Effective Observations of Rip Currents for Forecasting Operations in Southern California

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Background

Rip currents on beaches can pull beachgoers away from shore and cause fatalities. The Meteorological Development Laboratory (MDL) of NWS has developed a low cost model to integrate rip current dynamics into an internet-based reporting system in support of forecast operations. Real-time beach observations recorded by lifeguards are communicated with marine forecasters to improve beach safety operation. Efforts began in 2007 when MDL initiated a rip current project at Moonlight Beach in Encinitas, CA. MDL, in coordination with NWS forecasters, used observations recorded by lifeguards to deliver improved rip current risk forecasts to the public. This service has resulted in improved NWS hazard outreach by raising public and media awareness of rip current risk. Using the real-time data of surfs and rip current observations as well as wind and tide levels, Weather Forecast Office's can effectively learn the characteristics of local beaches to better respond to beach hazards, high surfs, and rip current activities on beaches. Below we describe how we set up the monitoring system for the forecasting process. Application case studies of forecasting rip hazards are also presented.

NWS issues Surf Zone Forecasts and Rip Current Outlook :

The NWS Marine and Coastal Weather Services Branch has been standardizing Rip Current data in text products on May 15, 2003. Twenty seven Forecast Offices start to issue Surf Zone Forecasts, which includes surf heights and rip current threat in three-tiers Rip Current Outlook : Low, Moderate, and High risk with a local disclaimer statement. Yet there was no data specially for this mission.

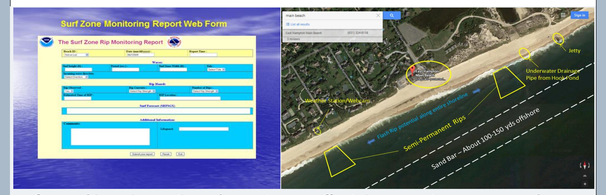
We propose visual observations of surfs and rip currents as a solution.

Recognize the Beaches in your Marine Zone

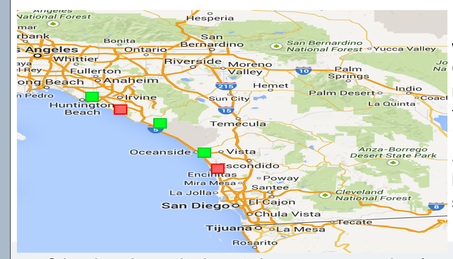
- Southern California has the second highest rip fatalities in the U.S. due to irregular shoreline orientation and the variety of beaches in So. California coasts.
- We observe typical rip currents in fixed (by the canyon or rip channel), permanent (near the piers), transient (due to group or bi-directional wave) and the mega moving type (by large swells along the shores, not shown here), below pictures are taken in S. California beaches:

- Sandy beaches, canyon finger directed beach and sheltered inner harbor side beach can cause different surfs along the coasts of So California.
- Rip current strength vary from weak (Seal Beach) to very strong (Mission Beach). We focus on beaches of frequent and high risk rip currents.
- To give user a general definition of rip current mechanism, basic information is prepared on-line for general rip currents in the US, the reader is refer to: http://www.nws.noaa.gov/mdl/rip_current/ and a fundamental module is listed at
- http://opensky.library.ucar.edu/collections/OSGC-000-000-019-181

Design of a data format to connect operations for WFO



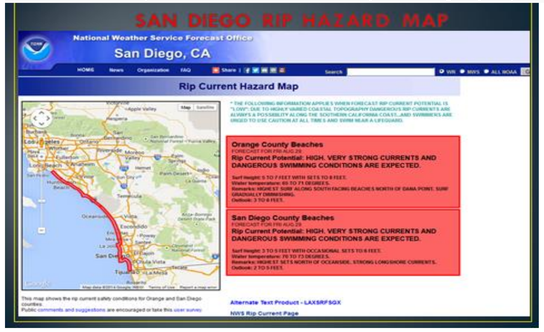
Several beach weather elements can affect rip current occurrence. In So California, swell waves, water levels and beach seabed profiles are dominating factors. At times, summer sea breezes can amplify surfs. In designing a report form, we reviewed beach office log reports in various beaches to ensure that lifeguards could provide the needed data for NWS to issue surf zone forecasts. Each beach was given an identifier which includes the beach location and location of rip currents (as shown above). We assigned the rip current classifications and specified how to read the size of surf height on beaches. The data entered on the top left form are then transmitted via e-mail to the Forecast Office.



To start, we held a workshop at Encinitas City, CA and met the marine safety officers to test-run the form at Moonlight Beach. Since then, the data has been running for six years.

Other beach monitoring stations were soon developed and run twice daily in the Southern California coasts within the San Diego Forecast Office's area of responsibility.

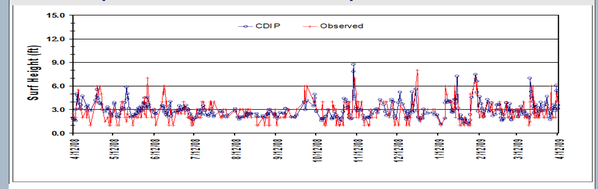
It should be noted that San Diego WFO has been in collaboration with the Scripps Inst. Of Oceanography and beach community actively. Routine outreach activities with local offices help the WFO to ensure beach safety and emergency response.

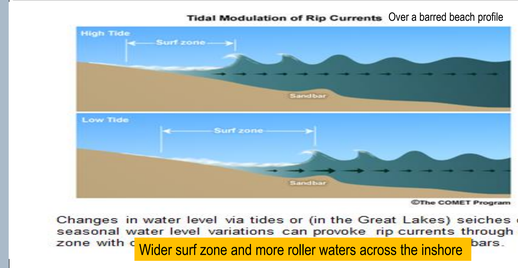


On-line data is issued twice daily along with other forecasts of coastal waters based on NWS wave models. The marine forecasters use surf height data for verifying forecasts and increase updates when beach reports indicate extra risk occurrence at the beach. This operation significantly minimizes risks and effectively improves forecast quality. The record of rip fatalities are better controlled as forecasters continuously learn about rip current mechanisms from the reported beach data.

Calibration and Analysis of lifeguard observed beach data.

Observed surf heights are subject to personal experience. It is a normal procedure to check the validity before using it. We do calibrations with near shore wave model data offered by CDIP of UCSD. The lifeguard observed surf heights are found in 12 % error compared with CDIP data which predicts breakers ashore.





Wider surf zone and more roller waters across the inshore

Rip currents are driven by breakers which are influenced by winds, wave height, wave period and water depths. From rescue record on the right, it is seen higher risk of rips at lower waters.

Longer **wave period** swells can cause high risk even low surfs at low water levels, as shown in the following cases.

Number of Rescues under Waves and Tides at Moonlight Beach, California

Surf (ft) / Tide level	1.5 - 2.0	2.0 – 3.0	3.0 - 5.0	Preventive warnings
Low	2	5	3	1270
Mid	3	9	0	456
High	0	4	1	49
Sub-total	5	18	4	1775

Encinitas Lifeguards safety service record (7/1-8/30/2008)
Many beach RESCUES are done in 2-3 ft waves at a variety of tide levels.

On-shore strong **winds** (>15 kts) does affect wave breaking zone but marginally. In summer afternoon, the sea breezes blowing onshore caused many rescues.

Practical cases that rip currents risk are updated for decision support

- On July 8, 2011, the offshore waves were small wind swells of 16 sec arriving at the falling tide level below MSL. As a result, rip currents are present throughout the beach. Forecaster updated a high risk rip threat.
- On Oct 6, 2014, the southern swells above chest level were from SSW direction driving longshore currents but producing weak rip cells at shores. So, rip currents are vulnerable with varying waves and water levels.

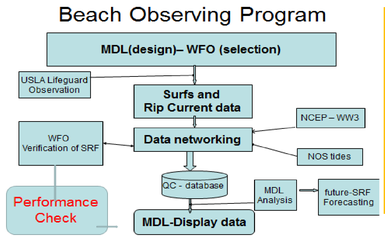
LOCATION: Mission Beach (L58)

OBSERVATION TIME (Z): 2011-07-08T00:30:00
SURF HEIGHT (FT): 1-2
SURF ZONE WIDTH (YDS): 200
TIDE CATEGORY: Falling
WAVE DIRECTION: North
RIP OBSERVED (Y/N): Yes
RIP CURRENTS ACTIVITY: Strong
COMMENTS: Rip currents throughout the entire area. Beginning to pull strong with the dropping tide

LOCATION: Moonlight Beach
OBSERVATION TIME (L): 10/6/2014 0825
SURF HEIGHT (FT): 4-5
SURF ZONE WIDTH (YDS): 120
WAVE DIRECTION: From South of Shore
WATER LEVEL CATEGORY: Rising
RIP CURRENT OBSERVED (Y/N): Yes
RIP CURRENTS ACTIVITY: Weak
RIP RESCUES: 0
WATER ATTENDANCE: Low
LIFEGUARD: Rob.

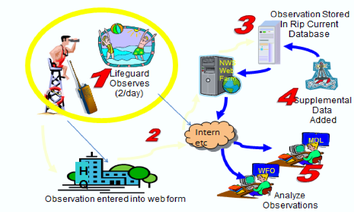
Effective use of observational data in the monitoring system

Below is the flow chart showing the data generated and processed to the Forecast Office and benefits for operational use.



Choice of data forms in use:

- One is a desk-top friendly web form and the data is sent to WFO via e-mail.
-The other is on a smart phone format developed by John for lifeguards with access to cell phones.



(1) Look up past rip fatality data identifying beaches with high risk.
(2) The forecaster gets support from WCM to work with MDL to coordinate rip current hazards.
(3) MDL and the WFO coordinate with the lifeguard agency to train the lifeguards on usage of the rip reporting form.
(4) Link with wave and tide data.
(5) Examine the data quality and check for consistency, comparing the reported rip events against simultaneously recorded data.

The archived data (5) are for analysis and can be found in the URL at the bottom.

Summary:

This monitoring system was created to assess the threat of rip currents in the surf zone. The beach-WFO service was developed to provide an updated beach hazard nowcasts for the coastal community. It helps address a data-gap in in-situ observations that hinders operation of NWS rip current products. Due to the subjective nature of the beach observations, periodic quality check and on-site training is essential in maintaining the data set. Noted that wrong data is WORSE than no data. In the near future, gridded model forecast may be available for certain areas at high risk for rip currents. The rip current observations may be applied for model verification and performance score.

Acknowledgement: This project is sponsored by the Storm Prediction Project under the Meteorology Development Laboratory of the Office of Science and Technology. Special thanks to Jim Purpura, Edwin Clark and Rob Balfour for assistance in this task before their retirements. Chris Brewster of USLA helps NWS maintain connections and provides numerous comments, and senior lifeguards (Rob Veria, Paul Chapman, and Larry Giles) in Encinitas Office are sincerely appreciated.

For education material, refer to NOAA Web Page:
http://www.noaa.gov/rip_currents
For technical needs, see MDL rip current database web page:
http://preview.weather.gov/ripcurrent/ripReportsTable.php