

## Dehydration in New Zealand fishing vessel crews

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High musculoskeletal injury rates in crew on large (>28 m) New Zealand fishing vessels lead to an exploratory investigation of ergonomics risk factors. Initial findings indicated that hypo-hydration appeared to be both significant and common, and was of concern as crew work rotating shifts for up to 6 week periods.

Review of the international (English language) literature reveals that no hydration evaluation specific to crew on fishing vessels has been published to date. Dehydration research has however occurred in forestry, mining and manual labour industries with knowledge that can be applied to the maritime work environment. This includes an understanding of the problems that may develop in relation to dehydration, and relevant research and intervention methodologies. Further, the health effects of consuming the desalinated water that is typically provided on large fishing vessels appears to be little understood by fishing operators.

This paper describes the hydration findings of an exploratory ergonomics assessment of crew on NZ fishing vessels, and reviews the relevant literature. Further research and industry interventions are proposed.

**Practitioner Summary:** Dehydration impacts on physical and cognitive aspects of worker performance and long term health. Hypo-hydration of crew on working fishing vessels may lead to performance decrements and productivity losses. Assessing hydration of crew on-vessel poses some challenges to researchers but offers a powerful learning environment for participating crew members.

**Keywords:** Fishing, dehydration, musculoskeletal, vessels.

### 1. Background - New Zealand's fishing industry

Fishing is New Zealand's fifth largest export earner making \$1.2 – 1.5 billion per annum, with more than 90% of all fish landed destined for the overseas market. Commercial fishing and aquaculture employs around 5700 full time equivalents, with the north-west region of the South Island having 38% of this workforce. Anecdotally, there are around 12 factory fishing vessels in New Zealand, and a larger fleet of smaller fresher vessels that fit the <24 metre description (Edwin, 2013).

Maritime New Zealand (MNZ) is the marine transport regulator agency (per the Marine Transport Act 1994) with duties encompassing safe and sustainable transport systems, and protecting the marine environment. MNZ is responsible for administering the Health and Safety in Employment Act for work on board ships and for ships as places of work. As the fishing industry operates in a highly regulated environment there is a need for solutions to be developed in close partnership with industry to ensure practicality. Leading commercial operators in 2013 formed the Fishing Safety Forum to jointly address health and safety issues and this industry partnership is providing new opportunities to positively impact injury rates.

### 2. Injury rates and types

New Zealand's fishing industry has high rates of work-related injury. MNZ et al (2012) identified that New Zealand's marine fishing and marine based aquaculture had the highest injury rate of all industry sectors (figures averaged for 2001-2009 per industry per year). The work-related injury rate in fishing was 7.29%, with mining and quarrying next at 4.47% and construction at 3.29%. MBIE (2012) reported that over the previous 10 years the fishing industry had the highest ACC

entitlement claim rate per sector, only in 2008 dropping to less than forestry. Statistics NZ (2013) report that 1 in 4 fishery workers made a work-related claim in 2012. Equal with agriculture, this was the highest rate by occupation. International data also reflects high injury rates such as the McGuinness et al (2013) finding that European Union fishers had a 1 in 7 rate of accidents per year.

Health and safety personnel from the fishing company Sealord in 2012 sought ergonomics input to address high musculoskeletal injury rates (over 50% of recorded injuries) on commercial fishing vessels. This was supported by industry injury data: MNZ et al (2012) reported that for 2002-2010 ACC accepted claims the most common injuries in the fishing industry are 51% soft tissue (contusion, strain, sprain); and for <24 metre fishing vessels Kahler and Chau (2012) identified 'human and gravitational energy' as cause for 58% of injuries - suggesting the need to address manual handling and slip/trip/fall issues. Moreover, Guard (in Edwin, 2013), found that vessels of >24 metres (just 7% of the national fleet) were responsible for a disproportionate 68% of serious harm injuries – so the larger the vessel the higher the risk of serious harm.

Table 1. Serious Harm 2000-2008.

Vessel Length	Number and % of Serious Harm	Number and % of Vessel Population	Total quarterly operating hours	Rate of serious harm per 1,000 vessel operating hours	Total Crewing Numbers	Rate of serious harm per 1,000 crew
Under 6m	0 0%	251 23%	20,331	0	437	0
6-12m	11 6%	356 33%	60,164	0.18	652	16.8
12-24m	51 27%	405 37%	197,640	0.26	1300	39.2
24m+	129 68%	79 7%	103,569	1.24	1991	64.8
<b>Total</b>	<b>191 100%</b>	<b>1091 100%</b>	<b>381,704</b>	<b>0.5</b>	<b>4380</b>	<b>43.4</b>

Consequent to these findings, ACC (New Zealand's injury prevention, compensation and rehabilitation provider) provided funding for an industry-wide 'ergonomics scoping assessment' to determine the opportunities to prevent musculoskeletal injuries on large fishing vessels.

### 3. Ergonomics scoping assessment

#### 3.1 Literature review

Literature review (Edwin, 2013) found that New Zealand was not alone in having limited understanding of vessel-based manual handling risks and interventions to reduce these risks. Whilst some recent ergonomics assessment and intervention work has been reported out of North America, few resources targeting the prevention of musculoskeletal injuries were available. Some studies over the last 10 years have begun to investigate the increased manual handling risks posed by vessel motion but no clear guidance on the magnitude of the increased risks is yet available. No literature on the hydration of fishers was found.

#### 3.2 On-vessel assessment

To gain an understanding of the work environment and demands on fishers on large commercial vessels an experienced ergonomist (for the first time in New Zealand) 'went to sea'. Between May and September 2013 several introductory trips on a factory vessel (9 days) and two fresher vessels (3 days) from two different fishing companies occurred. (Factory vessels process fresh fish

at sea and return with packaged frozen fish ready for market, with trips taking around 6 weeks. Fresher vessels are smaller, returning with chilled whole fish for on-shore processing, with trips taking a few days to 2-3 weeks). The trips occurred over the busy hoki season, gave insight into the nature of work and living activities aboard two different types of fishing vessel, and allowed the researcher to gain a general understanding of the industry and her 'sea-legs'.

Whilst on-vessel a range of exploratory data was gathered via a modified Nordic Musculoskeletal Questionnaire, anthropometry, semi-structured interview, task observation, hydration assessment, and dimensional assessments. The researcher engaged in all aspects of life and work on board a working vessel and participated in many discussions broadening her understanding of the fishing industry and fisher motivations. Hydration assessment was specifically included as anecdotal reports suggested a high frequency of urinary tract and kidney infections among crew. The links between dehydration and performance (including cognitive function, fatigue, work capacity, muscle function and muscle recovery) and long term health (such as kidney stones and bladder cancer) are well documented in both the popular literature, and the scientific literature (including Bates and Schneider, 2008; Kenefick and Sawka, 2007; and Gopinthan, Pichan and Sharma, 1988). Specifically, Bates and Schneider (2008, citing Sawka and Pandolf, 1990) report that in a moderate environment, a 1-2% deficit of body weight (water loss from sweating etc) results in a 6-7% reduction in physical work capacity, and water loss of 3-4% of body weight a reduction of 22% physical work capacity, increasing to a 50% decrement in a hot environment.

The ergonomics scoping assessment consequently identified many factors contributing to musculoskeletal injury. These included: heavy work tasks; repetitive tasks; frequent lifting and handling of awkward loads; sustained, constrained and awkward work positions; unpredictable vessel movement; seasickness; an indoor environment that may be cold (freezer/chiller) or heated (cabins), and outdoors work in all conditions; little work with cardiovascular loading and limited opportunity for on-vessel exercise; continuous shift work (such as 6 hours on, 6 hours off); poor work-station and work system design (often creating double-handling); very close living and working quarters with associated social pressures; little time or opportunity for leisure activity; industry training that did not include the benefits of stretching, break-taking, good hydration/nutrition and general fitness; an outdated approach to lifting and handling techniques without specific training; little explicit task training for safe and efficient work methods; fatigue related to shift-work patterns; payment systems at odds with injury prevention initiatives; and worker hypo-hydration.

These factors suggest that an array of physical design, organisational design and education/training opportunities exist to address musculoskeletal injury risks, as discussed in Edwin and Guard (2014).

### **3.3 Scoping assessment hydration findings**

Urine samples were collected from crew members (volunteers, all job types, from all vessels) and immediately tested with a refractometer to determine the urine specific gravity (USG).

For the initial tests (n=49), occurring within the first days/week of the vessel trip and at varied times during the day/shift, results indicated that only 8.2% of fishers were euhydrated (USG 1.003 – 1.015), and 8.2% were hypo-hydrated (USG >1.015 – 1.020). 83.6% of the fishers tested were dehydrated (USG >1.020), with 16.3% that were clinically dehydrated (USG >1.030).

Following general discussion of the topic some further hydration testing was completed on-vessel, for individuals interested in improving their hydration status. Of these individuals (n=10) 8 improved their hydration status and two became more dehydrated. Additional testing was then carried out with this same crew on their return to port, some 4 weeks after the original testing on-vessel. Of these 23 retests, 10 had a worse level of hydration, 12 had better levels of hydration, and one had the same level of hydration as the initial assessment. Comments suggested that

those with better levels of hydration had consciously worked to improve their hydration following the on-board focus on this topic and new learning.

These results suggest that further consideration of hydration and its impact on the function and wellbeing of fishers may be beneficial. As water is provided on-vessel by desalination units this may have further bearing on health effects. These results are of concern due to the length of exposure due to the weeks of on-vessel time, and the generally demanding and risky nature of work on a vessel.

### **3.4 Factors impacting on crew hydration**

On-vessel discussions and observations yielded valuable knowledge of associated factors that create an environment for hypo-hydration. A key component for one vessel was that the mixed male and female crew had access to one primary toilet nearest the factory. For men with the cultural practise of urinating in standing, urinating aboard a moving vessel has the frequent result of urine spray around the toilet bowl. Women using the same facility then contend with the need to clean up before sitting to urinate. Many female crew members consequently avoided use of this toilet – reportedly by limiting their fluid intake so that they only needed to use the toilet in their own cabins. When this observation was made and discussed with the vessel management team and crew, a solution was quickly identified – men were able to access a second toilet a little further from the factory.

Another factor likely impacting on crew hydration is that cabins are closed rooms that are heated and ventilated, with this at times creating an apparently hot and dry sleeping environment. (Environmental data was not gathered during the scoping assessment). A number of crew reported that they often woke feeling thirsty and ‘dry’.

Older fishers that had first experienced fishing on smaller inshore vessels (that carry their own freshwater supplies that taste notoriously poor) reported that they had learned not to drink water when aboard a vessel, and would only drink coffee or other flavoured drinks. This interesting ‘historical’ aspect seemed to be linked closely with the intake of caffeine to manage the demanding work hours and shift rosters. For some individuals this extended to bringing on board cases of highly caffeinated and sugar-loaded energy drinks.

Access to drinking water whilst working was also impacted by the nature of the vessel environment – water bottles were considered by crew as not allowed in the factory for hygiene reasons, drinking fountains were limited, and there was little storage for any personal items including water bottles near to work areas. In addition, some crew suffered varying effects of sea-sickness with an impact on both nutritional and hydration status.

The various 6, 8 and 12 hour shift schedules have a knock on to the frequency of showering and available time for self-care. Discussion with some crew suggested that as a consequence they didn’t have the time and energy to attend to good eating and drinking regimes. Other workers carrying out more active work duties (such as stacking crates in the hold of fresher vessels) reported that they didn’t like to sweat too much whilst working (creating more personal laundry) so they reduced fluid intake for this reason.

Vessel training and the work culture did not include knowledge of hydration as a means of keeping fit for work, despite the very challenging work environment and demanding task nature. Thus most crew had no notion of this as an element of self-care. The notable exception was the few crew members that when on-shore were keen sports people. Some of these individuals had an effective knowledge of hydration and an approach to nutrition and fitness that gave them considerably more capacity to cope with the demanding work environment than others.

### **3.5 On-vessel intervention opportunities**

Whilst on-vessel it became apparent that the close living/working environment provided many opportunities for the provision of fisher education and training (particularly on the factory vessel). Whilst an atypical training environment, it was possible to have discussions with all crew levels/types - skipper, first mate, factory manager, factory workers, deck hands, cook and galley hand, medic, and engineers - with relative ease. Respect for the importance of sleep was critical - due to the 6, 8 or 12 hour shift schedules – and a flexible approach to training provision was necessary. Much was via informal discussion – perhaps over a meal, in passing in a passageway, or at a coffee break. However fishers were generally receptive to new learning that might assist them to both feel better and work more effectively.

Training able to be accomplished included: stretching and fitness, safer work methods, lifting and handling techniques, discomfort and injury management advice, optimal hydration/nutrition, and break practices. Training was able to be provided in the tea-break areas, in the mess, or on the bridge. Training was formalised in consultation with the skipper and management team and able to be done both in small groups, or one-to-one. Shy crew members were comfortable asking questions of the researcher as their comfort levels with her presence gradually increased – particularly when on-vessel for over a week. This allowed health and wellbeing concerns to be shared, some for the first time.

The topic of hydration proved to be of high interest, particularly as many fishers were returning hypo-hydrated results on testing. It became clear that the researcher's presence on-vessel made it possible to provide bio-feedback through repeated hydration assessment, and the opportunity to have ongoing discussions with crew members about hydration. A number of crew members altered their hydration practises accordingly.

Crew appeared grateful for the attention of an 'expert' on-vessel, as their training is usually restricted to standard on-vessel topics, and training that occurs in the very busy time ashore at vessel-turnaround. Given high fatigue levels the ability to 'drip-feed' new learning, and to clarify and reinforce key messages over several days appeared beneficial. In addition, the industry credibility of the researcher was heightened by spending time on-vessel with a willingness to share knowledge and engage in discussion.

## **4. Industry hydration literature**

The literature on hydration within various industry groups provides comparative data sets and knowledge of more rigorous methodology than that used in the 'ergonomics scoping assessment'.

A study of United Arab Emirates construction workers was completed by Bates and Schneider (2008). Continuous heart rate monitoring and aural temperature was used to determine physical fatigue; hydration was assessed using urine specific gravity measurement and tracking of fluid consumption; and environmental conditions were measured to determine wet bulb globe temperature (WBGT) and thermal work limit (TWL) values. Data was collected over 3 days. In this group (n = 66) they found that workers were well hydrated at start and end of the work day, with average values between 1.010 and 1.014 USG (overall average 1.012 USG). These authors reported that for workers exposed to heat, USG of below 1.020 at start of shift is desirable. Further, the interpretation of USG readings was <1.015 – well hydrated; 1.015 – 1.020 mildly dehydrated; 1.020 – 1.025 mildly dehydrated; 1.025 – 1.030 dehydrated; > 1.030 – clinically dehydrated. Bates and Schneider concluded that if workers are provided with appropriate fluids and can self-pace, they can work without difficulty in hot conditions. They also determined that TWL was a valuable tool for assessing thermal stress in the Gulf conditions.

Parker, Ashby and Bates (2001) in a pilot study of New Zealand loggers (n=31) found that 30% of loggers were inadequately hydrated (USG >1.020). A consequent study of New Zealand loggers by the same authors (2002) collected data on environmental conditions and fluid consumption, and for four consecutive days tested urine specific gravity (n=24) on logger's arrival

at work, at the main meal break and immediately after finishing work. They found that USG ranged 1.010-1.033 in winter, and 1.010-1.035 in summer (12 loggers in sample for both seasons). Most loggers were hypo-hydrated with USG 1.016-1.030, with a median of USG 1.025.

South African forestry workers were studied by Biggs, Paterson and Maunder (2011). Pre-shift USG testing showed that in autumn (n=103), 43% were dehydrated (USG >1.020), and in winter (n=79) 47% were dehydrated. Post-shift dehydration levels were higher at 64% in autumn, and 63% in winter. Around 22% of workers were found to be dehydrated by  $\geq 2\%$  body weight. These authors also found that pre-shift in autumn 23% of workers were over-hydrated (USG <1.013), and in winter that 13% were over-hydrated.

Australian miners have been the focus of a number of studies considering heat stress and hydration. A study of heat illness in Australian surface mine workers (Hunt, Parker and Stewart, 2013) compared 91 surface mine workers with 56 underground mine workers in terms of symptoms for heat illness, and considered hydration status via average urine colour. 87% of surface mine workers and 79% of underground miners experienced heat illness symptoms. Only 29% of surface and underground miners were considered well hydrated, with 61% classified as 'minimally hydrated' and 10% 'significantly dehydrated', using colour as the measure. Polkinghorne, Gopaldasani, Furber, Davies and Flood (2013) studied hydration status and considered factors that may impact on the hydration of underground miners (n = 88). They found that 58% of workers were dehydrated (USG >1.020) before and after shift, with a number clinically dehydrated. These authors also found that those with average USG results indicating dehydration were more likely to be obese, and suggested the need to link education on healthy lifestyles, body weights and hydration for underground miners. Peiffer and Abbiss (2013) studied thermal stress in open-cut mine workers (n=31) and iron ore processing/shipping workers (n=42) in north-west Australia. Mean hydration (from pre, mid and post-shift measures) was found as USG 1.029 for the mine workers and USG 1.021 for the processing/shipping workers. They found that 22% of workers reached or exceeded the safety guidelines for regulating work in hot environments to maintain core body temperatures, and found hydration practices to be inadequate. A 2007 study of fly-in/fly-out minerals extraction and processing in north-east Australia (Carter and Muller) included hydration status (at 6 am and 6 pm), hydration behaviour and knowledge, and perceived taste of water. Mean USG (n=46) was 1.022. They found that dehydration knowledge seemed adequate, but the perceived taste of water appeared to influence hydration behaviour.

Table 2. Hydration status in various industry groups.

Industry group studied	Dehydration with USG/colour measure	Mean hydration with USG measure
NZ fishers	83.6% dehydrated (USG >1.020),	USG 1.025
NZ loggers (Parker et al, 2001)	30% dehydrated (USG >1.020)	
South African forest workers (Biggs et al, 2011)	Post shift dehydration (USG >1.020) 64% autumn, 63% winter	
Australian surface/underground miners (Hunt et al, 2013)	71% minimally or significantly dehydrated per urine colour	
Australian underground miners (Polkinghorne et al, 2013)	58% dehydrated (USG >1.020)	
Australian miners/processers (Peiffer and Abbiss, 2013)		USG 1.029 for miners, USG 1.021 for processers.
Australian fly-in/fly-out minerals workers (Carter and Muller, 2007)		USG 1.022

These findings are summarised in Table 2 alongside results of the ergonomics scoping assessment data. Thus a greater percentage of NZ fishers are dehydrated than for New Zealand and South African loggers and Australian surface and underground miners; and NZ fishers average hydration measure shows that they are dehydrated, though not as dehydrated as

Australian open cut miners working in hot conditions. This suggests that NZ fishers may be at considerable risk from dehydration.

## **5. Desalinated water**

As many vessels provide drinking water via desalination plants, the impact of drinking desalinated water over long periods at sea should be considered. Desalinated water is corrosive (WHO, 2011) with health concerns focused on ensuring that pathogens and chemical contaminants are removed, and addressing water quality to reduce its corrosiveness and provide remineralisation.

It is recommended that desalinated water should be rebalanced to contain: a minimum level for dissolved salts, bicarbonate ions, and calcium; an optimum level for total dissolved salts; and a maximum level for alkalinity, sodium, boron and bromine (WHO, 2005). WHO outlines the possible adverse effects of consuming water with low mineral content - increased urine output, body water volume and serum sodium concentrations; decreased serum potassium concentration; and increased elimination of sodium, potassium, chloride, calcium and magnesium ions from the body. An adequate intake of electrolytes must therefore be ensured to prevent dilution of the electrolytes dissolved in the body. Symptoms related to electrolyte dilution might initially include tiredness, weakness and headache, or become more severe and lead to muscular cramps and impaired heart rate. Further, a lack of calcium and/or magnesium in drinking water is associated with cardiovascular disorders, tiredness, weakness and muscular cramps.

Therefore, if seeking a robust understanding of the issues around hydration for fishing crew this topic should be investigated further.

## **6. Industry resource development and use**

Following the ergonomics scoping assessment it became apparent that the fishing industry required access to resources addressing a range of issues around musculoskeletal injury prevention for crew. Funding was established to work up fishing-specific material within ACC's 'WorkSmart Tips' resource package, and the finished resource was available online from mid-2014. The fishing industry funded the completion of the stretching and manual handling images used to illustrate the online material, and also developed a set of stretching/manual handling posters for on-vessel use.

This resource material, whilst available to all, has not yet become commonly or completely used within NZ fishing companies. Its release coincided with a major change to safe ship management systems that has been a focus over recent months, and in combination with musculoskeletal injury prevention initiatives being new to most fishing companies, it seems that most are still developing the capability to use the material effectively.

However, one organisation is the exception. Consequent to the development of the industry resources Sealord Group initiated additional training for fresher and factory vessel crews. This ninety minute group session addresses topics including manual handling methods, sleep, hydration, stretching, break practices and fitness, delivered in a land-based training venue while crews are in port. Whilst some vessel crews are yet to receive the training, results are seen to be positive. At the 2014 year-end Sealord vessels had a lost time injury frequency rate (LTIFR) of 1.06 – a considerable drop from the previous year's (pre-intervention) LTIFR of 3.15. Soft tissue injury reporting for the 2013 year end (121) was more than double that of the 2014 year end (55). Moreover, the vessel crew the researcher had spent most time with reported a productivity gain of 9.3% from 2013 to 2014. Vessel management attribute this largely to the various ergonomics interventions that were enacted, with recognition that ongoing efforts were simultaneously being made around improved discomfort and injury reporting, gaining a stable and effective crew mix, and factory design aspects to reduce manual handling. It was suggested by Gaskin (2013) that considerable financial gain could result from fishing companies investing in targeted injury prevention and process improvement strategies. This is confirmed by this vessel moving from the

fleets overall 'worst performer' to 'best performer' (across a range of measures) and is providing strong motivation for an ongoing focus on ergonomics.

## 7. Proposed hydration research

Scoping assessment findings suggest that dehydration is common and significant among crews on large NZ fishing vessels but is poorly understood by the industry despite that it impacts on both physical and cognitive performance. Initial results of new training initiatives (that include hydration awareness) to address musculoskeletal injury in one company are positive, indicating that change is both possible and likely to be rewarding. Further, as most fishing organisations in New Zealand have not yet adopted use of the new resources, an opportunity exists to measure hydration status of crew before intervention, during an on-vessel intervention period, and to re-measure hydration post intervention. Thus a measure of intervention efficacy can be gained, and further development of intervention resources can occur.

Literature review and scoping assessment findings suggest that fisher hydration research could include: hydration measures using a refractometer, triangulation with body weight before/after shift, clothing ensembles, fluid type/quality, tracking of fluid consumption, general health and wellbeing (including seasickness), heart rate monitoring, aural temperature, perceived water taste, environmental measures (WBGT and TWL), and access to fluids/fluid quality on vessel.

This research is proposed with the support of the NZ Fishing Safety Forum and funding support from a range of sources is being pursued to enable commencement.

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