Development and application of a low cost, dual use GPS drifter system to measure rip and benthic nearshore currents for use in Search and Rescue and Lifesaving applications

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Abstract

The purpose of the research is to develop a process and methodology that can be used to map out nearshore currents (rip/benthic) using an inexpensive, dual use GPS drifter. Upon completion of the trial the process will have the capacity to be applied across nearshore environments focusing on pre-determined high risk beaches and headlands over New Zealand. Search and Rescue NZ and associated authorities are interested in building up a database of these nearshore currents that can be used to refine search patterns for missing persons in the nearshore environment and this research direction addresses this.

Key words: Headland rip currents, dual use drifter, benthic currents, beach safety, search and rescue

Introduction

Drowning is a very current issue on the New Zealand coastline, current figures released by Water Safety New Zealand state that an average of 102 people drown each year, but up to 80 of these deaths are preventable. Incidences on beaches represent an alarming 22% of the figures. Within the 2016/17 summer alone there were 67 drownings, of those 18 occurred at beaches and this figure represents a 40% increase on the summer prior (Surf Life Saving New Zealand, 2017). The increase in fatalities was distressing, especially in light of the New Zealand Water Safety Strategy 2020 whose aim was to reduce preventable drownings by 35% in a five year period. These facts highlight the importance of research, especially on beaches, to contribute towards reducing the number of NZ coastal drownings.

The understanding of nearshore currents, particularly those focused around headland structures are vital for locating persons either drifting offshore in topographically controlled rip currents or more critically submerged as drowned bodies within sub-surface currents. A vast wealth of knowledge exists for rip currents, however there is a rudimentary understanding of nearshore sub-surface currents outside of the surf zone. This research will introduce the state of knowledge that exists on rip and benthic (sub-surface) currents, before developing information and mapping hazardous rip currents on Mount Maunganui beach; a pre-determined high risk beach highlighted by the national lifesaving service: Surf Life Saving New Zealand. The research will then introduce a tool to aid body recovery for search and rescue agencies, before finally developing a summary of the project and recommendations for future work

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Literature Review

2.1 Rip currents

Rip current research over the last 50 years has been extensive and has developed an understanding of how these shore normal, seaward flowing bodies of water operate within the surf zone. Recent research has identified several circulation types that occur on open-coast (beach) rips; most notably closed cell circulation. This behaviour results in recirculation and retention of water within the surf zone and occurs with episodic discharges that moves water out to sea past the break zone. These findings have been consistent with research on different tidal regimes on meso-macrotidal (Australia and France) and macrotidal (UK) beaches (MacMahan, et al. 2010; Scott, et al. 2014). In contrast, topographic (headland) rip flows can form when alongshore currents are driven by waves approaching the beach at an oblique angles (McCarroll et al., 2014). Permanent obstructions to alongshore currents in the form of headlands, rocky outcrops or groynes can deflect the current in an offshore direction in the form of rips (Loureiro et al., 2012; McCarroll et al., 2014). Pocket and embayed beaches can disrupt the normal rip circulation pattern creating a higher velocity topographic rip (Loureiro et al., 2012), this high energy current has also been referred to as a megarip. Megarips are of particular danger especially to the exposed West and the cyclone dependant East coasts of New Zealand (NZ) which can both experience high energy wave regimes. In NZ it is estimated that 85% of all recorded incident statistics by lifeguards are caused by rip currents (SLSNZ 2017)

Fig.1. A headland Megarip occurring on an embayed beach, Saint James Point (South Australia). The rip neck and rip head are both easily identifiable off the Northern headland as a mushroom shaped plume. (Photo courtesy of Prof. A.D. Short)

2.2 Sub-surface currents

Sub-surface current research has been mainly driven on continental shelf regions, with focus on benthic current effects on coral occurrence (Rengstorf, et al., 2014). In contrast, the nearshore sub-surface current knowledge is primarily focused on the surf zone, with use of Acoustic Doppler current profilers (ADCP) (Johnson, Stocker, Head, Imberger, & Pattiaratchi, 2003) which can measure water current velocities over a specified depth range. To date there has been no research that addresses benthic currents in the nearshore or around headlands. This research will address sub-surface (hereafter known as benthic) currents that are confined to the sublittoral zone of embayments and headlands, located between the intertidal zone of the nearshore and offshore areas, at depths of upto 20m.

2.3 Search and rescue

The requirement for near real-time data on surface current measurements in close proximity to the last known position (LKP) is essential for search and rescue (SAR) operations. Soon after the advance of computer technology, the Monte-Carlo probability distribution method developed during the 1980's and 90's used computer modelling to predict drift on an object in the open ocean (Breivik, et al., 2012). To further enhance accuracy of localised searches the SAR sector has focused on the tracking of surface currents with the use of self-locating datum marker buoys (SLDMB) which were deployed for long term searches in the open ocean (Allen, 1996). The technology was commissioned by the US Coastguard for deployment from vessels aswell as fixed wing and rotary aircraft. The inexpensive SLDMB drifter was developed to use GPS tracking, which can produce real-time live data to the end user, for use in time critical searches to ascertain current direction and obtain sea surface temperatures (Iridium, 2017).

2.4 Lagrangian drifters and associated sub-surface current apparatus

Open ocean langrangian drifters are apparatus that measure the current flow and velocity on the sea surface and drogues are used to measure the sub-surface flow at up to depths of 10m. The traditional Langrangian drifter has since been modified for short term data collection in nearshore and lake environments (Johnson, et al., 2003). The main application in the nearshore has been for rip current research (MacMahan, Brown, & Thornton, 2009; Scott, Masselink, Austin, & Russell, 2014) with modification enabling it to be used in the surf zone. The design allows the drifter to sit in the top 30cm of the water column, which is the depth rip currents operate in the surf zone. They are designed to effectively replicate a human body in a rip. The design of the apparatus uses an inexpensive plastic construction as the new drifter type no longer requires ocean going capabilities. As a result of the research highlighted here, this project will build on the success of the surf zone drifter developed by Scott, Masselink, Austin, & Russell (2014) to create a simplified dual purpose drifter for use in both surface and subsurface applications.

Project outputs

The purpose of this paper is to develop a dual use GPS drifter and an accompanying methodology for their application within rip current and benthic current research for Surf Life Saving New Zealand and the Search and Rescue sector respectively. Increased knowledge and understanding of localised headland rip currents can influence and promote a more pragmatic approach by the Lifesaving Service, whereas a simplified and easy to use underwater drifter can provide nearshore benthic current information that can enable search and rescue authorities to predict the locations of a submerged body accurately. The resulting search patterns have the capability to be further refined; applying both real time data alongside local knowledge, thus avoiding searching simply off instinct.

The main applied outputs from the research will produce:

- **Educational output for SLSNZ**: Providing the lifesaving services department an additional knowledge base and understanding of rip currents. The outputs will give SLSNZ direction of how to educate the general public on their dangers.

- **Rip current research template**: A methodology and costing profile for SLSNZ to study one beach in detail

- **Live benthic current monitoring system**: A pilot methodology and apparatus design for live deployment by SAR agencies

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Methods

In this paper a dual use methodology is developed using GPS Langrangian drifters which allow rip currents to be measured at the surface and upon submersion of the apparatus, benthic currents can be tracked. These two outputs will be split into separate experiments, with a week-long intensive rip current field exercise and a two day rudimentary trial for the testing and development of the benthic current methodology.

3.1 Study site

Both experiments were carried out at Mount Maunganui main beach, Bay of Plenty region, New Zealand (Fig.2) over a 6 week period between January and March 2017. The beach is the busiest in the Bay of Plenty region and regularly receives over 3000 beach users during the peak summer period from mid-December to early February. The average wave climate over the summer consists of a mixture of low period wind waves and long period North-easterly groundswells. These are generated by tropical cyclonic events that originate in the tropics and advance poleward creating powerful, high energy swells on the East coast.

Fig.2. Mount Maunganui beach location, with the two labelled study sites: Leisure Island and North Rock

3.2 Dual use drifter

The freely floating, impact resistant, GPS-tracked surf zone drifters are 0.5-m tall cylindrical structures with most of their volume below the water line. Three fins were attached to the main body of the drifter and this allowed it adequate stabilisation to effectively keep with the head of the current. A horizontal disc at the bottom of the body tube dampens vertical motions in the waves, allowing broken waves to pass over the drifter without pushing or “surfing” it ashore. The GPS drifter was built in-house on a design modified from that of (Scott, et al., 2014).

The methodology used here builds on the model of the langrangian drifter explained above. Additional features include two openings sealed by retractable watertight bungs which are used to regulate the volume of water in the main body of the drifter, which creates a ballast effect. Regulation of the water contained in the ballast can be finely controlled to achieve appropriate negative buoyancy to sink to drifter yet allow it to flow in benthic current freely. Regulation of the water contained in the ballast can be finely controlled to achieve appropriate negative buoyancy to sink to drifter yet allow it to flow in the benthic current unrestricted. Testing in a controlled environment showed the drifter would achieve negative buoyancy and sit at the desired water depth of 5m with 850ml of sea water in the body of the drifter. The submerged drifter was then attached to a buoy at the surface by a tether line and to compensate for the wind induced slippage on the buoy an external 30cm of line was used.

3.3 Rip current data collection

The fieldwork week conducted from the 30th Jan- 3rd Feb provided a snapshot of typical summer conditions and their implications on beach safety at Mount Maunganui main beach. The rip current field study was carried out at the Leisure Island headland rip system on Mount Maunganui using Langrangian field observations under low-moderate (0.5-1.5m) wave conditions. The period (30/1-3/2) for the rip current research was selected as small clean long period waves were forecast. This ensured the study represented average summer wave conditions and assessed the hazards they can generate.

The fieldwork required three research assistants who were all qualified surf lifeguards, their jobs were to operate the Inshore Rescue Boat (IRB) and deploy and retrieve the drifters once they either washed up or exited the experiment area. Deployment was carried out over a total of 8 sessions, each lasting 2 hours. The week comprised of 7 mid tide and 1 high tide drift sessions, which covered a range of different wave heights, periods and peak swell directions. It is worth noting that due to the restricted time constraints of the experiment period, mid tide on both pushing and ebbing tidal cycles was focused on as the headland rip was most prominent at this stage of tide and presented the greatest hazard to bathers.

Drifters were deployed in 1m of water on the seaward edge of the sandbar, which is typically within the shore side boundaries of the rip neck as defined by MacMahan et al. (2009). This was to ensure complete spatial and temporal coverage of the feeder and rip channels throughout each drift. Drifters were always deployed at the same point on the beach (Fig.3), on the sandbank adjacent to Leisure Island to ensure consistency. A minimum of four drifters was always deployed at one time into the surf zone, with a maximum of six deployed during smaller wave conditions.

Fig.3 Drifter deployment position on sandbank adjacent to Leisure Island, as marked in box. During the experiment itself the deployment area was marked out by Emsisoft flags.

3.4 Benthic current data collection

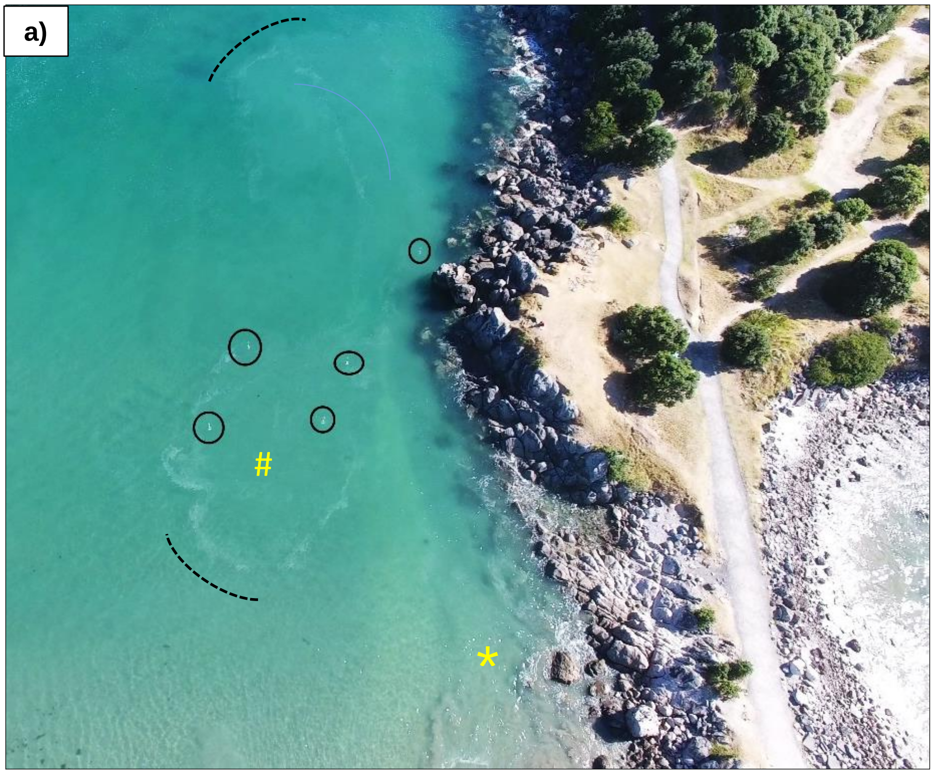
The benthic currents were measured using a novel instrumentation over two separate trial field days on the 6th and 14th March 2017 respectively. The deployment of a singular Langrangian drifter took place over two ebbing tidal cycles and was left in for an hour at a time. Benthic current measurements were assessed off North Rock, located just off the eastern seaward perimeter of Mount Maunganui. Once deployed and the drifter was submerged at the pre-specified depth of 5m the apparatus was left to freely track the current. A diver was used to track the progress of the drifter underwater and gain footage using a Go-pro Hero 4. The trial was carried out in low (<1m) wave conditions to ensure the safety of the diver near the rocks and an Inshore Rescue Boat was used to transport the equipment and personnel to and from the location.

3.5 Ethical considerations

The experiment locations were selected as they represented two prominent drownings which occurred during recent years. Jack Dixon, a 5 year old who was swept off the Eastern side of Mount Maunganui during large swell conditions in October 2014 (NZ Herald, 2014) would have been moved by strong currents off North Rock. This hazardous feature just offshore from the Mount funnels water between the tidal estuary discharge from Tauranga harbour and the Mount main beach. The Leisure Island headland rip system and the interrelated underwater benthic current proved an integral problem for the SAR operations in the determination of the search direction for the recovery of the local Mount Maunganui volunteer lifeguard, Hamish Reiger who was swept off the rocks at Leisure in January 2016 (Herald, 2016). The vast majority of search assets were concentrated to the southern end of the beach. His body was eventually located at the Northern end of the main beach, contradictory to local predictions. Before the commencement of the research, permission was sought from the family of Hamish Reiger to ensure the ethical research was approached in the correct manner.

Results

4.1 Educational output for SLSNZ



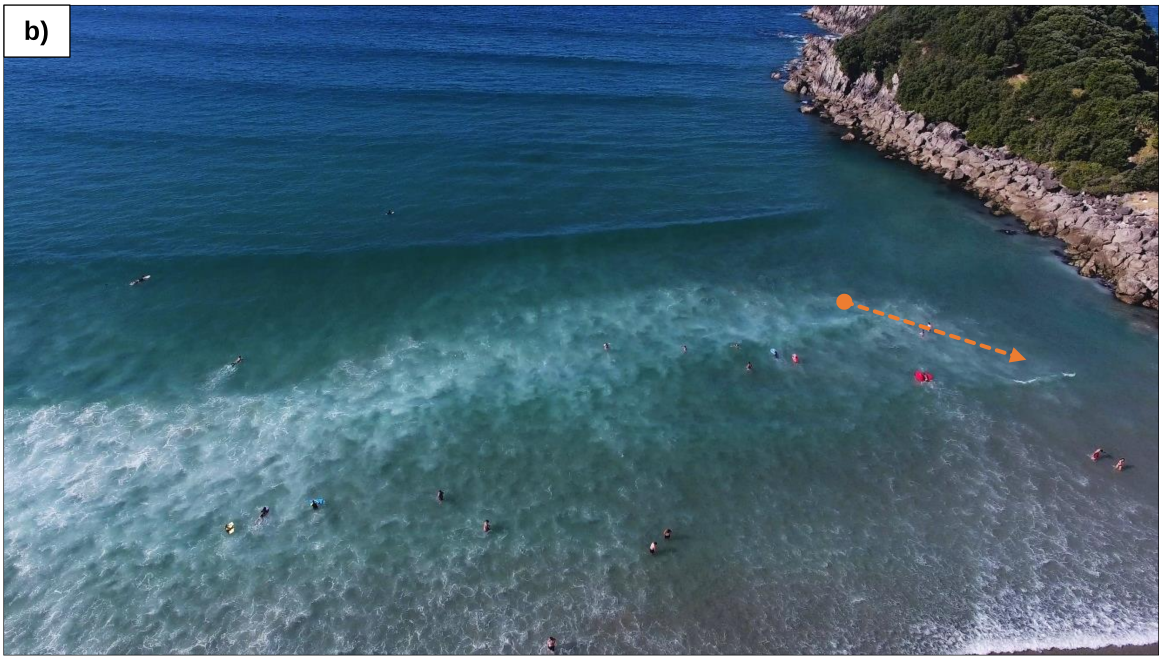


Fig.4 a) Birdseye angle of headland rip current, Leisure Island. Drifters identifiable by circles. (*) Rip neck of inner feeder rip. (#) Rotational rip behaviour on outer bar. Dashed lines represent the landward and seaward extent of the main rip system; **b)** Oblique angle image of nearshore surf zone and headland rip position at Leisure Island. Dashed arrow highlights the angled wave breaking action into the rip; **c)** Headland rip clearly displaying deeper water shown in a dark blue colour.

The above imagery displays a birds-eye (fig.4a) and oblique overhead angle view (fig.4b) of the headland rip off Leisure Island, Mt.Maunganui during a small, long period groundswell (31/1/17). Feature tracking technology was used by the drone in fig.4a to follow each drifter out through the rip and each instrument is clearly circled to show their relative positions. Due to the consistent nature of the topographic rip and its associated feeder currents, all drifters were shown to display rotational behaviour on the sandbar before moving offshore. The image also clearly shows the light coloured plumes of sand and turbulent water moving offshore which dissipates at the rip head which is labelled in fig.4a. Further, there is an interesting interaction with the shallow feeder rip. The feeder is shown to drain the water run-up on the shoreline with the discoloured rip path along the rocks (*). The draining of water from the outer bar centred at point (#) is seen to join the main headland rip in pulsing events after a large set of waves. Within the image micro-eddies are also seen to be forming on the edge of the sandbar, which were created during the pulsing of the feeder and rip currents during a lull between waves.

The second image shown in fig.4b shows the relative unawareness from bathers to a defined deeper water channel which exists to the immediate right of the sandbar. The arrow highlights waves that are breaking diagonally into the rip channel (*). This could present a danger to body boarders and small children alike as waves can easily refract into the rip and drag bathers into areas of deeper water that are also adjacent to rocks. The resultant scenario can effectively create a heightened sense of panic and detrimentally effect an efficient rip escape strategy, which can have serious implications for bathers out of the patrolled season. The same scenario can also be applied to fisherman, except with the additional lines, gum boots and clothing would prove to be significantly more life threatening.

4.1.1 Significant rip current data from GPS drifter fieldwork

The GPS drifter tracks show a mixture of rotational and exit dominated behaviours in Fig.5a with a more evenly spread mixture between alongshore transport and exit/rotational behaviour in Fig.5b. The headland rip morphology exists over the sandbar during the mid-tidal cycle. Therefore the measurements on both days were taken during this period.

The wave conditions on the 30/1 were 1.05m with a significant wave period of 10 seconds and a shore normal North-east wave approach. These prevailing conditions represent a small, long period groundswell typical of summer conditions in the Bay of Plenty. The cluster of points located close to the headland in Fig.5a represent the rotational behaviour of the rip current on the sandbank at mid tide, as circled. The varying velocities of the drifters shown by the yellow and blue line colours in Fig.5a indicate the pulsing nature of the rip as they circulate on the sandbars before joining the headland rip. Further the plots show the definition of a strong headland rip which extended on average over 100m offshore and significantly past the break zone before dissipating.

The 31/1 produced smaller wave conditions (0.9m, 9 seconds) and a NNE oblique swell incidence angle (Fig.5b). The Langrangian drift patterns showed a considerable amount of alongshore directed current moving in a northerly direction, contrary to what was expected at the Mount. The alongshore current on North-east swell direction down the coast at Omanu and Papamoa would usually sweep in a southerly direction, so the same was expected at the Mount. It was noted that once drifters were deployed on the sandbar (Fig.3) they would either join the Leisure Island headland rip, or move alongshore down the beach. On some occurrences the drifters successively joined several open coast rips as they moved in a northerly direction along the beach. This was before exiting the surf zone via the northern embayment headland rip, towards North rock (Fig 1). A large proportion of drifters showed that exit/rotational behaviour was still active, however, the headland rip at Leisure was seen to dissipate earlier, most probably due the decreased wave incidence energy provided by the wind swell.

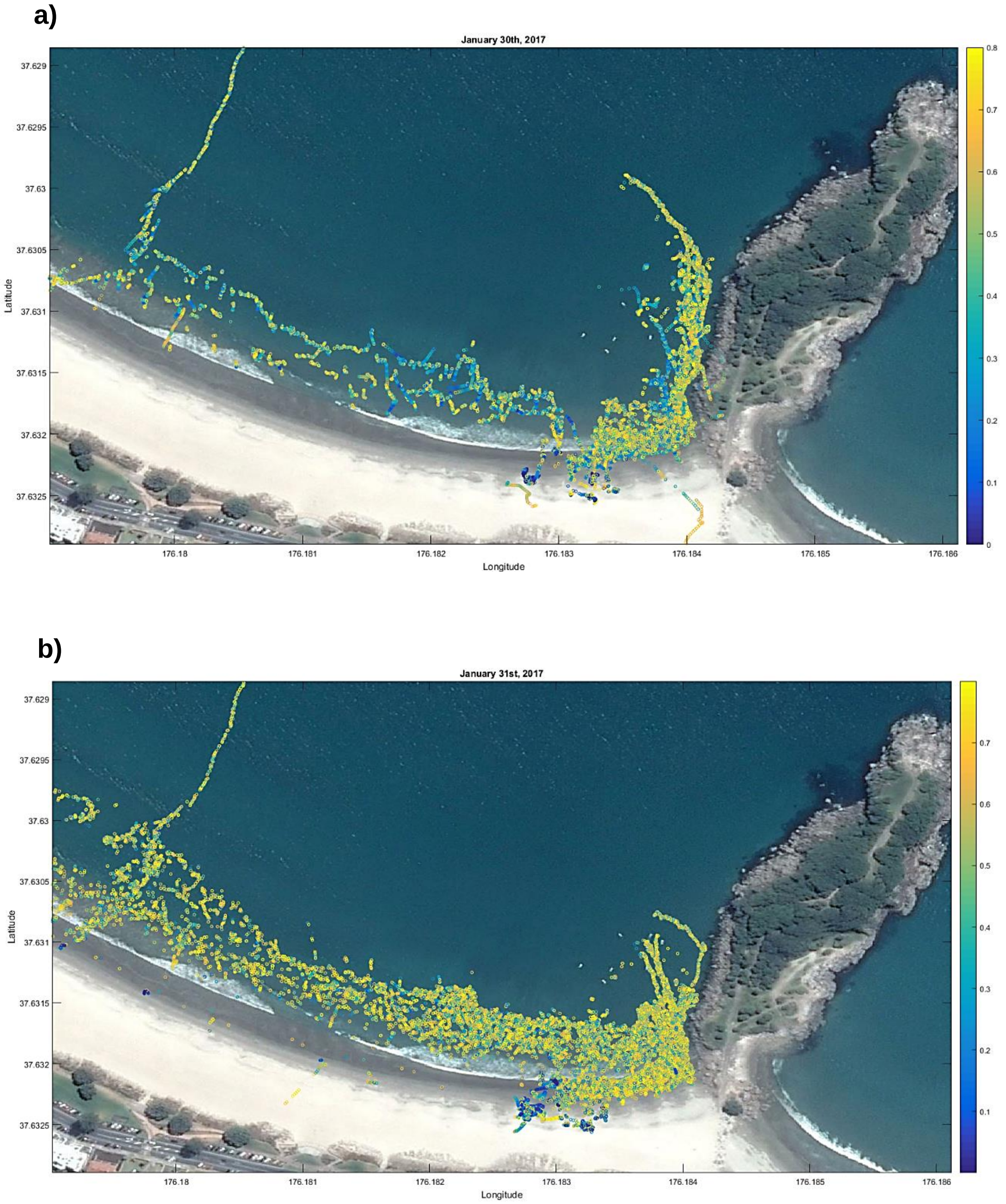


Fig.5 Maps showing combined GPS drifter motion in rip and alongshore currents, velocity is represented in m/s. Using **a)** 4 drifters (30/1/17). Circled area highlights rotational rip behaviour on sandbar; **b)** 6 drifters (31/1/17)

In **conclusion** results can indicate that the Mount experiences its own cellular circulation with two topographic rips draining the beach from the southern (Leisure Island) and northern ends, with several cellular open coast rips existing between. Further, a groundswell from the North-east was seen to produce a well-defined headland rip system that predominated over alongshore transport.

Following the discussion on the behaviour of the headland and beach rip current systems in operation at the Mount, guidelines below highlight the main educational messages that can be used by Surf Life Saving NZ:

Recommendations for Beach Safety:

- Guidelines to educate public about dangers of rock jumping/fishing off headlands during swell, as currents can be unexpectedly stronger than they appear.

- Body boarders and swimmers not to bathe on sandbars adjacent to headland rips, even if it appears there is considerable wave action. Headland rips are intense, narrow and fast moving areas of deeper water.

- Headland rips can extend far past the ‘last breaking wave’, sometimes up to 100’s m offshore in the form of a mega rip (~2 m/s).

- The deployment of the drifters on days of moderate to strong wave conditions can aid decisions relating to the positioning of the bathing areas at the beginning of the day.

4.2 Rip current research template for SLSNZ / Emsisoft

The project brief and cost profile required to study Mount Maunganui will here be evaluated alongside recommendations for SLSNZ directed at extending the study to beaches throughout New Zealand will be discussed.

Operational brief

- A minimum team of 4 is required for operations:

-2 IRB (**IRB 1**)

- 1 person in shallows retrieving/deploying drifters (**Inshore 1**)

- Co-ordinator (**Dan**)

- Surface drifters are numbered **D1-D4** (stripes on shaft), Benthic drifters are numbered **B1/B2** (stripes on shaft)

- All personnel to wear Surf lifeguard rash vests and **IRB 1** to wear Surf Lifeguard rash vests + SLSNZ lifejackets.
- **IRB 1** and **Inshore 1** to retrieve/carry drifters at the base of the shaft on instrument.
- Take extra time and precaution if retrieving within the surf zone, they are heavy!
- If anyone is tired, cold or wants to swap roles just radio through/signal to **Dan**.
- If drifters are nearing surfers, swimmers or rocks and are posing a hazard simply remove from water, this is only an experiment!

Beach set up

- The boundaries of the experiment area should be clearly flagged with the **EMSISOFT** banners so the **Inshore**/**IRB** teams can see when the drifter has exited the experiment area.
- 2 Training signs to be displayed on beach.
- A foam board should be used as a standby device by the inshore team to collect drifter.

Drones

- Operated by **Nathan Smith** from the headland.

3) Fieldwork execution

During the experiment

- Radio contact maintained throughout experiment on C3 between **Dan**, **IRB 1** and **Inshore 1**
- **Dan** to radio **IRB 1/ Inshore 1** to tell you to deploy/pick up drifter**.**
- Clear distinct behaviour required by **IRB 1/ Inshore 1** to highlight where drifter starts/stops.

Drifter deployment

- Each drifter (e.g D1/B1) must be identified and radioed to **Dan** before release.
- Before release **Inshore 1** must walk in a straight line seaward for 5m to show recognisable behaviour.
- Benthic drifters should be deployed upside down so no air bubbles catch under the antenna.
- All drifters deployed at a depth of 1m, ideally at the seaward edge of the inner bar so complete measurement of the feeder/rip currents can be covered
- **Inshore 1** deploying should wait until radio contact from **Dan** before drifters are released.

Drifter retrieval

- Drifters will not be retrieved by **IRB 1** unless they have received a radio comms from **Dan**.

- **IRB 1** to accelerate shorewards in a straight line to display recognisable behaviour.
- **IRB 1** handover drifters to **Inshore 1**.
- **Inshore 1** brings drifters back to shore walking in straight line to show recognisable behaviour.

The rip current research template (shown above) is designed for use by any person with prior knowledge of rip currents and how they operate, which can be expected of a qualified lifeguard with a Surf Lifeguard Award (Bronze Medallion).

The operational brief for the team was the most vital stage of preparation for the success of the fieldwork and subsequent data analysis. Moreover, this ensured that the drifters could be recording as much information as possible on the rip current dynamics and this increased the efficiency of the process.

4.2.1 Equipment available

<u>Resources</u>

- 1 x IRB (Emsisoft marked)
- 10 x Rip drifters (University of Waikato)
- 10 x Dual use drifters (SLSNZ/Emsisoft)
- 4 x DJI Phantom 4 drones
- 21 x QStarz (BT-Q1000eX) GPS devices (11 x University of Waikato/10 SLSNZ)
- 3 x Emsisoft flags to mark out study area
- Yute (4WD)
- 3 x VHF radios
- Volunteer lifeguards at each beach
- Laptop
- 4 x Samsung Galaxy Tab 3 Lite VE 7.0" Tablet

Above lists the available resources for SLSNZ to complete a rip current study; all equipment is located at the Eastern region office, Mount Maunganui. Some equipment is on loan from the University of Waikato, including 11 x GPS devices and 10 x rip drifters which are marked red/yellow. The cost of the project (Table 1) simply represented the research cost in hours for the research plus the accommodation costings for 4 nights’ accommodation at a surf club.

Table 1. Total asset cost for studying one beach in detail (5 days) based on Mount Maunganui; including personnel cost based on a minimum of four people (3 research assistants and 1 research lead).

Assets	**Cost ($)**
Total cost of personnel (3x Research assistants @ $18/hour / 1x Lead researcher @ 25/hour)	2893
Surf club accommodation (4x @ $20/night)	320
Total cost	**3213**

4.2.2 Limitations and recommendations for future study

The research presented here was conducted over the course of one week, this ensured an adequate understanding of rip current behaviours that were limited to small wave conditions. Therefore, the research did not classify rip current behaviour and their associated hazards over medium and large wave conditions. The rip study template was designed to provide an overview of rip behaviours for one beach over a specified amount of time, dependant on personnel available and logistical constraints.

For a complete understanding of beach morphodynamics, a four to six week study would be recommended with a minimum of 6 researchers. This would allow the study to measure rip current behaviours over a complete range of swell, wind and tidal regimes. The study does however provide the regional and volunteer lifeguard services a tool to measure rips on any timescale they desire. A recommendation could be the deployment of the apparatus on days of moderate to strong wave conditions to aid decisions relating to the positioning of the bathing areas at the beginning of the day. An additional application of the research could be used as an operational tool for lifeguard education and development.

4.3 Development of a Dual use GPS drifter for benthic current measurement

The following section will build on the development of the dual usage GPS drifter methodology (see section 2.4) and discuss how it was applied in the field. Further an evaluation will also assess how the apparatus performed during the experiments and finally a summary will highlight any recommendations for further apparatus development including future research.

4.3.1 Field trial

Two trial dates (7.3.17 / 14.3.17) were conducted to measure benthic currents around North Rock, Mt Maunganui. The two deployments successfully trialled the new dual use drifter at water depths of 5m.

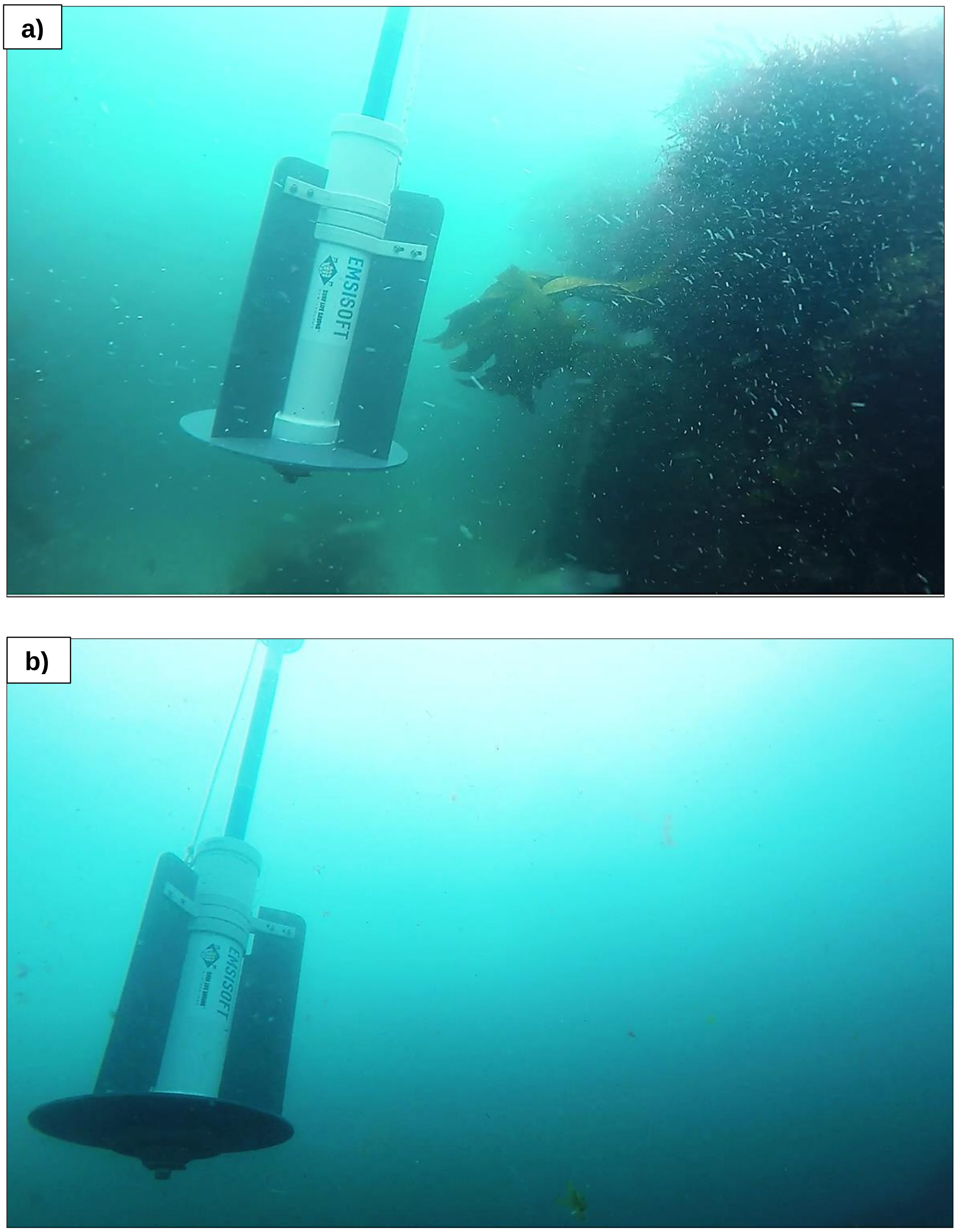


Fig.6 a), b) Underwater images taken of the drifters at 5m depth.

The imagery displayed in Fig.6 shows the submerged drifters within the benthic current. Fig.6a shows the drifter moving freely between beds of kelp. The interaction between the drifter and large kelp was minimized due to the twisting motion of the apparatus underwater. The experiment also revealed an oscillating vertical motion in the benthic current, as the drifter would surface slightly before moving horizontally within the current. Fig.6b shows the drifter on an updraft vertical motion taken from a video screenshot. The disc at the base of the drifter presented an adequate surface area to feel the current and allowed visualisation of the displacement. However the GPS device on the surface was unable to measure the vertical oscillating motion, so this could be an addition to the *in situ* design.

The novel technology presented here allows for easy deployment from various vessels, for the research presented here an IRB was used to effectively transport, launch and retrieve the drifters whilst maintaining safe operational practice. The drifter was simply lowered into the water, with care ensured to eliminate air pockets underneath the antenna head. After the drifter had settled at 5m depths (indicated by ~30cm excess of line at the surface), the GPS was switched on and the buoy deployed to initiate the exercise. The simple, hooked buoy had a low profile and was shown to experience minimal wind induced slippage influence. The drifter was attached to the surface float by a tether line and its drag was found to be negligible, which is consistent with findings by Johnson, et al. (2003).

In a live context the drifter can be set-up and deployed within 5 minutes, which would enable it to become a vital tool within time critical SAR applications. As highlighted there is demand for a nearshore dataset by SAR agencies in NZ and the methodology proposed could aim to cut search times and facilitate efficient body recovery with the live deployment of the dual use drifters, allowing closure for the families involved. The timescale, costings and personnel involved of each search effort also have the capacity to be reduced with the availability of historical and real time data in a localised nearshore area.

The research presented here also has an accompanying fieldwork brief to aid with the deployment and retrieval of the benthic drifter during a live search or for fieldwork exercises. The brief was carefully designed to be understood for all who have either a background in either lifesaving or Search and Rescue.

4.2.2 Limitations and recommendations for future study

Limitations within the apparatus design were noted during the trial days. The basal plate proved problematic, as it caught on rock crevices and ledges. As a recommendation; the next generation of drifters could have a more robust, moulded heavy duty plastic construction with reduced use of metal and bolts and move towards using moulded plastic fins. The floatation device at the surface also has the potential to be modified; the proposed new profile would be of lower surface area, constructed of polystyrene to minimalize wind effect and be lightweight enough to accurately follow the drifter's underwater movements over surface current influences. As a result of the trial, it can be concluded that the dual use drifter is only currently suitable for sand bottom environments until a modified more robust design can be implemented. In regards to the GPS device, a higher spec unit could be used that feeds directly onto a live computer system. This would be the most critical component if the drifters were to be used effectively in a maritime search.

Fig.7 Deployment of the dual use drifter from an Inshore Rescue Boat

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Summary

- Developed a simple methodology for the drifters to be used by multiple agencies in a **live** Search and Rescue application (SAR, Coastguard, police) and for collecting a **database** of statistics.
- This methodology can be used for individual beach research that can be applied nationally.
- Drones are an effective means of data collection and analysis alongside being excellent beach education outputs.
- The continuation of the field work could have the potential to develop the depth of understanding of not only headland rips but, also benthic currents. This has future scope for both the life-saving and SAR communities.

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