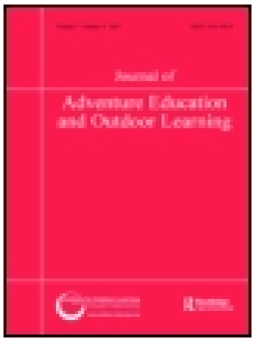

Journal of Adventure Education and Outdoor Learning

ISSN: 1472-9679 (Print) 1754-0402 (Online) Journal homepage: http://www.tandfonline.com/loi/raol20

Sea kayaking incidents in Norway 2000–2014: an issue of bad weather or poor judgement?

Eivind Aadland, Gunnar Noer & Odd Lennart Vikene

JOURNAL OF ADVENTURE EDUCATION AND OUTDOOR LEARNING, 2015
http://dx.doi.org/10.1080/14729679.2015.1121505

Sea kayaking incidents in Norway 2000–2014: an issue of bad weather or poor judgement?

Eivind Aadland [a], Gunnar Noer [b] and Odd Lennart Vikene [a]

[a]Faculty of Teacher Education and Sports, Sogn og Fjordane University College, Sogndal, Norway; [b]Forecasting Division of Northern Norway, The Norwegian Meteorological Institute, Tromsø, Norway

ABSTRACT
The aims of this study were to analyse recreational sea kayaking and touring incidents in Norway with a specific focus on wind conditions and to elaborate on practical implications for the prevention of future incidents. We included 49 incidents reported by the media between 2000 and 2014. Incidents occurred in various wind conditions, but most incidents (60%) occurred in moderate to strong breezes (9–14 m/s). Wind strength and direction were generally forecast accurately and conditions were mainly stable throughout the day of the incident. Thus, sea kayaking and touring incidents in Norway seem to happen in various wind conditions; however, paddlers should have been well informed and aware of the hazards they were facing. Future incidents could be prevented by increasing sea kayakers' situation awareness through discussion of experts' decision-making processes and the arrangement of situated learning experiences in realistic settings.

KEYWORDS
Paddling; situation awareness; experience; outdoor education

Introduction

Sea kayaking has gained widespread popularity as a means for recreation and exploration of stunning coastlines in many parts of the world. However, with exposure to a potentially hazardous environment come incidents of varying severity. Although sea kayaking incidents are multifaceted, a typical incident seems to involve a young-to-middle-aged male kayaking alone or in a small group, caught in strong wind (possibly combined with current or swell) resulting in a capsize. The victim is neither dressed nor trained for the conditions and does not manage to get back in the boat, does not get others' attention and becomes hypothermic and eventually drowns (Bailey, 2010; Broze, Gronseth, & Cunningham, 1997; Cunningham, 2014). Thus, except for some relatively rare cases of collisions with motor-powered vessels, collisions with whales, shark attacks or medical problems out of the paddler's control, incidents seem to be the result of inadequate skills relative to the environmental conditions encountered (Bailey, 2010; Broze et al., 1997; Cunningham, 2014).

Generally, incidents result from complex combinations of and interactions among multiple human and environmental factors (Meyer, 1979; Priest & Gass, 2005). Specific to sea kayaking, obvious risk factors in the environment are strong winds, currents, large swells and cold water. Human risk factors include poor skill (e.g. navigation and technical skills related to kayak handling and rescue), poor knowledge (e.g. the effect of weather on the sea state, knowledge of water temperature and clothing, and the use of safety equipment) and poor judgement (e.g. being overconfident about one's skills and stamina, and a lack of back-up in case of an incident

CONTACT Eivind Aadland eivind.aadland@hisf.no
Supplemental data for this article can be accessed at: http://dx.doi.org/10.1080/14729679.2015.1121505.

[inadequate clothing, not wearing a personal floatation device, kayaking solo or separated from a group, fatigue, lack of communication and signalling devices]). Although environmental hazards do pose a threat to kayakers, insufficient understanding of those hazards relative to one's ability to handle those hazards (poor knowledge and judgement) is a human factor, meaning that most incidents result from human errors, not environmental hazards *per se*.

According to Endsley (2006, 1999), the main cause for most human errors is poor situation awareness. High situation awareness plays a critical role in situations where one needs to keep track of many factors that can change quickly and interact in complex ways (Endsley, 2006). The concept of situation awareness might therefore provide a useful framework for understanding incidents in outdoor activities involving risk management, such as sea kayaking. Situation awareness has three key elements: perception of our surroundings; interpretation and understanding of the information received; and judgement and projection of future status (see Endsley, 2006, for a comprehensive review). A sound development of the first two levels (i.e. understanding the current situation) is a prerequisite to achieving the third level of situation awareness (i.e. what is about to happen?). According to the model, paying attention to and recognizing the relevant cues in our surroundings (level 1) in a given situation are of crucial importance to our decisions. However, the value of the perceptions depends on our previous knowledge and understanding in a bidirectional fashion.

For a sea kayaking novice, the process of gathering information from the surroundings is deliberate and inefficient, and might lead to overload and fatigue, as the novice does not have any established understanding or stored schema that fit with the information obtained (Endsley, 2006). Relatively poor skills will further inhibit their ability to monitor their surroundings as they are fully engaged in handling their craft (Endsley, 2006). Expert performance is characterized by highly intuitive and efficient judgement and decision making (Endsley, 2006; Kahneman, 2011; Ross, Shafer, & Klein, 2006; Simon, 1992). Based on previous experience in a variety of situations, experts have acquired complex mental models or schema that render their perception and interpretation of the hazards in their surroundings very efficiently. Therefore, experts may easily focus their attention on the most relevant factors, quickly interpret the meaning of this information in a given context and anticipate what might happen in the future (Endsley, 2006). The distinction between how novices and experts make decisions has gained wide interest in the literature and is generally understood in terms of dual processes (Kahneman, 2011; Shooter & Furman, 2011). Kahneman (2011) refers to the intuitive (fast) system as system 1 and the analytic (slow) system as system 2. Despite some controversy regarding the accuracy and validity of intuition (Kahneman & Klein, 2009), reliance on intuition may be a valid means for judgement and decision-making for experts who have had the opportunity to learn, recognize and interpret the patterns and signs of the complex, dynamic environments that they encounter (Kahneman & Klein, 2009; Kahneman, 2011). However, experience or expertise does not ensure against incidents, as persons of all levels of competence are victims of sea kayak incidents (Bailey, 2010; Broze et al., 1997; Cunningham, 2014; Peddelpraat Coastal Kayaking Committee, 2010), which is also the case for snow avalanche incidents (McCammon, 2004) and climbing incidents (Westhoff, Koepsell, & Littell, 2012). According to Kahneman, intuition or the use of 'heuristics' can often lead to poor decisions (Kahneman & Klein, 2009; Kahneman, 2011), and several 'heuristic traps' have been suggested to bias skiers' decisions in avalanche terrain (Furman, Shooter, & Schumann, 2010; McCammon, 2004). Such biased decisions show that intuition might be inappropriate in some conditions and call for a deeper involvement of the analytic system (system 2) to improve decision-making.

Prior knowledge and experience are critical to control or prime our attention and therefore dictate what we expect and look for and how we sort relevant from irrelevant information (Endsley, 2006; Feltovich, Prietula, & Ericsson, 2006; Kahneman, 2011). The weather forecast provides sea kayakers with an expectation regarding what hazards they might encounter, and could therefore prime their attention to those hazards. A critical factor when interpreting the weather forecast, however, is whether the kayaker understands the forecast and what consequence such conditions would have in a given context (e.g. sea kayaking). According to Lazo, Morss, and Demuth (2009), forecast wind strength and direction are given relatively little attention among the lay public. This might be a problem for novice kayakers, as wind may be their greatest hazard.

As previously stated, in most cases the cause and severity of an incident results from poor situation awareness and bad decisions, not bad weather *per se*. This argument is supported by the only previous study that has sought to systematically analyse historical sea kayaking and touring incidents (Bailey, 2010). Bailey (2010) studied 50 incidents involving rescues in New Zealand from 1992 to 2005, of which 37 were private recreational trips and 14 were fatalities. Other than an overrepresentation of male victims (85%), few clear risk factors were identified among the incidents (victims varied in age and competence level, approximately one-half of the incidents involved solo kayakers and incidents took place during all months of the year). Regarding weather conditions, 50% of incidents occurred in rough seas (defined by Bailey as waves >1.25 m) and 69% occurred in strong winds (fresh breeze; i.e. ≥9 m/s). The finding that wind poses a certain element of surprise to many sea kayakers is in line with many incident case reports (Broze et al., 1997; Cunningham, 2014). Thus, the literature points toward wind as the most critical environmental factor in most sea kayak incidents.

A serious limitation of the study by Bailey (2010) is a lack of valid wind data. Wind data were unknown for almost one-half of the incidents (42%) and were based on observations from the meteorological service for only five incidents. Moreover, weather forecasts and any differences between the forecast and actual winds were not reported. This limits the validity of the conclusions drawn. There is thus a need to examine wind conditions in sea kayak incidents to improve our understanding of wind as a factor that may compromise safety for sea kayakers.

Norway has a long and varied coastline (stretching from latitude 58° to 71° north) that is well suited for sea kayaking. However, the coastline is exposed to rough weather from the North Sea, and the sea temperature is relatively low (from close to 0°C in the winter to <18°C in the southern areas during summer). The terrain in coastal areas is dominated by mountains with deep fjords and valleys. This terrain can impact the weather considerably, giving rise to coastal jets, gap winds and local katabatic winds of gale force mainly during the autumn, winter and spring seasons. Generally, currents are relatively weak, but tidal currents in the main fjord basins can be significant and can vary over time and by location. Thus, whether conditions are suitable for sea kayaking may be hard to predict and demands a sufficient level of situation awareness.

The aims of this study were to analyse recreational sea kayaking and touring incidents in Norway from 2000 to 2014 with a specific focus on wind conditions and to elaborate on practical implications for the prevention of future incidents. Thus, we hope to increase sea kayakers' understanding regarding critical factors related to sea kayak incidents and prevent future incidents from taking place.

Methods

Literature search

We searched for kayak incidents reported by the media between January 2000 and February 2014. The search was performed in three steps. First, a comprehensive search was performed in Atekst, a media archive that at present includes 161 Norwegian national, regional and local newspapers, using a broad Norwegian search-string (*padleulykke* or *kajakkulykke* or [(*drukning* or *druknet* or *drukna* or *nedkjølt* or *nedkjøling* or *velt* or *veltet* or *velta* or *reddet* or *redda* or *redningsaksjon*) and (*kajakk* or *padling* or *padler* or *padlar*)]), resulting in 661 media articles. Further, we searched for incidents in an archive of media reports provided by a kayak club in Norway (Nøklevann Ro- og Padleklubb, 2014), which has collected media reports for incidents from 1999 to 2009. Finally, a non-systematic search using the above-mentioned search terms in various combinations was performed using Google.

We used the following inclusion criteria: reports had to concern an incident that happened in Norway (excluding Svalbard); reports had to involve sea kayaking or touring incidents (excluding white-water kayaking and canoeing); and incidents had to involve help from external sources (private persons or professionals at land or sea, or search and rescue personnel). Incidents involving organized trips or courses were excluded from the main analyses because of their very small number (n = 3). Moreover, reports concerning false alarms (drifting or lost kayaks, kayakers reported missing), or reports concerning situations that easily could have got out of hand but did not (almost capsized, became separated but found one another, etc.), have been excluded.

Information sought from reports

We sought to retrieve the following information from the media reports: place (coded according to the three climatological regions of Norway: the south-eastern part [Oslofjorden and the areas south-west of Oslo, down to and including the southernmost point of Norway, Lindesnes], the western part [from Lindesnes up to and including Nord-Trøndelag] and the northern part [including the three northernmost counties]); date and time of the incidents (nearest hour); number of persons involved, gender, age and nationality (Norwegian vs. foreign); outcome (fatal vs. non-fatal); 'cause' of the incident (capsize vs. other); who attracted or called for external help (the victim[s], the rest of the group or external person[s]); and weather (wind conditions and temperature).

Wind direction and strength (forecast and actual) at the time of the incident were obtained from the Norwegian Meteorological Institute. Forecast wind was retrieved from text forecasts issued by a meteorologist at least four hours prior to the incidents (night before the incident [18:00–], early in the morning [06:00–08:00] or at midday [12:00] on the day of incident, depending on when the incident occurred).

Actual wind conditions were estimated from two sources of data: the Norwegian Reanalysis with 10 km resolution (NORA10) and observations from nearby meteorological stations. The NORA10 is created by running the Norwegian Regional High Resolution Limited Area Model (HIRLAM) with 10 km resolution on the global European Centre for Medium Range Reanalysis (ERA40/ERA-interim). It describes past weather with a finer resolution than did the operational models used historically, which typically had a resolution of 20–50 km. Additionally, because the HIRLAM 10 km uses modern dynamics and physics descriptions, it provides a more precise description of the meteorological situation than was available in the past. We applied a standard forecasting methodology to the NORA10 data to make an assessment of the weather on the known location in question, with a temporal resolution of three hours, and a forecast length from NORA10 of a maximum of nine hours. By considering topography and the general weather situation, we also made an assessment of the risk of hazardous weather such as local strong winds, mountain waves, gap winds and so forth.

The NORA10 formed the basis for the main analysis. In addition, wind observations were collected from the meteorological station closest to where the incidents took place (median, interquartile range: 10, 20 km) to compare observed mean wind versus wind gusts and to assess changes over the course of the day. In cases where the closest station was located in a protected/sheltered area and thus might not provide valid data regarding the wind, the nearest exposed stations were chosen. All observations were reported as standard meteorological observations: wind is measured 10 m above the ground and reported every hour as the mean wind strength (m/s) for the highest consecutive 10 minutes during the last hour, and as the strongest wind gust (m/s) lasting three or more seconds within the last hour. In addition, the development of the wind strength and direction (hour by hour on the day of incident) was noted (≥3 m/s increase in mean wind over the last 2 hours vs. no increase).

Statistical analyses

Victim age and wind strength were reported as the mean values and standard deviation. All other data were reported as numbers (percentages). The risk of a fatal incident (dependent variable) as a function of paddling solo versus paddling in a group, of paddling in the winter/spring versus summer/autumn, of sea temperature and of wind conditions (independent variables) was tested using a binary logistic regression model and reported as odds ratios (ORs) (95% confidence intervals [CIs]). Models 2–4 were controlled for paddling solo versus paddling in a group. The distribution of incidents over the months of the year and over different wind conditions are shown as histograms. The difference between actual and forecast wind strength was assessed using a Bland–Altman plot, which shows actual wind strength minus forecast wind strength as a function of the mean wind strength (Bland & Altman, 1986). The difference was tested using a one-sample t test. Differences in wind strength between the three climatological regions of Norway were tested using one-way analysis of variance.

All analyses were performed using IBM SPSS v. 20 (IBM Corporation, Software Group, Somers, NY, USA). $p < 0.05$ indicated statistically significant findings.

Results

In total, we detected 55 incidents, four of which were excluded for being organized events (two fatal incidents probably resulting from cardiac arrest in two male paddlers [one attending a beginners course and one participating in a sea kayak touring race]; two non-fatal incidents involving six of 19 paddlers participating in an event at work and two of 40 foreign cruise passengers). Of the remaining 51 incidents, two could be claimed to be caused by factors external to the paddler's control (one non-fatal incident occurred when one of three male paddlers was hit by a motorized vessel; one fatal incident occurred when a female paddler among a group of eight paddlers was hit by a falling rock). These incidents were excluded from the analyses, which left 49 incidents for analysis (see Supplemental Table 1 for case characteristics).

Place and time

Incidents happened all over Norway (south-eastern part: 17 (35%) incidents; western part: 22 (45%) incidents; northern part: 10 (20%) incidents) and during all seasons and months of the year (Figure 1), with possible peaks in May, July and December. There was no association between season and outcome (fatal vs. non-fatal incidents) (OR = 0.96 [95% CI 0.27–3.44], $p = 0.615$), nor any relationship between sea temperature and outcome (OR = 0.91 [95% CI 0.77–1.07], $p = 0.248$).

Age, nationality, gender, number involved and outcome

Incident characteristics are presented in Table 1. The ages of the victims ranged from 8 to 88 years; however, most victims were middle-aged, with 61% of victims being between 40 and 60 years old. Moreover, most victims were males and most incidents involved Norwegians. However, age and nationality were rarely reported. Two-thirds of the incidents involved solo paddlers, all of whom were male, whereas five women and 23 men (gender was unknown for five victims) paddling in groups were involved in incidents (gender was reported for 30 [91%] and 13 [81%] incidents involving solo paddlers and groups, respectively). One-third of the incidents were fatal. There was a significantly increased risk of a fatal incident among solo kayakers compared with kayakers in groups (46 vs. 13% fatalities, OR 5.83 [95% CI 1.14–29.84], $p = 0.029$).

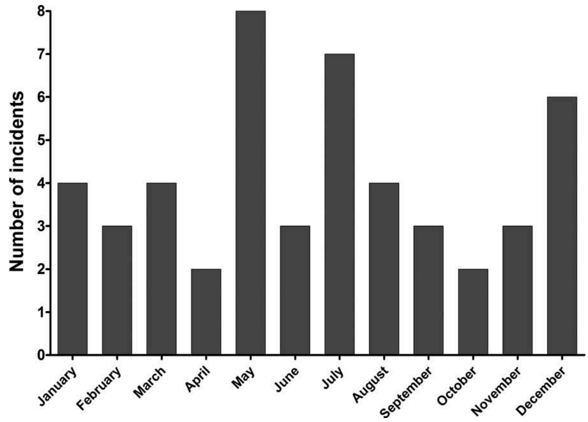

Figure 1. Seasonal distribution of incidents.

Table 1. The incidents' characteristics.

	Frequency	Incidents with available information
Age	47.6 (16.3)	28 (57)
Nationality		26 (53)
Norwegian	21 (81)	
Foreign	5 (19)	
Gender		43 (88)
Male	53 (91)	
Female	5 (9)	
Number involved		49 (100)
Solo	33 (67)	
Group	16 (33)	
Outcome		49 (100)
Fatal	17 (35)	
Non-fatal	32 (65)	

Note: All numbers are *n* (%), except for age which is reported as the mean (standard deviation).

Capsize and rescue

All of the non-fatal incidents were a result of a capsized kayak where the victim(s) did not manage to get back in the boat, either alone or with help of their group members (information on cause was not available for fatal incidents). Victims were either reported missing (n = 10, 21%), called for help themselves (n = 13, 28%) or were spotted by a third party (n = 24, 51%) (information available for 47 [96%] incidents). All of the incidents where someone was reported missing involved solo paddlers. Of those solo paddlers (information available for 29 incidents), only three (10%) called for help themselves, while the corresponding number for group paddlers was 10 (63%). Of those solo paddlers who survived, 13 (81%) incidents (of 16 incidents for which the information was available) were spotted by a third party. In general, the paddlers remained in the water or climbed onto rocks or islets until they were rescued by private vessels, professional vessels or search and rescue operations.

Wind conditions

Of the 47 incidents in which wind conditions could be determined (the time of the incident was unknown for two fatal incidents involving solo paddlers), 34% occurred in moderate breeze (6–8 m/s, beaufort 4) or less, whereas 60% took place in fresh to strong breezes (9–14 m/s; beaufort 5–6) and 6% occurred in near-gale or gale conditions (15–18 m/s, beaufort 7–8) (Figure 2). Overall, the mean wind strength was 9.9 (3.7) m/s, and wind gusts were 4.2 (2.1) m/s (59%) stronger than

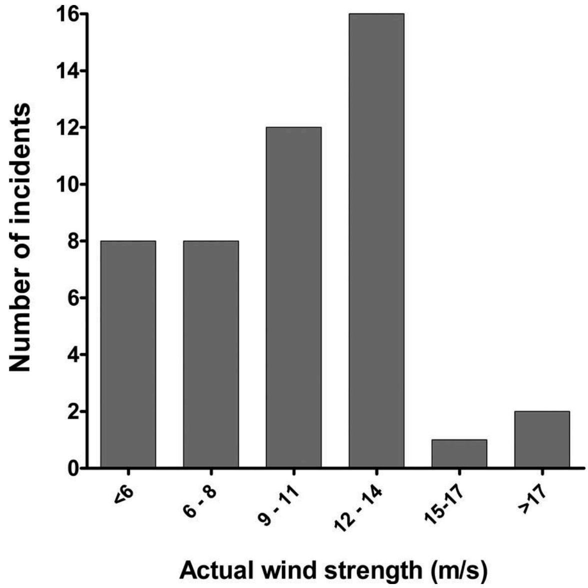

Figure 2. Distribution of incidents according to actual wind strength.

the observed mean wind strength. There was no difference in mean wind strength (south-eastern part: 8.6 [3.0] m/s: western part: 10.8 [3.5] m/s; northern part: 9.8 [4.7] m/s; $p = 0.203$) or difference between wind gusts and observed wind strength (south-eastern part: 3.5 [1.9] m/s: western part: 4.8 [2.2] m/s; northern part: 3.9 [3.1] m/s; $p = 0.149$) between the three climatological regions. There was no evidence of a specific wind direction (neither heading nor onshore or offshore wind) or particular type of weather system in the incidents.

The distribution of the forecast wind strengths is shown in Figure 3. Forecast wind strength was generally somewhat higher than actual mean wind strength (observed—forecast wind strength:

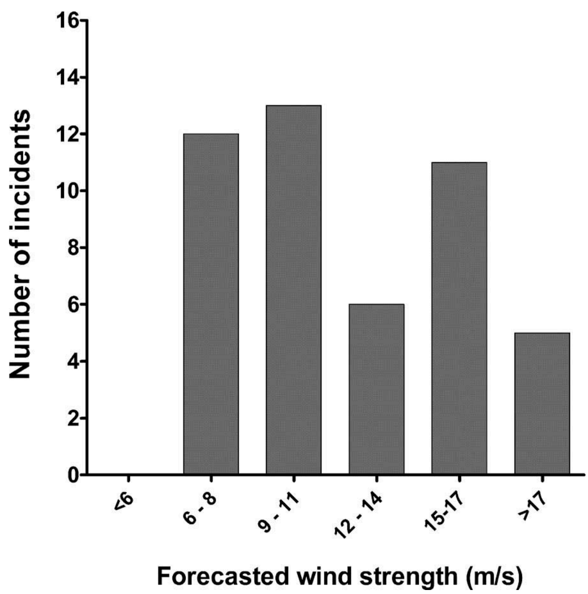

Figure 3. Distribution of incidents according to forecast wind strength.

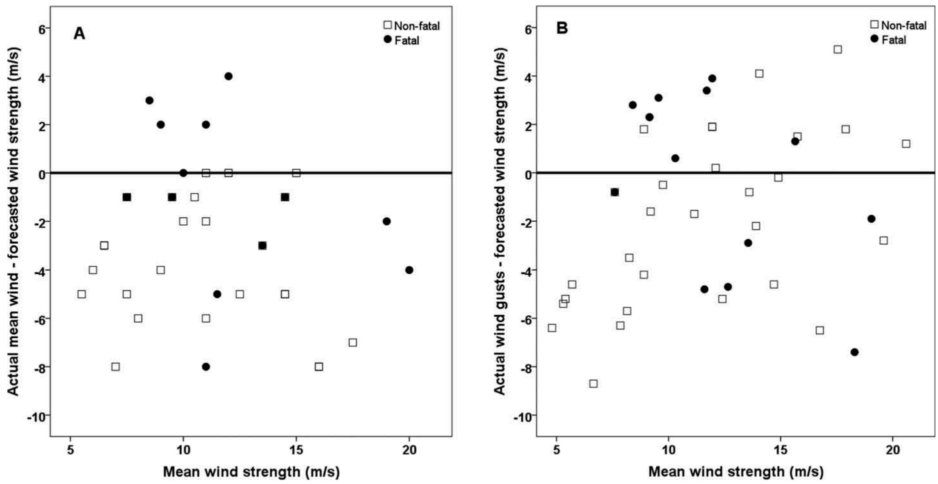

Figure 4. Bland–Altman plots showing the difference between actual mean wind strength (a) and actual wind gusts (b) compared with forecast wind strength as a function of the mean values.

Table 2. Associations between wind strength and the risk of a fatal incident, adjusted for whether the incident involved a solo paddler or a group.

	OR	95% CI	*p* value
Mean wind (m/s)	1.14	0.94–1.38	0.177
Wind gusts (m/s)	1.40	0.97–2.04	0.076
Mean wind—forecast wind (m/s)	1.34	1.01–1.78	0.045
Wind gust—forecast wind (m/s)	1.11	0.90–1.36	0.332
Wind change (yes/no)	2.24	0.56–9.05	0.256

−2.5 [2.9] m/s, $p < 0.001$) and wind gusts (observed—forecast wind strength: −1.4 [3.6] m/s, $p = 0.015$) (Figure 4). However, in some cases ($n = 4$ and $n = 17$ for mean wind and wind gusts, respectively), actual wind strength was higher than forecast wind strength. Wind direction was accurately forecast in all incidents.

An increase in wind strength during the two hours prior to the incident was found in eight (17%) incidents. Thus, for most incidents, wind strength was stable throughout the day. In all of the incidents where an increase in wind strength was found over the course of the day, the actual mean wind strength was lower than the forecast wind strength (underestimated by 1–6 m/s), whereas in four (50%) cases, wind gusts were higher than the forecast wind strength (1–5 m/s).

Associations between the wind conditions and outcome (fatal vs. non-fatal incident) were mostly insignificant (Table 2). The only association that reached a statistically significant level was the difference between observed mean wind and forecast wind strength.

Discussion

The present study's main findings were that: most sea kayaking and touring incidents in Norway between 2000 and 2014 involved a capsize and lack of rescue skills relative to the environmental conditions encountered; two-thirds of the incidents involved solo kayakers, who had a significantly increased risk of fatalities compared with paddlers in groups, probably because they were not able to attract external help; and incidents occurred under various wind conditions that may have had a complexity that was not understood by the paddler. Mostly, however, wind conditions were well forecast and stable throughout the day, and paddlers therefore should have been well informed and aware of the hazard they were facing. In our opinion, the present findings clearly indicate that some paddlers lack a basic understanding of the environmental hazards they may encounter and of their competence and skill to handle those conditions. Thus, our findings seem to be consistent with those of Bailey (2010), who concluded that poor judgement and inadequate skills were the most frequent contributory factors to sea kayaking and touring incidents in New Zealand.

When interpreting our findings, some strengths and limitations should be kept in mind. The main strength of the present study is that we used weather forecasts and observed wind at the time of the incidents as registered by the Norwegian Meteorological Institute, instead of relying on wind information from media reports as Bailey (2010) did. Yet the actual wind conditions during the incidents were still difficult to determine accurately, as the sources of wind data generally do not account for local topography. The limitations of the present study relate to the accuracy and scarcity of information in the media reports. For this reason, we did not report information regarding the victims' expertise or formal training, familiarity with the area where they were kayaking, type of kayak being used, clothing or safety equipment, the kayakers' thinking and rational judgement, the course of events or the cause of death. The lack of such information restricts us from making a direct assessment of the situation awareness of the victims and at what level(s) errors occurred (i.e. perception of information, interpretation of this information or projection of future status and judgement). It also restricts us from elaborating on several factors that may have been relevant in understanding contributing factors to the incidents. Information regarding formal training was not included because most media reports were anonymous (80%), because the Norwegian course system '*Våttkortsystemet*' only dates back to 2006 and also because formal training does not necessarily provide a valid measure of expertise. It is probable that some deaths may have been caused by medical factors, as reported previously (Andkjær & Arvidsen, 2012). In support of this, two of the three incidents that were excluded for being organized events were fatalities resulting from cardiac arrest. However, such deaths may not be independent of the activity performed, as immersion in cold water after capsize can induce a strong stress response that may cause reduced cerebral perfusion and syncope, arrhythmia and cardiac arrest (Mantoni, Belhage, Pedersen, & Pott, 2007; Shattock & Tipton, 2012). Furthermore, we do not have information regarding the sea state or current for the incidents. Although currents generally are weak in Norway compared with many other areas in the world, we cannot exclude current as a contributing factor to some incidents. Finally, weather forecasts in Norway can be obtained from several different sources. The two most commonly used are Yr and Storm, but recently several different forecasts have become available as apps for smart phones. The weather forecast from the Norwegian Meteorological Institute (Yr) applied in the present study compares favourably with Storm in terms of precision (Norwegian Meteorological Institute, 2015) and is the forecast most used by the public, especially by people on the sea because it is available via very high frequency (VHF) radio, in addition to the Web, radio and television. It is a weakness of the present study that sea kayakers may have relied on forecasts provided by outlets other than those analysed. Still, forecasts from several outlets could be examined and conservative actions taken according to the worst-case scenario.

A typical incident in the present study involved a young-to-middle-aged male paddling solo or in a small group, who capsized and did not manage to get back in the boat, often resulting in hypothermia and/or death. This finding is consistent with previously published case reports (Broze et al., 1997; Cunningham, 2014) and studies from New Zealand and Denmark (Andkjær & Arvidsen, 2012; Bailey, 2010). The present study's fatality rate (35%) was somewhat higher than that of previous studies (23 and 28% in Denmark and New Zealand, respectively) (Andkjær & Arvidsen, 2012; Bailey, 2010). This might be explained by a higher percentage of solo kayakers in the present study (67%) compared with the previous studies (44% in New Zealand) (Bailey, 2010), as we found significantly increased odds for fatalities in incidents involving solo paddlers compared with paddlers in groups. To our knowledge, such a relationship has not previously been shown. Obviously, solo kayaking has a lack of back-up compared with kayaking in a group, because a solo paddler has to rely on self-rescue in the case of a capsize whereas group paddlers can perform an assisted rescue, which is much easier to execute in rough conditions. Moreover, the study by Bailey (2010) indicated that approximately half of the victims were separated from their kayak, showing the importance of having a buddy to pick up the lost boat. However, the present study showed that assisted rescues often failed. Thus, what seems to be the clear difference between solo kayaking and group incidents in the present study was the ability to obtain external help (10 vs. 63% for solo vs. group paddlers, respectively). Nevertheless, an alarming finding was that rescue was initiated by a third party for one-half of the incidents. This finding underlines the importance of carrying (preferably) two or more means of attracting outside help (a waterproof mobile phone, a VHF radio, a personal location beacon, flares, etc.). Although such equipment might be deemed redundant on certain occasions, a critical situation is never planned. Thus, such equipment should be brought on every trip and not left behind, as evidenced from an excellent incident report involving expert sea kayakers in the Netherlands (Peddelpraat Coastal Kayaking Committee, 2010).

Consistent with Bailey (2010), we found that most incidents occurred in fresh to strong breezes (9–14 m/s). Although this might be explained by the fact that such 'moderate' conditions are quite common and provide good surf conditions for playing, thus placing many persons at risk, it might also indicate that such conditions are the most difficult to judge, as the perceived risk is not imminent. Incident reports (Broze et al., 1997; Cunningham, 2014) indicate that ignorance of and/or marginal decisions related to the weather forecast and actual weather are quite common in sea kayaking incidents, as might also be supported by the current study, because the difference between mean wind and forecast wind was associated with an increased risk of a fatal incident. This indicates that some sea kayakers seem to lack an appropriate understanding of their surroundings (i.e. environmental hazards) in relation to their expertise (knowledge and skills) to handle those hazards; that is, they suffer from poor situation awareness. Because poor situation awareness has been claimed to be the main cause of most human errors (Endsley, 2006, 1999), we will use the concept of situation awareness as a framework to discuss the current findings regarding wind as an important contributing factor to the incidents.

Understanding the current situation (i.e. situation awareness levels 1 and 2) is a prerequisite to predicting what is about to happen (situation awareness level 3) (Endsley, 2006). Thus, paying attention to and recognizing the relevant cues in our surroundings (level 1) in a given situation are of crucial importance in making decisions. However, the value of the perceptions made depends on our previous knowledge and understanding (level 2) in a bidirectional fashion. Therefore, sea kayakers are faced with several problems regarding situation awareness.

First, sea kayakers obviously must have a basic awareness that they are at risk in order to take conscious actions to mitigate that risk. By experience, most novice kayakers have a clear understanding that they are vulnerable and may capsize the first time they put their body inside a boat approximately as wide as their hips. However, many novices build their confidence in the kayak very quickly as their technical skills increase and their handling of the boat improves. This confidence may lead them to feel less vulnerable, although the activity is potentially still lethal. Interestingly, a survey of 229 Danish sea kayakers showed that none of the respondents believed sea kayaking to be dangerous (although 97% reported that there were some risks associated with the activity). At the same time, 64% reported the risk of a capsize to be low, and 64% reported that they would always be able to perform a self-rescue (Andkjær & Arvidsen, 2012). This may indicate overconfidence resulting from a disproportionate development between their skills and their ability to understand the hazards that surround them and the consequences of their actions.

Second, prior knowledge and experience are critical to focus our attention and therefore dictate what we expect and look for and how we sort relevant from irrelevant information (Endsley, 2006; Feltovich & Ericsson, 2006; Kahneman, 2011). For a sea kayaker, the weather forecast is very valuable as it can prime attention toward certain hazards. Yet it is of little value if the kayaker is unable to make sense of it or anticipate the consequences for the near future. Forecast wind strength and direction is given relatively little attention among the lay public (Lazo et al., 2009), which could be a problem for novice kayakers because wind may be their greatest hazard.

Moreover, if conditions generally are more favourable than forecast (as the meteorologist tries to account for locally shifting conditions), as shown in the present study, this may lead kayakers to pay less attention to the forecast. This may be consistent with findings showing that people may underestimate extreme weather warnings (Lazo et al., 2009; Savelli & Joslyn, 2012). Based on the findings of the present study, sea kayakers should acknowledge and understand that weather forecasts are uncertain and take conservative actions to mitigate their risk.

Third, the quality of the learning that takes place also depends on prior knowledge and experience (Hogarth, 2001; Kahneman & Klein, 2009). For example, a novice sea kayaker may expect waves of two metres to follow a fresh breeze (9–11 m/s) (as suggested by the literature; Met Office, 2014) and thus may be prone to interpret a more favourable sea state as good for sea kayaking. However, the kayaker may ignore information regarding fetch and delay (the open distance and time needed to build waves), or may not have experience with judging waves from a distance, upwind versus downwind conditions or how waves are affected by currents. Moreover, wind conditions vary or might deviate substantially from the forecast conditions according to local topography (e.g. sheltered areas, funnelling, corner effects, etc.).

Fourth, as a novice sea kayaker does not have any established understanding or stored schema that fit with the information obtained from the environment (Endsley, 2006), the process of gathering information is deliberate and inefficient. In contrast, expert sea kayakers have acquired complex mental models or schema that accurately render their perception and interpretation of the patterns they observe, leading to intuitive and very efficient decision-making (Endsley, 2006; Kahneman, 2011; Ross et al., 2006; Simon, 1992). However, expertise does not ensure against incidents, as persons of all levels of competence are caught in sea kayak, snow avalanche and climbing incidents (Bailey, 2010; Broze et al., 1997; Cunningham, 2014; McCammon, 2004; Peddelpraat Coastal Kayaking Committee, 2010; Westhoff et al., 2012). Intuition might thus be insufficient in some contexts, lending support to a somewhat more deliberate process of decision-making for sea kayakers at all levels of expertise.

Practical implications to prevent future incidents

If we believe the main contributing factor to incidents is poor situation awareness, not poor skills or wrong equipment *per se*, how could sea kayakers increase their situation awareness? The best way to accrue experience in a sea kayak under safe conditions would be to join sea kayak experts in an informal setting or undertake formal education, focusing on the acquisition of both technical skills and expertise related to the management of the environmental hazards that sea kayakers face. Although experienced kayakers constantly keep their situation awareness high, these processes are often intuitive and tacit (Collins & Collins, 2013; Endsley, 2006; Kahneman, 2011). Thus, less experienced sea kayakers (learners) may observe only the decision made by the expert (the outcome) and not how the decision was made (the process) (Collins & Collins, 2013). Therefore, we suggest experts should share their thinking through dialogue with learners (Cianciolo, Matthew, Sternberg, & Wagner, 2006) and provide them with some tools or structure of thinking to apply in the future (Collins & Collins, 2013), thus scaffolding the learners' process of constructing mental models for making good decisions. By experience and based on the three levels of situation awareness provided by Endsley (2006), we suggest that questions such as those presented in Table 3 would stimulate a useful way of thinking. Some questions (Questions 3, 5, 6, 10, 15, 16, 17, 18, 19 and 20) will require an evaluation of the environmental factors against the human factors, and thus necessitate an integration of many sources of information. We believe the 'why' questions are crucial to make the process of decision-making explicit to the kayaker(s), as such questions require the involvement of system 2 by weighing different arguments and reasons for actions (Kahneman, 2011) and thus make sharing of tacit knowledge possible. Such a dialogue is important for learners to reflect upon their experiences, which is essential to effectively learning from their experiences (Collins & Collins, 2013; Tozer, Fazey, & Fazey, 2007). Moreover, such questions can

Table 3. A proposed set of questions that an outdoor leader could use as a basis for a dialogue with learners to facilitate their reflection concerning how to assess and interpret the weather conditions throughout a sea kayak session and thus increase situation awareness.

1. What does the weather forecast say regarding today's weather?
2. What information in the weather forecast is relevant to us?
3. What does the weather forecast mean for us (e.g. is 8 m/s wind from the north a problem for us)?
4. What will likely be today's problems (wind strength, wind direction, waves, water temperature, etc.)?
5. Can we go as planned?
6. Why or why not?
7. Does the forecast seem to be correct?
8. Can we judge the conditions correctly from where we are now? If not, where could we go to do that?
9. What are actually today's problems (wind strength, wind direction, waves, water temperature, etc.)?
10. How big is the problem (consequence), and how likely is it that we will experience it (probability)?
11. How can we expect the weather to change over time and based on location?
12. What should we look for (white caps or darker areas on the water surface, breaking waves, etc.)?
13. Did you notice the current over there?
14. How are the waves behaving now, compared with earlier?
15. What is the consequence for us (e.g. increase awareness, go on as planned, turn around)?
16. Why? (Large group, poor skills, fatigue, etc.)
17. Did we make the right decision before that crossing?
18. Why or why not?
19. What would have been the appropriate action?
20. Why?

work as a checklist and aid decision-making, similar to the application of checklists in many other areas, such as travelling in avalanche terrain (McCammon & Hageli, 2007), health care (Haynes et al., 2009), aviation (Degani & Wiener, 1990) and reporting of research (Schulz, Altman, & Moher, 2010).

Some paddlers may lack a realistic understanding of their competence, vulnerability and risks. As we believe the environment provides a kind learning structure (Hogarth, 2001; Kahneman & Klein, 2009) for sea kayakers, a sea kayak expert can facilitate a learner's direct feedback from the environment in a realistic setting by scheduling sessions at or beyond the learner's limits of competence. Sea kayak learners can experience how difficult it is to manoeuvre the kayak, perform a self-rescue or communicate in strong wind; or feel the hopeless situation of a lost kayak in cold water. It is well agreed that a learning situation should be authentic and context specific to the situation where the knowledge or skill is supposed to be applied for the most effective learning to occur (Brown, 2010; Brymer & Renshaw, 2010; Feltovich et al., 2006; Ingold, 2000; Newell, 1986; Thomas, 2007). Therefore, we believe a situated approach to learning where each individual gets to embody their experience of meeting relatively demanding situations, given their unique affordances (Brymer & Renshaw, 2010; Newell, 1986), will be the most effective way to stimulate learners to adjust and attune their mental models of sea kayaking risks. Magnussen (2012a, 2012b) describes how sea kayakers being engaged in realistic situations where they continuously move in and out of control as they are being played by the waves creates deep experiences. Loss of control and failure provide a reality check and construct solid memory traces and powerful learning outcomes. Such experiences form the basis for development of situation awareness by helping learners to recognize, match and retrieve their mental models in future settings that provide the same pattern of cues as the current setting, thus facilitating better decisions (Endsley, 2006). Finally, this lends support to the use of a discovery-learning approach as the preferred means for teaching sea kayak skills and safety (Brymer, 2010; Magnussen, 2012b; Thomas, 2007).

Although several groups collect incident reports related to sea kayaking (New Zealand Mountain Safety Council, 2014, New Zealand; British Canoe Union, 2014, UK; Norwegian Canoe Association, 2014, Norway; Kayak Academy, 2014, USA), to our knowledge thorough analyses of such databases have not been made publicly available. More research on historical incidents along with research that explores and analyses the kayakers' process of thinking concerning risk management and decision-making with respect to wind and weather conditions is needed to prevent future incidents. We propose that future studies directly target the situation awareness of sea kayakers of different levels of competence to increase knowledge concerning their understanding of different sea kayaking hazards and how hazards change over time and based on location. This field of research would benefit from both qualitative and quantitative approaches, as well as different study designs.

Conclusion

We conclude that most sea kayaking and touring incidents in Norway between 2000 and 2014 involved capsize and lack of rescue skills relative to the environmental conditions encountered. Two-thirds of the incidents involved solo kayakers, who had a significantly increased risk of fatalities compared with paddlers in groups, probably because they were not able to attract external help. Incidents occurred under various wind conditions; however, wind strength and direction were generally well forecast, and wind conditions were stable throughout the day of the incidents. Thus, paddlers should have been well prepared if they had taken precautions according to the weather forecast and if they had been able to recognize and understand relevant cues regarding the environmental hazards they encountered. We propose that future sea kayaking and touring incidents may be prevented by increasing paddlers' situation awareness. This may be best achieved through scaffolding less experienced paddlers' thinking concerning the recognition, interpretation and prediction of what is going on around them; providing them with the opportunity to embody deep experiences in realistic situations; and encouraging them to reflect on their interpretations and the decisions they made. Conservative, and not marginal, decisions should be the goal.

Acknowledgements

The authors thank The Norwegian Meteorological Institute for their provision of weather forecasts for the incidents. They also thank associate professor Vegard Fusche Moe for valuable discussions during the preparation of this article, and the experienced sea kayak coaches Torbjørn Bjelland and Ronny Riise for feedback on the article.

Disclosure statement

No potential conflict of interest was reported by the authors.

Author biographies

Eivind Aadland, PhD, is a researcher at the Faculty of Teacher Education and Sports at Sogn og Fjordane University College in Sogndal, Norway. His research interests include various aspects of sport science and outdoor education. He is an experienced sea kayaker, certified at the highest level of sea kayak leadership through The Norwegian Canoe Association, and has been engaged in sea kayak education on various levels for several years.

Gunnar Noer, MSc, is a senior forecaster and developer for polar meteorology at the Norwegian Meteorological Institute in Tromsø, Norway. He is specialized in operational forecasting of polar lows and extreme wind and precipitation events. He is an experienced sea kayaker and is currently chairman of the sea kayakers club in Tromsø.

Odd Lennart Vikene, MSc, is an experienced lecturer in outdoor education at the Faculty of Teacher Education and Sports at Sogn og Fjordane University College in Sogndal, Norway. His main interests are motor learning, outdoor leadership and learning perspectives in practical outdoor education contexts.

ORCID

Eivind Aadland http://orcid.org/0000-0001-9654-2653

References

Andkjær, S., & Arvidsen, J. (2012). *[Safe in the nature] Tryg i naturen*. Odense: Department of Sport Sciences and Clinical Biomechanics, University of Southern Denmark.

Bailey, I. (2010). An analysis of sea kayaking incidents in New Zealand 1992–2005. *Wilderness & Environmental Medicine*, *21*, 208–218. doi:10.1016/j.wem.2010.01.009

Bland, J. M., & Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *The Lancet*, *327*, 307–310. doi:10.1016/S0140-6736(86)90837-8

British Canoe Union. (2014). *British canoe union incident report form*. Retrieved 9th of May, 2014, from http://www.canoe-england.org.uk/media/pdf/BCU%20Incident%20Report%20Form.pdf

Brown, M. (2010). Transfer: Outdoor adventure education's Achilles heel? Changing participation as a viable option. *Australian Journal of Outdoor Education*, *14*(1), 13–22.

Broze, M., Gronseth, G., & Cunningham, C. (1997). *Sea kayaker's deep trouble: True stories and their lessons from Sea Kayaker Magazine*. Camden: Ragged Mountain Press.

Brymer, E. (2010). Skill development in canoeing and kayaking. In I. Renshaw, K. Davids, & G. Savelsbergh (Eds.), *Motor learning in practice. A constraints-led approach*. New York: Routledge.

Brymer, E., & Renshaw, I. (2010). An introduction to the constraints-led approach to learning in outdoor education. *Australian Journal of Outdoor Education*, *14*(2), 33–41.

Cianciolo, A. T., Matthew, C., Sternberg, R. J., & Wagner, R. K. (2006). Tacit knowledge, practical intelligence and expertise. In K. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The cambridge handbook of expertise and expert performance*. New York: Cambridge University Press.

Collins, L., & Collins, D. (2013). Decision making and risk management in adventure sports coaching. *Quest*, *65*(1), 72–82. doi:10.1080/00336297.2012.727373

Cunningham, C. (2014). *Sea kayaker's more deep trouble: More true stories and their lessons from Sea Kayaker Magazine*. Blacklick: McGraw-Hill Education.

Degani, A., & Wiener, E. L. (1990). *Human factors of flight-deck checklists: The normal checklist*. Ames Research Center, California: National Aeronautics and Space Administration.

Endsley, M. (1999). *Situation awareness and human error: Designing to support human performance*. Paper presented at the High Consequence Systems Surety Conference, Albuquerque.

Endsley, M. (2006). Expertise and situation awareness. In K. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The cambridge handbook of expertise ans expert performance*. New York: Cambridge University Press.

Feltovich, P. J., Prietula, M. J., & Ericsson, K. A. (2006). Studies of expertise from phychological perspectives. In K. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance*. New York: Cambridge University Press.

Furman, N., Shooter, W., & Schumann, S. (2010). The roles of heuristics, avalanche forecast, and risk propensity in the decision making of backcountry skiers. *Leisure Sciences*, *32*(5), 453–469. doi:10.1080/01490400.2010.510967

Haynes, A. B., Weiser, T. G., Berry, W. R., Lipsitz, S. R., Breizat, A. H. S., Dellinger, E. P. … Gawande, A. A. (2009). A surgical safety checklist to reduce morbidity and mortality in a global population. *New England Journal of Medicine*, *360*(5), 491–499. doi:10.1056/NEJMsa0810119

Hogarth, R. M. (2001). *Educating Intuition*. Chicago: The University of Chicago Press.

Ingold, T. (2000). *The perception of the environment. Essays on livelihood, dwelling and skill*. USA/Canada: Routledge.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar: Strauss and Giroux.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: A failure to disagree. *A Failure to Disagree. American Psychologist*, *64*(6), 515–526. doi:10.1037/a0016755

Kayak Academy. (2014). *Sea kayak accident reports*. Retrieved 9th of May, 2014, from http://www.kayakacademy.com/pages/accident.html

Lazo, J. K., Morss, R. E., & Demuth, J. L. (2009). 300 billion served. Sources, perceptions, uses, and values of weather forecasts. *Bulletin of the American Meteorological Society*, *90*(6), 785–798. doi:10.1175/2008BAMS2604.1

Magnussen, Ll. (2012a). I feel so alive in the boat! *Journal of Experiential Education*, *35*(2), 341–356. doi:10.5193/JEE35.2.341

Magnussen, Ll. (2012b). Play—the making of deep outdoor experiences. *Journal of Adventure Education & Outdoor Learning*, *12*(1), 25–39. doi:10.1080/14729679.2010.532995

Mantoni, T., Belhage, B., Pedersen, L. M., & Pott, F. C. (2007). Reduced cerebral perfusion on sudden immersion in ice water: A possible cause of drowning. *Aviation Space and Environmental Medicine*, *78*(4), 374–376.

McCammon, I. (2004). Heuristic traps in recreational avalance accidents: Evidence and implications. *Avalanche News*, *68*, 1–10.

McCammon, I., & Hägeli, P. (2007). An evaluation of rule-based decision tools for travel in avalanche terrain. *Cold Regions Science and Technology*, *47*(1–2), 193–206. doi:10.1016/j.coldregions.2006.08.007

Met Office. (2014). *Beaufort wind force scale*. Retrieved 22nd of March, 2014, from http://www.metoffice.gov.uk/weather/marine/guide/beaufortscale.html

Meyer, D. (1979). The management of risk. *Journal of Experiential Education*, *2*, 9–14. doi:10.1177/105382597900200203

New Zealand Mountain Safety Council. (2014). *The national incident database*. Retrieved 9th of May, 2014, from http://www.incidentreport.org.nz/

Newell, K. M. (1986). Constraints on the development of coordination. In M. Wade & H. Whiting (Eds.), *Motor development in children: Aspects of coordination and control*. Dordrecht: Nijhoff.

Nøklevann Ro- og Padleklubb. (2014). Padleulykker. Retrieved 4th of March, 2014, from http://idrett.speaker.no/Organisation.asp?WCI=wiKlubbKassaNews&WCU=810017

Norwegian Canoe Association. (2014). *[Incident report form] Avviksskjema*. Retrieved 9th of May, 2014, from http://www.vaattkort.no/Incident/Create

Norwegian Meteorological Institute. (2015). *[Which service is the best of Yr and Storm?]* Hvilken tjeneste er best av yr og storm? Retrieved 9th of March, 2015, from http://artikkel.yr.no/yr.no-vs-storm.no-1.11009369

Peddelpraat Coastal Kayaking Committee. (2010). *Sea kayaking incident Noorderhaaks 13 June 2010*. Retrieved 9th of May, 2014 from http://www.seakayaker.nl/TMP/ReportSeaKayakIncidentNoorderhaaks13June2010.pdf

Priest, S., & Gass, M. A. (2005). *Effective leadership in adventure programming* (2 ed.). Champaign: Human Kinetics.

Ross, K. G., Shafer, J. L., & Klein, G. (2006). Professional judgment and "Naturalistic Decision Making". In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance*. New York: Cambridge University Press.

Savelli, S., & Joslyn, S. (2012). Boater safety: Communicating weather forecast information to high-stakes end users. *Weather Climate and Society*, *4*(1), 7–19. doi:10.1175/WCAS-D-11-00025.1

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 Statement: Updated guidelines for reporting parallel group randomised trials. *British Medical Journal*, *340*, 698–702. doi:10.1136/bmj.c332

Shattock, M. J., & Tipton, M. J. (2012). Autonomic conflict': A different way to die during cold water immersion? *Journal of Physiology-London*, *590*(14), 3219–3230. doi:10.1113/jphysiol.2012.229864

Shooter, W., & Furman, N. (2011). Contextualizing recent judgment and decision-making concepts for outdoor leadership research. *Journal of Outdoor Recreation, Education, and Leadership*, *3*(3), 189–2013. doi:10.7768/1948-5123.1092

Simon, H. A. (1992). What is an "explanation" of behavior? *Phychological Science*, *3*(3), 150–161. doi:10.1111/j.1467-9280.1992.tb00017.x

Thomas, G. (2007). Skill instruction in outdoor leadership: A comparison of a direct instruction model and a discovery-learning model. *Australian Journal of Outdoor Education*, *11*(2), 10–18.

Tozer, M., Fazey, I., & Fazey, J. (2007). Recognizing and developing adaptive expertise within outdoor and expedition leaders. *Journal of Adventure Education & Outdoor Learning*, *7*(1), 55–75. doi:10.1080/14729670701349780

Westhoff, J. L., Koepsell, T. D., & Littell, C. T. (2012). Effects of experience and commercialisation on survival in Himalayan mountaineering: Retrospective cohort study. *BMJ*, *344*, e3782–e3782. doi:10.1136/bmj.e3782