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An ergonomic assessment of small boat lobster fishing.

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An Ergonomic Assessment of Small Boat Lobster Fishing

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ABSTRACT

Fishing is a high-risk occupation: one of these risks is the high frequency of work-related musculoskeletal injury. While the industry is regulated world-wide, the safety focus is on larger fishing vessels, which is significant given that the vast majority of commercial fishing is carried out by crews using smaller vessels. There is also very little research investigating the impact of such activity on the health and wellbeing of small boat fishers. Given that such operations are less industrialised and involve strenuous physical labour over long hours, this area deserves further study. This paper describes a case study of small boat lobster fishing off the North East coast of Scotland. A flexible approach combined task and postural analysis with qualitative data, identifying task elements posing particular risks to musculoskeletal health and suggesting strategies for risk reduction.

KEYWORDS

Small boat lobster fishing; OWAS; REBA; RULA; Strain Index

Introduction

Fishing is a high-risk occupation, often ranking highest in terms of fatality rate (Fulmer and Buchholz, 2002; Davis, 2012). The situation with regard to non-fatal work-related injury is less clear – some studies suggest accuracy of injury rates is confounded by under-reporting (Fulmer and Buchholz, 2002). Many fishers are self-employed, remuneration is based on the catch size and work is seasonal, meaning injury can be costly. Fishers are less likely to seek medical care and/or take time off to recover, meaning these injuries often go unrecorded (Marshall et al., 2004). This is compounded by attitudes to risk: Evidence (summarised in Davis, 2012) suggests fishers tend to come from families with a strong fishing heritage. Experiences are shared within such communities, including a ‘survival folklore’ that leads to trivialisation of risk. Risk aversion correlates negatively with financial reward, and the combination of these factors seems to result in the self-selection of ‘adventurous’ personality types likely to downplay injury as a normal outcome.

The term ‘fishing industry’ covers commercial operations ranging from highly mechanised large ocean-going vessels to single crew independent operators. Existing literature focuses mainly on deep sea and large scale industrialised operations (Marshall et al., 2004). Small-scale independent fishers tend to be less industrialised, fish in coastal areas and inland waterways, and are exposed to strenuous physical labour over long hours (Dabholkar et al., 2004). They are less likely to take a standardised approach – methods are personal, mixing modern and traditional techniques. Small fishing boat safety is not helped by a complex regulatory picture. Larger vessels (>24m) must comply with the International Management Code for the Safe Operation of Ships (Storkersen et al.,

2017) which requires operators to have a safety management system in place. There is no such requirement for smaller vessels and while guidance exists, few countries have made this mandatory. Where national policy exists, lack of inspection capability makes enforcement challenging (Thorvaldsen, 2015). Given that small-scale operators account for the majority of fishing activity, their absence from both regulation and the literature is a concern.

Safety developments across the industry have centred primarily on the seaworthiness of vessels and the prevention of major incidents, ignoring the fact that much of the risk to fishers relates to cumulative effects of repetitive, physically demanding activity carried out in restricted spaces under challenging environmental conditions. Musculoskeletal disorders are common, reflecting the high manual handling activity. The lower back and upper limbs are vulnerable, but knee injuries are also common, largely resulting from attempts to stay upright in a moving environment (Kaerlev et al., 2008). Ergonomic approaches to identifying and reducing exposure to high-risk elements of work processes provide opportunities for making work safer (Jezewska et al., 2011). Data from multiple sources allow modelling of the work system, supporting adaptation of system elements (eg. equipment and task design) and improving the relationship between work demands and worker capabilities. In addition to variation in working (and regulatory) environments between operators, the physical demands also vary with the type of catch as this determines the techniques used. Context is critical and there is a need to explore working practices across a range of settings.

The majority of commercial lobster fishing involves creel fishing or 'potting.' Creels (pots) are cages formed from plastic-coated tubular metal covered in netting and are baited and dropped to the seabed to 'soak.' Lobsters enter the pot through netted tunnels at each end. When the vessel returns, creels are lifted to the surface, and the contents removed alive and undamaged. Females with eggs or undersized lobsters can be returned to the water without damage, making creel fishing environmentally sustainable. The small size of the boats - combined with operating close to shore – means the carbon footprint is small and profitability good. It makes economic sense to optimise lobster fishing system outcomes, including improving the health and wellbeing of lobster fishers. This research is also timely in that the current financial and political environment has resulted in lower seafood prices, while fuel costs have significantly increased, threatening the profitability. This may be further exacerbated by the UK's departure from the European Union, which is likely to result in barriers (physical borders *and* trade tariffs) to export. Improving health and wellbeing may result in fewer fishing days lost to injury, and therefore protect profitability.

A case study approach was selected: such studies explore a specific contemporary phenomenon from within its real-life context, allowing the investigator to go into considerable depth. It is also true that an individual vessel can be viewed as an organisation in its own right. This is particularly appropriate in ergonomics – an in-depth exploration of one specific work system supports optimisation of that system, but also contributes to the body of research knowledge as generalisations may be possible. This case explored the creel-fishing practices of a 46-year –old male with 15 years' experience working single crew on a 6m vessel out of Portsoy harbour in the North East of Scotland. The study focussed on a physical assessment of the demands of lobster fishing activities. The aim was to use direct observation and postural analysis, combined with qualitative data, to identify high-risk activities and suggest appropriate risk-reduction interventions.

Methods

While a single case study approach was selected for this investigation, it was recognised that risk perception is sociocultural. Fishing practices are deeply influenced by social norms, being heavily based on traditional views of acceptable practice (Thorvaldsen, 2013). Consequently, a questionnaire was designed by an expert panel to capture a mixture of quantitative and qualitative data. Questions covered frequency and duration of fishing activities, but also included open text-boxes inviting participants to describe their own techniques. Questions also covered injury incidence, and there was space for respondents to include suggestions for task improvement. Resultant qualitative data was thematically analysed (initial open codes were grouped into axial codes and then themes). *Sampling*: a 'snowball' approach was taken – the first participant was known to one of the researchers, and he suggested potential participants. *Inclusion criteria*: registered creel-fishers based in NE Scotland engaged in hauling lobster pots in <10m vessel coastal fishery. *Exclusion criteria*: those not currently active. Participants received a questionnaire, information leaflet (including consent form) and a stamped, addressed envelope to allow anonymous return of the questionnaire. The total number of respondents was 5. The selection of a subject for the case study was opportunistic – one had a Go-Pro Hero 4 camera fixed to his vessel for recording fishing activity, providing many hours of footage for the researchers to use with minimal personal risk. Ethical approval was obtained from the School Ethics Committee.

Task analysis: Hierarchical task analysis is based upon a theory of performance, providing an efficient way of expressing how work organisation allows system goals to be met (Kirwan and Ainsworth, 1992). It involves decomposing tasks into smaller operations allowing identification of possible sources of performance failure, which can be targeted for improvement. Hierarchical task analysis diagrams for lobster fishing were constructed according to Stanton (2006).

Physical assessment: There are methods that directly measure muscular effort or resultant physical effects but these have limited use in the field. Interpretative methods are commonly used, including postural analysis. Ovako Working posture Assessment System (OWAS), Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA) and Strain Index (SI), all involve direct observation of recorded postures (Rucker and Moore, 2002; David, 2005; Kee and Lee, 2012). In selecting methods users should consider:

- All methods have face validity (other validity measures are limited)
- Methods are only partly correlated (consider using more than one)
- Methods employ subjective ratings which can be supported by quantitative data: reported 'discomfort' strongly correlates with e.g. spinal compressive loading (Chung et al., 2005)
- OWAS has high generability, but low sensitivity (Hignett and McAtamney, 2000 and 2006). Consequently, high OWAS scores are worthy of further investigation
- OWAS is time-driven and is the simplest technique (can be used as a filter)
- RULA is an upper limb assessment – use REBA to capture whole body postural load
- REBA takes into account unpredictable loads with moving centres of gravity
- SI captures task demands by combining postural analysis with other indices of effort (e.g. duration/intensity). Intensity is subjective, relying on observations such as facial expression

Taking into account all these considerations, it was decided to use OWAS as a filter, selecting stills from the video footage at 15-second intervals (e.g. Figure 1) and selecting the highest scoring postures for further analysis with REBA and RULA (Hignett and McAtamney, 2006) as well as SI (Rucker and Moore, 2002). All methods measure postural deviations from neutral. The best camera angle is thus perpendicular to the plane in which the deviation occurs. Consequently, intermediate angles are best for capturing deviations in multiple planes, but as this may impact on apparent angles, additional information from the observer is important. This was obtained by viewing the footage with the participant and seeking further clarification where necessary. This also allowed the participant to comment on his perception of discomfort in relation to specific postures.

Figure 1: Exemplar still from video footage

Postural analysis was carried out by one researcher (AD) and validated by a second researcher (HV). Posture is not only influenced by the task demands, but also physical environment in which the task is carried out. Consequently, the workspaces on the boat were mapped to display the different areas of work.

Results

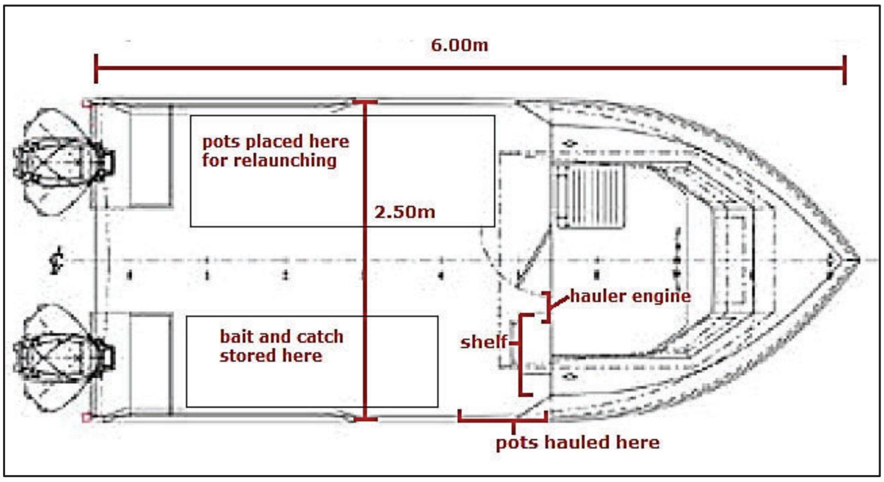

Figure 2: Mapping of the work environment. It can be seen that the work space is very small. During fishing, much of the available space is taken up either by the lobster pots themselves or by the catch store (Figure 1). Lobster creels are hauled onto the boat, and the railings make this more challenging.

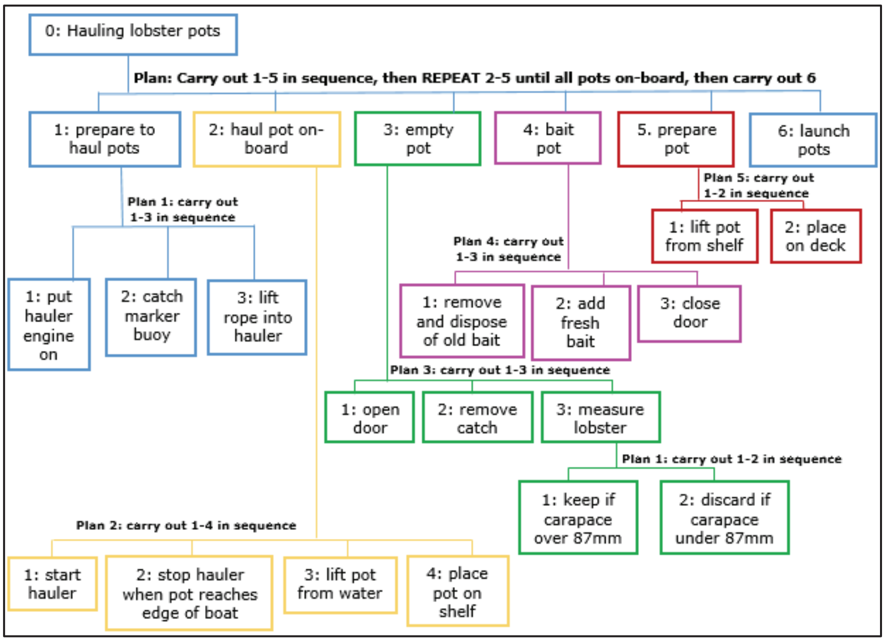

Figure 3: the task analysis for the main fishing task of hauling and re-setting creels. There are two techniques for setting lobster pots. ‘Singles’ involve a single pot attached to a buoy, while ‘trawls’ have multiple pots attached to a line. This case study involved trawl setting. Particularly high joint torques are exerted by the trawl method, as lifting the pot from the water involves taking some of the load of the whole line.

Postural analysis: Images were analysed by OWAS. Those scoring 4 (high risk, correction required immediately) were analysed further. The associated task elements are shown in **Table 1**.

Table 1: Task elements associated with an OWAS score of 4.

Image number	Task element
1	Catching marker buoy
19	Lifting pot from water and placing on shelf
20	Placing pot on deck
26	Removing catch
57	Disposing of old bait
74	Putting hauler engine on

Individual body segment scores suggested risk arises from hip flexion, back twisting, unstable weight bearing and upper limb position. REBA, RULA and SI scores were calculated (**Tables 2-3**).

Table 2: Action required for each image analysed by REBA and RULA using REBA and RULA scores and action levels respectively.

Image number	REBA score	Action level	RULA Score	Action level	Action
1	12	4	7	4	Necessary now/Change required immediately
19	11	4	7	4	Necessary now/Change required immediately
20	11	4	7	4	Necessary now/Change required immediately
26	11	4	7	4	Necessary now/Change required immediately
57	11	4	6	3	Necessary now/Change required immediately
74	12	4	7	4	Necessary now/Change required immediately

Table 3: Strain index. Information about duration and intensity were derived from video footage.

Image number	Task	Strain Index score	Rating of task
1	Catching marker buoy	13.5	Job is probably hazardous
19	Lifting pot from water	13.5	Job is probably hazardous
20	Placing pot on deck	4.5	Increased risk of distal upper extremity disorders
26	Removing catch	10.1	Job is probably hazardous
57	Disposing of old bait	4.5	Increased risk of distal upper extremity disorders
74	Putting hauler engine on	14.6	Job is probably hazardous

Questionnaire: 5 questionnaires were completed, out of 7 distributed (return rate = 71%). All respondents were male (age 26–73 years old: mean = 52.8). The majority (60%) participated in hauling lobster pots 3-6 times a week. The number of pots pulled per trip varied from 41-200. Each trip lasted 3-6 hours (average = 4.1). All boats were fitted with hydraulic pot haulers to assist in lifting the pots. Pot weight ranged from 20-40kg (mean = 29kg). All worked as single crew. The main themes identified from qualitative analysis of the questionnaires are summarised below:

Type of injuries experienced: Back pain was prevalent, with 100% of respondents identifying issues, both at work and rest. One fisherman described suffering from narrowing of the nerve root foramen and wear and tear in the lower spine, while another described muscle pain and strain in the lower back. Shoulder pain and knee problems were also identified.

Relationship of injuries with specific task elements: Specific tasks which caused pain were identified by 60% of respondents. Catching the marker buoy was cited by 20% as particularly troublesome, while 40% reported placing the creel on the deck as causing the most discomfort.

The contribution of environmental factors to task demands and injury: All participants stated ‘choppy’ seas made tasks more difficult with increased strain felt due to the need to keep balanced.

Suggestions for reducing task demands: These included an additional crew-member, while design ideas suggested fitting a ‘door’ in the railings at deck level at the point at which creels are hauled onto the boat and fitting a shelf at waist height so that creels do not have to be placed on the deck.

Importance of the affective domain: The task was described as mentally and emotionally challenging, while damaged pots or a poor catch cause frustration. Comments indicated that fishermen love what they do, regardless of the highly demanding nature of the job.

Discussion

Table 4: Comparison of outcomes from postural analysis tools

Task	**Action category/recommendation generated**			
	OWAS	**REBA**	**RULA**	**SI**
Catching marker buoy	Immediate corrective action required	Necessary now	Changes required immediately	Job is probably hazardous
Lifting pot from water to shelf	Immediate corrective action required	Necessary now	Changes required immediately	Job is probably hazardous
Placing pot on deck	Immediate corrective action required	Necessary now	Changes required immediately	Increased risk of distal upper extremity disorders
Reaching into pot to remove catch	Immediate corrective action required	Necessary now	Changes required immediately	Job is probably hazardous
Disposing of old bait	Immediate corrective action required	Necessary now	Changes required soon	Increased risk of distal upper extremity disorders
Putting hauler engine on	Immediate corrective action required	Necessary now	Changes required immediately	Job is probably hazardous

Postural analysis tools

The postural analysis tools show concordance, with all indicating that the 6 tasks (filtered by OWAS) were high risk, requiring immediate intervention. This echoes other studies confirming inter-method reliability (Jones and Kumar 2010). The study size makes it difficult to comment on validity, but qualitative data suggested catching the marker buoy and putting the creel on the deck were task elements workers found particularly uncomfortable, yet did not score significantly differently from other task elements. This lack of apparent discrimination is interesting: the results suggest all task elements analysed are ‘high risk,’ which is perhaps unsurprising, given the high incidence of MSDs reported among fishers (Kaerlev et al., 2008). Having so many high-risk elements suggests the entire process (and the boats) should be re-designed, which may be ineffective given the socio-cultural norms that govern fishing. Workers ‘inherit’ fishing techniques and can be reluctant to change (Davis, 2012). Furthermore, the remuneration model means suggested changes would need a clear commercial advantage *and* be affordable and readily implemented. This is further complicated by attitudes and beliefs - it appears musculoskeletal injury is just one aspect of the job, not necessarily viewed as something which must be avoided:

“Does not matter the pain I go through. Would not want to do anything else. Best job in the world.”

An alternative would be to explore the apparent lack of discrimination provided by existing postural analysis tools. While it could be argued that all these activities are dangerous and need to be changed, it may be there are differences. A tool that dissects high-risk tasks might identify the very highest risk activities allowing modification of existing processes rather than complete re-design. While not ideal, this may be more acceptable. Also, REBA was developed for the healthcare environment, specifically considering the fact that loads may be unstable (Hignett and McAtamney 2000; 2006). No tool takes into account a moving *environment* – in this study, all participants indicated this increased task demands, confirming previous studies. This is particularly problematic for small boats which, unlike larger vessels, do not 'damp' the waves (Fulmer and Buchholz, 2002).

Activities identified as particularly high risk and possible mitigation strategies

Ergonomics is valuable in a setting like this: it recognises workers as the 'experts' - engaging in this way is more likely to yield achievable solutions. While fishers are geographically dispersed, socially they are close-knit, and achievable innovations with a commercial advantage are likely to diffuse rapidly (Marshall et al., 2004). One of the most achievable solutions (both from a cost and a technical perspective) would be the installation of a shelf at waist height, meaning creels do not have to be placed on the deck. Placing the creels on the deck involved trunk twisting, combined with flexion of >60°. Furthermore, the upper arm was typically flexed between and 45 and 90° with the shoulder raised. Addition of the shelf minimises bending and removes the need for the trunk to be twisted and the shoulder to be raised. REBA scoring of a simulated 'improved task' saw the action category reduced from 4 to 2 ('very high' to 'medium' risk).

Reaching into the pot to remove the catch scored highly (REBA 11, 'very high risk'). This is again partly due to trunk bending (which would be alleviated by the shelf mentioned above) but also because there is only a 'door' at one end of the creel, meaning the fisher usually had to reach right to end of the creel, an action requiring twisting and often a shift of weight on to one leg. Addition of a second door at the opposite end of the creel would half the maximum reach required, reducing twisting and allowing maintenance of bilateral weight-bearing. However, lobster creel construction is a complex (and traditional) task carried out by the fishers themselves, and this would likely have a high time and cost burden, making it less attractive as a potential solution. In this specific case study, disposing of old bait was also problematic. The store for this was placed directly behind the creel emptying space, which resulted in extensive twisting and change of weight-bearing. This was easily remedied by moving the position of the store.

Strengths and limitations

One limitation of this work is that a case study, while providing rich data, can lack generalisability. However, this study confirms previous findings that fishing is high-risk in relation to musculoskeletal injury and that delivering significant change is complex, not least because of the highly autonomous work practice. It is also clear that fishers show a high degree of acceptance of injury, and it may be that financial incentivisation in terms of improving profitability is likely to be the main driver of change. This is a strength of this current study – the participatory nature of an ergonomics approach allows personal change drivers to be identified. It is unlikely that tasks will change in ways that will remove all risks, and it may therefore be appropriate to develop postural analysis tools that allow discrimination at the higher risk end. The relationship between fishers and their work is succinctly captured by one of the participants:

"Fishing is more of a lifestyle/hobby which pays than a job. If it was a job only, no-one would do it."

References

Chung, M.K., I. Lee, D. Kee. 2005. Quantitative postural load assessment for whole body manual tasks based on perceived discomfort. *Ergonomics* 48(5): 492-505. Doi: 10.1080/00140130400029217

Dabholkar, T.A., Nakhawa, P., Yardi, S. 2014. Common musculoskeletal problems experienced by fishing industry workers. *Indian Journal of Occupational and Environmental Medicine* 18(2): 48-51. Doi: 10.4103/0019-5278.146888

David, G.C. 2005. Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational Medicine* 55: 190-199. Doi: 10.1093/occmed/kqi082

Davis, M.E. 2012. Perceptions of occupational risk by US commercial fishermen. *Marine Policy* 36: 28-33. Doi: · 10.1016/j.marpol.2011.03.005

Fulmer, S., Buchholz, B. 2002. Ergonomics exposure case studies in Massachusetts fishing vessels. *American Journal of Industrial Medicine* Supplement 2: 10-18. Doi: 10.1002/ajim.10086

Hignett, S., L. McAtamney. 2000. Rapid Entire Body Assessment (REBA). *Applied Ergonomics* 31: 201-205. Doi: 10.1016/S0003-6870(99)00039-3

Hignett, S., L. McAtamney. 2006. REBA and RULA: whole-body and upper limb assessment tools. *In* Marras W.S. and W. Karkowski eds. Fundamentals and assessment tools for occupational ergonomics. Boca Raton, Florida CRC Press 42: 1-12

Jezewska, M., Grubman-Nowak, M., Jaremin, B., Leszczunska, I. 2011. Assessment of the European Guide for Risk Prevention in Small Fishing Vessels. Guide applicability in Polish coastal fishing. *International Maritime Health* 62(4): 286-290

Kaerlev, L., Jensen, A., Neilsen, P.S., Olsen, J., Hannerz, H., Tuchsen, F. 2008. Hospital contacts for injuries and musculoskeletal diseases among seamen and fishermen: A population-based cohort study. *BMC Musculoskeletal Disorders* 9(8). Doi: 10.1186/1471-2474-9-8

Kee, D., I. Lee. 2012. Relationships between subjective and objective measures in assessing postural stresses. *Applied Ergonomics* 43: 277-282. Doi: 10.1016/j.apergo.2011.06.002

Kirwan, B., Ainsworth, L.K. 1992. A guide to task analysis. London, UK: Taylor & Francis Ltd.

Marshall, S.W., Kucera, K., Loomis, D., McDonald, M.A., Lipscombe, H.J. 2004. Work related injuries in small scale commercial fishing. *Injury Prevention* 10: 217-221.

Rucker, N., Moore, J.S. 2002. Predictive validity of the Strain Index method in manufacturing facilities. *Applied Occupational and Environmental Hygiene* 17(1): 63-73.

Stanton, N.A. 2006. Hierarchical task analysis: Developments, applications, and extensions. *Applied Ergonomics* 37: 55-79. Doi: 10.1016/j.apergo.2005.06.003

Storkersen, K.V., Antonsen, S., Kongsvik, T. 2017. One size fits all? Safety management regulation of ship accidents and personal injury. *Journal of Risk Research* 28(9): 1154-1172.

Thorvaldsen, T. 2013. The importance of common sense: How Norwegian coastal fisherman deal with occupational risk. *Marine Policy* 42: 85-90. Doi: 10.1016/j.marpol.2013.02.007

Thorvaldsen, T. 2015. Managing risk in the Norwegian fishing fleet. *Policy and Practice in Health and Safety* 13(1): 17-30. Doi: 10.1080/14774003.2015.11667809