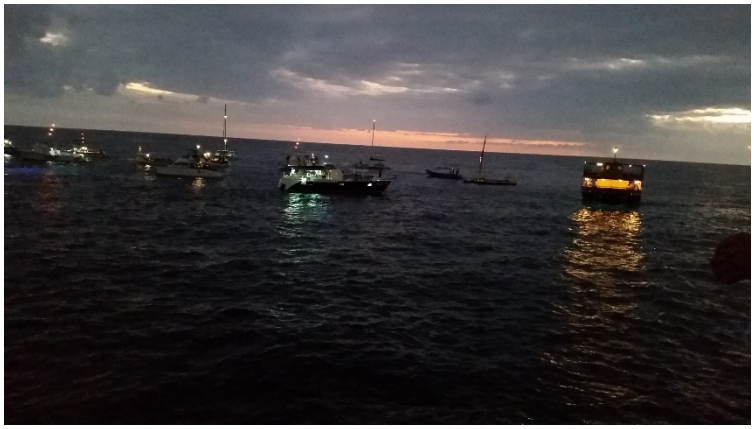
Manta Ray Viewing Boating Operations and Safety Assessment

Prepared for the Hawaii Coral Reef Initiative Research Program (HCRI-RP) on September 6th, 2015



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Executive summary

The manta ray viewing operations at two primary locations (Makako Bay and Keauhou Bay) on the Kona coast of Hawaii Island were assessed for human safety. Stakeholder input, historical data, field surveys, and direct observations were used to identify safety issues, quantify activity levels, and independently verify current hazards. While the probability of an accident (e.g., motoring vessel striking an in-water person) causing severe injury or death is relatively low, the current activity provides ample opportunity for a severe accident to occur. Given the large number of vessels and in-water persons participating in this night-time activity, a severe accident will likely occur in the future without significant mitigation of the existing risk factors. The numbers of vessels and persons participating in manta ray viewing activities are major factors increasing the likelihood of an accident, however, there are currently no effective controls regulating capacity despite the growing demand for this activity. There are also no regulations governing recreational or commercial swimming/snorkeling activity at night amongst actively motoring vessels despite the inherent hazards associated with this activity. A formal assessment and vetting of regulatory options are recommended to determine how best to mitigate the severity of existing hazards and reduce the likelihood of severe accidents.

Study objectives and scope

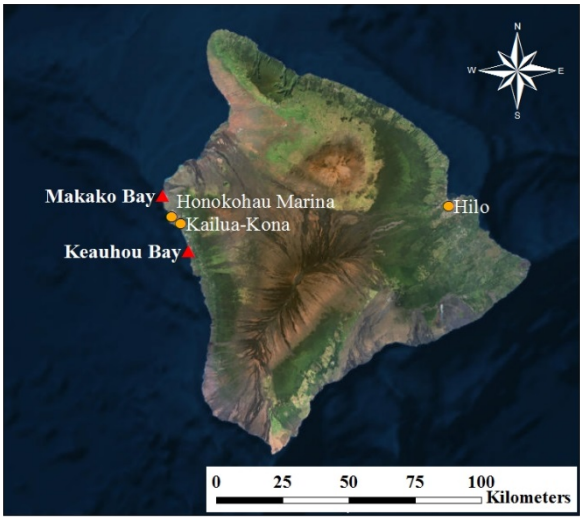
The overall objective of this project was to assess the current manta ray viewing operations relative to human safety. This study objectively and quantitatively reviews current operations and provides an independent verification and analysis of safety issues previously raised by various stakeholders. The scope of this assessment focuses on the operations at the two main viewing sites (Makako Bay and Keauhou Bay) and addresses only human safety issues, not the safety of marine life or the environmental impacts of the manta ray viewing activities.

Acknowledgements of contributions

This assessment has been led and conducted by Marine Science Consulting LLC under the leadership of Dr. Samuel E. Kahng in collaboration with the Hawaii Coral Reef Initiative Research Program (HCRI-RP) and Hawaii DLNR Division of Boating and Ocean Recreation (DOBOR). Contributors to this project include the following individuals:

- Meagan Putts, GIS analyst – coordinated email survey, conducted field studies, generated report figures
- Maria Robben Gaydos, DOBOR – coordinated and conducted stakeholder interviews; assessed regulatory frameworks
- Risa Minato, HCRI – coordinated and conducted stakeholder interviews
- Keller Laros, Manta Pacific Research Foundation – conducted mooring verification surveys, provided daily statistics on vessel activity
- Dan Mersburgh, DOBOR – contributed boat support for conducting mooring verification surveys
- Finn McCall, DOBOR – provided engineering assessments on mooring capacity
- Teri Leicher, Malama Kai – provided specifications for day-use moorings
- Jan War, NELHA – provided shoreline access to the Makako Bay site

Introduction/background



On the Kona coast of the Big Island of Hawaii, the commercial and recreational activity of viewing manta rays (*Manta alfredi*) at night has increased significantly thereby raising concerns about human safety in the midst of congested boating, snorkeling, and scuba diving activity in the dark. The night time manta ray viewing activities are centered around two main viewing sites: Makako Bay (also called "Garden Eel Cove") and Keauhou Bay ("Manta Village" in front of the Sheraton Kona Resort & Spa at Keauhou Bay) (Figure 1). The Makako Bay site is primarily accessed via vessels from Honokohau harbor. The Keauhou Bay site is primarily accessed via vessels from the adjacent Keauhou Bay harbor and boat ramp, but it is also accessed by vessels from Kailua-Kona pier and from Honokohau harbor.

Manta rays are large (up to 5.5 m wide), visually majestic creatures which feed by ingesting small

Figure 1. Map of the Big Island of Hawaii and the location of the two primary manta ray viewing

zooplankton through their toothless mouths while swimming (Figure 2). Tiny marine animals called zooplankton (much of which hide in the reef during the day) rise into the water column at night to feed and are attracted to artificial lights. At both sites, artificial lights are used to attract and aggregate zooplankton in high densities which in turn attract manta rays to nightly feeding opportunities. Tour operators use a variety of waterproof lights to localize and attract the manta rays for the viewing pleasure of their clients.

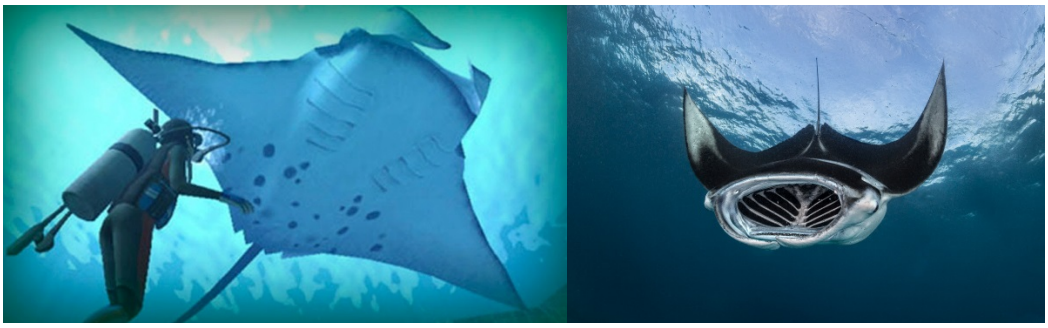


Figure 2. Manta ray swimming amongst scuba divers (*left*) and feeding on zooplankton (*right*). Images from California Divers and Adrian Basques.

The opportunity to view manta rays, sometimes in large numbers, is a significant attraction for both visitors and residents of Hawaii. The manta ray scuba diving and snorkeling tours in Kona (Figure 3) are widely advertised in the international travel & tourism media and are literally world renown. Scuba diving magazines and websites regularly list the Kona manta ray night dive and animal encounter as a top rated activity and scuba diving destination. The consistency with which mantas are available for viewing, the relatively easy access to these sites, and predominately calm ocean conditions of the Kona coast are major factors in their popularity. While not assessed in this study, the direct and indirect economic contributions of this activity to the local economy are likely substantial.

Figure 3. Manta ray swimming amongst scuba divers at night (*left*) and underneath snorkelers (*right*). Images from Alert Diver and Splashers Ocean Adventures.

Project methodology

The project was conducted in three phases consisting of User Requirements, Field Investigations, and Synthesis. For the User Requirements phase the existing information relevant for the manta ray

viewing operations was reviewed including the Manta Ray Working Group meeting notes, the voluntary Manta Tour Operator Standards (endorsed by 20 operators), and existing regulations. Via interviews and email surveys, voluntary stakeholder input was compiled from 26 stakeholder organizations/companies (Appendix A) to assess current operations (equipment, normal procedures, crew training & experience, and emergency protocols), perceived human safety risk factors, efficacy & limitations of voluntary protocols, and perceived regulatory solutions & limitations. Attempts were made to contact all known manta ray tour operators via email survey to give everyone the opportunity to provide input. In addition to tour operators, input was received from safety and regulatory organizations, relevant nonprofit organizations, adjacent land owners/managers, and a private boater.

For the Field Investigation phase, the two primary viewing sites were surveyed and mapped, all existing moorings were inspected and photographed, and night time operations were observed in detail on nine nights. Visual observations of operations were conducted at both sites from land and onboard tour operator vessels. Four days of operations were observed at Makako Bay and six days of operations were observed at Keauhou Bay. The operational observations quantified & characterized in-water activities, quantified & characterized boating activity, recorded behavior or activities increasing/decreasing safety risks, independently verified & confirmed potentially hazardous operational aspects.

Manta ray viewing operations

As of August 2015, at least 42 commercial tour operators (Appendix B) have been identified as visiting these two sites providing night time snorkeling and/or scuba diving tours for viewing manta rays. While some companies operate on a nightly basis, others provide manta tours less frequently or service the private charter vessel market. A few of the larger companies operate multiple motorized vessels on a nightly basis. The capacity of the vessels also varies from small six passenger boats to large vessels with over 40 passengers (Appendix C). Depending on weather, the number of vessels, snorkelers, and divers varies widely by date but averages 12-13 motorized vessels at one time. However, maximum number of vessels at each site on the busiest night is roughly double the average (Figure 4).

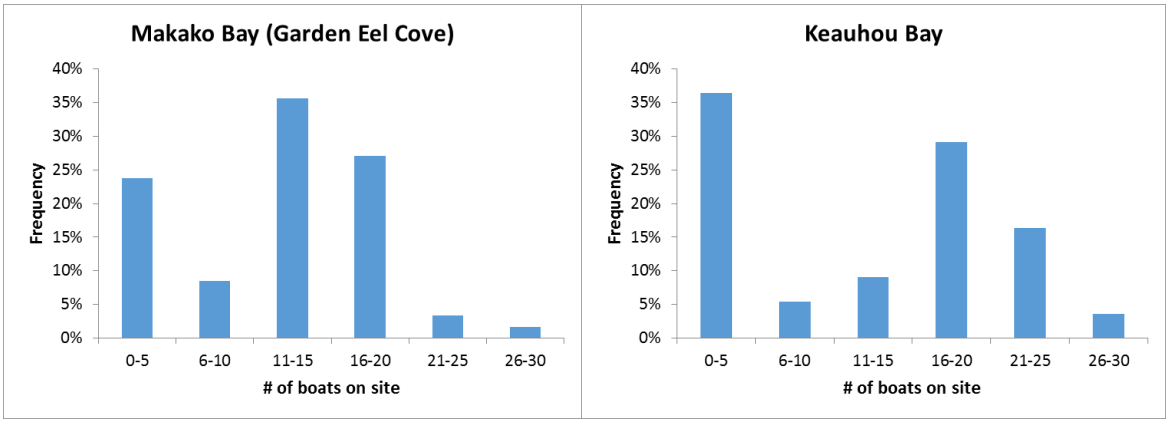


Figure 4. Frequency distribution of number of motorized vessels per night at each manta ray viewing site. Data derived from daily observation logs January-July 2015 from Manta Pacific Research Foundation. These data were collected from an operating vessel and therefore represent concurrent vessels on site. Total number of vessels visiting per night may be higher.

Makako Bay (Garden Eel Cove)

At Makako Bay, some scuba diving boats providing two tank dives arrive early, well before sunset, but most vessels arrive just prior to sunset while there is sufficient ambient light facilitate mooring/anchoring. Snorkelers entering the water and are generally associated with floating rafts (Figure 3). Peak in-water activity occurs 30-45 minutes after sunset before the first groups of snorkelers leave and after most scuba divers enter for their final night dive. A few vessels either operate a second shift or arrive very late (~2 hours after sunset) after most vessels have already departed the site.

During observations on Aug 10-13, 2015, a total of 16-19 vessels per night were observed with a visual count of 160-190 persons (snorkelers and divers) in the water concurrently. Due to limitations in visibility at night, this count represents a conservative estimate and the actual number was likely higher. Considering that up to 26 concurrent vessels have been recorded at this site (on April 3, 2015), the maximum number of persons in the water concurrently likely exceeds 290 persons on the busiest nights. During the observation period, the arrival and departure of vessels to the manta viewing area was somewhat synchronous with little live boating activity when a majority of persons are in the water (Figure 5). The tour operators who only cater to snorkelers tend to depart early while scuba divers are still underwater. Due to the limited number of moorings, the amount of live boating activity on busy nights is likely higher than observed during this study.

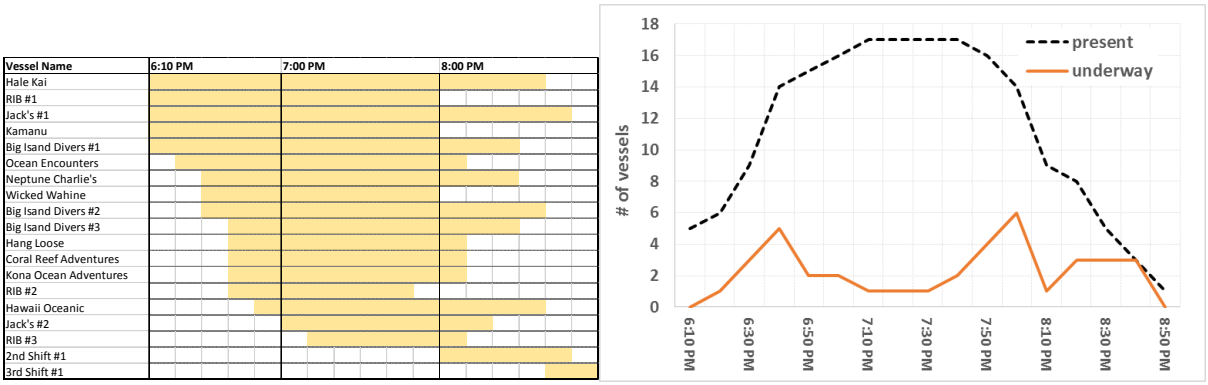


Figure 5. Time-motion statistics at Makako Bay on August 13, 2015 from 6:10-9:00 pm. Yellow bars indicate when each vessel, watercraft, or group was present at the manta viewing site. Each cell represents a 10 minute block of time. The beginning and end of each continuous yellow bar denotes when each vessel/group arrived and departed respectively. A nightly total of 19 vessels were observed with approximately 209 persons. During peak in-water activity 7:00-7:40 pm, most vessels were moored/anchored and relatively few were underway (i.e., actively motoring).

Snorkelers are accompanied by a guide, associated with rafts (e.g., floating boards with handles and equipped with downward facing lights, Figure 3), and remain at the surface of the water (free diving is discouraged by tour operators). In some cases the rafts are tethered to the originating vessel but in other cases, the rafts are free floating enabling the group to adjust their location independent of the originating vessel. While a majority of the snorkelers observed had individual lights, many regularly do not. On occasion, individual snorkelers or guides without lights were observed straying > 40 ft from their group raft.

Scuba divers are accompanied by a diver master/professional and generally begin their descent next to their originating vessel before transiting underwater to a central “campfire” site where underwater lights are aggregated to attract manta ray feeding. Given the dispersion of vessels, the underwater transits originate from all directions. In general, divers return to their originating vessel prior to

ascending to the surface. However, an individual scuba diver was observed briefly surfacing in an unplanned location during their transit to/from an originating vessel.

Keauhou Bay (Sheraton Kona Resort)

At Keauhou Bay, the activity by "regular" operators (who are based on Keauhou Bay) are primarily focused on snorkelers and the boat activity can be considerably lower than at Makako Bay (Figure 4). Unlike the operations at Makako Bay which is adjacent to restricted shoreline access (i.e., Kailua-Kona International Airport and Natural Energy Laboratory of Hawaii Authority), the Keauhou Bay site is accessible from shore by kayaks, stand up paddleboards (SUPs), and individual swimmers via a nearby public shoreline access point. Given the proximity of the snorkeling site to Keauhou harbor and boat ramp, a few commercial operators operate up to three shifts nightly. When manta rays are not frequenting the Makako Bay site, commercial operators who normally visit Makako Bay move their scuba diving and snorkeling operations south to Keauhou Bay. The result is a bimodal distribution in activity and the potential for very high boating activity on certain nights (Figure 4).

During observations on June 22-23 and Aug 19-21, 2015, a total of 7-22 vessels per night were observed with a visual count of 114-177 snorkelers and divers (including customers and guides) in the water concurrently. A few of the Keauhou based snorkel charters operate vessels (i.e., *Hula Kai*, *Hokuhele, Kona Style*) with high capacity. On the busiest days (e.g., 28 boats on July 6, 2015), the maximum number of persons in the water concurrently likely exceed 310 persons. In general, the activity at Keauhou Bay is less synchronous than at Makako Bay with vessels continuously arriving and departing throughout the night. The result is continuous live boating activity at the site.

To help illustrate the overlap in boating activity with in-water snorkelers and divers, an intensive time & motion study was conducted on August 21, 2015 from 6:20-10:00 pm from the 2nd floor of the Sheraton Kona Resort. In addition to static totals (21 vessels, 6 kayaks, 1 SUP, and 301 persons), the arrival & departure and the live boating activity for each vessel was tracked across time along with the timing of persons entering and exiting the water from each vessel and from shore. Data was aggregated for each 10 minute block of time, where the number of in-water persons were quantified verses the number of vessels actively motoring at the site. Peak overlap occurred between 7:20-8:00 pm with 98-177 persons in the water while 5-10 vessels were actively motoring in the confined area (Figure 6-7).

Greater overlap between actively motoring vessels and in-water persons would occur on busier days especially given the limited availability of moorings. For example, up to 28 concurrent vessels have been observed at Keauhou (April 3, 2015) which would represents a 38% increase over the maximum of 16 concurrent vessels observed on the date of this time-motion study.

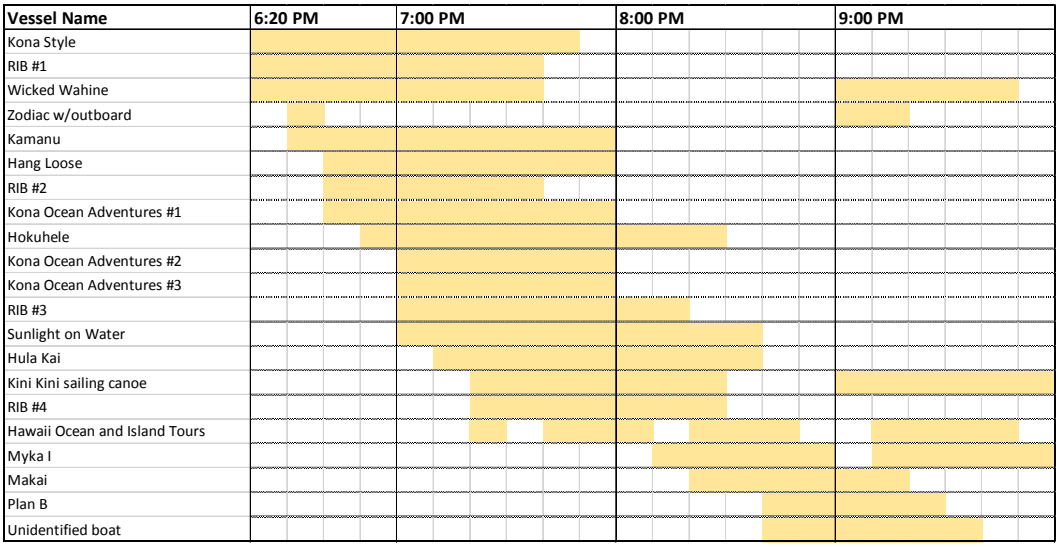


Figure 6. Time-motion chart at Keauhou Bay on Aug, 21, 2015 from 6:20-10:00 pm. Yellow bars indicate when each vessel, watercraft, or group was at the manta viewing site. Each cell represents a 10 minute block of time. The beginning and end of each continuous yellow bar denotes when each vessel/group arrived and departed respectively. Note that some vessels visit the site multiple times per night.

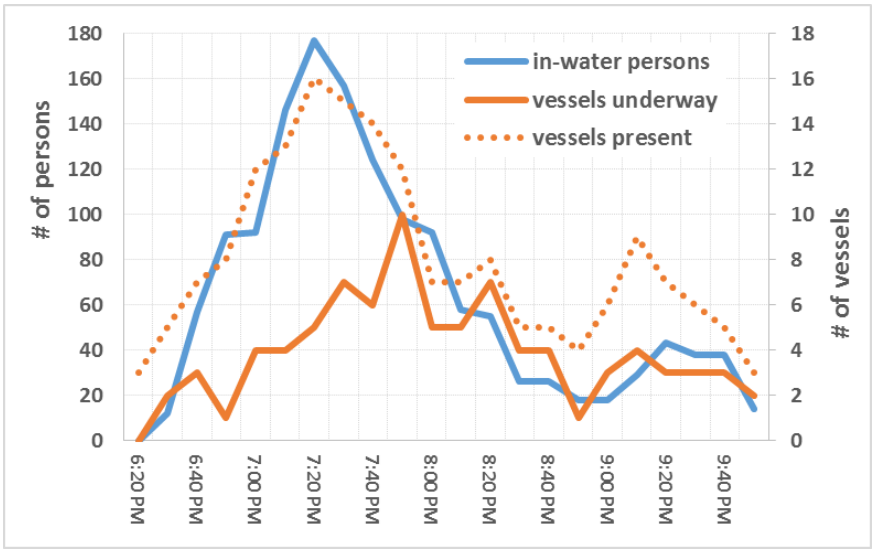


Figure 7. Overlap between in-water persons and live boating activity (i.e., vessels underway) at the Keauhou Bay manta ray viewing site on August 21, 2015. A total of 21 vessels and 301 persons visited the site.

Attempts to collect similar quantitative details at Makako Bay were not successful due to the lack of a feasible observation platform. The distance and elevation of the available shoreline observation stations did not provide sufficient night time visibility to obtain reliable counts. The elevation and motion stability from available vessel observation platforms also did not support the ability to obtain consistently reliable counts across time.

Mooring usage

At Makako Bay, seven moorings with subsurface floats are used on a nightly basis (Figure 8, Table 1). Five are anchored using double pins, one (north inside) is anchored with a single pin, and one (north outside) is secured to a large boulder via chains (Figure 9). The north outside mooring is not a U.S. Army Corp of Engineers (USACE) permitted mooring. These moorings are located in close proximity and surround the circle of rocks known as the stone circle "campfire" where scuba divers place lights and sit on the seafloor to view manta rays (Figure 8). The campfire is the primary manta ray viewing site for scuba divers in Makako Bay.

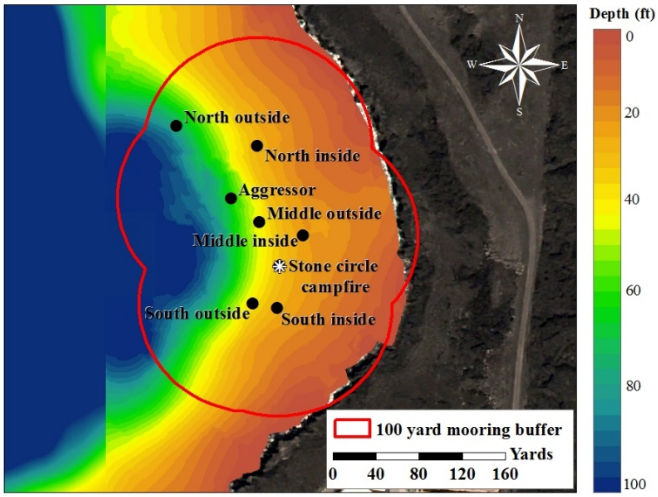


Figure 8. Map of the Makako Bay manta viewing site and the day-use mooring locations – both official and unofficial. The red outline indicates the 100 yard perimeter surrounding the official day-use moorings.

Given the number of vessels compared to available moorings, at least 2-3 vessels simultaneously use each mooring on a nightly basis. The boats are attached end-to-end ("daisy chained") to each other. Given that the number of vessels observed at Makako Bay during this study was well short of its peak activity, the number of vessels per mooring likely increases on busier days. Due to the limited number of moorings and space constraints, vessels also commonly anchor nearby (within 100 yards of the moorings). Some vessels, particularly smaller boats arriving after dark, do not moor or anchor but "live boat" throughout the duration of the night. These boats typically drop-off and pick-up snorkelers near the campfire and wait offshore in the interim.

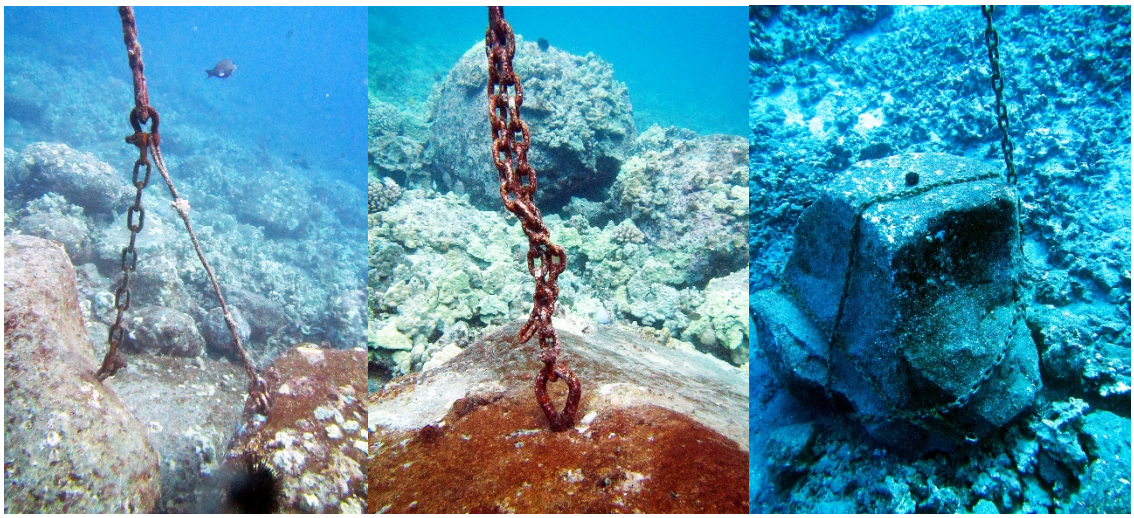


Figure 9. Day-use moorings at Makako Bay: (*left*) middle outside with double pin anchor, (*middle*) north inside single pin anchor, and (*right*) north outside with chain anchor.

At Keauhou Bay, there are seven moorings but only four have subsurface floats. Three are anchored using double pins, one (inside north) is anchored with a single pin, and three (Aggressor north, Aggressor south, south chain) are anchored to large boulder via chains (Figure 10, Table 1). The three chain moorings do not have subsurface floats and are not USACE permitted moorings. Additionally, the south chain mooring is not secure and consists of a chain loosely looped over a boulder (Figure 11). The

Keauhou moorings are located in close proximity to the boat channel which is actively used throughout the day and night by vessels not associated with the manta ray viewing operations.

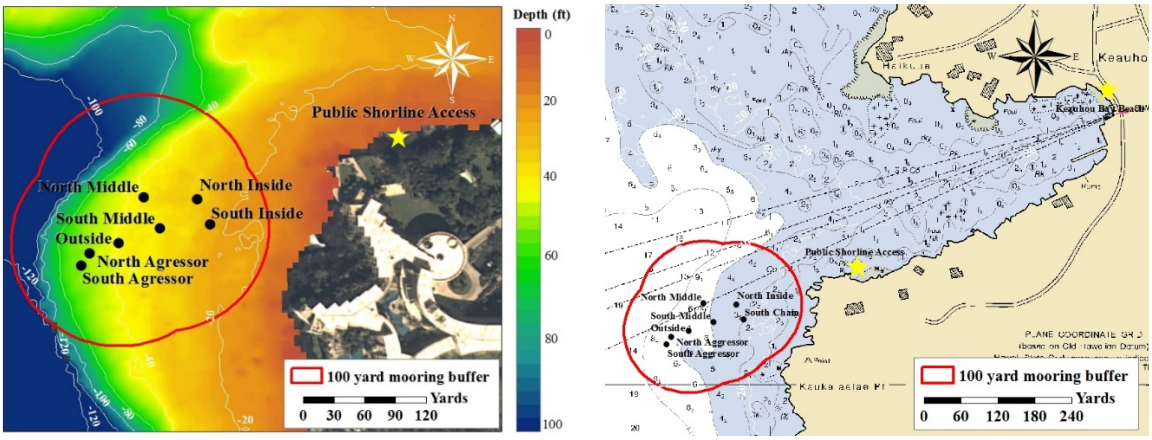


Figure 10. Map of the Keahou Bay manta viewing site (*left*) and the day-use mooring locations– both official and unofficial. The red outline indicates the 100 yard perimeter surrounding the official day-use moorings and the yellow star indicates the location of the public shoreline access. The NOAA nautical chart (*right*) showing the Keauhou harbor boat channel and its proximity to the day-use moorings.

Based observations, the four moorings with subsurface floats are regularly used by at least one vessel. Some vessels, arriving after dark, do not moor but instead drop anchors presumably due to their inability to locate available moorings. Boats have also commonly been observed live boating throughout the duration of the night. During busy nights, 3-4 boats were observed using each mooring simultaneously. Compared to the Makako Bay site, the vessels at Keauhou Bay are less centralized and more dispersed along the shoreline and anchoring is much more frequent. While not assessed within the scope of this study, the live coral cover was observed to be quite high throughout the area where anchoring was observed. Damage to live coral colonies is likely unavoidable when anchoring in this area, especially at night.

Figure 11. Day-use moorings at Keauhou Bay: (*left*) middle south with double pin anchor, (*middle*) inside north with single pin anchor, and (*right*) south chain which is only loosely wrapped around a boulder.

Attempts were made to reconcile the moorings verified during this study with existing records from Malama Kai (http://www.malama-kai.org/) and DLNR DOBOR administrative rules. However, GPS

coordinates listed in the records do not align with the high sensitivity GPS coordinates recorded by a Garmin 72H directly over each mooring in this study (Table 1). Assuming that the Malama Kai records list all day-use moorings approved by the Army Corp of Engineers and the Hawaii DLNR Land Board, there are several unapproved moorings which are being used at both sites. Despite the discrepancies with the Malama Kai online records, Teri Leicher of Malama Kai states that all of the double pin and single pin moorings at both sites are approved.

At Makako Bay, at least one or two of the moorings with subsurface floats are not permitted/approved. At Keauhou Bay, three chain based moorings and possible one of the moorings with a subsurface float are not permitted/approved. Of all day-use moorings at both sites, only one at Makako Bay is actually codified in the DLNR DOBOR administrative rules which guide enforcement activities (per Dan Mersburgh, DLNR DOBOR).

The risk of mooring failure was not assessed in this study due to external dependencies for information and engineering expertise which were not met in time for issuing this report. However, rough engineering calculations on the available mooring specification data suggest that the mechanical force exerted on a single mooring from four rafted vessels may easily exceed the design specifications of the mooring causing potential failure under conditions of high wind (e.g., 30 mph) and significant swell (per Finn McCall, DLNR DOBOR).

Hazards to human health and safety

Consistent with classical risk assessment and management methodology, this safety assessment defines and assesses the **hazards** to human health & safety independently from their **likelihood** (i.e., probability) of occurrence (Figure 12). Hazards are prioritized in order of potential severity. **Risk factors** which increase hazard severity and/or likelihood will be assessed. **Mitigating factors** employed to reduce severity and/or likelihood will also be assessed.

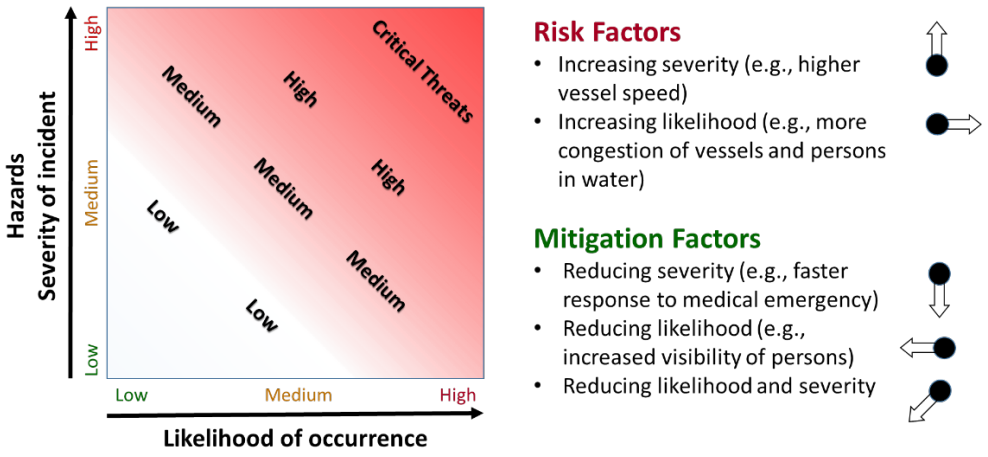


Figure 12. Classical risk assessment and management framework. The severity or impact of a hazardous incident occurring is represented in the vertical axis while the likelihood or probability of occurrence is represented in the horizontal axis. The resulting gradient represents the highest threats (upper right corner) which should be prioritized for management attention. Risk factors increase the threat level either by increasing severity of a hazard and/or increasing the likelihood of occurrence. Conversely, mitigating factors reduce the threat level posed by hazards by reducing the severity of the hazard and/or reducing the likelihood of occurrence.

Given the nature of the manta viewing operations, there are several potential human safety hazards which range in level of severity. Some hazards are inherently associated with any in-water activity but others are exacerbated by specific nature of the manta viewing operations and/or the level of congestion on a given night. Hazards have been classified based on potential severity of injury and resulting consequences.

For purposes of this assessment, hazards have been classified as **high** if they can result in severe injury or death, **medium** if they can result in injury requiring professional medical attention but are most likely non-life threatening, and **low** if they can result in minor injury (i.e., not requiring professional medical attention) but possibly ending recreational activity for the individual(s). Specific hazards identified via stakeholder input and review of current operations include the following:

High: severe injury or death possible

(1) Live vessel (while engines in gear) or propeller strike on swimmer/diver
(2) Anchor strike on subsurface diver
(3) In-water medical emergency (i.e., heart attack, stroke, etc.)
(4) Drowning (e.g., due to panic, loss of floatation, or subsurface loss of air)
(5) High speed boat-to-boat collision

Medium: injury requiring medical attention possible

(6) Drifting vessel strike (engines off)
(7) Swimmer/diver hitting idle vessel (e.g., swimming into boat or surfacing under boat), or accidentally kicking idle propeller
(8) Manta ray colliding with swimmer/diver
(9) Slow-no-wake speed boat-to-boat collision

Low: minor injury possibly ending recreational activity

(10) Contact with hazardous marine life (urchins spines, coral abrasion, stinging organisms)
(11) Swimmer accidentally hitting/kicking another swimmer
(12) Mild hypothermia
(13) Swimmer fatigue

The scope of this assessment will address high severity hazards relative to the manta ray viewing operations and factors affecting their severity and likelihood. While the likelihood of hazardous incidents occurring cannot be definitively calculated without substantial, detailed historical data, valuable qualitative insights can be gleaned from the available data, assessment of stakeholder input, and limited observations performed in this study. Generic diving or boating related hazards not specific to or exacerbated manta ray viewing operations are not addressed.

Risk factors contributing to severity and likelihood of incidents/accidents

For each type of hazard there are risk factors that influence the severity and likelihood of hazards occurring (i.e., incidents/accidents). Some of these factors can be influenced to varying degrees by operating procedures employed by individual tour operators. For purposes of this assessment, these factors have been classified in the following categories with an indication of whether they are addressed within the scope of this study and if so, what information was used in their assessment.

- **Natural ocean & atmospheric conditions** including level of ambient light, wave swell, wind speed, currents, and underwater visibility
    - *not addressed in this study; can be mitigated via operator decision to cancel tours*
- **Customer health and snorkeling/diving ability**
    - *not addressed in this study; can be mitigated via operator screening of customers*
- **Operator skill/experience/readiness** including number of crew, level of training & experience of captain & crew, crew utilization & attentiveness, emergency procedures & medical equipment
    - *voluntary stakeholder input collected via interviews & email survey*
- **Operating procedures & equipment** including in-water supervision ratios, aggregation versus dispersion of swimmers/divers, use of group flotation & lights, use of individual flotation & lights
    - *Assessed via direct observations, and voluntary stakeholder input collected via interviews & email survey*
- **Crowding/congestion** including number of boats and divers/swimmers in water
    - *Assessed via direct observations, compilations of statistics provided by Manta Pacific Research Foundation, and voluntary stakeholder input collected via interviews & email survey*
- **Live boating near swimmers & divers** including the synchronicity of operations and the behavior of vessel captains, swimmers, and divers
    - *Assessed via direct observations, and voluntary stakeholder input collected via interviews & email survey*
- **Mooring availability & integrity** including mooring specifications, number of vessels using each mooring, and vessel size(s)
    - *Assessed via mooring verification survey, commercial vessel specifications, mooring specifications, and DLNR DOBOR engineering calculations*

Risk assessment of individual hazards

Live vessel or propeller strike on swimmer/diver at night

Probably the most severe hazard associated with the night time manta viewing operations is a live vessel or propeller strike on a person in the water, particularly on the head. Several risk factors which can increase the likelihood of a live vessel or propeller strike include the following:

(a) Number of live boating vessels and in-water persons
(b) Timing overlap of in-water persons and live boating activity
(c) Spatial proximity of live boating vessels and in-water persons
(d) Visibility of in-water persons (including use of lights) and surfacing behavior of scuba divers & free divers
(e) Speed of live boating vessels
(f) Crew utilization and attentiveness, and use of spot lights on live boating vessels

Of these risk factors, vessel speed (**e**) is the only factor which also increases severity of hazard.

In the operational statistics previously reviewed, the level of congestion and overlap of in-water persons and live boating vessels have been quantified and demonstrate ample opportunity for an

accident to occur due to (**a**) and (**b**), especially on the busiest days. Additionally, the spatial proximity of the Keauhou manta viewing site to an active boat channel increases the likelihood of an accident (Figure 10).

Ten days of direct observations (confirming stakeholder input) have recorded operator and swimmer/diver behavior which needlessly increases the likelihood of an accident occurring due to (**c**), (**d**), and (**e**). On a nightly basis, multiple vessels have been observed traveling above minimum operating speeds (**e**) and passing within 10-20 ft of in-water persons (not associated with the vessel) (**c**) who are not wearing individual lights (**d**). Unlit swimmers have also been observed venturing away (>40 ft) from their groups/rafts or swimming to/from shore (at Keauhou Bay). On one occasion, a scuba diver was observed briefly surfacing unexpectedly (**d**) halfway between their originating vessel and the campfire (at Makako Bay). The visibility of in-water persons (**d**) by vessel operators can be both enhanced and degraded by the use of strong lights. The use of strong lights by one operator can substantially enhance their vision and ability to avoid in-water persons while concurrently hampering the vision of other operators.

During the night-time observation periods, unrelated vessels exiting and entering the Keauhou harbor at high speed avoided the manta ray viewing area where most moored/anchored vessels were well lit. This behavior contrast to day-time activity when vessels commonly transit over the day-use moorings at high speed when entering & exiting the Keauhou boat harbor. However, on one night multiple groups of swimmers associated with lighted rafts were observed following manta rays well into the boat channel (north of the North Middle mooring) as defined by the NOAA nautical chart (Figure 10).

On three occasions, vessels were observed transiting above minimum operating speed directly over submerged divers (**c**) visible from their dive light and in one case confirmed by the diver's behavior afterwards (i.e., waving their dive light upward in response). Due in part to congestion, vessels regularly pass within 20 ft of subsurface divers (**c**). The movement and dispersion of subsurface divers relative to moored/anchored vessels contributes to this spatial proximity. On one occasion, subsurface divers moved to within 10 ft of the stern of a moored vessel (**c**) and remained stationary for an extended period of time (>30 minutes). Subsurface divers transiting underneath moored/anchored vessels is a common occurrence due to the congestion of vessels in a confined area.

Direct observations also confirm some operators employing mitigating behavior to reduce the likelihood of accidents. Many vessels (but not all) clearly take the most evasive route possible (**c**) and use minimum operating speed (**e**) exercising an abundance of caution when approaching or leaving the area with in-water persons. Some (but not all) moving vessels also employ extra crew on the bow or stern with spotlight(s) to avoid in-water persons (**f**). A majority of operators place individual lights on in-water persons (**d**) although this practice appears less consistent on the snorkeling guides themselves. The general procedure practiced by all scuba diving operators is to descend and surface next to their originating vessel (**d**), however, unplanned surfacing inevitably occurs for a small percentage of scuba divers. Scuba divers at the manta viewing sites do not use surface markers or dive flags due to the entanglement hazard they pose to the manta rays at night.

Free diving (**d**) is also discourage by all tour operators but has been observed, especially at Keauhou Bay. In close proximity to moving vessels, lengthy free dives which may include transiting a significant distance underwater disproportionately increases the risk of an accident.

Anchor strike on subsurface diver

Another potentially severe hazard associated with the night time manta viewing operations is an anchor strike on a subsurface diver, especially on the head. Risk factors which can increase the likelihood of an anchor strike include the following:

(g) The number of vessels using anchors and number of subsurface scuba divers

(h) Timing overlap of subsurface diving and arrival time of vessels

(i) Anchor deployment procedures

Of these risk factors, anchor deployment procedures (**i**) is the only factor which can also increase the severity of hazard.

The risk factors associated with this hazard differ by manta ray viewing site. At Makako Bay where scuba diving occurs nightly weather permitting, the vessel arrival schedules are more synchronized with fewer vessels arriving after dark while subsurface scuba divers are in the water (**h**). At Keauhou Bay, scuba diving is less regular but the vessel constantly arrive throughout the night (e.g., Figure 6). At both locations, the busier nights (**g**) result in an increase in both the need for anchoring (due to limited availability of moorings) and the timing overlap between subsurface divers and arriving vessels (**h**).

Dropping an anchor from a vessel at night without inspecting the seafloor and allowing it to free-fall at maximum speed to the bottom not only increases the likelihood of an accident but also maximizes the severity of the hazard. This behavior was observed on several occasions at Keauhou Bay and appears to be a common practice. This practice was not observed at Makako Bay during the four days of observation. Less caution at Keauhou Bay may be the result of scuba diving being less common there.

Direct observations also confirm this most operators mitigate this risk by slowly lower their anchor hand-over-hand and/or employing an in-water observer to help guide the anchor. However, even when lowered hand-over-hand, an anchor strike on the head on a subsurface diver has the potential to injure or render them unconscious.

In-water medical emergency

Due to preexisting medical conditions, medical emergencies (i.e., heart attacks, strokes, etc.) will be directly proportional to the number of at-risk persons involved in any physical activity. Due to the increasing number of persons engaging in night time manta ray viewing, its widening appeal to snorkelers, and the low barriers to entry (i.e., no prerequisite training or skill required), such incidents can be expected at a consistent ratio. Based on stakeholder input, such events appear to occur every year and should increase as the number of participants increase.

The most direct and possible only effective way for operators to lower the likelihood of such incidents is to screen customers for medical condition and skill level prior to in-water activities. While this practice is institutionalized in the scuba diving industry, there are no standards associated with snorkeling tours. Some snorkeling operators have indicated that they deliberately screen customers based on health or snorkeling experience. However, customer dishonesty about their medical condition or skill level has been noted in the past. Another practice which prevents operators from proactively screening customers is the use of independent third party booking agents. In these situations, the operators do not meet the customers until they are ready to board the vessel.

The risk major factors affecting the severity of incidents and conversely the mitigating factors reducing severity are as follows:

(j) Response time to medical attention

(k) Ratio of crew/guides to customers and their vigilance

(l) Crew preparation, response training, skill, and equipment

While no in-water medical emergencies occurred during the observation period, risk factors were assessed based on observations and stakeholder input. Response time (**j**) will be directly affected by the level of congestion blocking the shortest path of getting a victim onto a responding vessel, the proximity of originating vessel to in-water persons, and in some cases the sheer size of the in-water victim.

The number and size of floating rafts and number of snorkelers can impede the ability to quickly transfer an in-water victim to a responding vessel. Due to the configuration of snorkeling rafts and the absence of fins on some snorkelers the speed and mobility of a raft is often dependent on a single

guide's ability to pull everyone through the water. Noise levels (e.g., people shrieking with delight as they see manta rays) can also inhibit timely detection of a medical emergency and subsequent communication to a responding vessel.

Direct observations of operations suggest that response time to an in-water victim can be hampered by distance and congestion on busy days. Some operators commonly allow their free floating rafts of snorkelers to travel >100 yds from their vessel and out of direct line of sight. In some cases due to congestion, the originating vessel remains unmoored/unanchored offshore. A past fatality associated with slow response to an in-water medical emergency has prompted one operator to keep their snorkeling rafts tethered to the vessel keeping them in close proximity at all times.

Supervision of recreational scuba divers by diving professionals is governed industry standards (i.e., PADI, SSI, NAUI, etc.) in terms of training & certification requirements and the appropriate supervision ratios associated with each type of diving situation. All scuba diving operators reportedly adhere to industry standards and guidelines due in part to certification and insurance requirements.

For swimming or snorkeling tours, there are no industry standards on training & certification requirements for operators or guidelines on supervision ratios. Via voluntary input, tour operators have indicated that they maintain in-water snorkeler to guide ratios ranging from 6:1 to 13:1 (**k**). Given the scuba diving orientation of many tour operators, snorkel guides are often PADI certified Dive Masters or Rescue Divers. At least one company states that they only hire snorkeling guides with American Red Cross Lifeguard certification, CPR & First Aid certification, and prior lifeguarding work experience. Based on stakeholder input, companies can and do employ snorkel guides without any formal training or certification. The extent and level of lifeguard training associated with operators and their crew were not confirmed by this study.

Since there are no uniform requirements, the medical equipment available on vessels varies by operator but can include First Aid equipment, Medical Oxygen (e.g., DAN Oxygen), and Automated External Defibrillators (AED). The formal training associated with this medical equipment also varies by operator.

Drowning (excluding medical emergencies)

As with any in-water activity, drowning is a potential hazard that increases proportionately with the number of persons in the water. The risk major factors affecting the likelihood of a drowning incident include the following:

(m) Ocean conditions
(n) Swimming ability
(o) Availability and use of personal floatation

The most direct ways for operators to lower the likelihood of a drowning are via preventative measures including cancellation of operations during adverse ocean conditions (**m**), screening customers for skill level prior to in-water activities (**n**), and requiring the proper use of adequate personal flotation (**o**).

While reported by multiple stakeholders as a potential risk factor, this study was not designed to assess the swimming ability of visitors to the manta ray viewing sites. However, small children were observed joining in night time snorkeling activity and having to be individually escorted back to their originating vessel prematurely by their snorkeling guide.

The use of flotation in the form of group rafts appears to be universally employed by commercial snorkel operators. However the use of personal floatation varies and includes the use of inflatable swim vests, naturally buoyant neoprene wet suits, and unattached floats (e.g., foam noodles for keeping legs afloat). All operators surveyed indicated that personal floatation devices (PDFs) are always made available for customer utilization. Some snorkelers, presumably those comfortable in their swimming ability have been observed without personal floatation which can interfere with swimming efficiency.

The risk major factors affecting the severity of drowning incidents and conversely the mitigating factors reducing severity are analogous to those of an in-water medical emergency (**j**) (**k**) (**l**) and discussed in the prior section. In the opinion of Hawaii Fire Department Ocean Safety Division Capt. Chris Stelfox, formal lifeguard training and certification should be required of all snorkeling guides with a maximum swimming to lifeguard ratio of 25:1 when swimmers are associated with a central floating raft. Capt. Stelfox does not consider scuba diving training and certification (e.g., PADI Rescue Diver) as a sufficiently rigorous qualification for snorkel guides.

High speed boat-to-boat collision

The major risk factors which can increase the likelihood of a high speed boat collision include aforementioned (**f**) crew attentiveness, (**e**) vessel speed, and the following:

- **(p)** Proximity of vessels to boat channel traffic
- **(q)** Visibility of vessel moored/anchored or underway (including natural ocean & atmospheric conditions)

Given the isolation of the Makako Bay site and the shape of the embayment, the only vessels visiting the site are those participating in the manta ray viewing activities. Therefore, a high speed collision at the site is unlikely. However, due to the multiple shifts of tours conducted at Makako Bay, there is concurrent high speed vessels traffic travelling in both directions between Honokohau harbor and Makako Bay at night. While this hazard is not unique to manta ray viewing operations, the nature of the scheduling guarantees that vessels will encounter each other on busy nights.

At Keauhou Bay, the proximity of the boat harbor elevates the interaction between manta ray operators and unrelated vessel traffic. For regular night-time Keauhou harbor users, familiarity with the manta ray viewing site likely mitigates the likelihood of a collision due to (**e**) (**f**) (**q**) despite (**p**). During the observation period, vessels entering & exiting the harbor at night consistently gave the manta ray viewing site a wide berth. Under normal conditions, significant operator negligence would be required for an accident to occur. However, a few vessels at the Keauhou manta ray viewing site have been observed mooring/anchoring without the use of lights in the midst of several well lit vessels. Additionally, on one occasion a zodiac without any lights was observed repeatedly entering & exiting the harbor to/from the manta ray viewing site.

Existing regulatory frameworks

Several regulatory frameworks currently regulate various aspects of the manta ray viewing operations. These frameworks include permits, zone restrictions, mooring use, navigation restrictions, and environmental protection. Manta ray tour operators are required to obtain a **Commercial Use Permit for State Ocean Waters** and either a **Harbor Commercial Use Permit** or a **Launch Ramp Permit** depending on the status of their vessel(s). The recent increase in the number of permits issued has led to an increase in the number of tour operators offering manta ray viewing activities. There are currently no activity-specific restrictions (e.g., associated with manta ray diving or snorkeling or night time activities), capacity restrictions (e.g., number of persons), location restrictions, or equipment requirements/restrictions (e.g., lighting, propeller guards, medical equipment, etc.) associated with these state permits.

While location and activity specific restrictions within **Ocean Recreation Management Areas (ORMAs)** have been applied to regulate and limit activities and ensure safety at other locations,

activities at Makako Bay and Keauhou Bay are not currently regulated by location or activity specific administrative rules. There are currently no regulations restricting the locations for live boating, diving, or swimming at these sites.

With respect to **mooring and anchoring** at the manta ray viewing sites, a few regulatory frameworks are currently in place. Day-use moorings are required to be approved by the Army Corp of Engineers and the DLNR Land Board. As mentioned in the previous section, unapproved day-use moorings exist at both sites and are used on a nightly basis. DLNR administrative rules limit day-use mooring usage to 2.5 hrs while another vessel is waiting and prohibit anchoring within 100 yds of a day-use mooring. *See* HAR §§ 13-257-3, 13-257-4. There are currently no regulations or restrictions associated with rafting multiple vessels on a single mooring.

General DLNR and U.S. Coast Guard **navigation** related rules govern vessel navigation in proximity to a displayed dive flag and light/signaling requirements for vessels anchored/moored, with divers in the water or with restricted movement. Vessels are prohibited from approaching within 100 ft of a displayed dive flag unless there are intending to conduct diving or swimming activities in which case they are required to approach at a speed of slow-no-wake. This buffer is reduced to 50 ft within navigational channels. From discussions with the U.S. Coast Guard and DOBOR, the definition of the regulatory term "slow-no-wake speed" is potentially ambiguous and may include speeds in excess of minimum operating speed (required to maintain steerage). There are currently no regulations governing how close vessels (involved in diving/snorkeling operations) are allowed to travel to unrelated in-water persons. For examples, vessels are allowed to motor over subsurface divers at slow-no-wake speed.

DLNR administrative rules and U.S. Coast Guard require divers (SCUBA and free divers) to display **dive flags** within 100 ft of them either in the water or on the highest point of their vessel. Despite the lack of flag visibility in the dark, there are no regulations regarding the use of lighted flags/markers by divers at night. There are currently no regulations governing the visibility of surface snorkelers/swimmers (i.e., non-divers) in the ocean at night despite the obvious hazard.

Unrelated to human safety, DNLR environmental protection regulations prohibit knowingly capturing or killing manta rays and anchor damage to stony corals. *See* HRS § 199-39.5, HAR § 13-95-70.

As with any government regulation, compliance can vary and is affected by practical constraints on enforcement. During this study, several technical violations of existing regulations were observed. During this study, a vessel was observed operating at night without running lights (at Keauhou Bay) and anchored/moored without any lights (in the midst of several other vessels with proper lights). One vessel was observed dropping off an individual with a lighted raft at the Keauhou Bay manta ray viewing site, leaving the site to go to the harbor, then returning 20 minutes later.

At both sites, vessels often occupy day-use moorings longer than 2.5 hrs and routinely anchor within 100 yds of occupied day-use moorings. Since only a single mooring at Makako Bay (DLNR #13, Table 1) and none at Keauhou Bay are formally listed in the DLNR administrative rules, enforcement of existing day-use mooring regulations may not be feasible until the administrative rules are updated.

At both sites, vessels routinely operate at speeds above minimum operating speed within close proximity to in-water persons. Arguably these vessels are not violating the slow no-wake speed requirement but they are easily exceeding minimum operating speed required to maintain steerage which is considerably slower when conditions are calm.

Voluntary tour operator standards

Independent of government regulations, community cooperation and voluntary standards can govern aspects human safety of manta ray viewing operations. A working group of tour operators have established a list of voluntary operating standards aimed at maintaining human safety and environmental stewardship. These standards were finalized in March of 2013 and promoted online by Manta Pacific Research Foundation (http://www.mantapacific.org/#!manta-tour-operator-standards/ci5b) and the Manta Ray Green List (http://www.mantaraygreenlist.com/operator-standards/). While not universally adopted by all operators, these voluntary standards have in many ways have improved the safety of manta ray viewing operations despite the high number of participants. For example, the widely adopted and voluntary practices of using individual lights on snorkelers/swimmers, centralizing them on floating rafts, and prohibiting free diving, have substantially (but not totally) mitigated some of the risks associated with placing large numbers of persons in the water at night amongst actively motoring vessels.

Since the goals of this study was to assess the current operation relative to human safety, it is important to acknowledge the substantial contributions to human safety associated with some of these voluntary standards. It is also important to acknowledge that some of the provisions in the voluntary operating standards are unrelated to human safety. Some provisions also conflict with the operating model employed by some tour operators (e.g., providing dry boat-based manta ray viewing opportunities) and are a source of contention among tour operators. Providing a critical assessment and/or endorsement of the individual provisions within these voluntary standards was not an objective of this study and not performed.

Conclusions

Severe safety hazards are currently associated at the manta ray viewing activities at Makako Bay and Keauhou Bay. The probability for a severe accident is relatively low since a concurrent overlap in both time & space of two or more hazardous behaviors is required for a severe accident to occur (e.g., vessel motoring over subsurface divers and unplanned/uncontrolled diver ascent). However, substantial overlap in the timing of hazardous behaviors and complete spatial overlap in hazardous behaviors occurs on a nightly basis. These existing data and observations suggest that a severe accident is mathematically inevitable and will occur in the future without significant mitigation of the existing risk factors.

While voluntary tour operator standards have contributed to increased human safety and current government regulations address general boating and diving safety, the unique human safety issues associated with this activity (e.g., high density of in-water persons and vessels in the ocean at night) warrant special attention. In particular, night-time congestion and the overlap (in time & space) between live boating and in-water persons are major factors which substantially increase the likelihood of a severe accident. Existing permit requirements provide an overall level of capacity control for all commercial vessels; however, no other regulatory control is in place to prevent further growth commercial and recreational activity. Unsuccessful attempts to “develop” additional manta ray viewing sites by tour operators have exacerbated the congestion at Makako Bay and Keauhou Bay. If popular demand for this activity continues to exceed supply (e.g., tour operators often fully booked during peak season) and commercial revenue potential remains high, continued growth in commercial activity can be expected.

The onset of adverse weather conditions reducing visibility (e.g., rain), increasing minimum operating speed (e.g., wind), or the rapid departure from normal operations associated with an

unexpected emergency (e.g., medical emergency, mooring failure, shark sighting, etc.) can significantly elevate risk and the likelihood of an accident. The extent of elevation is dependent in part on the skill, experience, and reaction of tour operators and their crew and may be disproportionately influenced by the lowest common denominator, especially in a confined & congested area.

A formal assessment and vetting of regulatory options are recommended to determine how best to mitigate the severity of existing hazards and reduce the likelihood of severe accidents. This process should include as assessment of regulatory limitations with detailed input from all stakeholders to anticipate the potential for unintended consequences, identify regulatory loopholes, and recognize practical enforcement limitations.

Table 1: Day-use moorings at Makako Bay and Keauhou Bay

Existing moorings verified in this study

Site	Name	Mooring Type	Latitiude N	Longitude W	depth (ft)	photos
Makako	North Outside	chain around rock	19 44.242	156 03.281	80	G7
Makako	North inside	single pin	19 44.233	156 03.244	23	G3
Makako	Aggressor	double pin	19 44.209	156 03.256	72	G6
Makako	Middle outside	double pin	19 44.198	156 03.243	38	G2
Makako	Middle inside	double pin	19 44.192	156 03.223	30	G1
Makako	South outside	double pin	19 44.161	156 03.246	34	G5
Makako	South inside	double pin	19 44.159	156 03.235	23	G4
Keauhou	Outside	double pin	19 330543	155 58.065	36	K01
Keauhou	Aggressor North	chain around rock	19 33.538	155 58.079	47	K02
Keauhou	Aggressor South	chain around rock	19 33.532	155 58.083	48	K03
Keauhou	Inside North	single pin	19 33.564	155 58.027	29	K04
Keauhou	Middle South	double pin	19 33.550	155 58.045	34	K05
Keauhou	Middle North	double pin	19 33.565	155 58.053	38	K06
Keauhou	South Chain	chain around rock - loose	19 33.552	155 58.021	26	K07

Day-use moorings listed in the Malama Kai records

Site	Name	Mooring Type	Latitiude N	Longitude W	depth (ft)	
Makako	Garden Eels North		19 44.230	156 03.240		
Makako	Garden Eels Central		19 44.202	156 03.235		
Makako	Garden Eels East		19 44.198	156 03.215		
Makako	Garden Eel Cove-1		19 44.186	156 03.260		
Makako	Garden Eel Cove-2		19 44.186	156 03.260		
Keauhou	Keauhou Manta-1		19 33.558	155 58.023		
Keauhou	Keauhou Manta-2		19 33.558	155 58.023		
Keauhou	Keauhou Manta-3		19 33.558	155 58.023		

Day-use moorings listed in the DLNR DOBOR administrative rules

Site	Name	Mooring Type	Latitiude N	Longitude W	depth (ft)	
Makako	DLNR #13		19 43.940	156 03.470		

Appendix A: Manta ray tour operation stakeholders

Name/Contact	Company/Organization	Inteview Participant	Survey Response	Survey Recipient
Iwa Kalua	Aloha Kayak Co.	x		x
(808) 557-5668	Aloha Kona Tours			
Captian Kris Henry	Aloha Ocean Excursion (formerly Sea Hawaii Rafting)			x
Craig Napier	Big Island Divers	x		
Frank Hendricks	Big Island Divers	x		
Kristina Dowling	Big Island Divers	x	x	x
Norman Cinch	Big Island Divers	x		
Sarah Rafferty	Big Island Divers		x	x
Erica	Blue Sea Cruises Inc.		x	x
Ray Lemay	Blue Sea Cruises Inc.		x	x
Denise Vidosh	Blue Wilderness		x	x
Mariko	Breeze Hawaii		x	x
coralreefadventures@gmail.com	Coral sea Adventures (Coral Reef Snorkel Adventures)			x
Alex Dent	Fair Wind Cruises	x		
Mendy Dant	Fair Wind Cruises	x		x
Mitch Stauffer	Fair Wind Cruises	x		
Daniel Mersburgh	Hawaii DOBOR Honokohau	x		
Capt. Chris Stelfox	Hawaii Fire Department Ocean Safety	x		x
Johnathan Droge	Hawaii Island and Ocean Tours LLC		x	
LeeAnn P. Leslie	Hawaii Island and Ocean Tours LLC		x	x
Jason Thurber	Hawaii Oceanic			x
Bari Mims	Hawaii Pack and Paddle			x
http://www.hawaiianscubashack.com/	Hawaii Scuba Shack			x
Lisa Christensen	Honu Sports			x
Keller Laros	Jacks Diving Locker	x		
Teri Leicher	Jacks Diving Locker	x		x
Wendy Laros	Jacks Diving Locker	x		x
info@kamanu.com	Kamanu Charters			x
kohalakayak@yahoo.com	Kohala Kayaks			x
Captian Chris Wade	Kona Agressor		x	x
Evin	Kona Agressor			x
Katie Gaab	Kona Diving Company			x
Kerry Key	Kona Diving Company		x	x
Ralph Jewell	Kona Glass Bottom Boat		x	x
info@konahonudivers.com	Kona Honu Divers			x
Laure and Danny Scott	Kona Ocean Adventures		x	x
info@konaoceanx.com	Kona Ocean Experience			x
Ty and Cyrus Widhalm	Kona Sea Adventures			x
Kalani Nakoa	Kona Snorkel and Sail	x		x
info@konasnorkelandsail.com	Kona Style			x
liquid@liquidhawaii.com	Liquid Hawaii			x
Keller Laros	Manta Pacfic Research Foundation	x		
Seth Conae	Manta Ray Dives of Hawaii			x
Robert Hudson	Miss Mojo Sports	x		x
Jan War	Natural Energy Laboratory of Hawaii Authority	x		
Dani Knapp	Neptune Charlies Ocean Safaris			x
Seth Conae	Neptune Charlies Ocean Safaris			x
ecoinfo@oceanecotours.com	Ocean Eco Tours			x
Brain Wargo	Ocean Encounters			x
Deenen Wargo	Ocean Encounters			x
Yumi	Ocean Spirit Diving		x	x
James and Martina Wing	Ocean Wings Hawaii Inc.			x
Frank and Patrice Heller	Pacific Rim Divers		x	x
Bob Gladden	private boater	x	x	x
Jay Smith	Scuba Shack		x	x
Kris Henry	Sea Hawaii Rafting			x
Rich and Holly Kersten	Sea Paradise		x	x
Kyle	Sea Quest Hawaii			x
Lily Dudoit	Sheraton Keauhou Kona Resort	x		
info@splashersoceanadventures.com	Splashers			x
Colin Adams	Sunlight on Water	x		
Josh	Sunlight on Water	x		
Melainah and Mike Yee	Sunlight on Water	x	x	x
Nicole Milligan	Torpedo Tours		x	x
Lt. Joshua Williams	U.S. Coast Guard Marine Safety	x		
www.wahinecharters.com	Wahine Charters			x

Appendix B: Manta Ray Tour Operators serving the Kona coast

Aloha Kayak Company
Aloha Kona Tours
Aloha Ocean Excursions
Big Island Divers
Blue Sea Cruises
Breeze Hawaii Diving
Coral Reef Snorkel Adventures
Dolphin Journeys
Fair Wind Cruises
Hang Loose Boat Tours
Hawaii Island and Ocean Tours
Hawaiian Scuba Shack
Honu Sports
Hawaii Oceanic
Iruka Hawaii
Jack's Diving Locker
Kamanu Charters
Kohana Iki
Kona Aggressor
Kona Diving Company
Kona Honu Divers
Kona Nature School
Kona Ocean Adventures
Kona Ocean Experience (KOEX)
Kona Sea Adventures
Kona Style (Kona Snorkel & Sail)
Kukio Boats
Liquid Hawaii
Miss Mojo (Kiholo Inc.)
My Kona Ocean Adventure
Neptune Charlies Ocean Safaris/Manta Ray Dives
Ocean Encounters (Bite Me)
Ocean Eco Tours
Ocean Spirit Hawaii
Pacific Rim Divers
Sandwich Isle Divers
Sea Paradise
SeaQuest Snorkel Tours
Splasher's Ocean Adventures
Sunlight on Water
Torpedo Tours
Wahine Charters LLC

Appendix C: Vessels operating manta ray viewing activities at Makako Bay and Keauhou Bay

Company	Vessel Name	Length (ft)	Gross Register Tonnage	Max Passengers	Max Total	Height (ft)	Width (ft)	Official Number
Aloha Kayak Company	(kayaks)							
Aloha Kona Tours	Aloha Kona Tours			12				
Aloha Ocean Excursions	Zodiac Hurricane 733	25						
Big Island Divers	Moana Olapa	35	14					1166964
Big Island Divers	Moana Lu'u	28						
Big Island Divers	Hono Iki	36	20					1206121
Big Island Divers	Naia							
Breeze Hawaii Diving	Umi Katana	27	5	11				HA1357CP
Blue Sea Cruises	Makai	46	14	32	84	18	16	978116
Blue Sea Cruises	Spirit of Kona	70	78	100	149	20	28	11955628
Coral Reef Snorkle Adventures	Makua	25	2	6	8	12		1636CP
Fair Wind Cruises	Fair Wind II	58	55	124	132			993088 (U.S.)
Fair Wind Cruises	Hula Kai	55	27	48	51		21	1176109 (U.S.)
Hang Loose Boat Tours	Hang Loose	29.3	8	24	26		9.4	1251486 (U.S)
Hawaii Island and Ocean Tours	Box top			6				
Hawaiian Scuba Shack	White force	28						
Hawaii Oceanic	Pueo Kai	30		6				
Honu Sports	The Honu Adventure	28		8			10	
Iruka hawaii	Kona Naia	32	13	21	23			1030297 (U.S.)
Jack's Diving Locker	Kea Nui	46	40	38	40	16		1196519 (U.S.)
Jack's Diving Locker	Nai'a Nui	32	8	15	17			1189298 (U.S.)
Jack's Diving Locker	Na Pali Kai	33.8	12	25	27			687068 (U.S.)
Jack's Diving Locker	Diver II	38		28				
Kamanu Charters	Kamanu	36	4	24	26			HA463CP
Kohana Iki	Kaikea							
Kiholo Inc.	Miss Mojo	41	24	6				982338 (U.S.)
Kona Aggressor	Kona Aggressor II	73						
Kona Diving Company	Hale Kai	34						
Kona Honu Divers	Honu I	46	44	36	39	16	9	1122486
Kona Nature School	Black and yellow Zodiac							
Kona ocean Adventures	Ipo Kai							
Kona ocean Adventures	Mega Bites							
Kona Ocean Adventures	White Fishing cat	28		12	17			
Kona Ocean Experience	Lei Plana							
Kona Ocean Experience	Horizon	RIB						
Kona Sea Adventures	Ahi Lani	34						
Kona Snorkel & Sail	Kini Kini	38	under 5	6				HA1705CP
Kona Snorkel & Sail	Noa Noa	50		43				
Kona Snorkel & Sail	Kona Style							
Kukio Boats	?							
Liquid Hawaii	Liquid Hi	25		6				HA1949CP
Neptune Charlies Ocean Safaries	The Manta	36	20	29	32		6	1179815 (U.S.)
My Kona Adventure	(white boat red letters)							
Ocean eco Tours	Zodiac							
Ocean Encounters	Ocean Encounters	41.8	26	35	40	25	14.2	548605
Ocean Spirit Hawaii	White force	25						
Pacific Rim Divers	Hapa Naia	26.5		6				
Pacific Rim Divers	Boundless	34	n.a.	n.a.	n.a.			
Sandwich Isle Divers	(force with fly bridge)							
Sea Paradise	Hokuhele	50	unk	39	42			
SeaQurst Snorkel Tours	Vitos boat							
Splasher's Ocean Adventures	Orca	26.7	8	19	21		3.8	972712 (U.S)
Sunlight on Water	Uhani Nui O Naia	40		35?				
Torpedo Tours	Napali Kai II	38		27				
Wahine Charters LLC	Wicked Wahine	27	9	14	16		5.1	1097318 (U.S.)