A. COVER PAGE

Project Title: Improving vessel equipment: evaluating fishermen-led safety design ideas in the Dungeness crab fleet	
Grant Number: 1U01 OH011927-01	**Project/Grant Period**: 09/01/2019 - 08/31/2022
Reporting Period: 09/01/2019 - 08/31/2022	**Date Submitted**: 11/15/2022
Program Director/ Principal Investigator JEONG HO KIM, PHD Phone number: 541-737-2166 Email: jay.kim@oregonstate.edu	**Administrative Official Information** CINDY L TAITWITHROW 312 Kerr Administration Building Corvallis, OR 973312140 Phone number: 541-737-4933 Email: cindy.tait-withrow@oregonstate.edu
Change of Contact PD/PI: N/A	
Human Subjects: Yes	**Vertebrate Animals: No**
hESC: No	**Inventions/Patents: No**

B. ACCOMPLISHMENTS

B.1. What are the major goals of the project?

The West Coast Dungeness crab fleet suffers from a high incident rate and prevalence of both fatal and non-fatal injuries and is considered one of the highest-risk commercial fishing fleets in the US. Our recent NIOSH-funded study [1], the Fishermen Led Injury Prevention Program (FLIPP), indicates the significance of nonfatal injuries among this commercial fishing fleet. The FLIPP survey showed that the majority of limiting nonfatal injuries (88%) occurred with deckhands and that the most common injuries were sprains and strains (36%). Most of these injuries were associated with handling, hauling, and setting crab pots (72%), which posed forceful exertions, awkward postures, and repetitive motions [2]. Moreover, these physical risk factors could potentially increase fall risks (potentially falls overboard, which are a major source of fatal injuries in commercial fishing) as muscular fatigue is known to increase a risk of fall [3-12]. Previous studies have focused on fatality prevention while non-fatal injuries, and especially musculoskeletal disorders, have been understudied. There is a critical need to evaluate risks for non-fatal injuries and potential injury prevention measures.

Feedback collected in FLIPP [13, 14] provided an idea for an engineering control to reduce the aforementioned physical risk factors related to handling crab pots. This fishermen-led engineering control referred to as a “banger bar” adds padding and a bar to the sorting table so that a retrieved pot can be tipped and banged against it to release the crab. Its primary potential benefits include reduction of awkward postures, forceful exertions, and repetitive motions. Moreover, this engineering control could potentially lower fall risks. Despite the potential benefits, this engineering control might affect productivity and introduce other potential risks such as pinch point hazards. However, we do not have scientific evidence on the efficacy of the engineering control (i.e., banger bar) in reducing the physical risk factors and fall risks during handling crab pots during harvesting.

To fill this critical research gap, our objectives are to quantify the impact of crab pot handling on biomechanical risk and postural balance (fall risk), understand how this impact can be mitigated by the engineering control (i.e., banger bar), and identify the factors related to designing for broad use since all vessels, decks and sorting tables vary in design and size. The anticipated impact of this research is the improvement of commercial fishermen’s occupational health and safety by reducing physical risk factors and related non-fatal injuries (musculoskeletal disorders) and fatality (fall-related injuries), which also addresses and supports the current NOFO purpose and NORA priorities.

To achieve our research objectives, we propose the following specific aims:

Aim 1. Characterize the current vessel environment, crab pot manual handling activity, standard work practice, and anthropometry of pacific northwest crab fishermen. By building on the existing data collected from the FLIPP study and completing field studies, we will 1) characterize vessels, crab sorting tables, banger bars, blocks (cranes on vessel), and crab pots to document the distribution of their characteristics, 2) document standard work practices (the frequency and duty cycle of tasks, and fishermen’s body postures) during crab pot manual handing activity, and 3) collect anthropometric data and grip strength of crab fishermen. In addition, these field studies can be used to identify other safety features or equipment used on deck.

Aim 2: Characterize the biomechanical and fall risk during simulated crab harvesting tasks and evaluate the efficacy of a fishermen-led engineering control in reducing the biomechanical and fall risks. In a repeated-measures laboratory experiment with 25 subjects, we will 1) characterize the biomechanical (hand pull force, joint torque and muscle activity in the upper extremity and low back, and the subjective rating of exertion) and fall risk (postural balance) during simulated crab harvesting tasks, and 2) evaluate the efficacy of a fishermen-led engineering control (i.e., banger bar) by comparing the biomechanical and fall risk measures between the crab harvesting tasks with and without the engineering control.

B.2. What did you accomplish under these goals?

We successfully accomplished the specific aims of the project. This project objectively characterized and documented the current vessel environment and job characteristics. In addition, this project quantified biomechanical and fall risk associated with crab harvesting and evaluated the efficacy of banger bars in reducing the injury risks. The study results have been actively dissimilated through OSU websites, meetings with fishermen, and OSU Sea Grant offices. Detailed accomplishments are summarized by aim:

1) Major Activities accomplished

Aim 1

- **Vessel measurements**
  - We completed 13 vessel measurement to characterize vessels, crab sorting tables, banger bars, blocks (cranes on vessel), and crab pots to document the distribution of their characteristics.
  - We summarized the results based on 13 measurements, which were used for Aim 2.
- **Structured interview**
  - We conducted the structured interviews and anthropometric/grip strength measurements from 24 commercial Dungeness Crab fishermen.
  - We summarized the results based on 24 measurements, which were used for Aim 2.
- **The feasibility study using wearable sensors to document work practice**
  - We completed this feasibility study with a total of 11 commercial Dungeness Crab fishermen.
  - We demonstrated that objective ergonomic assessments are feasible through wearable sensors to characterize the crab harvesting tasks.
- **r2P**
  - The sensor data results were disseminated to the participants via a newsletter with aggregated results mailed to them with the opportunity to discuss results with the study team. Additionally, the newsletter was shared through the OSU website (https://health.oregonstate.edu/labs/oeb/research/commercial-fishing), conference presentations, and a peer-reviewed journal article.

Aim 2

- **Laboratory study**
  - Working with professional commercial fishermen and a local fabricator, we successfully built a research environment allowing realistic commercial fishing task simulation and objective biomechanical risk assessment with various bioinstruments (e.g., 3-D motion capture, electromyography, load cells, and force plates). This research setup can be used for future studies.
  - With 25 participants, we characterized biomechanical loads in the low back, shoulders, and upper extremities, and measured postural instability during a Dungeness crab harvesting task. With these measures, the efficacy of a fishermen-developed ergonomic control (banger bar) in mitigating the physical risk factors was evaluated.
  - We demonstrated that the ergonomic control substantially reduced the low back and shoulder joint angles and moments, muscle activities in low back, shoulders, upper extremities, perceived exertion ratings, and postural sway measures.
  - The results also showed that the increased height of the bar substantially improved these biomechanical and postural sway measures.
- **r2P**
  - The study results were aggregated and refined into a one-page infographic. This was disseminated to commercial fishermen through commodity and fishermen meetings in the region and shared with an expert pool of fishermen and fabricators. A Fishermen's News article has been submitted for future publication in

this lay journal. These results will continue to be shared at events in our region and through our training of fishermen. Additionally, the study results were disseminated via the OSU website (https://health.oregonstate.edu/labs/oeb/research/commercial-fishing), conference presentations, and a peer-reviewed journal article (under review).

B.3. Competitive Revisions/Administrative Supplements

N/A

B.4. What opportunities for training and professional development did the project provide?

This project provided two graduate students with opportunities to learn and develop biomechanical modeling skills while developing biomechanical models to quantify the physical risks associated with musculoskeletal disorders during commercial crab harvesting tasks.

B.5. How did you disseminate the results to communities of interest?

We developed and shared brief reports via printed and online flyers based on the sensor feasibility study (Aim 1) and the laboratory study (Aim 2). We related the results from the fishermen to what we know about ergonomics. These reports were written in plain languages to provide the fishermen:

- the implications of their injury risks in the arms, shoulders, and low back;
- the design recommendations for the banger bars.

While sharing these results with the commercial fishermen community via in-person meetings, we also solicited feedback and questions that we will incorporate to our future work. This result has also been posted on our study website: https://health.oregonstate.edu/labs/oeb/research/commercial-fishing. Lastly, the study results have been also disseminated via 2 conference presentations and 2 peer-reviewed journal articles (one published in Agromedicine*; one under review in Applied Ergonomics).

* PMID: 35440281

B.6 - What do you plan to do during the next reporting period to accomplish the goals?

N/A

C. PRODUCTS

C.1. Publications, conference papers, and presentations

1. Kim JH, Vaughan A, Kincl L (2022) Characterization of musculoskeletal injury risk in Dungeness crab fishing, *Journal of Agromedicine.* PMID: 35440281
2. Kia, K, Kincl L, Chen A, Kim JH (under review) A Fishermen-developed Intervention Reduced Musculoskeletal Load Associated with Commercial Dungeness Crab Harvesting, *Applied Ergonomic*
3. Kia K*, Laurel K, **Kim JH** (2022) Evaluation of an Ergonomic Intervention Demonstrates Reduced Low Back Loads Associated with Commercial Dungeness Crab Harvesting. 2022 International Meeting of the Human Factors & Ergonomics Society. Atlanta, GA
4. Kia K*, Laurel K, **Kim JH** (2022) Effects of an ergonomic intervention on biomechanical stress during a simulated commercial fishing task. Ergonomics Society of Korea Meeting. Seoul, Korea.

C.2. Website(s) or other Internet site(s) – include URL(s)

https://health.oregonstate.edu/labs/oeb/research/commercial-fishing
https://health.oregonstate.edu/labs/osh/research/commercial-fishing-safety

C.3. Technologies or techniques

NOTHING TO REPORT

C.4. Inventions, patent applications, and/or licenses

NOTHING TO REPORT

C.5. Other products and resource sharing

Two additional briefs have been developed and will be shared via the Oregon Sea Grant.

D. PARTICIPANTS

D.1. What individuals have worked on the project? Please include calendar, academic, and summer months.

Commons ID	S/K	Name	Degrees(s)	Role	Cal	Aca	Sum	Foreign	Country	SS
JAYKIM	Y	Kim, Jeong Ho	PhD	PD/PI	0.0	4.5	1.5			NA
LKINCL06	Y	Kincl, Laurel	PhD	Co-PI	0.0	4.5	0.4			NA
	N	Vaughan, Amelia	MLIS	Project manager	1.8	0.0	0.0			NA
	N	Kia, Kiana	MS	Graduate student	11.5	0.0	0.0			NA
	N	Bunnell, Justin	MPH	Graduate student	0.5	0.0	0.0			

D.2 Personnel updates

a. Level of Effort: No
b. New Senior/Key Personnel: No
c. Changes in Other Support: No
d. New Other Significant Contributors: No

E. IMPACT

E.1 - What is the impact on the development of human resources, if applicable?

This project provided graduate students with opportunities to develop their communication skills by developing dissemination materials including briefs, newsletters, conference proceedings, and peer-review journal articles as well as attending and presenting an international scientific conference.

E.2 - What is the impact the Public Health Relevance and Impact? The investigator should address how the findings of the project relate beyond the immediate study to improved practices, prevention or intervention techniques, legislation, policy, or use of technology in public health.

The impact of this project is three-fold:

1. It proved the feasibility of objective risk assessment using wearable sensors for commercial fishermen.
2. It increased the awareness of physical risk factors and non-fatal injury risks associated with commercial Dungeness crab harvesting.
3. It provided scientific evidence on the effectiveness of the banger bars and design recommendations.

F. CHANGES

F.1 - Changes in approach and reasons for change, including changes that have a significant impact on expenditures

No Change

F.2 - Actual or anticipated challenges or delays and actions or plans to resolve them

The current COVID-19 pandemic significantly affected this research, stopping short some of the data collection activities for the Aim1 and potentially will delay data collection for Aim 2. While complying with the guidelines from CDC, local health authorities and Oregon State University, we minimized the impact of this pandemic on this project and therefore successfully completed the project.

F.3 - Significant changes to human subjects, vertebrate animals, biohazards, and/or select agents

No Change