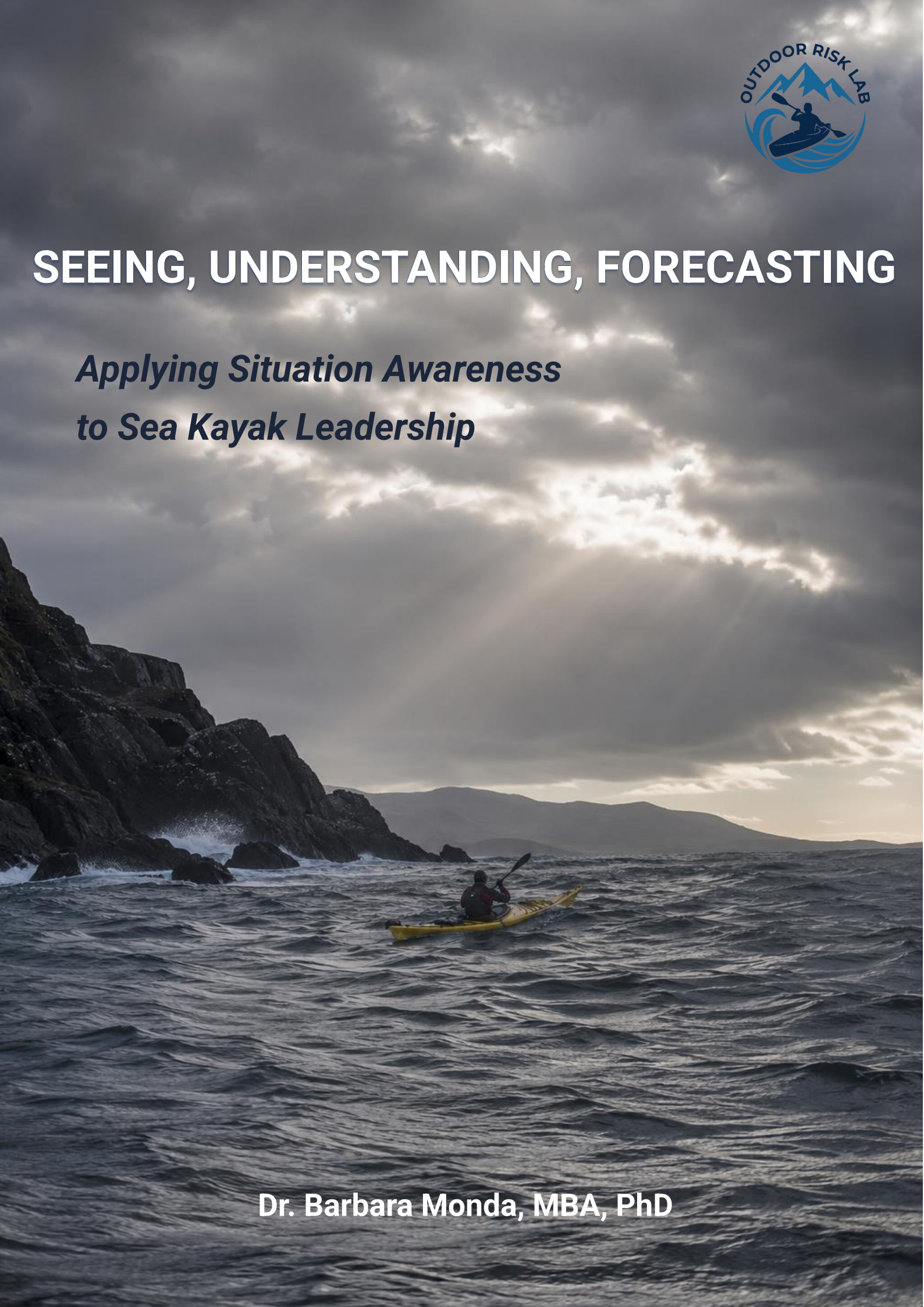

SEEING, UNDERSTANDING, FORECASTING

Applying Situation Awareness to Sea Kayak Leadership

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ABOUT OUTDOOR RISK LAB

Outdoor Risk Lab *is an independent research hub and educational platform dedicated to evolving safety culture in the outdoor industry. By synthesising traditional Risk Management principles with cognitive psychology, the Lab provides practitioners and organisations with advanced frameworks to navigate environmental and human uncertainty. This paper is part of a series of technical publications aimed at fostering analytical honesty and systemic resilience in high-stakes leadership.* *www.outdoorrisklab.org*

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Introduction

In 1995, Dr. Mica Endsley published a landmark paper in the journal *Human Factors* titled *"Toward a Theory of Situation Awareness in Dynamic Systems."* Originally developed to analyse decision-making processes in high-risk military aviation—specifically for U.S. Air Force fighter pilots navigating complex, high-velocity environments—Endsley's Three-Level Model of Situation Awareness (SA) quickly transcended its military origins.

Today, Endsley's model serves as a cornerstone of cognitive ergonomics and human factors research across safety-critical domains. It is actively utilized in air traffic control, nuclear power plant operation, emergency medicine, crisis management, and commercial maritime navigation. In all these environments, operational failure is rarely caused by a sudden loss of physical or technical skill. Instead, accidents almost always trace back to a breakdown in how humans perceive, comprehend, and project environmental and situational dynamics under pressure.

For those involved in sea kayaking—whether as personal paddlers, trip leaders, or professional coaches—the concept of Situation Awareness is far from foreign. National governing bodies around the globe, including Paddle UK, the American Canoe Association (ACA), and Paddle Canada, explicitly embed SA within their leadership and coastal navigation syllabi. In these contexts, SA is typically described as the ongoing process of "keeping an active mental picture of the group and environment," "staying ahead of the sea," or "tracking accumulating hazard factors."

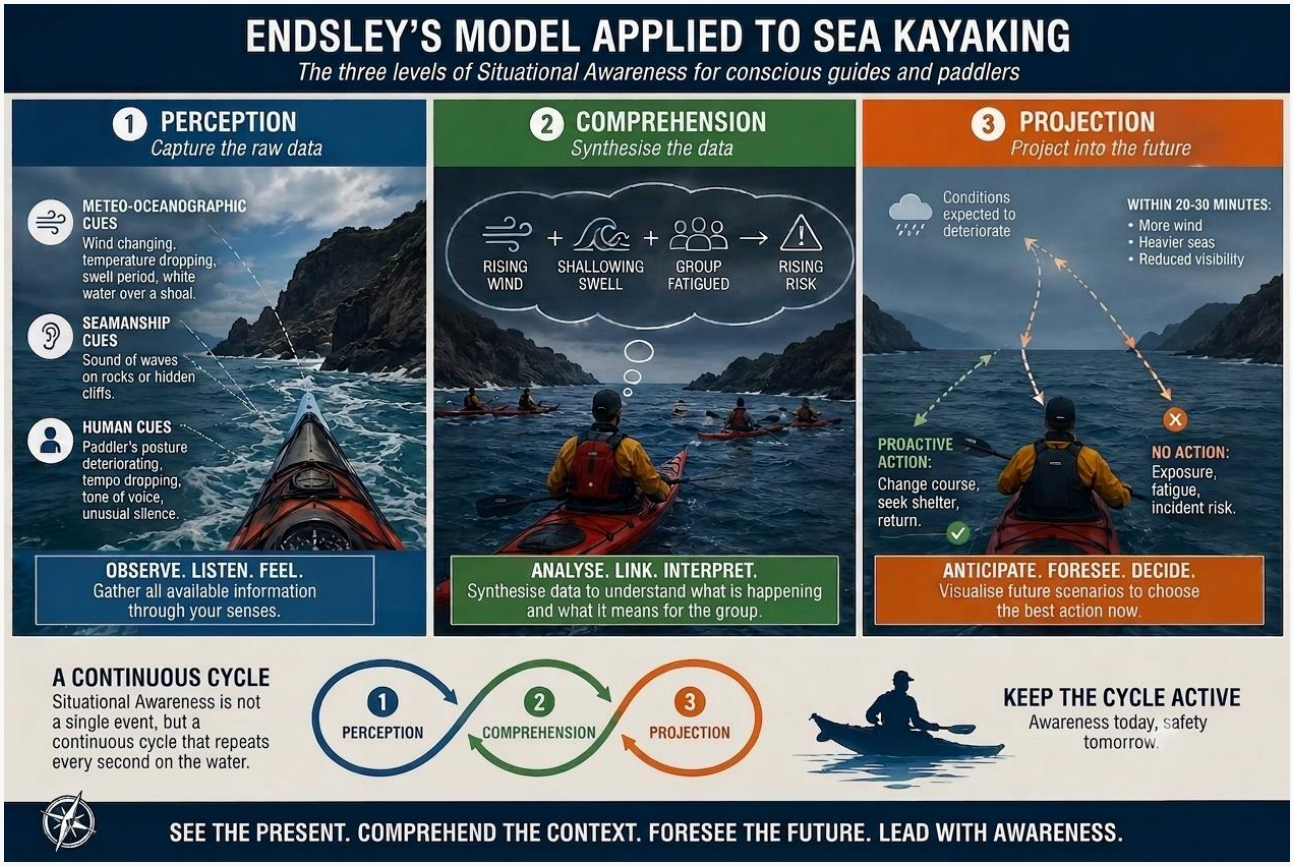
While Endsley's model originated in high-velocity aviation, its relevance to marine paddle sports is not merely theoretical. In a landmark empirical study, Collins et al. (2020) investigated Situational Awareness specifically among sea kayaking guides using simulated dynamic scenarios. Their findings revealed a critical cognitive pattern: while experienced paddlers naturally excel at Level 1 sensory perception, their ability to synthesize meaning (Level 2) and project future conditions (Level 3) degrades significantly under fatigue and cognitive load. This makes understanding and training Endsley's three distinct stages crucial for anyone leading groups on dynamic water.

While practical descriptions are invaluable for field application, Endsley's Three-Level Model takes this a step further by providing a clear breakdown of the internal cognitive steps that allow a leader to process that information effectively.

By applying Endsley's model to the water, we can better understand how our minds process the sea, why experienced leaders occasionally make critical misjudgements, and how we can systematically elevate our cognitive risk management on the water.

The Three Levels of Situation Awareness

Understanding SA requires breaking down how a leader processes information in dynamic, moderate-to-advanced water environments.



Level 1: Perception — Capturing the Raw Data

Level 1 SA is the baseline of the entire cognitive chain. It involves detecting critical environmental, physical, and human variables through sensory perception—sight, hearing, touch, and kinesthetics. In sea kayaking, Level 1 is simply about gathering raw, uninterpreted data from the sea and the group.

Rather than just scanning the horizon, a sea kayak leader operating with high Level 1 SA is constantly sweeping the environment for subtle sensory inputs:

- **Meteorological and Oceanographic Cues:** Noticing a slight drop in air temperature, a shift in wind direction across the face, a subtle change in swell period, or distant white water forming over a submerged reef.
- **Seamanship Cues:** Hearing the distinct low-frequency roar of swell striking a hidden cliff line around a headland before it enters the direct field of view.
- **Human Cues:** Observing a subtle deterioration in a group member's paddling posture, a drop in stroke rate, or a change in vocal tone and group chatter.

Without accurate perception at Level 1, subsequent decision-making is built on a flawed foundation.

Scenario: Navigating a Rocky Headland in Deteriorating Conditions

- **Level 1 Failure (Target Fixation & Missed Cues):**

A leader is guiding a group along a wave-battered cliff coast toward a headland as visibility drops. Fixated entirely on reading a deck compass and checking a digital chart plotter, the leader succumbs to "target fixation" and fails to maintain situation awareness. Suddenly, a dense fog bank swallows the group, wiping out all visual landmarks. Simultaneously, the group is caught off-guard by breaking seas over an unseen submerged reef. In the chaos and zero-visibility, the trailing paddler—whom the leader had also failed to notice dropping behind—capsizes on the rocks, instantly plunging the group into a high-risk, multi-casualty rescue in heavy surf.

- **Level 1 Success (Active Sensory Scanning & Proactive Fix)**:

In the same scenario, the leader maintains a continuous sensory sweep. They notice the damp shift in wind indicating incoming fog and hear the distinct roar of water crashing against the reef ahead. Catching these raw cues early prompts the leader to halt the group immediately in a sheltered eddy behind a rock outcrop. Safe from the surf, the leader verifies the team is tight, reassesses the route to bypass the reef at a safe distance, and prepares the group for fog navigation before visibility is lost, completely neutralizing the crisis.

Level 2: Comprehension — Synthesizing Meaning

Perceiving a cue is useless if you cannot interpret what it signifies. Level 2 SA is about making sense of those raw cues. It combines multiple Level 1 observations with personal experience and seamanship to build an accurate picture of what is happening right now. It answers the fundamental question: *"What does all this information mean right now?"*

In sea kayaking, comprehension requires integrating environmental mechanics with human capability:

- **Connecting Environmental Variables:** You observe an onshore wind picking up (Level 1 cue) and notice that the tide has just turned to ebb out of an estuary (Level 1 cue). Level 2 comprehension synthesizes these two distinct facts into a single, critical operational reality: you are currently in a wind-against-tide scenario that is generating steep, breaking seas.
- **Connecting Human Variables:** You notice a paddler who has become unusually quiet and is repeatedly adjusting their jacket (Level 1 cues). Level 2 comprehension interprets this pattern not as simple shyness or gear adjustment, but as early-stage hypothermia or cold-induced anxiety.

Scenario: Crossing an Open Tidal Sound

- **Level 2 Failure (Confirmation Bias & Misinterpretation):**

During an open crossing, a leader perceives that the ocean swell has grown significantly larger and that the tide has begun to ebb against the wind (Level 1 perception). However, because the morning forecast predicted benign conditions, the leader interprets the large waves merely as "harmless groundswell leftover from yesterday." Driven by confirmation bias, the leader pushes the group forward into the sound. Within minutes, the interaction between the accelerating ebb current and the shoaling seabed transforms the swell into steep, short-period breaking seas. The group is caught unprepared in a severe sea state, leading to panic, capsizes, and an emergency retreat in chaotic conditions.

- **Level 2 Success (Accurate Mental Model Synthesis):**

In the same scenario, the leader integrates the increased wave height with their knowledge of local bathymetry and current direction. They correctly comprehend that the ebb tide accelerates through this specific sound, actively steepening the waves into hazardous features. Recognizing the present reality, the leader immediately reorganizes the group into a tight formation, briefs the team on the upcoming rough water, and adjusts the trajectory to cross through a deeper, less turbulent channel, keeping the group safe and in full control.

Level 3: Projection — Anticipating the Future

Level 3 SA represents the pinnacle of cognitive risk management. It is the ability to project the future dynamics of both the environment and the group over short-to-medium time horizons (15, 30, or 60 minutes into the future). Level 3 SA allows leaders to transition from being reactive (responding to crises as they happen) to being proactive (altering course before a crisis materializes).

This aligns directly with the empirical findings of Collins et al. (2020) in their study on sea kayaking guides: while most leaders perceive immediate hazards (Level 1), the primary point of failure in real-world leadership occurs at Level 3—the inability to accurately forecast how environmental variables and group fatigue will compound 30 to 60 minutes into the future.

The sea environment is constantly changing. What is safe right now may become a trap in half an hour due to rising tides, shifting winds, or cumulative physical fatigue. Level 3 SA relies on calculating these trajectories in real time:

- **Environmental Projection:** Realizing that while a narrow passage between islets is currently passable, lingering in the area on a falling tide will expose a shallow, rocky reef at the exit within 20 minutes, trapping the group inside or forcing a portage.
- **Human Projection:** Calculating that if a struggling group member continues paddling into an increasing force 4 headwind at their current pace, their physical energy reserves will be completely depleted 20 minutes before reaching the shelter of the headland, creating an unavoidable towing situation in open water.

Scenario: Timing a Beach Landing on a Rising Tide

- **Level 3 Failure (Plan Continuation Bias):**

A leader approaches a designated shingle beach for a planned lunch stop. Conditions are currently moderate (Force 3 wind, 1-metre swell). The leader sees the breaking waves (Level 1) and comprehends that landing is currently manageable for the group on the lower foreshore (Level 2). However, they fail to project how the rising tide will interact with the steeper shingle slope over the next hour. Driven by "plan continuation bias"—the desire to stick to the schedule—they land the group. As the tide rises onto the steeper section, the wave dynamic changes, creating a heavy dumping shore break that turns a manageable landing into a stressful, high-risk re-launch at the water's edge.

- **Level 3 Success (Proactive Risk Projection):**

In the same scenario, the leader observes the current conditions (Level 1) and comprehends that landing is presently manageable (Level 2). However, they accurately project that within 45 minutes, the rising tide will reach the steeper shingle slope, transforming the manageable surf into a heavy dumping shore break. Even though the beach appears inviting right now, the leader anticipates the future hazard and proactively decides to divert to an alternative sheltered cove nearby, executing a smooth, drama-free landing and lunch stop.

Cognitive Traps and Heuristics in Dynamic Environments

Even experienced leaders can suffer from cognitive overload or fall victim to heuristic traps that degrade higher-level SA:

- **Plan Continuation Bias:** The unconscious tendency to stick with an initial plan despite changing environmental indicators or deteriorating group capability (often reinforced by the ***sunk cost fallacy***, where the effort already invested makes the leader reluctant to alter course).
- **Attentional Narrowing (Tunnel Vision):** Under high stress or heavy cognitive workload, a leader's focus shrinks to immediate, localized obstacles (Level 1), causing them to miss peripheral cues (Level 2) and sacrifice future projection (Level 3).
- **Outcome Bias:** Evaluating the quality of a past decision purely based on its final outcome rather than the rigour of the decision process itself (e.g., concluding in a debrief that a risky gap crossing was "safe" simply because no capsizes occurred). This creates a false sense of security that corrupts future Level 3 mental models.

Implications for Guide Training & Safety Practice

Recent empirical research into sea kayaking leadership (e.g., Collins et al., 2020) provides crucial insights into how SA functions in the field, shedding light on why even skilled paddlers struggle when stepping into leadership roles.

1. From Personal Paddling to Systemic Guiding (The Cognitive Shift)

Candidates entering guide or leadership training are typically competent personal paddlers with well-established Level 1 Situational Awareness—they can readily perceive swell, wind, and coastal hazards for themselves. However, a critical cognitive bottleneck occurs during the transition from personal paddling to leadership.

When managing a group, the guide's cognitive load increases drastically, causing Level 2 (comprehension) and Level 3 (projection) SA to collapse. The guide stops anticipating future scenarios and becomes trapped in purely descriptive, reactive observations. Guide training must therefore explicitly bridge this gap, training leaders to shift from individual environmental perception to systemic, group-level projection.

2. Bridging the Gap: Technical Ability vs. Tactical Competence

A key finding in empirical SA evaluations is that while novice leaders often possess adequate **technical skills** (boat control, stroke mechanics), their **tactical skills** are frequently lacking. Tactical competence—such as positioning prior to entering rock-hops, timing group movements between wave sets, and maintaining continuous lines of sight—is entirely dependent on Level 3 SA (predicting how environmental forces and group dynamics will interact over time).

To turn technical paddlers into tactical leaders, training must shift away from static risk checklists and focus on developing dynamic mental models.

Practical Takeaways for Leaders and Coaches

Understanding Endsley's model elevates Situation Awareness from a vague concept to an actionable, teachable skillset. As highlighted by Collins et al. (2020), effective training must move beyond simple visual scanning by embedding contextual, metacognitive prompts directly on the water—continually asking: *What do I see? What does it mean? What will happen next?*

For coaches and group leaders, the true value of this model lies in its application: it provides a structured method to train cognitive skills with the same discipline we apply to physical strokes.

Here is how leaders and coaches can actively operationalize Endsley's three levels on the water:

1. Structured SA Interrogations (In-Flight Coaching & Self-Prompts)

In leadership training and on-water coaching, coaches and leaders should actively integrate structured SA interrogations (as highlighted by Collins et al., 2020). By using targeted prompts on the water, coaches can explicitly train a candidate's cognitive process, moving them sequentially from raw observation to future planning:

- **Level 1 Interrogation (Perceive):** *"What specific changes did you notice in the surface texture of the water or the wind direction as we rounded that headland?"*
- **Level 2 Interrogation (Comprehend):** *"What does that change in water texture tell us about the seabed bathymetry and current interaction underneath us right now?"*
- **Level 3 Interrogation (Project):** *"If the wind increases by 5 knots over the next 45 minutes as forecasted, how will this landing site evolve, and what will our alternative exit options be?"*

By forcing trainees to articulate these steps out loud during pauses in the trip, coaches help them transform passive observation into an active, structured habit.

2. Managing Cognitive Bandwidth Through Task Delegation

Assigning routine operational tasks to competent group members—such as directing an experienced paddler to handle a standard rescue or manage a tow line—is a universally recognized best practice in sea kayak leadership. The rationale behind keeping a leader free from hands-on execution lies in the cognitive consequences of direct physical involvement. The primary risk when getting directly involved in a task is task fixation (or tunnel vision), where focus narrows so completely around the immediate job that even critical Level 1 environmental cues—such as a subtle drift towards a rocky lee shore—go entirely unnoticed. While an

accomplished leader might execute a rescue while maintaining visual awareness of their surroundings, Endsley's model reveals the hidden cognitive cost. Even when basic sensory signals reach the senses (Level 1), the bandwidth required to synthesize their meaning (Level 2) and project future consequences (Level 3) is severely degraded while physically engaged in execution.

Delegating routine operational tasks offloads low-level sensory monitoring, directly preserving the leader's primary cognitive bandwidth. This free mental space is precisely what allows a leader to operate at Level 3, maintaining the macro-level "big picture" projection required for safe trip management.

3. Building Shared Situation Awareness

In multi-leader teams, guided groups, or peer-paddling environments, safety relies not just on individual SA, but on **Shared Situation Awareness (SSA)**. Grounded in Mica Endsley's team cognition model (1995) and applied to high-risk environments by Gareth Lock (2019), SSA simply means that everyone in the group shares a compatible picture of what is happening and what comes next. A single leader's SA—no matter how sharp—is of limited use if it stays locked inside their head, though for very different reasons depending on group structure:

- **In multi-leader or peer environments:** Individual SA is insufficient because tactical execution is shared. Without shared SA, co-leaders cannot execute backup plans seamlessly, nor can they spot and correct a peer's cognitive blind spots or heuristic traps.
- **In guided groups:** Individual SA is insufficient because group members need operational predictability. If a leader holds accurate SA but fails to communicate where the group is going and why, members experience environmental shifts—such as sudden changes in sea state, swell, or wind—as chaotic threats, raising anxiety, hesitation, or non-compliance during critical manoeuvres.

To build appropriate SSA in practice, leaders must recognise how it shifts based on who they are paddling with:

- **Symmetrical SSA (Multi-Leader & Peer Environments):** Requires overlapping, highly detailed tactical agreement. Peers and co-leaders must explicitly agree on environmental triggers, hazard margins, and delegated roles.
- **Asymmetrical SSA (Guided Groups):** Does not require group members to process the leader's full risk matrix. Instead, the leader establishes practical alignment by translating complex Level 3 projections into clear operational intent—ensuring members understand what is happening, why, and what specific action is required of them right now.

To build this shared picture on the water, leaders can use **Cognitive Modelling**—thinking out loud. Before committing to a dynamic marine feature (a tide race, surf zone, or headland crossing), the leader explicitly states their three-level thought process:
"I am seeing steep, chaotic waves forming over that shoal (Level 1). The ebb current is accelerating against the wind (Level 2). I project that in 20 minutes this channel will be fully breaking, so we are keeping tight, moving now, and taking the southern line (Level 3)."

Crucially, Cognitive Modelling acts **also** as a primary defence against cognitive biases and heuristic traps, such as the "expert halo" or "social proof." By explicitly verbalising their logic and **actively inviting the group to ask questions, seek clarification, or challenge the plan**, the leader dismantles the dangerous assumption that they are infallible and beyond questioning.

However, for this process to work, the environment must foster **psychological safety** (Lock, 2019). Without it, peers may hesitate to question a flawed tactical plan, while less experienced group members may fail to voice critical Level 1 personal data—such as early fatigue, cold, or mounting anxiety—until it turns into an in-water crisis.

Finally, integrating a rapid **Mini Pre-Mortem** before a commitment point serves a dual purpose. Between co-leaders or peers (*"If someone capsizes in this gap right now, where do boat and swimmer wash, and who initiates the recovery?"*), it tests the strength of Level 3 tactical alignment. In a guided group (*"If we get separated near the headland, everyone holds position in the eddy while I extract the swimmer"*), it sets clear boundaries, manages expectations, and eliminates panic before entering the hazard.

4. A Practical Defence Against Heuristic Traps: The "3-Variable Check"

Theoretical knowledge of heuristic traps (such as outcome bias or plan continuation bias) is useful, but leaders need a concrete tool on the water to stop themselves from making automated Level 3 projection errors.

In Endsley's model, the transition from Level 2 to Level 3 relies on pre-existing mental models. Under time pressure or fatigue, the brain naturally defaults to cognitive shortcuts (*"We did this last year, so it's fine today"*). To break this automatic trap, leaders should implement a mandatory **3-Variable Check** before confirming any major route decision or plan continuation:

- **The Rule:** Before committing to a plan, the leader must explicitly identify three live, objective Level 1 variables from today's environment that justify the decision:
    1. **Environmental Trend:** Is the tide, swell, or wind improving or deteriorating over the next hour?

2. **Group Reserve:** What is the weakest paddler's actual physical and emotional stamina right now?
3. **Point of No Return:** Where is our last safe abort option or landing spot before committing to this stretch?

If the justification relies on *"It worked last time"* or *"The morning forecast said it would be calm",* the leader is relying on a stale mental model and must pause to re-evaluate their Level 3 projection.

5. Post-Session SA Debriefing (Cognitive Feedback)

Debriefing is a fundamental component of structured learning and professional leadership. Whether in coaching sessions, multi-leader teams, or peer groups, it provides the primary mechanism for consolidating experience, identifying operational gaps, and maintaining psychological safety within the team.

However, traditional debriefs often focus exclusively on physical outcomes or technical execution ("The tow went well," or "Your edging was effective"). Integrating a structured review of Situational Awareness into the debriefing routine shifts performance analysis onto the decision-making process itself.

In coaching sessions, this approach provides targeted cognitive feedback for trainees. Rather than evaluating only the physical manoeuvre or tactical choice, the coach deconstructs the underlying decision-making chain. By asking targeted questions—such as *"Did you notice any changes in the surface conditions as we approached the headland?"* (Level 1), *"What did that sudden change in surface texture indicate to you about the current?"* (Level 2), or *"When the tide began to turn, what did you expect the sea state to look like 30 minutes later?"* (Level 3)—the coach helps trainees identify the precise stage where a cognitive breakdown occurred.

Similarly, within multi-leader teams or peer groups, an SA-focused debrief serves as an operational review of shared decision-making. Even when Symmetrical Situational Awareness (SSA) is actively maintained on the water, the post-session environment remains essential for verifying that real-time alignment was genuinely shared rather than assumed. Co-leaders can explore questions such as *"Did the sea state evolve as quickly as we predicted at the morning briefing?"* or *"Was there a point where anyone noticed early signs of group fatigue that we didn't discuss on the water?"* This process recovers latent Level 1 cues filtered out by operational pressure during the trip and evaluates the accuracy of shared Level 3 projections.

Structuring post-session reviews around cognitive processes rather than personal performance normalises open communication, ensuring that catching a missed cue or updating a flawed projection is integrated into standard seamanship.

Conclusion

Sea kayaking is inherently a sport of dynamic decision-making. While refined physical strokes, robust bracing, and efficient rescues are essential tools in a paddler's arsenal, they are ultimately secondary recovery mechanisms. True seamanship lies in cognitive prevention.

By adopting Endsley's Three-Level Model of Situation Awareness and enriching it with contemporary findings on cognitive load and tactical competence, we gain a rigorous, proven framework to analyse how we process the ocean. By actively training our ability to perceive subtle cues, comprehend complex marine interactions, and project future scenarios, we move beyond simply reacting to the sea—we learn to read it, anticipate it, and lead within it with confidence and clarity.

References and Further Reading

- **Collins, L., Giblin, M., Stoszkowski, J. R., & Inkster, A. (2020).** A study of situational awareness in a small group of sea kayaking guides. *Journal of Adventure Education and Outdoor Learning*, 21(3), 251–263.
- **Endsley, M. R. (1995).** Toward a theory of situation awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 37(1), 32–64.
- **Lock, G. (2019).** *Under Pressure: Diving Deeper with Human Factors*. Human in the System Consulting.
- **McCammon, I. (2004).** Heuristic traps in recreational avalanche accidents: Evidence and implications. *Avalanche News*, 68, 42–50.
- **Osborne, S., & Stevenson, J.** *Leadership Course*. Online Sea Kayaking (www.onlineseakayaking.com)
- **Paddle Canada (2017).** *Sea Kayak Program Manual* (PDF).
- **Paddle UK / British Canoeing Awarding Body (2024).** *Participant Focused Leadership Guidance*.
- **Paddle UK / British Canoeing Awarding Body (2021).** *Leadership in the Challenging World of Paddlesports*.