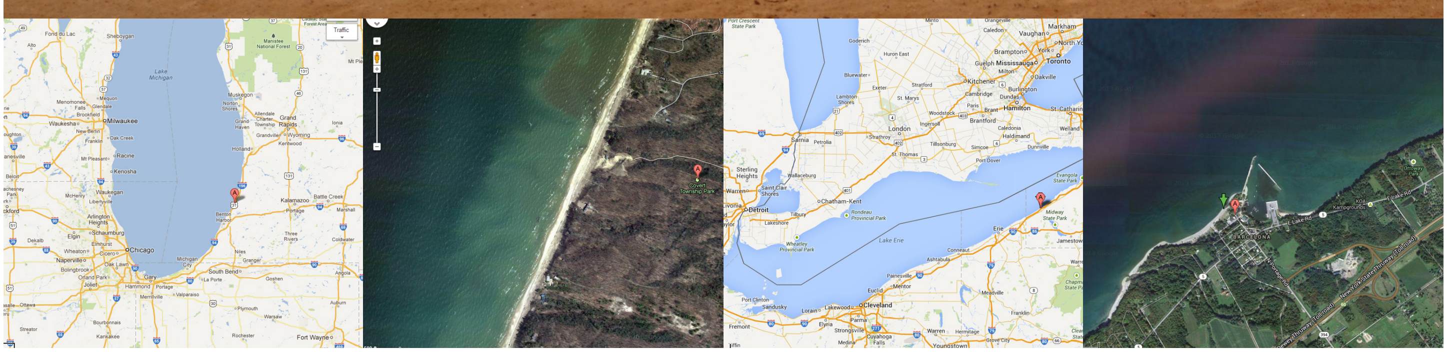
THE GREAT LAKES CURRENT INCIDENT DATABASE USER GUIDE



Great Lakes Current Incident Database (GLCID): User Guide
Table of Contents

About the Database

The National Weather Service has been collecting dangerous current information specific to the Great Lakes since 2002. The information presented in the database has been collected from a variety of sources and every attempt has been made to double check each record when possible.

The database began with the Mackinac Water Safety Review Team and Dave Guenther, a forecaster at the National Weather Service in Marquette, Michigan. Working with the Safety Team, Guenther began to investigate the conditions that caused dangerous currents to develop in the Great Lakes. He scoured media reports for details related to drowning and rescue incidents to learn more about atmospheric and lake conditions during incidents.

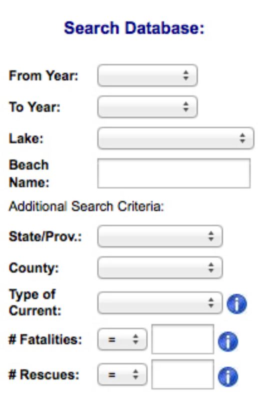
Guenther collected information on the weather and wave conditions at the time of the incident and victim demographics. The idea was to gather data that might help the NWS forecast dangerous conditions in order to alert the public on high-risk days.

The data that has been collected since 2002 is now available in this interactive database. This guide provides an overview of how to search the database, a description of each term used in both the overall search results table and the individual records, a description of the caveats and limitations of the data, and the history of the database.

Criteria: When were records included?

If eyewitnesses, victims or rescue/recovery teams identified a current as the primary or partial cause for an incident (a drowning or rescue), it was included in the database. This information was usually first found in media articles, and was then further investigated.

All events are current-related, meaning high waves also likely played an important role as the cause of an incident. Incidents believed to be solely due to high waves are not included in this database. Numbers from the database should be compared with the high number of visitors to the parks and local beaches each year, which is on the order of millions.



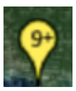
How to Search:

On the left side of the database page, there are a number of search criteria to select. You can select as many or as few specifics as you would like. For instance, you can leave all of the fields empty and the search results will include *all* records in the database. There are many ways and multiple combinations to run searches on the database.

Each time you run a search, the totals for that search will open in a pop-up box on the map. Average incidents per year by lake and average incidents per year, per lake are also calculated in the total box.

Once a search has been completed, the records will automatically appear in a table below the map. Each record contains more information than is displayed in the table. Click the record's date to get more details on a specific record.

You can also access the more detailed, specific record of an incident by clicking the colored balloon on the map. The number within the balloon indicates how many incidents were reported at the same time. For example, there are days where conditions are ripe for dangerous currents and calls for help are sent for the same beach, where several people may be in trouble in the water.



Yellow balloons indicate only rescues took place (i.e., no fatalities are recorded).

Red balloons indicate at least one fatality took place (which may or may not be in addition to rescues).

Database Notes and Limitations

Throughout the database, data was captured accurately enough for forecasters, researchers and the public to gain an understanding of beach features and the types of weather and water conditions involved with current related incidents in the Great lakes. However, there are limitations to the information, including the following:

Good to Know:

- Some individual records are more complete than others.
- The information in the database does contain some Canadian data, however, it is incomplete. It is likely that there are more incidents from Canada that are not included in the database.
- Sections within an individual record where data is unknown are marked with an "M."

- **Reporting and Information Gathering**

The media landscape has changed drastically since 2002. Differences in how current-related incidents are reported, as well as how information is gathered has, in most cases, made it easier to find data. For example, searching the Internet for current-related stories is typically more efficient now than it was 10 years ago. While easier access to more information is inherently a good thing when looking for data, it also can skew the database, weighting more recent years as a result.

Additionally, rip currents were not recognized to occur on the Great Lakes before the late 1990s-early 2000s, so incidents in the first few years of data collection were likely underreported or referred to incorrectly as the undertow.

These factors may impact the way the data looks. For example, it appears that drowning fatalities and rescues have increased since 2002, but it may just be that the term rip current was more widely used (especially after 2004), and the reports were easier to find via the internet in later years.

- **Mislabeled Events**

While increased familiarity with dangerous currents has led to an uptick in reporting incidents, there is also a downside. As a result of media outlets focusing on rip current stories after the large number of incidents in summer of 2010, Great Lakes drowning incidents have been labeled rip current incidents — even when the event was not rip-current related. Therefore, it was difficult to determine whether or not an event had another cause, such as rough surf, or if it actually was due (at least partially) to one of the various types of rip currents.

Additional verification was always attempted via eyewitness, rescue personnel or survivor accounts, but it was not always possible. Some of these mislabeled events may have been unintentionally included into the database.

- **Canadian Incidents**

Canadian events were difficult to find via newspaper articles, so the database is not complete. There may be varying types of rip currents on the northern side of Lake Superior, for example, but articles and information have not been obtained and have not been included in the records.

- **Inadequate Localized Data**

In some instances, smaller scale or localized processes — such as thunderstorms or waves — were involved with an incident and the data available was inadequate to assess the conditions near the beach. For example, in some of the reported incidents, the closest observation platform was an offshore buoy as much as 60 miles away.

Therefore, the observation could not provide a complete picture of the weather and wave conditions at the beach during a thunderstorm, or give an accurate depiction of the wave heights and directions that resulted from the bathymetry (shape of the lake bottom), refraction and reflection of waves around rocks, etc. More subjective sources of data, such as eyewitness accounts, lifeguard reports and police reports were used if possible when local data was not available. If these sources were not available, information from the nearest data collection site was used.

Explaining the Data and Terms

Within the database, there are two types of tables that provide data:

- The overall search results table (found below the map after running a search).

GLCID Search														
ID	Year	Date	Fatalities	Rescues	Beach Name	County	State/Province	Lake	Type Of Current	Wave Direction	Wave Height (ft)	CWA	GPS Lat	GPS Lon
1	2003	08-20-2003	1	1	GRAND HAVEN STATE PARK	OTTAWA	MICHIGAN	MICHIGAN	STRUCTURAL	S	3 TO 4	GRR	43.0597	-86.2517
2	2002	06-08-2002	0	1	GRAND HAVEN STATE PARK	OTTAWA	MICHIGAN	MICHIGAN	STRUCTURAL	S	3 TO 4	GRR	43.0597	-86.2517
3	2002	06-11-2002	0	1	GRAND HAVEN STATE PARK	OTTAWA	MICHIGAN	MICHIGAN	STRUCTURAL	S	3 TO 4	GRR	43.0597	-86.2517
4	2002	07-10-2002	1	0	NICKLE PLATE BEACH	ERIE	OHIO	ERIE	CLASSIC RIP	NE	5 TO 6	CLE	41.3963	-82.5438
5	2002	07-10-2002	1	0	NICKLE PLATE BEACH	ERIE	OHIO	ERIE	CLASSIC RIP	NE	5 TO 6	CLE	41.3963	-82.5438
6	2002	07-10-2002	1	0	NICKLE PLATE BEACH	ERIE	OHIO	ERIE	CLASSIC RIP	NE	5 TO 6	CLE	41.3963	-82.5438
7	2002	07-10-2002	1	0	NICKLE PLATE BEACH	ERIE	OHIO	ERIE	CLASSIC RIP	NE	5 TO 6	CLE	41.3963	-82.5438

- The individual, more detailed incident account (called up by clicking a record's date or by clicking a balloon on the map).

Incident		
Year: 2011	Date: 2011-08-09 00:00:00	Time LDT: 12:00-14:59
# of Fatalities: 2	# of Rescues: 0	Total Incidents: 2
Beach Name: SAUGATUCK DUNES STATE PARK	Additional Beach Info: *	
County: ALLEGAN	State/Province: MICHIGAN	Lake: MICHIGAN
Type of Current: CLASSIC RIP	Wave Direction (°): W	Wind Direction (°): NW
Wind Speed (Knots): 15 TO 25	Wave Height (ft): 7 TO 8	Wave Period (sec): 4 TO 5
Water Temp (°F): 75	Air Temp (°F): 77	CWA: GRR
NWS Swim Risk (If Applicable): HIGH	NWS Statement (If Applicable):	
Male Victims: 2	Female Victims: 0	Gender Unknown Victims: 0
Victim Ages: 46, 22	Victims Age Unknown: 0	Victim Hometown: REDFORD, MI; LIVONIA, MI
Distance Beach to Hometown: 179, 176	Waves Prior (ft): 3 TO 4	Angle of Approach: 30 TO 59
GPS Lat: 42.7017	GPS Long: -86.2077	ID: 158

There is some overlap in the data reported from each of the tables. The following terms explain the category headings found in one or both of the tables.

Year: The year the incident occurred. Year is listed as a separate column to make sorting easier.

Date: The month, day, and year the incident occurred. Click on the date for more information about the record.

Time LDT: The time that the incident occurred — Local Daylight Time (LDT), using a 24-hour clock. The exact time of the incident was not known in most cases, so each incident was grouped into one of the categories listed below. This occurs most often with the older rescue cases in the database that were difficult to verify with additional sources.

Time Category (LDT)	Descriptors in Articles
00:00-05:29	late night/overnight
05:30-9:59	Early morning
10:00-11:59	Late-mid morning
12:00-14:59	early afternoon
15:00-17:59	late afternoon
18:00-20:59	early evening
21:00-21:59	late evening
22:00-24:00	night

# of Fatalities: The number of current-related fatalities for that specific incident. Current-related means that the incident must have been all or at least partially related to currents. Many incidents are a combination of high waves and dangerous currents.

# of Rescues: The number of current-related rescues for that specific record.

Beach Name: The location of the beach nearest to where the incident occurred. If the beach name was unknown, a name was assigned to it based on location.

Additional Beach Information: If additional information about the location was known, it was placed in this column. For example, the name of a nearby town is sometimes added to help provide geographic context.

County, State/Province and Lake: The county, state and Great Lake where the incident occurred. Information is divided into three columns for easy sorting by each variable.

Type of Current: The dangerous current determined to be the total or partial cause of an incident. In cases where the exact location of the incident was not known, it is categorized by the features present at the beach where the incident occurred (Table 2). For example, if a drowning occurred at Grand Haven State Park, and it was not known where the person was swimming when they drowned, the incident would be categorized as “classic rip/structural” since there are sandbars and a breakwall at the beach. In this example, the combination of waves and either structural or classic rip currents could have been the cause of the incident, depending on where the victim was swimming. In most cases, the area where the victim was swimming and the type of current is known.

Beach Features/Where Victim was Swimming	Classification for Type of Current
Swimming near breakwall, pier or similar structure	Structural Current
Swimming at a beach with sandbars	Classic Rip Current
Swimming near river mouth or similar outlet	Outlet Current
Exact location of struggle unknown, but a breakwall and sandbars were both present on the beach where the incident occurred	Classic Rip/Structural
Exact location of struggle unknown, but a river mouth and sandbars were both present on the beach where the incident occurred	Classic Rip/Outlet
Swimming/walking on a sandbar connecting an offshore feature (such as rocks or an island) to the shore, and a current pushed swimmer off the sandbar	Channel Current

Wave Direction (°): The direction the incoming waves are approaching from, in degrees. For example, a southerly wave direction would indicate waves were approaching from the south. Generally, wind direction can be used as an indicator of wave direction on the Great Lakes.

Wind Direction (°): The direction the wind is coming from, in degrees. For example, a southerly wind direction would indicate winds are blowing from south to north. This information was gathered from either an offshore observation buoy, nearshore observation buoy, or an automated surface observing system on land (typically at the beach). The corresponding degrees to each wind direction in the "Wind Direction" column are listed below.

Degree of Wave or Wind Direction	Category of Wave/Wind Direction
337.5-22.5	North (N)

23-67.5	Northeast (NE)
68-113	East (E)
112.5-157.5	Southeast (SE)
158-203	South (S)
202.5-248	Southwest (SW)
247.5-292	West (W)
292.5-337	Northwest (NW)

Wind Speed (Knots): The speed of the wind is in nautical miles per hour (MPH). The exact time of the incident was not always known, so wind speeds at the general time of the incident were categorized.

Wind Speed Categories (MPH):

- 0 to 10
- 5 to 15
- 10 to 20
- 15 to 25
- 20 to 30
- 25 to 35
- 35 to 40 [>35]

Wave Height: The significant wave heights observed at the time of the incident, or during the estimated time of the incident (in feet). Wave height was obtained using a combination of eyewitness accounts, buoy observations and the Great Lakes Coastal Forecasting System.

Wave heights were categorized into groups because in many cases the exact time of the incident was unknown. Values were rounded to the nearest foot.

Wave Height Categories (Ft):

- 0 to 2
- 3 to 4
- 5 to 6
- 7 to 8
- 9 to 10
- 11 to 12

Wave Period: The time it takes for two successive wave crests to pass a given point, measured in seconds. To say it another way, wave period is the time someone who is struggling in the water has to recover between waves. Wave period was obtained using the nearest buoy available.

Wave Period Categories (Seconds)
0 to 1
2 to 3
4 to 5
6 to 7
8 to 9
10 to 12

Wave periods were categorized in groups because in many cases the exact time of the incident was unknown. Waves on the Great Lakes are fetch limited, meaning they have less distance to travel over water than those on the ocean. Because of the shorter distance of travel, Great Lakes wave periods are generally less than 9 seconds.

Analysis of the 2002-2013 data suggests that Great Lakes current-related incidents most often occur when wave periods range from 4 to 5 seconds. These shorter wave periods are a significant hazard to Great Lakes swimmers, as they make the lake look and feel more chaotic than the ocean (Meadows et al., 2011). The shorter wave periods make it difficult to recover when a swimmer is knocked down by a wave, and they can mask the traditional rip current identification signs (muddy choppy water heading into the lake, or a break in the incoming waves).

Water Temp (°F): The temperature of the water during the incident (in degrees Fahrenheit). Temperatures were obtained using the closest observational site, including nearshore buoys and surface observing systems. When water temperature was not available from an area close to the beach, the closest offshore buoy water temperature was used. This temperature is usually colder than those observed closer to shore, so the water temperature listed in the database may be colder than actual temperatures during an incident.

Air Temp (°F): The temperature of the air during the incident (in degrees Fahrenheit). Temperatures were obtained using the closest observational site, including nearshore buoys and surface observing systems.

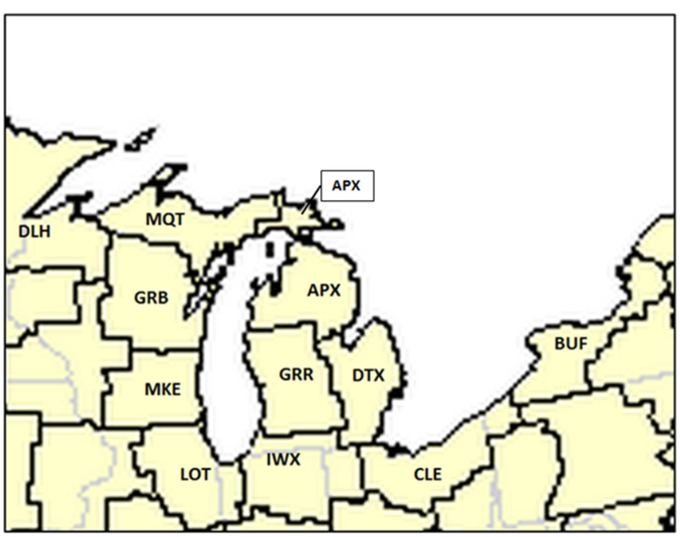
CWA: CWA stands for County Warning Area. This is a National Weather Service (NWS) acronym that indicates which National Weather Service Forecast Office is responsible for the area.

For example, Holland State Park is in Grand Rapid's County Warning Area. This means that the NWS in Grand Rapids issues all forecast and warning information for that park. Under the CWA column in the database, Holland State Park is listed as "GRR" — which is the site identification for Grand Rapids.

Site ID's and website information for various NWS offices are listed below as well as a map showing each CWA. If the incident occurred at a Canadian site, the CWA is listed as missing, or "M" in the database, as there are no National Weather Service Offices outside of the United States.

Office Identifiers for the	Office Location	Websites
GRR	Grand Rapids, Michigan	Weather.gov/grr
IWX	Syracuse/North Webster, Northern Indiana	Weather.gov/iwx
APX	Gaylord, Michigan	Weather.gov/apx
LOT	Chicago, Illinois	Weather.gov/lot
MQT	Marquette, Michigan	weather.gov/mqt
DTX	Detroit, Michigan	weather.gov/dtx
MKE	Milwaukee, Wisconsin	weather.gov/mke
GRB	Green Bay, WI	weather.gov/grb
CLE	Cleveland, Ohio	weather.gov/cle
BUF	Buffalo, New York	weather.gov/buf
DLH	Duluth, Minnesota	weather.gov/dlh

National Weather Service Forecast Offices



NWS Swim Risk (If Applicable): Indicates the swim risk level issued by the National Weather Service for the time of the incident. The swim risk is found in the recreational beach forecast (also known as the surf zone forecast) from roughly Memorial Day through Labor Day, depending on the local office policy. If the NWS Office does not issue a recreational beach forecast/surf zone forecast, or the incident occurred in Canada, then the column is left blank. Swim risk is categorized as low, moderate or high based on the following criteria:

- **Low:** Large waves and strong currents are not expected along the shore.
- **Moderate:** Moderate waves (generally 2 to 3 feet) and strong currents are likely along the shore. Only experienced swimmers should consider entering the water.
- **High:** Dangerous waves (generally 3 to 5 feet or higher) and currents are expected along the shore. Swimming conditions will be life threatening to anyone entering the water.

NWS Statement (If Applicable): Indicates with a “yes” or a “no” if the National Weather Service issued a statement. Statements are issued by the NWS to highlight a significant beach hazards risk to the public and decision makers (park personnel, lifeguards, media, and beach managers).

Male Victims/Female Victims: The number of victims that were male or female involved in the incident.

Gender Unknown Victims: The number of incidents where the gender of the victim was unknown. At times, additional information could not be found on an incident. In these cases, if the gender of the victim was not mentioned in the media or rescue report, the gender was listed as “unknown.”

Victim Ages: The age(s) of the victim(s) involved in the incident. Since there may be more than one victim on a given day involved in a specific event (such as family members all caught in the same current, etc.) and there is limited space, all ages are listed in one column. For example, if there were an incident with a 10-year old, a 16-year old and a 20-year old, the event would be listed in the column as 10, 16, 20.

If the age of the victim was not known, it is marked with an “M.” Only one M is listed, even when several victims’ ages were unknown. For example, if there was a 20 year old and two males (ages unknown) involved in an incident, the event would be listed in the column as 20, M.

Victims Age Unknown: The number of victims where the age was unknown. This column was included to make sorting of incidents with known age vs. unknown age easier.

Distance Beach to Hometown: The distance, in miles, between the victim’s hometown and the beach where the incident occurred. This was computed using Google Maps. In cases where the victim's hometown was not known, an M was recorded. The exact address of the victim was not typically known, and for a majority of the cases the town center was used to approximate distance.

On days with multiple victims, each distance is separated by a comma. If there were three victims, and one lived 20 miles from the beach, the other lived 100 miles from the beach, and the last victim lived 80 miles from the beach, it was recorded in the column as 20, 100, 80. If all three victims lived 100 miles from the beach, it was recorded just once as 100.

Waves Prior (ft): Wave heights up to 10 hours before the incident time. Data was collected because dangerous currents can still remain after winds or waves lessen. Though the waves at the time of an incident could only be 1 to 2 feet, dangerous currents could have been generated if waves were 3 to 5 feet prior to the time of the incident. One of the main purposes of the database is to collect as much data surrounding the time of the incident as possible, so scientists and the general public can learn what weather and wave conditions lead to the development of dangerous currents.

Angle of Approach: Refers to the approximate angle (measured in degrees) of the waves approaching the shoreline. For example, on a beach that runs north-south and opens to the water to the west (like Michigan's Lake Michigan coast), waves approaching from the west would have a 90-degree angle of approach (they are approaching the beach at an angle perpendicular to the shoreline). This angle is not exact, because beaches were smoothed out to be a straight line (which is not the case in real life), so each wave angle of approach was placed into a category to standardize the data.

The wave angle of approach is important in diagnosing the type of dangerous current that is most likely on a given beach. A generalization of the type of dangerous current expected with each angle of approach is given below, and is based off ocean research on classic rip currents and Great Lakes research on all of the different types of currents (Lushine 1991; Shepard et al. 1941; Lascody 1998, Engle et al. 2002; Dukesherer 2013; Dodson et al 2013). Currents development is also dependent on other factors such as wave height and wave period.

See chart on following page for more details.

Wave Direction and Current Development

90-60° angle of approach	30-59° angle of approach	0-29° angle of approach
Definite: Classic Rip Currents **Likely:** Structural Currents: • More perpendicular approaches (i.e. closer to 90°) indicate a lesser chance for development. • Slanting approaches (closer to 60°) indicate a greater chance for development. **Possible:** Outlet Currents Channel Currents: • Closer to 60 degrees Longshore Currents: • Weak to moderate • Closer to 60=moderate • Closer to 90=weak to none	**Definite:** Structural Currents **Likely:** Classic Rip Currents Channel Currents* **Possible:** Outlet Currents Longshore Currents: • Potentially a strong current, which develops a strong structural current. • Especially true if in an area with shore-parallel sandbars.	**Definite:** Structural Currents **Likely:** Outlet Currents **Possible:** Channel Currents* • Closer to 29° Classic Rip Currents: • Generally unlikely • Greater chance closer to 29° Longshore Currents: • Moderate to strong • Especially likely if in an area with shore-parallel sandbars.

**Recent research on channel currents (Dodson, Cooley 2013) indicates that the longshore current enhances channel currents to hazardous speeds.*

GPS Lat/Long: The approximate latitude and longitude of the *beach* where the incident occurred. The GPS coordinates are *not* specific to the exact location of the incident.

The Story of How the Database was Developed

In the late 1990's, a young boy named Travis Brown drowned in a rip current off the shores of Lake Michigan near St. Ignace. At the time, not much was known about dangerous currents in the Great Lakes. Swimmers and beach visitors were more likely to have heard of "the undertow." While being aware of potentially dangerous forces in the Great Lakes was a good start, calling them undertows or rip tides was inaccurate at best and misleading at worst. The specifics of a rip current or other dangerous currents weren't well known by swimmers or scientists.

In response to Travis' drowning and the lack of general information available about rip currents, the Brown family worked extensively to raise awareness by developing the Mackinac Water Safety Review Team. This team consisted of members with a wide variety of expertise in water safety, including Michigan Sea Grant, local emergency/law enforcement personnel and others.

The group contacted Dave Guenther, a forecaster at the National Weather Service in Marquette, Michigan (retired 2011), to investigate the conditions that cause dangerous currents to develop in the Great Lakes. The idea was to gather data that might help the NWS issue a forecast or statement that could alert the public of these hazards on high-risk days. Dave eventually worked with Guy Meadows, a researcher initially from University of Michigan, now with Michigan Technological University.

Together they developed a Great Lakes Rip Current Checklist (Guenther, 2006), taking the principles of rip current development in the ocean and modifying and applying them to the Great Lakes. To learn about the atmospheric and lake conditions during dangerous currents, Dave started collecting Great Lakes media reports on current-related rescues and fatalities. Information on weather and wave conditions at the time of the incident as well as victim demographics were collected when available. As interest in Great Lakes currents grew, so did the demand for data.

In 2011, Megan Dodson replaced Dave Guenther as the Beach Hazards Program manager at NWS Marquette, and worked with the Assistant Program Manager Keith Cooley to maintain the data. Because of the large volume of requests about Great Lakes current statistics, Dave's collection of fatalities and rescues was made into a searchable database internal to the NWS, and was named the Great Lakes Current Incident Database (GLCID).

Results from the analysis of the database (Dodson et al., 2012-2013) were used in 2012 and 2013 to modify existing NWS beach hazards forecast procedures to be more Great-Lakes-specific and in setting criteria for issuing Beach Hazards statements.

The Great Lakes Dangerous Current Incident Database website is a partnership of the National Weather Service and Michigan Sea Grant, and is hosted by Michigan Sea Grant. Dangerous current awareness is part of a state and regional effort led by Michigan Sea Grant in collaboration with the NOAA-National Weather Service, the Michigan Department of Environmental Quality (MDEQ), the Michigan Department of Natural Resources and others. The MDEQ Coastal Management Program supported the development of many educational programs and public outreach products.

In 2014, the Dangerous Currents Project team members worked to make the information available to the media, forecasters, researchers and the general public through this website. For questions and comments on the GLCID, please contact GreatLakesCurrentDatabase@umich.edu

References

Bowen, A.J., 1969: Rip currents, 1: Theoretical Investigations. *Journal of Geophysical Research,* 74, 5468- 5478.

Bowen, A.J., and D.L. Inman., 1969: Rip currents, 2: Laboratory and field observations. *Journal of Geophysical Research,* 74, 5479-5490

COMET, 2011: Rip Currents: Nearshore Fundamentals. [http://www.meted.ucar.edu/marine/ripcurrents/NSF/index.htm]

Cooley, K., Dodson, M., 2013: The Channel Current Project at Picnic Rocks, Marquette Michigan. Local Study at the National Weather Service, Marquette Michigan. Publication in progress. For questions contact Keith.Cooley@Noaa.gov. Results available online: [http://www.crh.noaa.gov/mqt/?n=channelcurrentsgl]

Cook, D.O., 1970: The occurrence and geological work of rip currents off southern California. *Marine Geology,* 9, 173-186.

Dalrymple, R.A., 1975: A mechanism for rip current generation on an open coast. *Journal of Geophysical Research,* 80, 3485-3487.

Dalrymple, R.A., 1978: Rip currents and their causes. *Proc. of the 16th International Conference of Coastal Engineering,* Hamburg, American Society of Civil Engineers, 1414-1427.

Dukesherer, B.; 2013: (National Weather Service Grand Rapids, MI). Transition to the Beach Hazards Messaging and New Terminology, *Personal correspondence and Beach Hazards presentations.* Some presentations are available online at: [http://www.dangerouscurrents.org]. Contact Bob.Dukesherer@noaa.gov with questions.

Engle, J., J. MacMahan, R.J. Thieke, D.M. Hanes, R.G. Dean., 2002: Formulation of a rip current Predictive Index Using Rescue Data. *Proc. of the National Conference on Beach Preservation Technology,* Biloxi, MS. Florida Shore and Beach Preservation Association.

Guenther, D., 2003: Rip current case study 3, 4 July 2003. *Marquette Michigan National Weather Service Office Report.* Contact Megan.Dodson@noaa.gov for a copy.

Great Lakes Observing System, 2013: The Great Lakes Coastal Forecasting System Point Query Tool. Available online at: [http://glos.us/data-tools/point-query-tool-glcfs]

Hite, M.P., 1925: The Undertow. *Science*, 62, 31-33.

Hydrometeorological Prediction Center (Weather Prediction Center), 2011: Hydrometeorological Prediction Center's Surface Analysis Archive. [Available online at http://www.hpc.ncep.noaa.gov/html/sfc_archive.shtml]

Hydrometeorological Prediction Center (Weather Prediction Center), 2011: The Daily Weather Map. [Available online athttp://www.hpc.ncep.noaa.gov/dailywxmap/]

Kinnunen, R.; The Mackinac Water Safety Task Force Accomplishments. Available online at: [http://www.dangerouscurrents.org] For questions, contact Ron Kinnunen at: Kinnune1@anr.msu.edu

LaPorte, E.; et al., 2013: The Dangerous Currents Project. Available online at: [http://www.dangerouscurrents.org.] For questions, contact Elizabeth LaPorte at: elzblap@umich.edu

Lascody, R.L., 1998: East Central Florida rip current program. *National Weather Digest,* 22(2), 25-30.

Lushine, J.B., 1991: A study of rip current drownings and related weather factors. *National Weather Digest,* 16, 13-19.

Meadows, G., H. Purcell, D. Guenther, L. Meadows, R.E. Kinnunen, and G. Clark, 2011: Rip Currents in the Great Lakes: An Unfortunate Truth. *Rip Currents: Beach Safety, Physical Oceanography, and Wave Modeling,* S. Leatherman and J. Fletemeyer, Eds., CRC Press, 199-214.

McKenzie, R., 1958: Rip current systems. *Journal of Geology,* 66, 103-113.

Munk, W.H., 1949: The solitary wave theory and its application to surf problems. *Ann. N.Y. Acad. Sci.*, 51, 376-424.

Nicholls, C.P.L., 1936: Rip Tides and How To Avoid Their Perils. *Calif. Beaches Assoc.*, vol. 1 No. 9, 12.

Shepard, F.P., 1936: Undertow, rip tide or rip current. *Science,* 84, 181-182.

Shepard, F.P., K.O. Emery, and E.C Lafond., 1941: Rip Currents: A process of geological importance. ***J**ournal of Geology*, 49, 338-369.

Shepard, F.P., D.L. Inman., 1950: Nearshore circulation. *Proc. of the 1st Conference on*

Coastal Engineering, Berkeley, CA, Council on Wave Research, 50-59.

Short, A.D., 1985: Rip current type, spacing and persistence, Narrabeen Beach, Australia. *Marine Geology*, 65, 47-71.

Sonu, C.J., 1972: Field observations of nearshore circulation and meandering currents. *Journal of Geophysical Research,* 77, 3232-3247.

Tang, E. and R.A. Dalrymple., 1989: Rip currents, nearshore circulation, and wave groups. In Nearshore Sediment Transport, R.J. Seymour, editor, New York, NY, Pelenum Press, 205-230.

Whalin, R. et al., 1984: Shore Protection Manual Volume I. *As Prepared for the United States Army Corp of Engineers.* Coastal Engineering Research Center: *Waterways Experiment Station, Vicksburg, Mississippi.*

Wood, W.L., and G.A. Meadows., 1975: Unsteadiness in Longshore Currents. *Geophysical Research Letters,* Vol 2, No 11.

Wright, L.D. and Short, A.D., 1984: Morphodynamic variability of the surf zones and beaches: A synthesis. *Marine Geology*, 56, 93-118.