not recommended to manually fill the scour trench between the hull main frame and port sidewall (see Appendix A *Muskegon* Orthomosaic, Zone A). Instead, the scour trench should be regularly monitored following pipe mitigation. If long term monitoring determines that natural infill is not occurring and the scour trench is undermining hull stability, manual filling should be considered.

Finally, as has been suggested previously (Beeker, Budziak, and King 2000; Kauffmann and Egan-Bruhy 2013), the *Muskegon* should be protected within a Marine Protected Area, such as the underwater preserve established on the *J.D. Marshall*. Underwater parks have been shown to provide valuable, local recreational and economic opportunities, as well as a means to preserve submerged cultural and biological resources (e.g. Whitehead and Finney 2003). As has been generally suggested for underwater archaeological preserves (Hanselmann and Beeker 2008; Smith, Finegold, and Stevens 1990), the site should be enhanced to promote responsible visitation with a historic marker and mooring buoys and an underwater plaque (see Image 9). Additionally, the public should be involved in MPA establishment with a dedication ceremony, improvement of interpretive facilities on land, and development of interpretive materials such as underwater guides. Following establishment, local divers and dive industry should be encouraged to assist with site monitoring and stewardship.

VII. References Cited

Agisoft LLC

2016 Agisoft Photoscan User Manual: Professional Edition, Version 1.2.

Beeker, Charles, Ania Budziak, and Carina King

2000 Assessment and Management Recommendations for the Historic Shipwrecks Located in Indiana Territorial Waters of Southern Lake Michigan. Report to Indiana Department of Natural Resources, Indianapolis, IN from Indiana University Office of Underwater Science, Bloomington, IN.

16. PROJECT BUDGET

Provide an estimated breakdown of the project budget using the table below. Please be certain to re-read the 2017 Full Proposal Guidance Document when completing this section.

All project categories

Category	LMCP Request	Match: Cash	Match: In-Kind	Total
Personnel	\$6,204		\$10,392	
Fringe	\$1,035		\$2,723	
Travel	\$3,000			
Supplies	\$1,500		\$4,750	
Contractual	0			
Indirect rate = 32 %	\$3,756			
Totals	\$15,495		\$17,865	\$33,360

a. Describe, in detail, project activities that will be funded with LMCP FEDERAL FUNDS. Please be specific.

Summer salary and travel (mileage, lodging, per-diem) for staff and research assistants, salary fringe benefits, coded photogrammetric targets, additional GoPro Hero camera for 3D documentation of the entire shipwreck site, and federally negotiated indirect (32%)

b. Describe, in detail, project activities that will be funded with NONFEDERAL matching funds.

Second summer salary (11% FTE) and fringe (26.2%) benefits for project director/Qualified Professional Archaeologist (\$10,392 salary, \$2,723 fringe)

In lieu of purchasing new equipment, IU scuba diving and research equipment (use value: \$4,750) provided by the Kinesiology diving locker will be utilized to include portable breathing air compressor, individual diving equipment, underwater GoPro Hero 4 camera and video use for photogrammetric documentation, diver specific first aid and safety equipment (with AED and Oxygen), underwater archaeological documentation equipment (measuring reels, compasses, writing slates, Canon G11 cameras with underwater housing, photobars, etc) and the use of Indiana University's computer with adequate processing power (32+ GB RAM) in order to process photogrammetric models.

c. Explain the source of these matching funds. Please be specific. Attach proof of match.

Indiana University Academic Diving Program, Department of Kinesiology, Center for Underwater Science

17. ACCEPTANCE OF THE TERMS OF THE GRANT GUIDANCE

All project categories

"I have read and accept the terms of the Lake Michigan Coastal Grants Program 2017 Funding Cycle Application Guidance document."

Signature:

Date:

**INDNR Division of Historic Preservation and Archaeology Permit #2016033
(2016)**

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY
School of Public Health
Bloomington



Division of Historic Preservation & Archaeology • 402 W. Washington Street, W274 • Indianapolis, IN 46204-2739
Phone 317-232-1646 • Fax 317-232-0693 • dhpa@dnr.IN.gov



June 24, 2016

Charles Beeker
Underwater Science
School of Public Health, Room 058
Indiana University
Bloomington, IN 47405

Re: Proposed scientific archaeological investigation at 12Le0381 in Lake Michigan, LaPorte County, Indiana

Dear Dr. Beeker:

Pursuant to Indiana Code 14-21-1-16, the Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology (DHPA) has conducted a review of the materials for investigations on state property in Lake Michigan, LaPorte County, Indiana. The plan is acceptable provided the following conditions:

1. All archaeological investigations will be directly supervised by a qualified professional archaeologist who meets the qualification standards for a principal investigator or field or laboratory supervisor under 312 IAC 21.
2. Any proposed revisions to the archaeological plan must be submitted in writing to the DHPA prior to implementation in the field or laboratory.
3. Human remains and any associated artifacts will be left in place and remain unexcavated. If any human remains dating before December 31, 1939 are encountered, the discovery must be reported to the IDNR within two (2) business days. The discovery must be treated in accordance with IC 14-21-1 and 312 IAC 22. In that event, please call (317) 232-1646. If human remains are accidentally discovered during field investigations or related laboratory analyses, and would be subject to the Native American Graves Repatriation Act (NAGPRA), the investigating or curational facility shall assure NAGPRA reporting and compliance (not the IDNR).
4. A complete report on the field investigations must be submitted to the DHPA for review and comment within one year of the completion of the fieldwork.
5. This plan is non-transferable.

With these conditions, the proposed plan is acceptable, and the field investigations may proceed (#2016033). A copy of this letter, along with proper identification, should be carried by personnel in the field. This will ensure minimal confusion should they be requested to produce proper identification in the field by law enforcement personnel. If you have any questions regarding this matter, please contact Cathy Draeger-Williams at (317) 234-3791 or cdraeger-williams@dnr.IN.gov.

Very truly yours,

Mitchell K. Zoll
Director, Division of Historic Preservation and Archaeology

MKZ:CDW:cdw

**INDNR Division of Historic Preservation and Archaeology Permit #2017021
(2017)**

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY
School of Public Health
Bloomington

Division of Historic Preservation & Archaeology 402 W. Washington Street, W274 Indianapolis, IN 46204-2739
Phone 317-232-1646 Fax 317-232-0693 dhpa@dnr.IN.gov



May 15, 2017

Dr. Charles Beeker
Indiana University Center for Underwater Science
1025 E 7th Street
Bloomington, Indiana 47405

Re: Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana

Dear Dr. Beeker:

The Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology (DHPA) has reviewed the plan you submitted regarding the proposed scientific archaeological investigations on state property pursuant to Indiana Code (IC) 14-21-1-16 (AD #2017021).

The archaeological plan is acceptable with the following conditions:

1. All archaeological investigations will be directly supervised in the field and laboratory by a qualified professional archaeologist who meets the qualification standards for a principal investigator or field or laboratory supervisor under 312 IAC 21.
2. The scientific investigations will conform to the current Indiana Guidebook for Indiana Historic Sites and Structures Inventory—Archaeological Sites.
3. Human remains and associated artifacts will be left in place and remain unexcavated. If any human remains dating on or before December 31, 1939 are encountered, the discovery must be reported to the Indiana Department of Natural Resources within two (2) business days. The discovery must be treated in accordance with IC 14-21-1 and 312 IAC 22. In that event, please call 317/232-1646. If human remains are accidentally discovered during the field investigations or related laboratory analyses, and would be subject to the Native American Graves Protection and Repatriation Act (NAGPRA), the investigating or curatorial facility shall be the entity responsible for NAGPRA reporting and compliance.
4. Any proposed revisions to the archaeological plan must be submitted in writing to the Division of Historic Preservation and Archaeology prior to implementation in the field or laboratory.
5. This plan is not transferable.

With these conditions, the proposed plan is acceptable, and the scientific investigations may proceed (AD #2017021). A copy of this letter, along with proper identification, should be carried by the archaeologist in the field. This will ensure minimal confusion should they be requested to produce proper identification in the field by law enforcement personnel. If you have any questions regarding this matter, please contact Cathy Draeger-Williams at (317) 234-3791 or cdraeger-williams@dnr.IN.gov.

Very truly yours,

Mitchell K. Zoll
Director, Division of Historic Preservation and Archaeology

MKZ:CDW:cdw

Post Project Maintenance Plan

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY

School of Public Health
Bloomington

Post-Project Maintenance and Management Plan

***Muskegon* (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation**

2018 Lake Michigan Coastal Program Grant CZ540

Intrusive Pipe Mitigation

The intrusive modern pipes on the *Muskegon* shipwreck are impacting a State of Indiana submerged cultural resource that is listed on the National Register of Historic Places, and should be responsibly mitigated to avoid further damage and to develop the shipwreck as a site appropriate for public interpretation. As can be inferred from the entanglement of two separate pipe segments on the *Muskegon*, any unrecovered pipes in the vicinity of the shipwreck have the potential to impact the site in the future due to movement caused by natural forces. Therefore, Indiana University Underwater Science recommends that all exposed pipe sections on and around the *Muskegon* shipwreck be removed from the site in such a way as to avoid any further damage to cultural resources.

The only exception to this recommendation are the sections of Pipes 1 and 2 that are pinned beneath the hull main frame and port sidewall (see Appendix A *Muskegon* Orthomosaic, Zone A), as removing these buried sections would cause serious and irreversible damage to the shipwreck. Instead, Pipes 1 and 2 should be cut where they emerge from under the hull, and the remaining pieces pinned beneath the hull left *in situ* and permanently capped to prevent scour formation caused by water movement through the pipes.

In order to remove the pipes, INDNR should contract a qualified commercial diving firm with experience in the recovery of large objects from sensitive archaeological contexts (see Appendix F). At all times, a qualified, diving archaeologist should be on site to supervise and, in communication with the recovery firm, plan pipe removal to avoid damage to cultural resources. Pipes should be cut strategically to avoid any possible hull damage and separated into sections no longer than 6 meters. This maximum length permits extraction of the section of Pipe 1 that crosses the hull main frame by only cutting the pipe where it does not

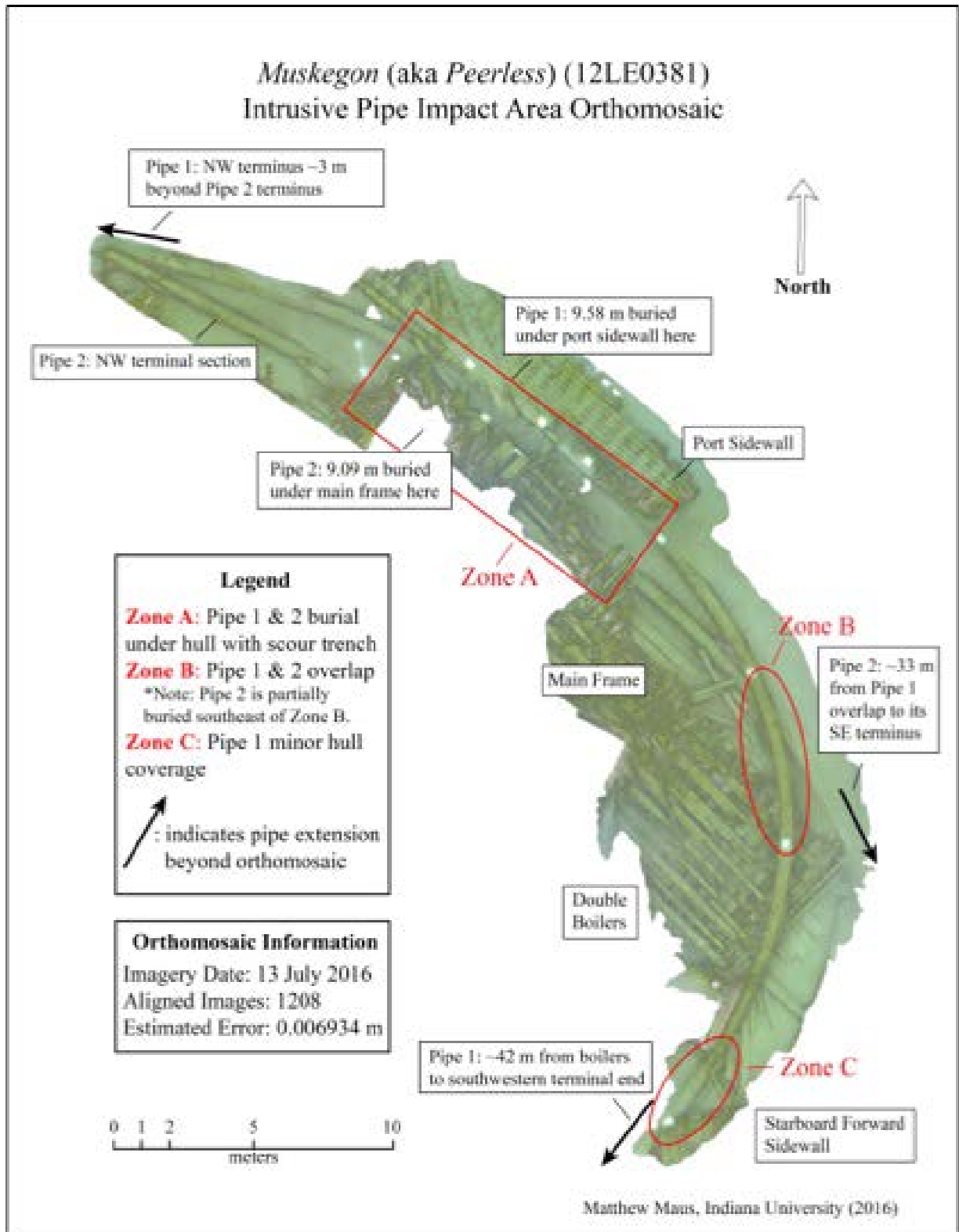
overlay the hull (see Image 7). This is anticipated to be the only section with a 5 – 6 m distance between acceptable cuts that do not risk impacting underlying cultural resources. Once separated, pipe sections should be lifted with their long axis parallel to the lake bottom to avoid damage to the shipwreck during extraction. The section of Pipe 1 which is partially under, but not pinned by, the edge of the starboard forward sidewall (see Appendix A *Muskegon* Orthomosaic, Zone C) should be cut, moved out from under the overhanging structure, and lifted. According to these recommendations, the total length of pipe to be extracted would be about 128.79 m (422.54 ft) with 18.67 m (62.5 ft) of buried pipe left *in situ*.

Long Term Management

Within three months after pipe mitigation, a qualified archaeologist should comprehensively document the *Muskegon*. While other recording methodologies are also appropriate, an updated photogrammetric model of the shipwreck could be used as a detailed, accurate, and cost-effective monitoring baseline and, if made available online, as a tool for interactive public outreach by the INDNR. In the long term, the *Muskegon* should be monitored according to an annual rapid assessment protocol conducted by divers under the guidance of a qualified archaeologist. Any loose, portable artifacts scattered on the lake bottom on and around the shipwreck—especially those of commercial value such as brass objects—should be recovered, conserved, and exhibited to prevent their loss to looting and to contribute to public education of the maritime heritage of Indiana.

At this time, it is not recommended to manually fill the scour trench between the hull mainframe and port sidewall. Instead, the scour trench should be regularly monitored following pipe mitigation. If long term monitoring determines that natural infill is not occurring and the scour trench is undermining hull stability, manual filling should be considered.

Appendix A
Muskegon Orthomosaic



Public Outreach Plan

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY

School of Public Health
Bloomington

Public Outreach Plan

***Muskegon* (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation**

2018 Lake Michigan Coastal Program Grant CZ540

Park Development

Preservation of historic shipwrecks in Indiana requires the state to take an active role in facilitating protection and public access. During Indiana University's 2000 assessment, the *Muskegon* was determined to be the best site for an archaeological preserve in Indiana territorial waters (Beeker et al. 2000). The same criteria utilized during the establishment of the Florida Keys Shipwreck Trail were used during this assessment (Smith et al. 1990; Beeker et al. 2000). The *Muskegon's* relatively intact features, depth, historical significance, and location give it the potential to be an exceptional park (Smith et al. 1990; Beeker et al. 2000; Kauffman and Bruhy 2013; Maus and Haskell 2016).

Indiana currently has one underwater shipwreck park, and the *Muskegon* should be extended the same designation and protection. In 2013, the *J.D. Marshall* was inaugurated as an underwater preserve under the Indiana Nature Preserves Act (1967). The *J.D. Marshall* Underwater Preserve was established with the mission to "promote understanding and appreciation of cultural values of areas by the people of Indiana" (Indiana Nature Preserves Act 1967). As the only shipwreck in the state of Indiana on the NRHP, the *Muskegon* is a prime candidate for nomination as an Indiana Nature Preserve to protect associated archaeological resources and promote cultural heritage tourism.

The first steps in successful park development involve enhancing site infrastructure to promote recreation and tourism. The *Muskegon* has been a popular location for recreational scuba divers since the 1960s, and the site currently lacks adequate infrastructure to enable and support these diving activities (Figure 4). The first step in enhancing a site for recreational use is

the installation of a mooring system for boat use. An adequate mooring system is necessary to provide safe, stable anchorage for boat captains while limiting potential anchor damage to the sensitive cultural material (Hanselmann and Beeker 2008). An upright, spar buoy should be placed on the site that identifies the historic shipwreck and preserve. A monument should be placed on the site with a commemorative, bronze plaque that gives park visitors basic information about the *Muskegon* and its preserve (Hanselmann and Beeker 2008).

A critical component of establishing an underwater park is public outreach and education. A waterproof, interpretive guide of the *Muskegon* should be created for divers that contains a detailed site plan, significant archaeological features, jurisdictional information, and safety information. This guide could be made available from local dive centers, charter operators, and the Michigan City Field Office of the Indiana DNR's Division of Fish and Wildlife.

Additional displays should be created on land for non-diving tourists. A kiosk should be created at the nearby Indiana Dunes State Park for park visitors to learn about the *Muskegon* and build resource stewardship amongst local stakeholders. The Indiana Dunes has approximately three million visitors annually, and accessible information about the *Muskegon* and other local, historic shipwrecks will help increase public awareness of the need to protect submerged cultural resources and archaeological sites (Indiana Dunes Tourism 2018). Another land display could be located at the Old Michigan City Light. The Old Michigan City Light is a decommissioned lighthouse located in the harbor of Michigan City, Indiana and just over a mile from the site of the *Muskegon* (Beeker et al. 2000). The lighthouse is now a museum owned and operated by the non-profit Michigan City Historical Society, Inc. (2017) and currently displays artifacts and exhibits about Lake Michigan shipwrecks and Indiana's maritime history. These terrestrial

venues would enhance tourism for shipwreck sites and would facilitate public outreach and education about Indiana's maritime heritage to the non-diving public.

3D Photogrammetry and Web Outreach

The Indiana DNR (2018) currently profiles the “Indiana Lake Michigan Shipwreck Survey Project” on their website, displaying virtual tours and photo galleries of Indiana shipwrecks. The website should be enhanced with updated interpretive materials and information about active research on the *Muskegon*. The posting of photogrammetric models and detailed site plans on the website would allow visitors to experience the submerged cultural resources of Indiana's territorial waters from their own computers, building excitement and promoting cultural heritage tourism. The models created as a result of this project will be shared with the Lake Michigan Coastal Program and Indiana Department of Natural Resources (see Data Sharing Plan).

Society for Historical Archaeology ACUA Manuscript

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



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School of Public Health
Bloomington

Indiana's Maritime Heritage: Ongoing Investigations and Management Strategies for the 1910 *Muskegon* (aka *Peerless*) Shipwreck (12LE0381)

Presented by Samuel I. Haskell at the 2018 Society for Historical Archaeology Conference in New Orleans, LA.

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Indiana's Maritime Heritage: Ongoing Investigations and Management Strategies for the 1910 *Muskegon* (aka *Peerless*) Shipwreck (12LE0381)

ABSTRACT

Built in 1872 as the *Peerless*, the *Muskegon* was a steamship that operated on the Great Lakes until 1911. Having functioned in a variety of roles, the *Muskegon* represents important 19th century innovations in maritime technology, becoming the first shipwreck accepted to the National Register of Historic Places in Indiana. Since 2016, Indiana University has been conducting ongoing direct diver and photogrammetric surveys to assist with management decisions and public outreach. This paper presents methodology and results of this ongoing assessment, discussing management strategies to develop the shipwreck as a marine protected area and underwater preserve for public interpretation.

Indiana's Maritime Heritage

The state of Indiana has the smallest territorial waters of any Great Lakes state, spanning just 45 miles of Lake Michigan shoreline and containing approximately 225 square miles of bottomland (Beeker et al. 2000). Despite the state's small amount of coastline, the Indiana Department of Natural Resources (DNR) has identified the potential for 50 unique, historic vessels in Indiana territorial waters, with wrecking dates ranging from 1843 – 1936 (Ellis 1989). 14 of these shipwrecks have been located and are included in the Indiana Marine Cultural Resource Inventory (Ellis 1989).

Historic shipwrecks in Indiana territorial waters are valuable examples of Indiana's diverse and unique maritime history. These vessels offer a cross section of Indiana and Great Lakes cultural heritage and commerce, giving historians and archaeologists an intimate look into the historic use of our state's coastal waters. Archaeological investigations of these shipwrecks can answer important questions concerning maritime technology and its influence on the historical landscape of the Great Lakes (Rogers 2016). They also act as a catalyst for increasing public awareness of the importance of maritime history and fostering a sense of stewardship for the protection of cultural resources.

The *Muskegon* shipwreck site represents the remains of a medium sized passenger freighter in southern Lake Michigan, just outside of Michigan City, Indiana (Ellis 1987). The only shipwreck in the state of Indiana on the National Register of Historic Places, the *Muskegon* is a significant piece of Indiana maritime history that should be protected and preserved for future generations.

The *Peerless*

The *Muskegon* was originally built in 1872 under the name *Peerless* in Cleveland, Ohio by Ira LaFranier for the Chicago transportation firm of Leopold and Austrian (Runge Marine Collection [RMC] 1959). The *Peerless* was built to serve as a passenger freighter in the firm's Lake Michigan and Lake Superior Transfer Company Fleet, operating on the Chicago-Duluth Run until 1879. In 1875 the vessel is listed as having a length of 211 feet, a 40-foot beam, and 12-foot draft and was constructed from the "best Ohio oak" (*The Evening News* [TEN] 1910; RMC 1959). The *Peerless* weighed in at 1,275 gross tons, capable of carrying several hundred passenger and hundreds of tons of packaged cargo (Ellis 1988).

The *Peerless* is an excellent example of the typical 19th century Great Lakes vessel built to serve as a combination passenger/cargo freighter. At the time of the ship's sinking, Michigan City's *The Evening News* (1910) described the ship as "one of the finest passenger vessels on the Great Lakes." The *Peerless* was built with a high pressure reciprocating engine and massive, dual boilers that remained with the ship throughout its operational life (Ellis 1988). Operating at 80 revolutions per minute with a 40-inch stroke, the 47.5-inch engine cylinder was able to stand up to the high demands of Great Lakes service (RMC 1959; Ellis 1988). The advanced steam management system's twin firebox boilers were able to provide the engine with sufficient high pressure to drive the engine at 400 horsepower (RMC 1959).

In addition to the state of the art engine assembly, the *Peerless* had a set of wooden Bishop Arches to provide exceptional load carrying capacity and to facilitate the efficient movement of goods and people. The wooden arches were connected across decks by timber

latticework, “limiting their lateral movement and allowing for such movement to be tempered” (Ellis 1988). While the rear 75 feet of the *Peerless* was dedicated to the engine, propulsion, and steam management, historic photographs show the original deck configuration of the ship as consisting of one main cargo deck, a spar deck, a passenger deck, and a forward wheelhouse (Figure 1) (Ellis 1988).

The *Peerless* served as the flagship of the Lake Michigan-Lake Superior Transportation Company until 1900, when it was sold to W.H. Singer of Duluth, Minnesota (RMC 1959). The *Peerless* was bought and sold several times before it was ultimately renamed the *Muskegon* in 1908 by its new owner, the Muskegon and Chicago Navigation Company.

The *Muskegon* (aka *Peerless*)

While owned by the Muskegon and Chicago Navigation Company, the newly-named *Muskegon* served as a “night boat” for a brief period of time and was alleged to have been used as a floating gambling house (RMC 1959). After being renamed in 1908, the *Muskegon* was cut down to serve as a lumber-hooker (Ellis 1987). Lumber hookers would carry precut and dressed lumber throughout the Great Lakes during the late 19th and early 20th centuries (Ellis 1988).

In 1910, the *Muskegon* was sold to the Independent Sand and Gravel Company in Chicago. The ship was moved from Michigan City, Indiana to Manitowoc, Wisconsin to be modified and reequipped as a sand mining barge. During refitting in Manitowoc, the *Muskegon*'s original passenger cabins were removed. Additionally, new steel and wood composite arches were installed in place of the ship's original, iconic wooden Bishop Arches (Ellis 1988).

After the *Muskegon* left Manitowoc, Wisconsin, it returned to Michigan City, Indiana to begin its new career as a sand reclamation barge. Shortly after returning to Michigan City, an accidental fire on 6 October 1910 burned the *Muskegon* to just above the waterline while it was berthed in the Indiana Transportation Company's dock on the north side of Michigan City harbor (Ellis 1987). The ignition of kerosene or oil residue near the boilers is thought to have started the fire, and *The Evening News* (1910) describes it as one of the worst fires to have ever been fought in the harbor. While the fire was eventually extinguished, the volume of water used to control the flames caused the vessel to settle at dockside (Ellis 1988).

Despite efforts by the Indiana Transportation Company to have the vessel removed, the *Muskegon* remained in place for eight months following the fire. In early June 1911, the Independent Sand and Gravel Company transferred the *Muskegon*'s sand-sucking equipment and deck to their new, replacement ship, the *J.D. Marshall* (Ellis 1987). The *Muskegon* was then towed out of the harbor and sunk just west of Michigan City by the Indiana Transportation Company on 11 June 1911. Outfitted with the *Muskegon*'s sand sucking equipment, the *J.D. Marshall* would ironically sink the following day (TEN 1911; Ellis 1986).

Archaeological Investigations

The *Muskegon* now rests in 30 – 35 feet of water, 0.28 miles offshore from the Indiana Dunes National Lakeshore's Mount Baldy. The vessel is embedded in a Pleistocene clay deposit that was once found under the ancient glacial Lake Chicago, ca. 20,000 – 12,000 B.P (Ellis

1988). The ship was discovered by recreational divers in the early 1960s and is still a popular and commonly known recreational dive site.

The first formal archaeological survey of the *Muskegon* was conducted by former Indiana State Archaeologist Gary Ellis over a three-year period, 1985-1988. Ellis (1988) and a team of divers from the Indiana Department of Natural Resources performed subsurface reconnaissance and intensive survey to determine the nature and extent of archaeological deposits. Ellis (1987) reported to Indiana's Division of Historic Preservation that the site was in relatively stable condition. At the time of the investigation, Ellis (1988) noted that the site was stable with the majority of the wreckage distributed southwest of the vessel's main frame. Ellis (1988) explained that very little of the site was likely to collapse or drift out of position, but that there is substantial wreckage covered by a thin layer of sand. This sand, Ellis (1988) observed, periodically shifts about exposing and covering units larger than 25 square feet without having a negative impact on the cultural material underneath.

The results of Ellis' initial survey were ultimately used to put together a nomination to the National Register of Historic Places in 1988. Due to its status as a historically significant shipwreck representing important innovations in engineering, commerce, transportation and industry, as well as its tremendous research potential, the *Muskegon* is now listed on the National Register of Historic Places (Maus and Haskell 2016).

In 2000, Indiana University's Center for Underwater Science conducted archaeological investigations relating to historic shipwrecks in Indiana territorial waters as a part of a larger scope project being conducted by the Indiana University Eppley Institute. Indiana University researchers visited the *Muskegon* with the goal of making recommendations on management of Indiana shipwrecks as recreational resources.

Indiana University noted little structural change in the site from Gary Ellis' initial archaeological assessment, with site features extending above the lakebed and a plethora of undisturbed cultural deposits (Beeker et al. 2000). The main exposed site features include major segments of the ship's main frame and sidewalls, steam engine, twin boilers, Bishop Arch assemblies, propeller, and propeller drive shaft. Beeker et al. (2000) identified that approximately 90% of the ship's iron components were covered with invasive Zebra mussels (*Dreissena polymorpha*).

A significant change from Ellis' initial survey that was noted during the Indiana University assessment in 2000 was the presence of a 24'' intrusive, modern pipeline. At the time of the investigation, the pipeline crossed the hull of the *Muskegon* north of the engine and two boilers, along the port of the ship's keel (Beeker et al. 2000). Despite none of the major machinery components being impacted, the pipeline covered some of the ship's hull. University divers believed that the pipeline had been placed relatively recently, as clay sediment showed evidence of recent settling and the pipe had no attached Zebra mussels (Beeker et al. 2000). In their official report, Indiana University recommended that an updated archaeological survey of the vessel to determine the extent of damage from the pipe and determine management strategies and mitigation of potential damage (Beeker et al. 2000).

Intrusive Modern Pipe

Between 2011 and 2013, Commonwealth Cultural Resources Group (CCRG) conducted several surveys of submerged cultural resources in Indiana's territorial waters. CCRG surveys

indicate that in 2011, the intrusive modern pipe appeared to have changed significantly since the 2000 Indiana University assessment and had actually become entangled under the hull of the ship (Kaufmann 2012). In 2012, CCRG conducted indirect sidescan sonar survey and direct diver reconnaissance to document the extent of the pipe and its impact on the shipwreck.

Kira Kaufmann (2012), Principle Investigator for CCRG, explained that the greatest potential for damage to the shipwreck site comes from “erosion caused by the change in water flow patterns that the pipe has created.” Kaufmann (2012) recommended that the pipe be closely monitored and ultimately removed from the site to prevent further damage to the shipwreck. With funding from the Indiana DNR, CCRG created a draft stabilization plan for the site, outlining recommendations for future management in regard to the shipwreck and pipe (Kaufman and Egan-Bruhy 2013).

In 2016, the Indiana DNR approached the Indiana University (IU) Center for Underwater Science seeking further clarification of the pipe’s impact on the shipwreck. While the main segment of pipe was clearly defined in CCRG’s 2013 stabilization plan, there was some uncertainty surrounding a potential second segment of pipe under the shipwreck. Indiana DNR provided a grant for IU to conduct an updated survey of the intrusive modern pipe to help determine the extent of its impact with the submerged cultural resources.

In July of 2016, a team of four Indiana University divers travelled to Michigan City, IN with the objective of assessing the extent of the intrusive modern pipe on the shipwreck and recommending strategies for its removal (Maus and Haskell 2016). With funding provided by the Lake Michigan Coastal Program and marine transport provided by the Indiana DNR Division of Fish and Wildlife at the Michigan City Field Office, IU documented the pipe using direct diver survey and photogrammetric recording on 12-13 July 2016 (Figure 2). As a result of this

fieldwork, IU researchers identified two pipe segments with a combined length total length of 147.46 m (483.79 ft.) currently impacting the *Muskegon* shipwreck (Maus and Haskell 2016).

The summary report of IU's 2016 assessment provides a number of recommendations for management of the *Muskegon*. The report recommended removal of all exposed pipe sections on and around the *Muskegon* shipwreck by a commercial diving firm, under supervision from a qualified diving archaeologist (Maus and Haskell 2016). The removal of pipe pinned underneath the hull main frame and port sidewall could cause significant damage to the shipwreck, and it is recommended that those sections be cut, left *in situ*, and permanently capped to prevent further movement (Maus and Haskell 2016). IU additionally recommended the necessity of annual monitoring according to a rapid assessment protocol conducted by divers under the guidance of a qualified archaeologist (Maus and Haskell 2016).

Photogrammetry as a Monitoring Tool

Following the 2016 photogrammetric survey of the intrusive modern pipe, Indiana University returned to the *Muskegon* to create a 3D, photogrammetric model of the shipwreck for use in baseline monitoring and management. The 2017 project was marked by low visibility conditions on the first day, which deteriorated significantly thereafter. As a result, it was only possible to photograph the stern and amidships sections of the *Muskegon*. IU hopes to return to the site to complete image acquisition of the bow section.

The central data collection technique for this project was structure-from-motion photogrammetric imagery acquisition, accomplished by divers using SCUBA and cameras to

collect images while swimming delineated site sections (Maus et al. 2015, 2017; Van Damme 2015a, 2015b). The ultimate objective of image acquisition was to collect sufficient overlapping imagery of the entire site in order to align images and generate a three-dimensional model and orthomosaic using computer vision photogrammetry (Agisoft 2016; Van Damme 2015a; Van Damme 2015b). These products can then be used to increase public access to the site and during annual monitoring according to a rapid assessment protocol (Maus et al. 2017).

The image acquisition and processing methods for this project were based on methods described in Maus et al. (2017; 2018). Prior to image acquisition, divers deployed 10 12-bit, coded targets to assist with image alignment, establishing scale, estimating error, and orienting the site to cardinal directions. Targets were deployed in lines, with each target line acting as a border between “chunks.” These chunks were processed individually to reduce processing time and computer memory usage (Maus et al. 2017).

Three project divers were utilized to acquire photogrammetric imagery. One diver swam slow transects over the site taking the primary top-down photos using an array of two GoPro Hero 5 cameras. A second diver photographed the borders between chunks using a single GoPro Hero 4 camera to aid in processing and chunk alignment. The third project diver managed chunk size and coded target distribution. As the first two divers finished photographing a chunk, the third diver redeployed coded targets to delineate the next chunk. In this way, a team of at least three divers could “walk” imaging chunks down the length of the shipwreck to rapidly record the site. Due to poor visibility during project dives, cameras were set to take photographs at half-second intervals. This allowed for the desired 80% forward-overlap and 60% side-overlap between images (Agisoft 2016).

Images were pre-processed in Adobe Lightroom for color correction and dehazing, prior to processing in Agisoft Photoscan. Images were processed in chunks using standard workflow commands to generate a sparse point cloud, dense point cloud, textured model, and tiled model (Agisoft 2016). The final model is composed of 7,373 images and has an estimated error of 0.00320015 m (Figure 3). Poor visibility during the project inhibited image alignment in some places. While this resulted in less-than-optimal image alignment (approximately 70% alignment rate), the majority of the photographed areas of the shipwreck were successfully modelled. While the stern and amidships sections, including engines, associated machinery, hull, and the intrusive modern pipe mostly rendered successfully, the complex vertical structures of the propeller and twin scotch boilers did not sufficiently resolve. To increase the rate of alignment and better resolve vertically complex structures, future projects in similar conditions should emphasize a higher density of image acquisition in these areas to compensate.

While the photogrammetric model of exposed ship remains will act as a baseline for future monitoring efforts, it is recommended that further photogrammetry be conducted on the *Muskegon* prior to the removal of the intrusive modern pipe. Computer vision photogrammetry provides a highly accurate and quantifiable method of tracking change over time and would provide archaeologists and resource managers with a cost-effective tool for damage assessment prior to and following the removal of the pipe. The ease and speed with which photogrammetric imagery can be acquired will facilitate economical monitoring and research on the *Muskegon* over time following the site's potential nomination as an underwater park.

Underwater Preserves and Park Development

Shipwrecks constitute finite resources with not just historic value to researchers and archaeologists, but an intrinsic, recreational value to the general public. Underwater parks and Marine Protected Areas (MPAs) have been shown to provide valuable recreational and economic opportunities across the world (Beeker et al. 2000; Whitehead and Finney 2003). Many U.S. states have developed successful programs establishing underwater parks and preserves; states like California, Florida, and Michigan have successful marine preservation programs that not only provide protection for shipwrecks but enhance site usage through recreation and tourism (Peterson et al. 1987; Halsey 1990; Beeker et al. 2000; Hanselmann and Beeker 2008; Maus et al. 2017).

Under federal law (Abandoned Shipwreck Act of 1987), the state of Indiana is directed to manage and protect abandoned and historic shipwrecks on Indiana lake bottomlands (United States Abandoned Shipwreck Act of 1987 1988; Beeker 2000). This law, combined with the National Park Service Federal Guidelines, give states a variety of responsibilities beyond the traditional parameters of historic preservation with regard to cultural resources (Beeker et al. 2000; National Park Service 2006). These responsibilities include dealing with a broad range of management issues, including public access to shipwrecks, recreation concerns, and the creation of underwater parks and preserves (Beeker et al. 2000; National Parks Service 2006).

Preservation of historic shipwrecks in Indiana requires the state to take an active role in facilitating protection and public access. During Indiana University's 2000 assessment, the *Muskegon* was determined to be the best site for an archaeological preserve in Indiana territorial waters (Beeker et al. 2000). The same criteria utilized during the establishment of the Florida Keys Shipwreck Trail were used during this assessment (Smith et al. 1990; Beeker et al. 2000).

The *Muskegon*'s relatively intact features, depth, historical significance, and location give it the potential to be an exceptional park (Smith et al. 1990; Beeker et al. 2000; Kauffman and Bruhy 2013; Maus and Haskell 2016).

Indiana currently has one underwater shipwreck park, and the *Muskegon* should be extended the same designation and protection. In 2013, the *J.D. Marshall* was inaugurated as an underwater preserve under the Indiana Nature Preserves Act (1967). The *J.D. Marshall* Underwater Preserve was established with the mission to “promote understanding and appreciation of cultural values of areas by the people of Indiana” (Indiana Nature Preserves Act 1967). As the only shipwreck in the state of Indiana on the NRHP, the *Muskegon* is a prime candidate for nomination as an Indiana Nature Preserve to protect associated archaeological resources and promote cultural heritage tourism.

The first steps in successful park development involve enhancing site infrastructure to promote recreation and tourism. The *Muskegon* has been a popular location for recreational scuba divers since the 1960s, and the site currently lacks adequate infrastructure to enable and support these diving activities (Figure 4). The first step in enhancing a site for recreational use is the installation of a mooring system for boat use. An adequate mooring system is necessary to provide safe, stable anchorage for boat captains while limiting potential anchor damage to the sensitive cultural material (Hanselmann and Beeker 2008). An upright, spar buoy should be placed on the site that identifies the historic shipwreck and preserve. A monument should be placed on the site with a commemorative, bronze plaque that gives park visitors basic information about the *Muskegon* and its preserve (Hanselmann and Beeker 2008).

A critical component of establishing an underwater park is public outreach and education. A waterproof, interpretive guide of the *Muskegon* should be created for divers that contains a

detailed site plan, significant archaeological features, jurisdictional information, and safety information. This guide could be made available from local dive centers, charter operators, and the Michigan City Field Office of the Indiana DNR's Division of Fish and Wildlife.

Additional displays should be created on land for non-diving tourists. A kiosk should be created at the nearby Indiana Dunes State Park for park visitors to learn about the *Muskegon* and build resource stewardship amongst local stakeholders. The Indiana Dunes has approximately three million visitors annually, and accessible information about the *Muskegon* and other local, historic shipwrecks will help increase public awareness of the need to protect submerged cultural resources and archaeological sites (Indiana Dunes Tourism 2018). Another land display could be located at the Old Michigan City Light. The Old Michigan City Light is a decommissioned lighthouse located in the harbor of Michigan City, Indiana and just over a mile from the site of the *Muskegon* (Beeker et al. 2000). The lighthouse is now a museum owned and operated by the non-profit Michigan City Historical Society, Inc. (2017) and currently displays artifacts and exhibits about Lake Michigan shipwrecks and Indiana's maritime history. These terrestrial venues would enhance tourism for shipwreck sites and would facilitate public outreach and education about Indiana's maritime heritage to the non-diving public.

The Indiana DNR (2018) currently profiles the "Indiana Lake Michigan Shipwreck Survey Project" on their website, displaying virtual tours and photo galleries of Indiana shipwrecks. The website should be enhanced with updated interpretive materials and information about active research on the *Muskegon*. The posting of photogrammetric models and detailed site plans on the website would allow visitors to experience the submerged cultural resources of Indiana's territorial waters from their own computers, building excitement and promoting cultural heritage tourism (Maus et al. 2017).

Summary and Conclusions

The results of the 2016 and 2017 Indiana University investigations demonstrate the need for improved site protection and monitoring. The intrusive modern pipe is an immediate management concern, but the site should be dedicated as a marine protected area in order to prevent further damage to the significant submerged cultural resources. Annual monitoring by a qualified professional archaeologist using structure-from-motion photogrammetry is necessary to create and modify management strategies for the *Muskegon*, as well as build resource stewardship through outreach and education. Using 21st-century technology, this 19th-century shipwreck can be made available to both the diving and non-diving public, fostering a sense of excitement and responsibility to protect and preserve archaeological sites.

In the United States and around the world, shipwrecks are of increasing interest to the diving and non-diving public. Shipwrecks spark a natural excitement and interest in archaeology and cultural heritage. Successfully nominated to the National Register of Historic Places, the *Muskegon* is representative of a specific class of steam-powered, iron-hulled passenger freighter built and used on the Great Lakes in the late 19th and early 20th centuries. For over 50 years, visitors have enjoyed this piece of maritime heritage as a recreational dive site. The *Muskegon* and its tangible remains should be protected as an underwater park to preserve and guarantee its availability to the public for future generations.

Acknowledgements

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Quarterly Progress Reports

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY

School of Public Health
Bloomington

Indiana Lake Michigan Coastal Grants Program Quarterly Progress Report

Project Identification Number: CZ 540

Date: July 20, 2017

Report Period: Second Quarter 2017

Project Sponsor:

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Administrator: Charles Beeker

Status of Tasks (Task Number and Title)	DATE: July 20, 2017
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TASK ONE: Project Planning [COMPLETE]

1. Apply for necessary permits and permission for archaeological investigation –AD #20170 Permit received May 15, 2017
Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana [COMPLETE]
2. Organize and secure equipment for field work- Thermo protection and 3D camera June 15, 2017[COMPLETE]
3. Coordinate travel and diving logistics (boats, hotels, etc)- Confirmed dive platform Indiana DNR Fisheries June 26, 2017. Accommodations confirmed Bridge Inn, Michigan City June 12, 2017 [COMPLETE]
4. Coordinate photogrammetric data collection strategy –completed NOAA Preserve America Diving Program photogrammetry training on *Benwood* and *City Washington* in preparation for Muskegon documentation in Lake Michigan. June 2, 2017 [COMPLETE]

TASK TWO: Project Implementation [IN PROGRESS]

July 2017

1. Conduct photogrammetric survey of *Muskegon* [INCOMPLETE]
2. Collect supplementary data using traditional methods [INCOMPLETE]
3. Identify key artifacts and features for interpretation and/or conservation [INCOMPLETE]]
4. Create database for the storage of data collected for this project [INCOMPLETE]

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan [INCOMPLETE]
2. Draft final report of photogrammetric survey with recommendations for future development as an underwater park [INCOMPLETE]
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database [INCOMPLETE]

TASK THREE: Public Outreach and Education [IN PROGRESS]

September 2017 – December 2017

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration [IN PROGRESS]

June 2017 – December 2017

1. Track and record the hours of volunteers and professionals whose work will be counted as match
2. Track and record the hours of staff whose work will be charged to the grant

Status of Work Products	DATE JULY 20, 2017
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1. A report detailing the methodology used and the recommendations for protecting the site [IN PROGRESS]
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource [IN PROGRESS]
3. All photos, processing data, and metadata collected during the project [COMPLETE]

Status of any Special Award Conditions	DATE
--	------

<p>Indiana Lake Michigan Coastal Grants Program Quarterly Progress Report</p>
--

Project Identification Number: CZ 540

Date: October 12, 2017

Report Period: Third Quarter 2017

Project Sponsor:

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Administrator: Charles Beeker

Status of Tasks (Task Number and Title)	DATE: October 12, 2017
---	------------------------

TASK ONE: Project Planning [COMPLETE]

1. Apply for necessary permits and permission for archaeological investigation –AD #20170 Permit received May 15, 2017
Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana [COMPLETE]
2. Organize and secure equipment for field work- Thermo protection and 3D camera June 15, 2017[COMPLETE]
3. Coordinate travel and diving logistics (boats, hotels, etc)- Confirmed dive platform Indiana DNR Fisheries June 26, 2017. Accommodations confirmed Bridge Inn, Michigan City June 12, 2017 [COMPLETE]
4. Coordinate photogrammetric data collection strategy –completed NOAA Preserve America Diving Program photogrammetry training on *Benwood* and *City Washington* in preparation for Muskegon documentation in Lake Michigan. June 2, 2017 [COMPLETE]

TASK TWO: Project Implementation [IN PROGRESS]

July 2017

1. Conduct photogrammetric survey of *Muskegon* [COMPLETE]
2. Collect supplementary data using traditional methods [COMPLETE]
3. Identify key artifacts and features for interpretation and/or conservation [COMPLETE]
4. Create database for the storage of data collected for this project [COMPLETE]

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan [INCOMPLETE]
2. Draft final report of photogrammetric survey with recommendations for future development as an underwater park [INCOMPLETE]
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database [INCOMPLETE]

TASK THREE: Public Outreach and Education [IN PROGRESS]

September 2017 – December 2017

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration [IN PROGRESS]

June 2017 – December 2017

1. Track and record the hours of volunteers and professionals whose work will be counted as match
2. Track and record the hours of staff whose work will be charged to the grant

Status of Work Products	DATE October 12, 2017
-------------------------	-----------------------

1. A report detailing the methodology used and the recommendations for protecting the site [IN PROGRESS]
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource [IN PROGRESS]
3. All photos, processing data, and metadata collected during the project [COMPLETE]

Status of any Special Award Conditions	DATE
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Indiana Lake Michigan Coastal Grants Program Quarterly Progress Report

Project Identification Number: CZ 540

Date: January 10, 2018

Report Period: Fourth Quarter 2017

Project Sponsor:

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Administrator: Charles Beeker

Status of Tasks (Task Number and Title)	DATE January 10, 2018
---	-----------------------

TASK ONE: Project Planning [COMPLETE]

1. Apply for necessary permits and permission for archaeological investigation –AD #20170 Permit received May 15, 2017
Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana [COMPLETE]
2. Organize and secure equipment for field work- Thermo protection and 3D camera June 15, 2017[COMPLETE]
3. Coordinate travel and diving logistics (boats, hotels, etc)- Confirmed dive platform Indiana DNR Fisheries June 26, 2017. Accommodations confirmed Bridge Inn, Michigan City June 12, 2017 [COMPLETE]
4. Coordinate photogrammetric data collection strategy –completed NOAA Preserve America Diving Program photogrammetry training on *Benwood* and *City Washington* in preparation for Muskegon documentation in Lake Michigan. June 2, 2017 [COMPLETE]

TASK TWO: Project Implementation [IN PROGRESS]

July 2017

1. Conduct photogrammetric survey of *Muskegon* [COMPLETE]
2. Collect supplementary data using traditional methods [COMPLETE]
3. Identify key artifacts and features for interpretation and/or conservation [COMPLETE]
4. Create database for the storage of data collected for this project [COMPLETE]

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan [COMPLETE]
2. Draft final report of photogrammetric survey with recommendations for future development as an underwater park [IN PROGRESS]
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database [IN PROGRESS]

TASK THREE: Public Outreach and Education [IN PROGRESS]

September 2017 – December 2017

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration [IN PROGRESS]

June 2017 – December 2017

1. Track and record the hours of volunteers and professionals whose work will be counted as match
2. Track and record the hours of staff whose work will be charged to the grant

Status of Work Products	DATE January 10, 2018
-------------------------	-----------------------

1. A report detailing the methodology used and the recommendations for protecting the site [IN PROGRESS]
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource [IN PROGRESS]
3. All photos, processing data, and metadata collected during the project [COMPLETE]

Status of any Special Award Conditions	DATE
--	------

<p>Indiana Lake Michigan Coastal Grants Program Quarterly Progress Report</p>
--

Project Identification Number: CZ 540

Date: 16 April 2018

Report Period: First Quarter 2018

Project Sponsor:

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Administrator: Charles Beeker

Status of Tasks (Task Number and Title)	DATE April 16, 2018
---	---------------------

TASK ONE: Project Planning [COMPLETE]

1. Apply for necessary permits and permission for archaeological investigation –AD #20170 Permit received May 15, 2017
Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana [COMPLETE]
2. Organize and secure equipment for field work- Thermo protection and 3D camera June 15, 2017[COMPLETE]
3. Coordinate travel and diving logistics (boats, hotels, etc)- Confirmed dive platform Indiana DNR Fisheries June 26, 2017. Accommodations confirmed Bridge Inn, Michigan City June 12, 2017 [COMPLETE]
4. Coordinate photogrammetric data collection strategy –completed NOAA Preserve America Diving Program photogrammetry training on *Benwood* and *City Washington* in preparation for Muskegon documentation in Lake Michigan. June 2, 2017 [COMPLETE]

TASK TWO: Project Implementation [IN PROGRESS]

July 2017

1. Conduct photogrammetric survey of *Muskegon* [COMPLETE]
2. Collect supplementary data using traditional methods [COMPLETE]
3. Identify key artifacts and features for interpretation and/or conservation [COMPLETE]
4. Create database for the storage of data collected for this project [COMPLETE]

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan [COMPLETE]
2. Draft final report of photogrammetric survey with recommendations for future development as an underwater park [IN PROGRESS]
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database [IN PROGRESS]

TASK THREE: Public Outreach and Education [IN PROGRESS]

September 2017 – December 2017

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration [IN PROGRESS]

June 2017 – December 2017

1. Track and record the hours of volunteers and professionals whose work will be counted as match
2. Track and record the hours of staff whose work will be charged to the grant

Status of Work Products	DATE April 16, 2018
-------------------------	---------------------

1. A report detailing the methodology used and the recommendations for protecting the site [IN PROGRESS]
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource [IN PROGRESS]
3. All photos, processing data, and metadata collected during the project [COMPLETE]

Status of any Special Award Conditions	DATE
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<p>Indiana Lake Michigan Coastal Grants Program Quarterly Progress Report</p>
--

Project Identification Number: CZ 540

Date: July 14, 2018

Report Period: Second Quarter 2018

Project Sponsor:

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Project Administrator: Charles Beeker

Status of Tasks (Task Number and Title)	DATE July 14, 2018
---	--------------------

TASK ONE: Project Planning [COMPLETE]

1. Apply for necessary permits and permission for archaeological investigation –AD #20170 Permit received May 15, 2017
Archaeological investigations at site 12Le0381 (the Muskegon) LaPorte County, Indiana [COMPLETE]
2. Organize and secure equipment for field work- Thermo protection and 3D camera June 15, 2017[COMPLETE]
3. Coordinate travel and diving logistics (boats, hotels, etc)- Confirmed dive platform Indiana DNR Fisheries June 26, 2017. Accommodations confirmed Bridge Inn, Michigan City June 12, 2017 [COMPLETE]
4. Coordinate photogrammetric data collection strategy –completed NOAA Preserve America Diving Program photogrammetry training on *Benwood* and *City Washington* in preparation for Muskegon documentation in Lake Michigan. June 2, 2017 [COMPLETE]

TASK TWO: Project Implementation [IN PROGRESS]

July 2017

1. Conduct photogrammetric survey of *Muskegon* [COMPLETE]
2. Collect supplementary data using traditional methods [COMPLETE]
3. Identify key artifacts and features for interpretation and/or conservation [COMPLETE]
4. Create database for the storage of data collected for this project [COMPLETE]

July 2017 – December 2017

1. Produce 3D model of *Muskegon* using Agisoft Photoscan [COMPLETE]
2. Draft final report of photogrammetric survey with recommendations for future development as an underwater park [IN PROGRESS]
3. Submit model, photos, data, and metadata for this project to the state for inclusion in the Heritage Database [IN PROGRESS]

TASK THREE: Public Outreach and Education [IN PROGRESS]

September 2017 – December 2017

1. Work with partners to make public aware of the project through outlets they use to communicate with the public
2. Post photogrammetric model and distribute this through outlets of project partners

TASK FOUR: Administration [Complete]

June 2017 – December 2017

1. Track and record the hours of volunteers and professionals whose work will be counted as match
2. Track and record the hours of staff whose work will be charged to the grant

Status of Work Products	DATE July 14, 2018
-------------------------	--------------------

1. A report detailing the methodology used and the recommendations for protecting the site [IN PROGRESS]
2. 3D model of the site as a baseline monitoring tool for future research and management of the *Muskegon* as a cultural resource [Complete]
3. All photos, processing data, and metadata collected during the project [COMPLETE]

Status of any Special Award Conditions	DATE
--	------

Quarterly Financial Reports

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



UNDERWATER SCIENCE

INDIANA UNIVERSITY

School of Public Health
Bloomington



INDIANA LAKE MICHIGAN COASTAL GRANT PROGRAM
QUARTERLY FINANCIAL REPORT
 State Form 55105 (R2 / 12-15)
 INDIANA LAKE MICHIGAN COASTAL PROGRAM

Project Number: CZ 540

Report Date (month, day, year): 10-Jul-17

Report Period: May 1, 2017 - June 30, 2017

Project Sponsor: The Trustees of Indiana University

Project Title: Muskeogon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Telephone Number: 812-855-5748

Project Administrator: Charles Beeker

Contact E-mail Address: cbeeker@indiana.edu

Category	Authorized Budget		Current Invoice		Previously Invoiced		Invoiced to Date		Balance	
	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match
Personnel	\$6,204.00	\$10,392.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$6,204.00	\$10,392.00
Fringe	\$1,035.00	\$2,723.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$1,035.00	\$2,723.00
Travel	\$3,000.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$3,000.00	\$0.00
Supplies	\$2,500.00	\$0.00	\$2,116.98	\$0.00	\$0.00	\$0.00	\$2,116.98	\$0.00	\$383.02	\$0.00
Contractual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Indirect 32%	\$ 4,077.00	\$4,197.00	\$ 677.43	\$0.00	\$0.00	\$0.00	\$677.43	\$0.00	\$3,399.57	\$4,197.00
Total	\$16,816.00	\$17,312.00	\$2,794.41	\$0.00	\$0.00	\$0.00	\$2,794.41	\$0.00	\$14,021.59	\$17,312.00

Other Cost Explained:

Other Match Explained:

Signature of Project Administrator: *Charles Beeker* Date Signed (month, day, year): *7/10/17*

Procurement Card

Doc Nbr: 61598667	Status: FINAL
Initiator: kfs	Created: 10:02 PM 05/28/2017

[expand all](#) [collapse all](#)
* required field

Document Overview [hide](#)

Document Overview

* Description: HPER UNDERWATER\SCI-0433-BL-2245003	Explanation:
Organization Document Number:	

Financial Document Detail

Total Amount: 773.85

Accounting Lines [hide](#)

Transaction #24692167144000177447718 hide detail			
Transaction Credit Card Number: *****		Transaction Total Amount: 399.00	
Card Holder Name: HPER UNDERWATER\SCI		Transaction Reference Number: 24692167144000177447718	
Transaction Date: 05/24/2017			
Vendor Name: AMAZON MKTPLACE PMTS			

Accounting Lines

* Chart	SubFundGrpCd	Org Cd	* Account	Sub-Account	* Object	Sub-Object	Project	Org Ref Id	* Amount	Actions
BL BLOOMINGTON	STATER	KINE	4746203 IDNR/0000000000000000000019560/BEEKER,C		4912 DURABLE-EQUIPMENT < \$1,000				399.00	
Line Description										
GoPro camera										
									Total: 399.00	

Transaction #24692167144000199079648 hide detail			
Transaction Credit Card Number: *****		Transaction Total Amount: 374.85	
Card Holder Name: HPER UNDERWATER\SCI		Transaction Reference Number: 24692167144000199079648	
Transaction Date: 05/24/2017			
Vendor Name: PADI AMERICAS INC			

Accounting Lines

* Chart	SubFundGrpCd	Org Cd	* Account	Sub-Account	* Object	Sub-Object	Project	Org Ref Id	* Amount	Actions
BL BLOOMINGTON	DOFDS	KINE	2346211 ACADEMIC DIVING PROGRAM		4080 TEACHING SUPPLIES				374.85	
Line Description										
PIC online credits & DM Crew Pak										
									Total: 374.85	

Accounting Lines for Capitalization [show](#)

Create Capital Assets [show](#)

Modify Capital Assets [show](#)

General Ledger Pending Entries [show](#)

Notes and Attachments (0) [show](#)

Ad Hoc Recipients [show](#)

Route Log [show](#)

[send ad hoc request](#) [close](#)

Procurement Card

Doc Nbr:	61592619	Status:	FINAL
Initiator:	kfs	Created:	10:01 PM 05/26/2017

[expand all](#) [collapse all](#)
* required field

Document Overview [hide](#)

Document Overview

* Description:	HPER UNDERWATER\SCI-0433-BL-2245003	Explanation:	
Organization Document Number:			

Financial Document Detail

Total Amount:	243.98
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Accounting Lines [hide](#)

Transaction #24692167143000590449417 [hide detail](#)

Transaction Credit Card Number:	*****	Transaction Total Amount:	48.98
Card Holder Name:	HPER UNDERWATER\SCI	Transaction Reference Number:	24692167143000590449417
Transaction Date:	05/23/2017		
Vendor Name:	AMAZON MKTPLACE PMTS		

Accounting Lines

	* Chart	SubFundGrpCd	Org Cd	* Account	Sub-Account	* Object	Sub-Object	Project	Org Ref Id	* Amount	Actions
1	BL BLOOMINGTON	STATER	KINE	4746203 IDNR/0000000000000000000019560/BEEKER,C		4938 RESEARCH SUPPLIES				48.98	
	Line Description										
	SD Card and GoPro case										
										Total: 48.98	

Transaction #24692167143000596539468 [hide detail](#)

Transaction Credit Card Number:	*****	Transaction Total Amount:	195.00
Card Holder Name:	HPER UNDERWATER\SCI	Transaction Reference Number:	24692167143000596539468
Transaction Date:	05/23/2017		
Vendor Name:	PADI AMERICAS INC		

Accounting Lines

	* Chart	SubFundGrpCd	Org Cd	* Account	Sub-Account	* Object	Sub-Object	Project	Org Ref Id	* Amount	Actions
1	BL BLOOMINGTON	DOFDS	KINE	2346211 ACADEMIC DIVING PROGRAM		4080 TEACHING SUPPLIES				195.00	
	Line Description										
	Certi. PIC online credits										
										Total: 195.00	

Accounting Lines for Capitalization [show](#)

Create Capital Assets [show](#)

Modify Capital Assets [show](#)

General Ledger Pending Entries [show](#)

Notes and Attachments (0) [show](#)

Ad Hoc Recipients [show](#)

Route Log [show](#)

[send ad hoc request](#) [close](#)

Procurement Card [?](#)

Doc Nbr:	62270195	Status:	FINAL
Initiator:	kfs	Created:	10:01 PM 06/16/2017

[expand all](#) [collapse all](#)

* required field

Document Overview [▼ hide](#)

Document Overview

* Description:	HPER UNDERWATER\SCI-0433-BL-2245003	Explanation:	
Organization Document Number:			

Financial Document Detail

Total Amount:	1,669.00
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Accounting Lines [▼ hide](#)

Transaction #24110397164556012100012 [hide detail](#)

Transaction Credit Card Number:	*****	Transaction Total Amount:	1,669.00
Card Holder Name:	HPER UNDERWATER\SCI	Transaction Reference Number:	24110397164556012100012
Transaction Date:	06/12/2017		
Vendor Name:	SOUTHERN INDIANA SC		

Accounting Lines

* Chart	SubFundGrpCd	Org Cd	* Account	Sub-Account	* Object	Sub-Object	Project	Org Ref Id	* Amount	Actions
BL BLOOMINGTON	STATER	KINE	4746203 IDNR/00000000000000000000000019560/BEEKER,C		5200 EXPENDABLE EQUIPMENT				1,669.00	
1	Line Description									
	Thermal Prot. Dry Suit for SCUBA									
									Total: 1,669.00	

- [Accounting Lines for Capitalization](#) [▶ show](#)
- [Create Capital Assets](#) [▶ show](#)
- [Modify Capital Assets](#) [▶ show](#)
- [General Ledger Pending Entries](#) [▶ show](#)
- [Notes and Attachments \(0\)](#) [▶ show](#)
- [Ad Hoc Recipients](#) [▶ show](#)
- [Route Log](#) [▶ show](#)

[send ad hoc request](#) [close](#)

INVOICE
INDIANA UNIVERSITY
BLOOMINGTON, IN 47405
FED ID #356001673

Page 1 of 1

Date: 07/10/2017

INVOICE: 63019167

CUSTOMER NUMBER: IND2753

BILLED BY (DO NOT REMIT TO):

ATTN:

RESEARCH ADMINISTRATION

PHONE: (812) 856-0578

SHIP TO: LAKE MICHIGAN COASTAL PROGRAM
1600 NORTH 25 EAST

FAX: (812) 855-9943

PREPARED BY: Sheena Hall

CHESTERTON, IN 46304

PO/AGREEMENT NO:

PO/AGREEMENT DATE:

QTY	UNIT	DESCRIPTION	ITEM CODE	UNIT PRICE	AMOUNT
1.00	EA			2,794.41	2,794.41

(additional invoice lines may be printed on the following pages)

PLEASE MAKE PAYMENT BY INVOICE DUE DATE

SEE ATTACHED BILLING

PAY THIS AMOUNT: 2,794.41

Detach & Return Lower Portion with Payment

PLEASE MAKE CHECKS PAYABLE TO: INDIANA UNIVERSITY

INVOICE DATE: 07/10/2017

INVOICE: 63019167

CUSTOMER NBR: IND2753

BL4746203

DUE DATE: 08/09/2017

AMOUNT DUE: 2,794.41

REMIT TO: INDIANA UNIV RESEARCH

DEPT 78867

P.O. BOX 78000

DETROIT, MI 48278-0867

ATTN:

LAKE MICHIGAN COASTAL PROGRAM
1600 NORTH 25 EAST

CHESTERTON, IN 46304



INDIANA LAKE MICHIGAN COASTAL GRANT PROGRAM
QUARTERLY FINANCIAL REPORT
 State Form 55105 (R2 / 12-15)
 INDIANA LAKE MICHIGAN COASTAL PROGRAM

Project Number: CZ 540

Report Date (month, day, year): 12-Oct-17

Report Period: July 1, 2017 - September 30, 2017

Project Sponsor: The Trustees of Indiana University

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Telephone Number: 812-855-5748

Project Administrator: Charles Beeker

Contact E-mail Address: cbeeker@indiana.edu

Category	Authorized Budget		Current Invoice		Previously Invoiced		Invoiced to Date		Balance	
	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match
Personnel	\$6,204.00	\$10,392.00	\$5,456.81	\$2,078.40	\$0.00	\$0.00	\$5,456.81	\$2,078.40	\$747.19	\$8,313.60
Fringe	\$1,035.00	\$2,723.00	\$1,068.14	\$836.16	\$0.00	\$0.00	\$1,068.14	\$836.16	-\$33.14	\$1,886.84
Travel	\$3,000.00	\$0.00	\$1,806.72	\$0.00	\$0.00	\$0.00	\$1,806.72	\$0.00	\$1,193.28	\$0.00
Supplies	\$2,500.00	\$0.00	\$535.00	\$0.00	\$2,116.98	\$0.00	\$2,651.98	\$0.00	-\$151.98	\$0.00
Contractual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Indirect 32%	\$ 4,077.00	\$4,197.00	\$2,837.12	\$932.66	\$677.43	\$0.00	\$3,514.55	\$932.66	\$562.45	\$3,264.34
Total	\$16,816.00	\$17,312.00	\$11,703.79	\$3,847.22	\$2,794.41	\$0.00	\$14,498.20	\$3,847.22	\$2,317.80	\$13,464.78

Other Cost Explained:

Other Match Explained:

Signature of Project Administrator: *Charles Beeker* Date Signed (month, day, year): 10/12/2017



INDIANA LAKE MICHIGAN COASTAL GRANT PROGRAM
QUARTERLY FINANCIAL REPORT
 State Form 551'06 (R2 / 12-15)
 INDIANA LAKE MICHIGAN COASTAL PROGRAM

Project Number: CZ 540

Report Date (month, day, year): 3-Jan-18

Report Period: October 1, 2017 - December 31, 2017

Project Sponsor: The Trustees of Indiana University

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Telephone Number: 812-855-5748

Project Administrator: Charles Beeker

Contact E-mail Address: cbeeker@indiana.edu

Category	Authorized Budget		Current Invoice		Previously Invoiced		Invoiced to Date		Balance	
	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match
Personnel	\$6,204.00	\$10,392.00	\$0.00	\$0.00	\$5,456.81	\$2,078.40	\$5,456.81	\$2,078.40	\$747.19	\$8,313.60
Fringe	\$1,035.00	\$2,723.00	\$0.00	\$0.00	\$1,035.00	\$836.16	\$1,035.00	\$836.16	\$0.00	\$1,886.84
Travel	\$3,000.00	\$0.00	\$56.66	\$0.00	\$1,806.72	\$0.00	\$1,863.38	\$0.00	\$1,136.62	\$0.00
Supplies	\$2,500.00	\$0.00	\$0.00	\$0.00	\$2,500.00	\$0.00	\$2,500.00	\$0.00	\$0.00	\$0.00
Contractual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Indirect 32%	\$ 4,077.00	\$4,197.00	\$18.13	\$0.00	\$3,455.53	\$932.66	\$3,473.66	\$932.66	\$603.34	\$3,264.34
Total	\$16,816.00	\$17,312.00	\$74.79	\$0.00	\$14,254.06	\$3,847.22	\$14,328.85	\$3,847.22	\$2,487.15	\$13,464.78

Other Cost Explained:

Other Match Explained:

Signature of Project Administrator: _____ Date Signed (month, day, year): _____



INDIANA LAKE MICHIGAN COASTAL GRANT PROGRAM
QUARTERLY FINANCIAL REPORT
 State Form 551'06 (R2 / 12-15)
 INDIANA LAKE MICHIGAN COASTAL PROGRAM

Project Number: CZ 540

Report Date (month, day, year): 2-Apr-18

Report Period: January 1, 2018 - March 31, 2018

Project Sponsor: The Trustees of Indiana University

Project Title: Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Telephone Number: 812-855-5748

Project Administrator: Charles Beeker

Contact E-mail Address: cbeeker@indiana.edu

Category	Authorized Budget		Current Invoice		Previously Invoiced		Invoiced to Date		Balance	
	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match	LMCP	Match
Personnel	\$6,204.00	\$10,392.00	\$0.00	\$0.00	\$5,456.81	\$2,078.40	\$5,456.81	\$2,078.40	\$747.19	\$8,313.60
Fringe	\$1,035.00	\$2,723.00	\$0.00	\$0.00	\$1,035.00	\$836.16	\$1,035.00	\$836.16	\$0.00	\$1,886.84
Travel	\$3,000.00	\$0.00	\$1,114.56	\$0.00	\$1,863.38	\$0.00	\$2,977.94	\$0.00	\$22.06	\$0.00
Supplies	\$2,500.00	\$0.00	\$0.00	\$0.00	\$2,500.00	\$0.00	\$2,500.00	\$0.00	\$0.00	\$0.00
Contractual	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Indirect 32%	\$ 4,077.00	\$4,197.00	\$356.66	\$0.00	\$3,473.66	\$932.66	\$3,830.32	\$932.66	\$246.68	\$3,264.34
Total	\$16,816.00	\$17,312.00	\$1,471.22	\$0.00	\$14,328.85	\$3,847.22	\$15,800.07	\$3,847.22	\$1,015.93	\$13,464.78

Other Cost Explained:

Other Match Explained:

Signature of Project Administrator:

Date Signed (month, day, year):

Figures

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



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Muskegon (aka Peerless) (12LE0381)
Orthomosaic Site Plan (Stern)

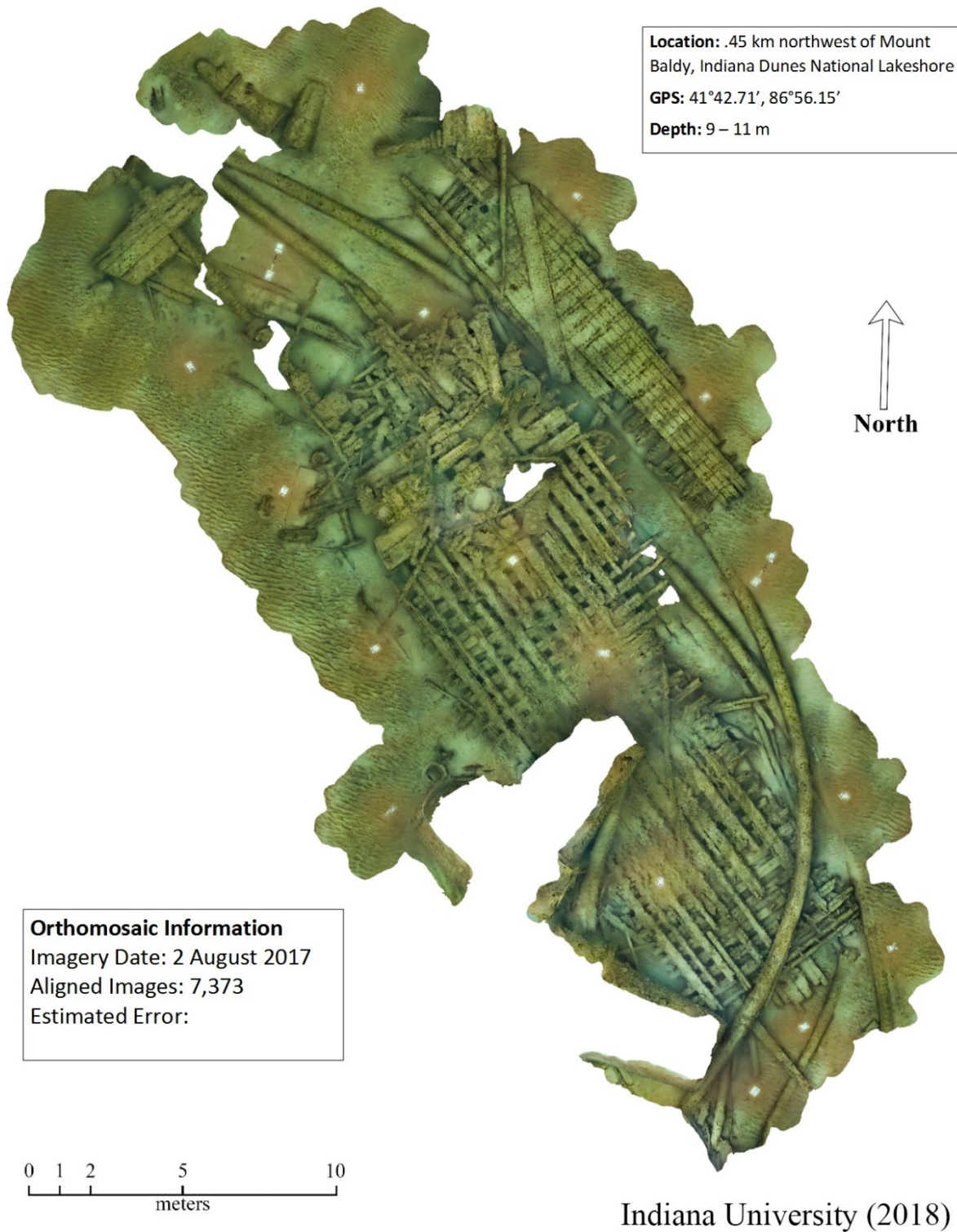


Figure 1 Photogrammetric site plan of the *Muskegon*'s stern section created using 7,373 images aligned in Agisoft Photoscan.



Figure 2 Historic photograph of the *Peerless*, circa 1880 (Courtesy of the Great Lakes Marine Collection, Milwaukee Public Library).



Figure 3 Historic photograph of the *Muskegon* (Courtesy of the Great Lakes Marine Collection, Milwaukee Public Library).

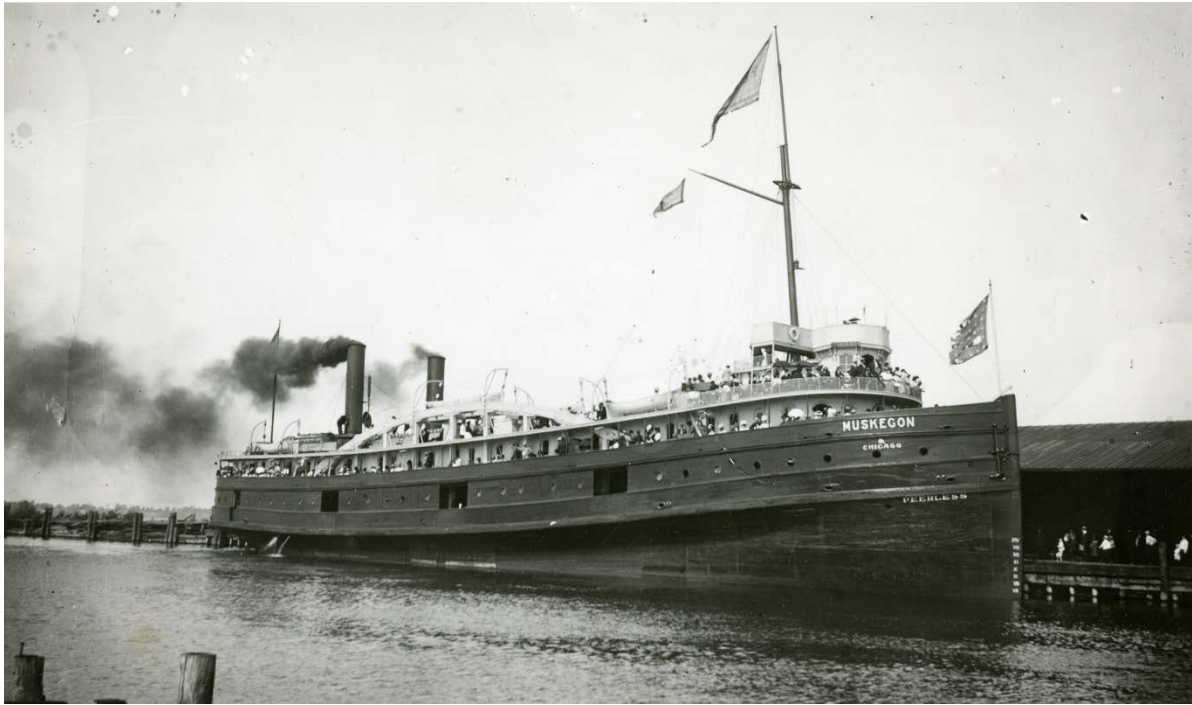


Figure 4 Historic photograph of the *Muskegon* (Courtesy of the Great Lakes Marine Collection, Milwaukee Public Library).



Figure 5 Indiana University Director Charles Beeker examines the *Muskegon* superstructure.



Figure 6 Propeller of the *Muskegon* remains intact and good condition but is covered in invasive zebra mussels.



Figure 7 Loose, portable artifacts on the *Muskegon* that could be illegally recovered by site visitors should be comprehensively documented and/or recovered for conservation.



Figure 8 Indiana University researchers prepare for photogrammetric survey of the *Muskegon*.



Figure 9 Indiana University scientific divers swim transects over the *Muskegon* to collect photogrammetric imagery.



Figure 10 Indiana University Director of Underwater Science identifies two pipe segments under *Muskegon* hull remains.



Figure 11 The Michigan City Lighthouse Museum provides an excellent venue for the display of artifacts and interpretive materials from Indiana's maritime heritage.

Data Sharing Plan

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

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Data Sharing Plan

***Muskegon* (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation**

2018 Lake Michigan Coastal Program Grant CZ540

Mailed with the physical copy of this report will be a USB drive containing all associated data. All photos, photogrammetric metadata, processing reports, Agisoft Photoscan data, 3D models, textures, tiled models, and any other digital files will be included on this USB drive. Additionally, Indiana University will keep copies of all data on file with the Center for Underwater Science laboratory in IU Bloomington's School of Public Health.

By request, the Center for Underwater Science will be able to provide any data from this backup, should the Indiana Department of Natural Resources, NOAA, Indiana Division of Historic Preservation and Archaeology, or Lake Michigan Coastal Program require it.

3D models of the *Muskegon* will be available on Indiana University's Sketchfab profile by October 1, 2018.

Muskegon Stern 2017 Agisoft Processing Report

Muskegon (12LE0381) 3D Photogrammetry and Underwater Museum Interpretation

Lake Michigan Coastal Program Grant CZ540



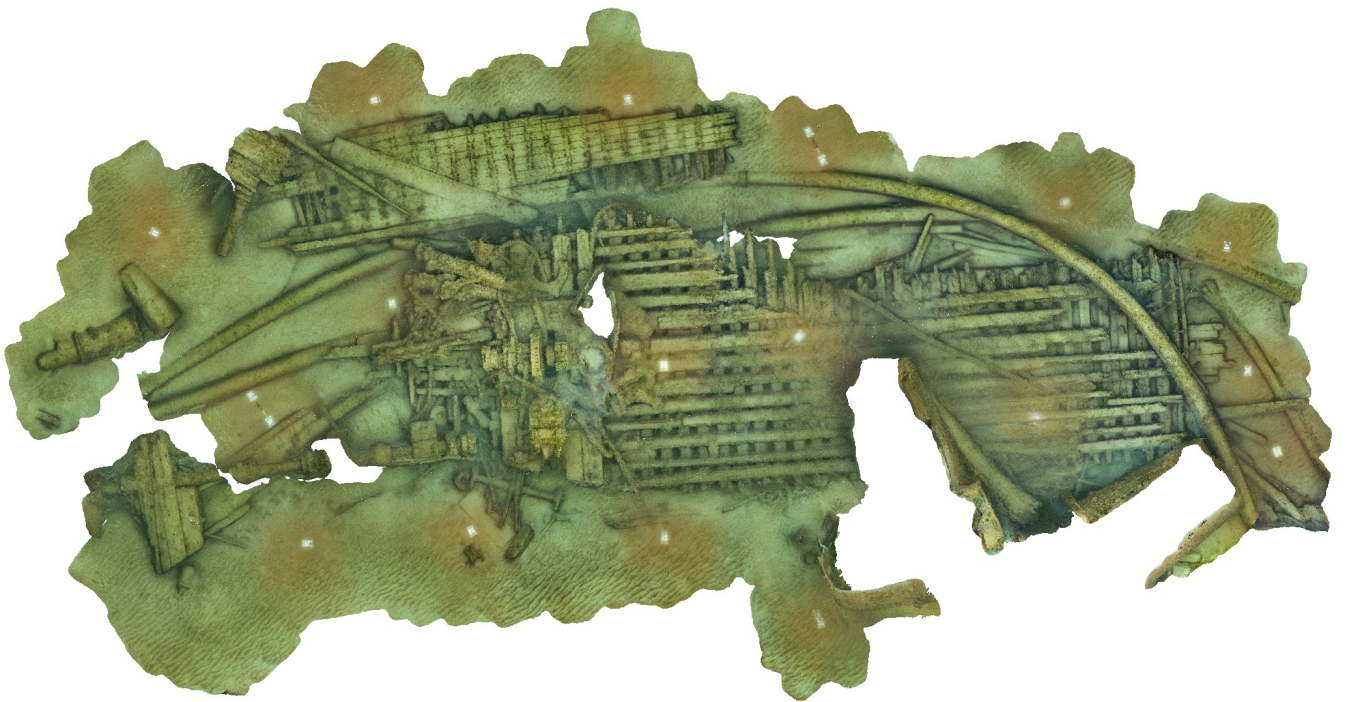
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Muskegon Stern 2017

Processing Report
01 March 2018



Survey Data

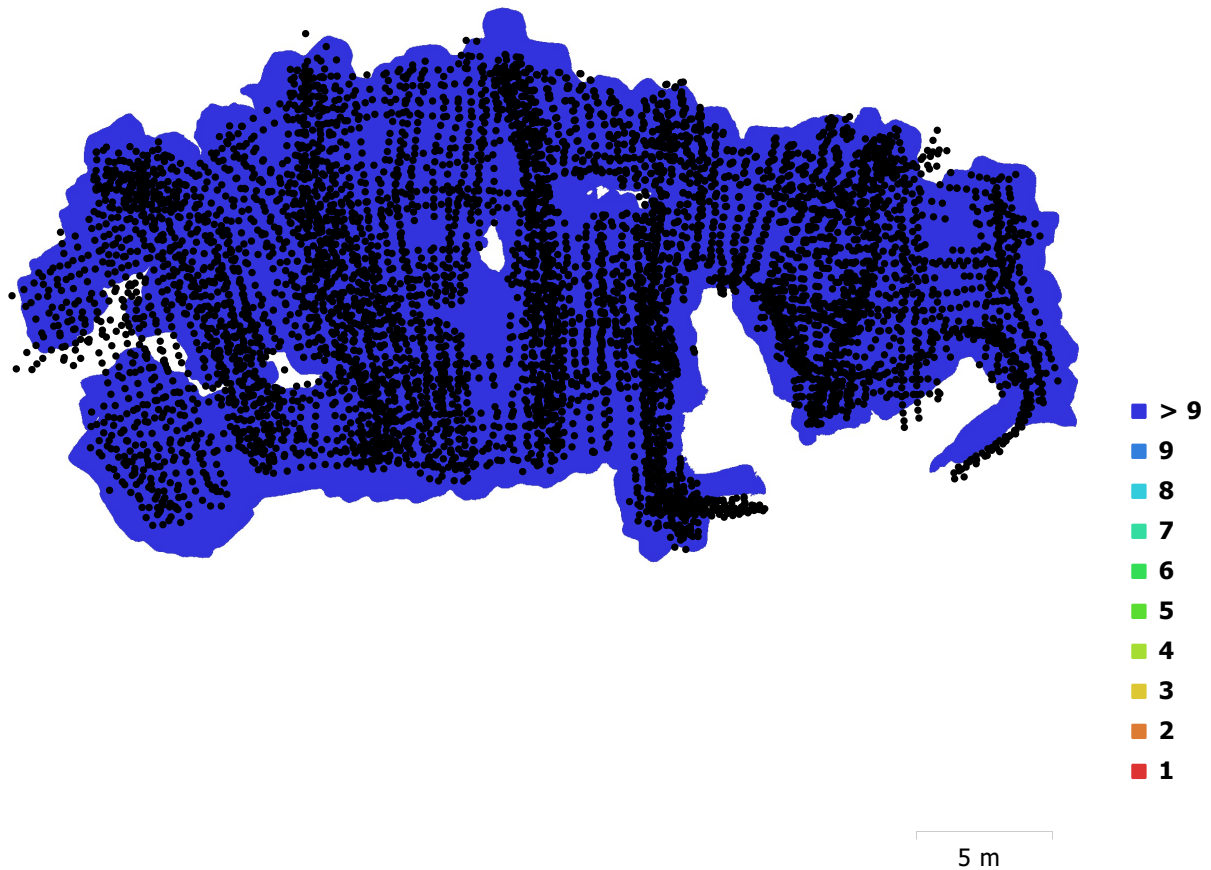


Fig. 1. Camera locations and image overlap.

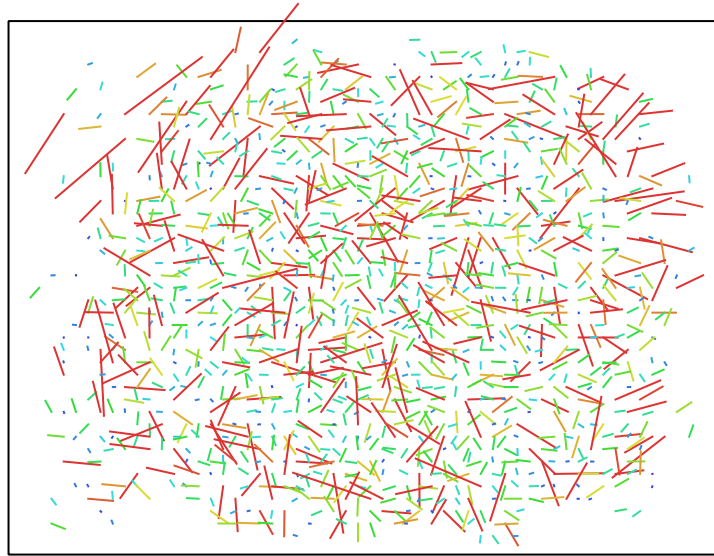
Number of images:	10,974	Camera stations:	7,373
Flying altitude:	1.32 m	Tie points:	599,653
Ground resolution:	0.595 mm/pix	Projections:	1,467,962
Coverage area:	495 m ²	Reprojection error:	4.21 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
HERO4 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μ m	Yes
HERO5 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μ m	Yes
HERO4 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μ m	Yes

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
HERO5 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO4 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO5 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO4 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO5 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO4 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes
HERO5 Black (3 mm)	4000 x 3000	3 mm	1.73 x 1.73 μm	Yes

Table 1. Cameras.

Camera Calibration



13 pix

Fig. 2. Image residuals for HERO4 Black (3 mm).

HERO4 Black (3 mm)

114 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	1733.44		
Cx:	0	B1:	0
Cy:	0	B2:	0
K1:	0	P1:	-0.00370723
K2:	0	P2:	-0.00751168
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

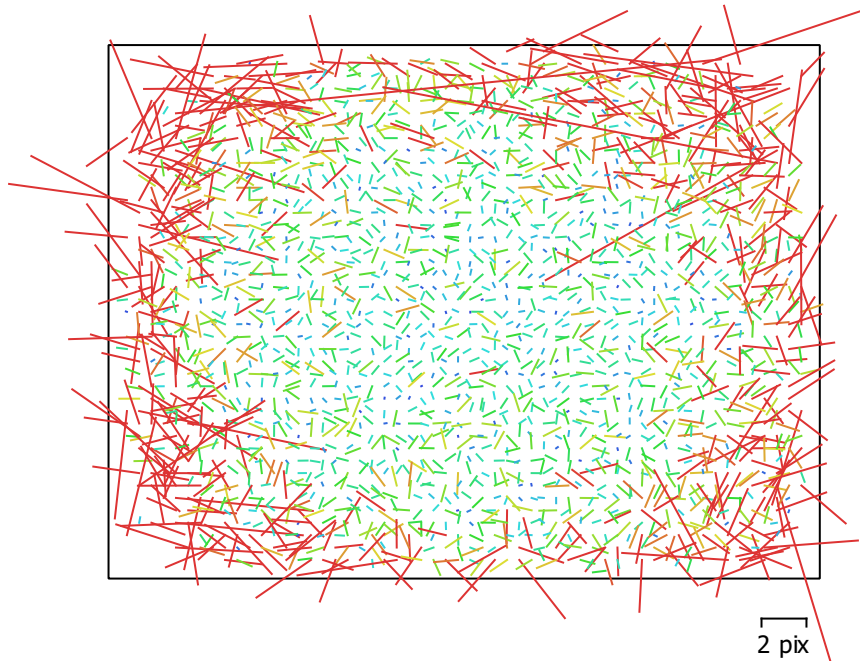


Fig. 3. Image residuals for HERO5 Black (3 mm).

HERO5 Black (3 mm)

923 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	2316.57		
Cx:	6.06642	B1:	-9.75926
Cy:	-11.883	B2:	-0.281612
K1:	-0.0980876	P1:	-0.00104505
K2:	0.0958929	P2:	-0.00318066
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

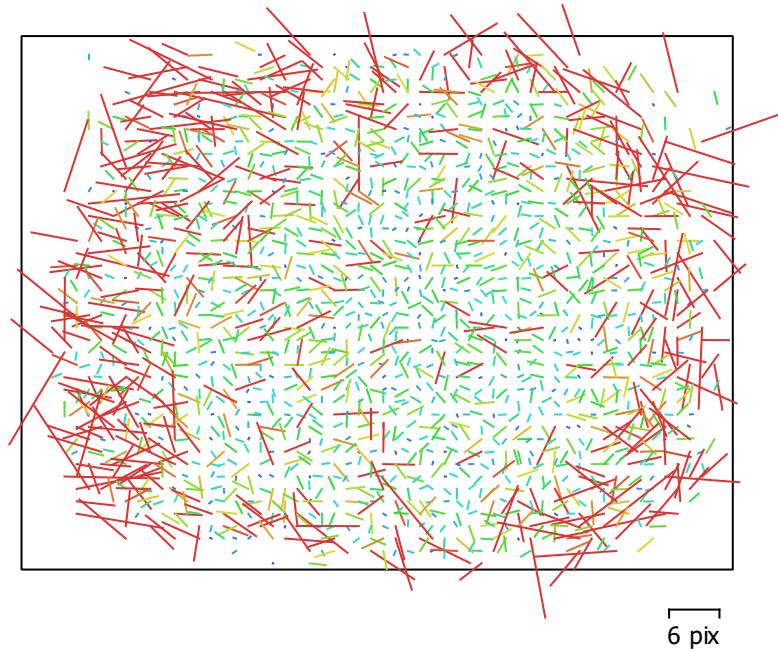


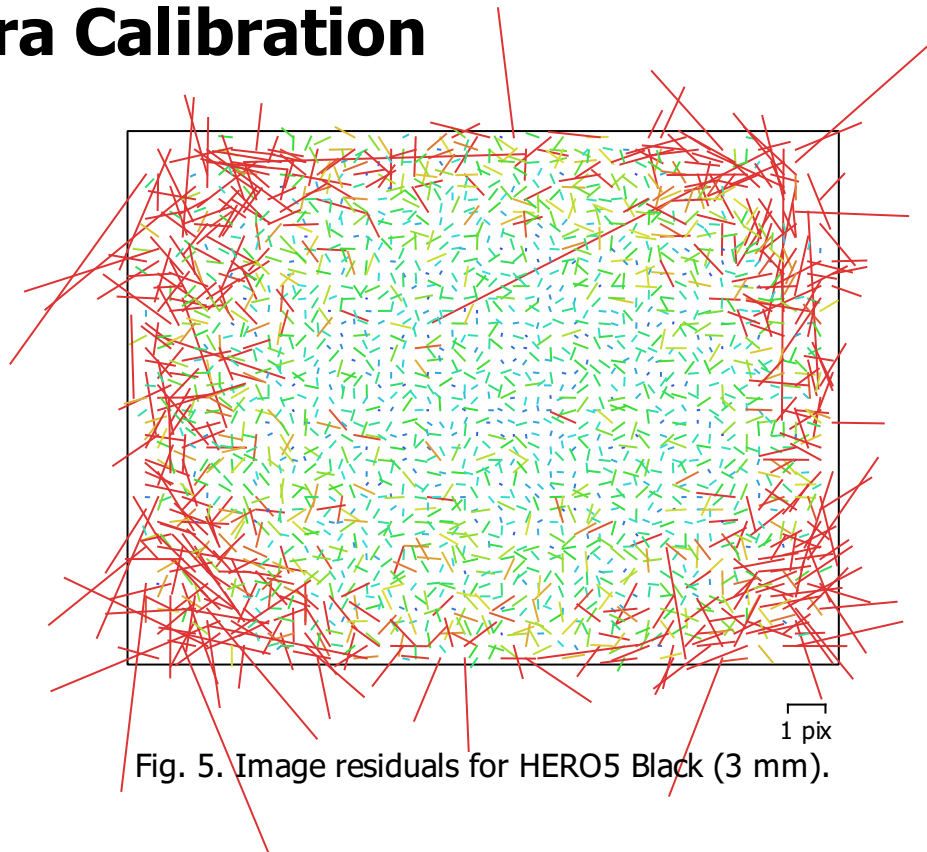
Fig. 4. Image residuals for HERO4 Black (3 mm).

HERO4 Black (3 mm)

113 images, precalibrated

Type Frame	Resolution 4000 x 3000	Focal Length 3 mm	Pixel Size 1.73 x 1.73 μm
F:	1733.44		
Cx:	0	B1:	0
Cy:	0	B2:	0
K1:	0	P1:	-0.00370723
K2:	0	P2:	-0.00751168
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration



HERO5 Black (3 mm)

1012 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	2316.57		
Cx:	6.06642	B1:	-9.75926
Cy:	-11.883	B2:	-0.281612
K1:	-0.0980876	P1:	-0.00104505
K2:	0.0958929	P2:	-0.00318066
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

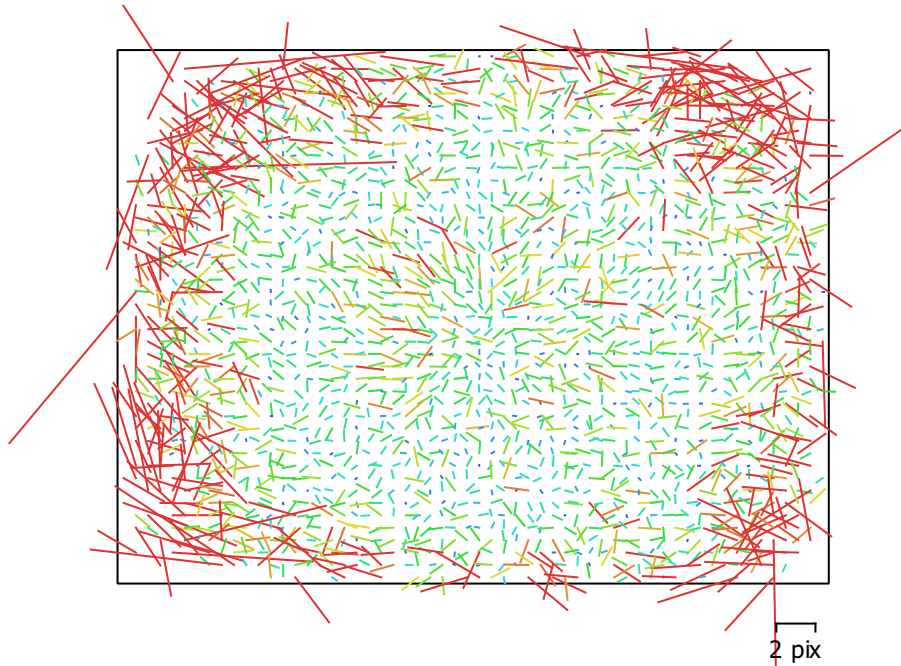


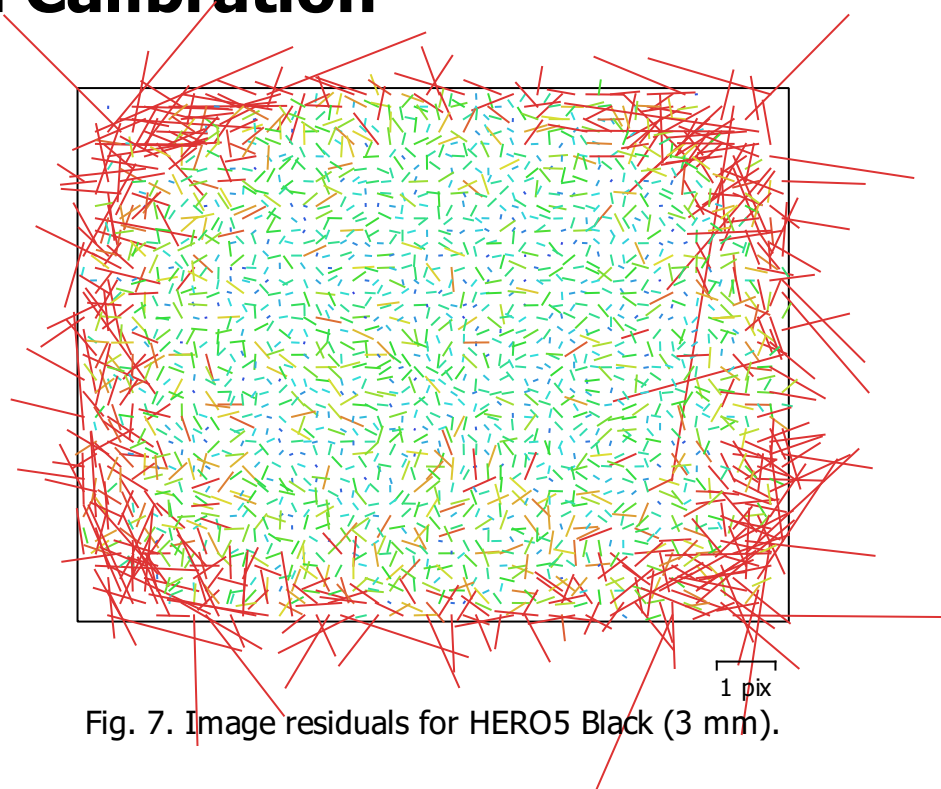
Fig. 6. Image residuals for HERO4 Black (3 mm).

HERO4 Black (3 mm)

1035 images, precalibrated

Type Frame	Resolution 4000 x 3000	Focal Length 3 mm	Pixel Size 1.73 x 1.73 μm
F:	1733.44		
Cx:	45.5075	B1:	0
Cy:	128.048	B2:	0
K1:	0	P1:	-0.00370723
K2:	0	P2:	-0.00751168
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration



HERO5 Black (3 mm)

2268 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	2316.57		
Cx:	6.06642	B1:	-6.11505
Cy:	-11.883	B2:	-0.281612
K1:	-0.0980876	P1:	-0.000884815
K2:	0.0958929	P2:	-0.00162389
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

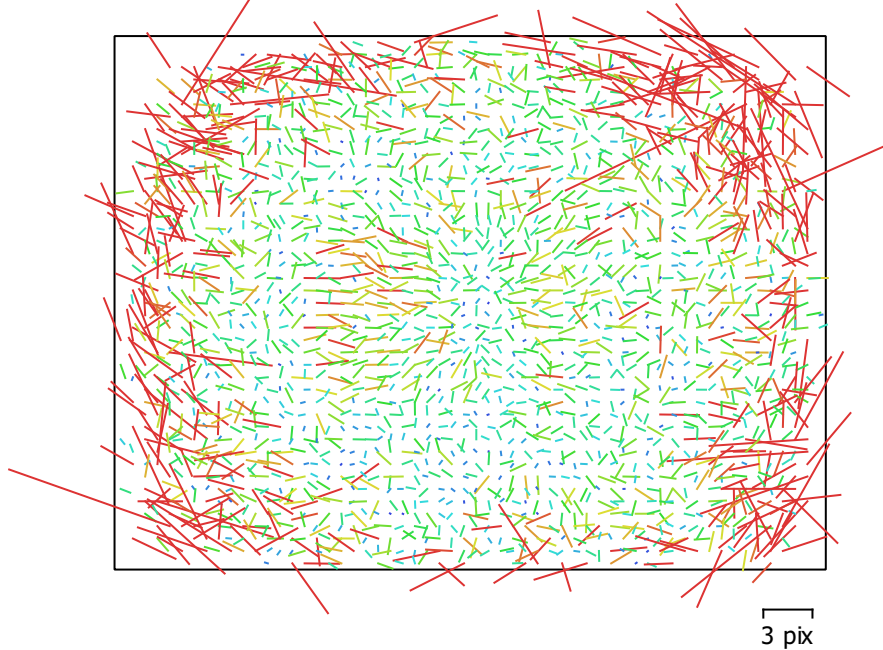


Fig. 8. Image residuals for HERO4 Black (3 mm).

HERO4 Black (3 mm)

844 images, precalibrated

Type Frame	Resolution 4000 x 3000	Focal Length 3 mm	Pixel Size 1.73 x 1.73 μm
F:	1733.44		
Cx:	0	B1:	0
Cy:	0	B2:	0
K1:	0	P1:	-0.00370723
K2:	0	P2:	-0.00751168
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

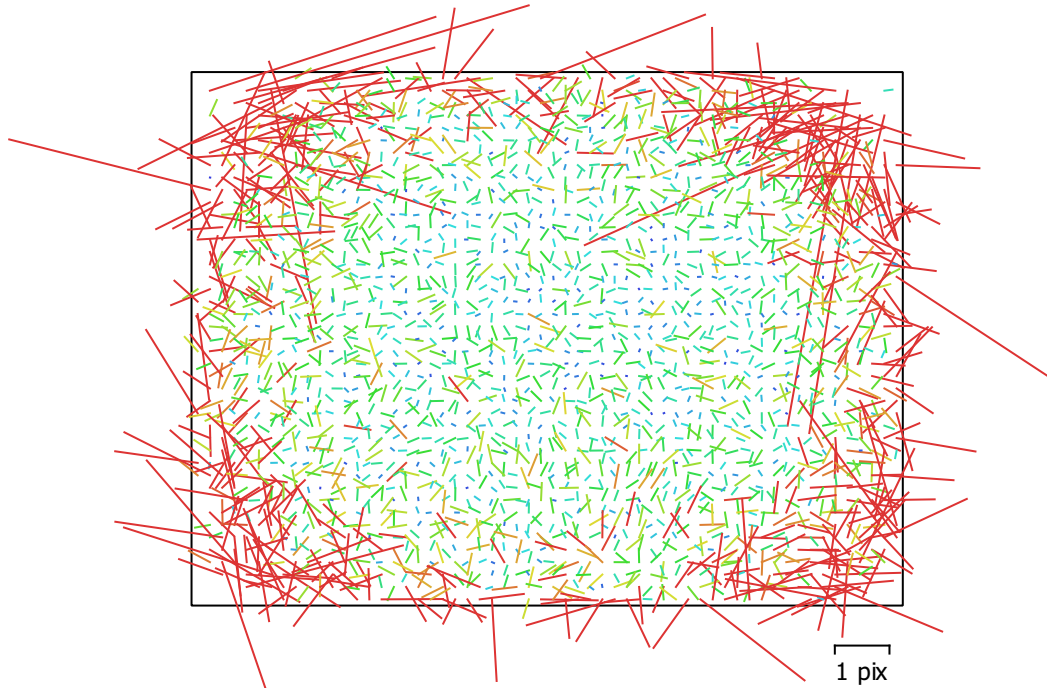


Fig. 9. Image residuals for HERO5 Black (3 mm).

HERO5 Black (3 mm)

2027 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	2316.57		
Cx:	6.06642	B1:	-9.75926
Cy:	-11.883	B2:	-0.281612
K1:	-0.0980876	P1:	-0.00104505
K2:	0.0958929	P2:	-0.00318066
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

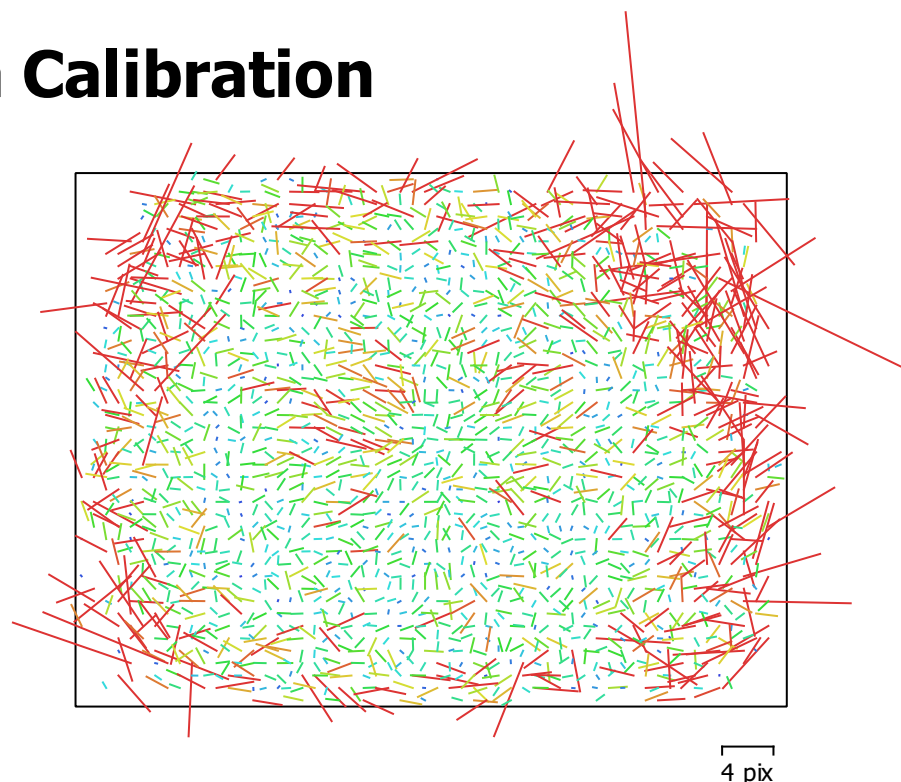


Fig. 10. Image residuals for HERO4 Black (3 mm).

HERO4 Black (3 mm)

318 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	1733.44		
Cx:	0	B1:	0
Cy:	0	B2:	0
K1:	0	P1:	-0.00370723
K2:	0	P2:	-0.00751168
K3:	0	P3:	0
K4:	0	P4:	0

Camera Calibration

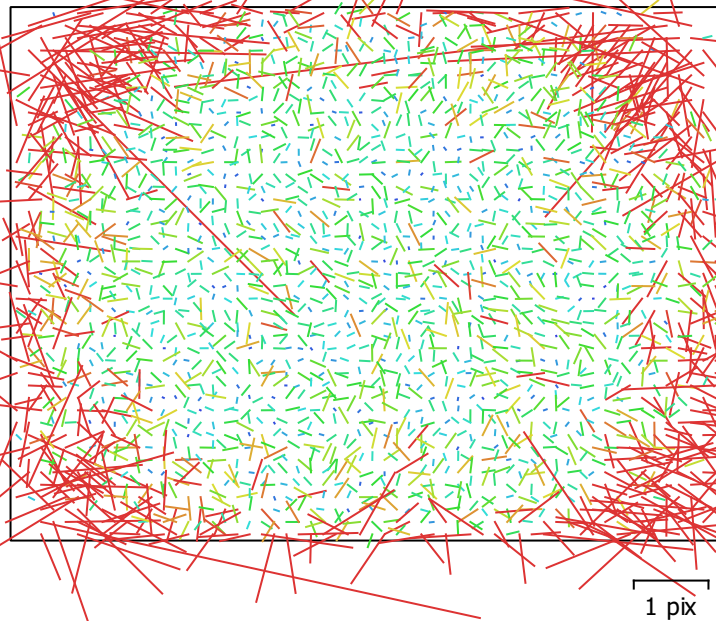


Fig. 11. Image residuals for HERO5 Black (3 mm).

HERO5 Black (3 mm)

2320 images, precalibrated

Type	Resolution	Focal Length	Pixel Size
Frame	4000 x 3000	3 mm	1.73 x 1.73 μm
F:	2316.57		
Cx:	6.06642	B1:	-11.493
Cy:	-11.883	B2:	-0.281612
K1:	-0.0980876	P1:	-0.00107156
K2:	0.0958929	P2:	-0.00327864
K3:	0	P3:	0
K4:	0	P4:	0

Scale Bars

Label	Distance (m)	Error (m)
c1-c2:1_c1-c2:2	0.996789	-0.00321095
c4-c5:2_c4-c5:1	1.00319	0.00318931
Total		0.00320015

Table 2. Control scale bars.

Digital Elevation Model

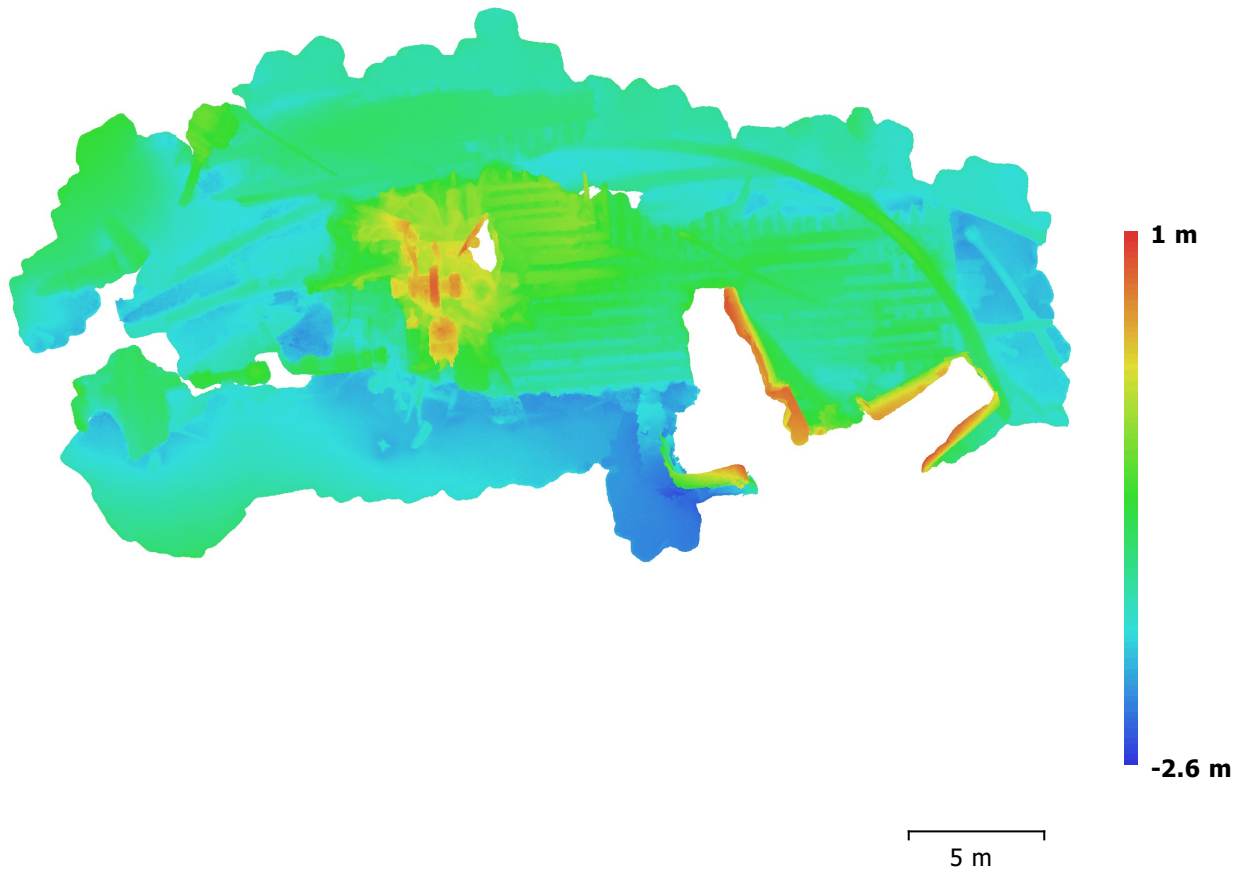


Fig. 12. Reconstructed digital elevation model.

Resolution: unknown
Point density: unknown

Processing Parameters

General

Cameras	10974
Aligned cameras	7373
Markers	19
Scale bars	2
Coordinate system	Local Coordinates (m)
Rotation angles	Yaw, Pitch, Roll

Point Cloud

Points	599,653 of 2,334,973
RMS reprojection error	0.247884 (4.2062 pix)
Max reprojection error	0.805858 (62.2897 pix)
Mean key point size	16.0554 pix
Effective overlap	2.39764

Dense Point Cloud

Points	57,300,218
--------	------------

Reconstruction parameters

Quality	Low
Depth filtering	Aggressive

Model

Faces	4,000,000
Vertices	2,003,539
Texture	4,096 x 4,096 x 8, uint8

Reconstruction parameters

Surface type	Arbitrary
Source data	Dense
Interpolation	Enabled
Quality	Low
Depth filtering	Aggressive
Face count	11,460,043
Processing time	49 minutes 49 seconds

Texturing parameters

Mapping mode	Generic
Blending mode	Mosaic
Texture size	4,096 x 4,096
Enable color correction	No
Enable hole filling	Yes
UV mapping time	2 minutes 48 seconds
Blending time	1 hours 10 minutes

Software

Version	1.3.4 build 5067
Platform	Windows 64

Works Cited

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UNDERWATER SCIENCE

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