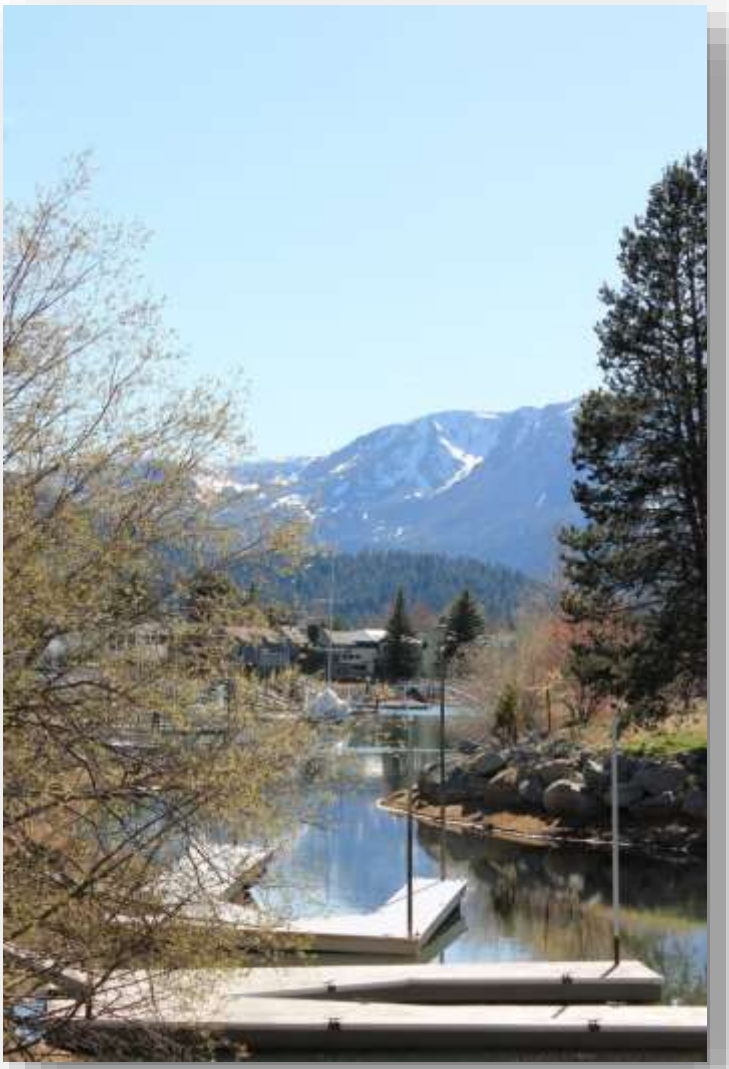
Evaluation of Active and Passive Skimmers for Macrophyte Fragment Collection



April 19, 2018

Evaluation of Active and Passive Skimmers for Macrophyte Fragment Collection

Prepared for

Tahoe Keys

Tahoe Keys Property Owners Association
South Lake Tahoe, California

Prepared by

Sierra Ecosystem Associates

TAHOE KEYS INTEGRATED MANAGEMENT PLAN

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EXECUTIVE SUMMARY

The Harvesting and Fragment Collection Program was significantly modified in 2016 by the Tahoe Keys Property Owners Association (TKPOA) following the submittal of the Draft Integrated Management Plan (IMP) to the Lahontan Regional Water Quality Control Board (LRWQCB). Fragment control is the first goal of the program and primarily consists of plant fragment collection in lagoon channels and prevention of escape into Lake Tahoe proper. The second goal of the program is the reduction of fragment spread within the lagoons. Reducing spread inside the Keys could lead to a reduction and better control of the aquatic weeds.

In 2016, TKPOA conducted a field trial to evaluate four differently designed boats that could improve weed fragment skimming activities by TKPOA crew members. The trial led to the purchase of one of the four boats and modifying the design of existing skimming boats. In 2017, TKPOA then undertook an evaluation of active and passive stationary skimmers, either floating or attached to docks, which may further assist and improve fragment control in the Tahoe Keys lagoons.

From the literature review, it has been determined that active stationary skimmers are readily available for purchase and are capable of successfully collecting fragments floating along the surface of the lagoons. Passive skimmers, however, are not readily available for purchase and are designed primarily for pond or pool maintenance and are therefore too small for the Tahoe Keys lagoons. Skimming of the main channels that connect with Lake Tahoe, as well as collecting fragments dislodged from boat propellers at the Boat Back-up Station, would best be managed by the Seabin, one of the evaluated active skimmers.

1.0 HARVESTING AND FRAGMENT COLLECTION PROGRAM

The Tahoe Keys Property Owners Association (TKPOA) Harvesting and Fragment Collection Program was greatly modified in 2016 following the submittal of the Draft Integrated Management Plan (IMP). The modified program focuses on reducing the spread of aquatic weed fragments that are responsible for the spread and growth of new plants throughout the Keys. Previously, operator driven skimmer workboats were evaluated for feasibility and efficacy in the Tahoe Keys. This report evaluates free-floating or dock mounted skimmers, either active or passive in nature, and their potential for use by the TKPOA to collect surface floating fragments.

Property in and around the Tahoe Keys lagoons is owned and controlled by the following entities: TKPOA, Tahoe Keys Marina and Yacht Club, Tahoe Keys Beach and Harbor Association (TKB&HA), California Tahoe Conservancy (CTC), and TKV Properties Holdings LLC. Through various agreements, TKPOA maintains the waterways for boating and other recreation. This waterway and adjacent land ownership pattern adds management complexity. TKPOA has no legal or other authority to require others to participate in the Integrated Management Plan or implement best management practices.

1.1 Background

As the Tahoe Keys lagoons are a combination of dead end coves and open water areas, with typical water column depths of 8 to 12 feet, the flow of water in the lagoons is generally very minimal. Water movement into and out of the Tahoe Keys lagoons is influenced by both baroclinic[1] and barotropic[2] forces. For example, annual filling of Lake Tahoe, and therefore the Tahoe Keys lagoons, occurs during the primary snowmelt runoff season (early to mid-summer) during which time water moves from the lake proper into the lagoons (La Plante 2008). Fragments created from mechanical harvesting, waterfowl feeding or wave action are distributed throughout the lagoons, and in some instances drift out into Lake Tahoe, which lead to the growth of new plants and expanded frequency of plant occurrence.

Docks create ideal places for the buildup of fragments. The TKPOA holds common individual docks used by owners and seasonal renters of townhomes in the Tahoe Keys development, including 1,012 docks in the Main Lagoon, 275 in the Marina Lagoon, and 94 in Lake Tallac. Furthermore, the TKB&HA maintains 266 boat slips for its members. Docks throughout the lagoons are fairly close to each other, making harvesting between slips difficult and further collection of fragments tedious. Lack of water movement in more dead end areas or channels away from the West Channel further aid to fragments collecting, and eventually settling, around docks.

To improve existing practices of harvesting and fragment collection in the Tahoe Keys lagoons, the TKPOA began investigating alternative boat skimmers, originally designed

[1] Warmer water temperatures create less water density and cooler temperatures create higher water density. In these instances, higher water density will move towards the lower water density.
[2] Pressure differentials created by constant unidirectional wind shearing.

for trash and debris collection, to be used to collect plant fragments in the lagoons. This investigation lead to an operator driven skimmer field trial to collect surface floating fragments.

The field trial occurred August-September 2016 and included the evaluation of four boats, including: a current TKPOA skimmer boat, a modified TKPOA skimmer boat, Weedoo's TigerCat, and ELASTEC's Omni Cat (see Figures 1 and 2). The four boats included in the field evaluation were all different with respect to plant fragment collection. Overall, as the primary need for the Tahoe Keys is fragment collection and constant skimming of the main channels, the Omni Cat was recommended and later purchased in early 2017 (TKPOA 2016b). Further evaluation of the Omni Cat was conducted in 2017 and will be available for review in 2018 (TKPOA 2017b).

Figure 1. Weedoo's TigerCat

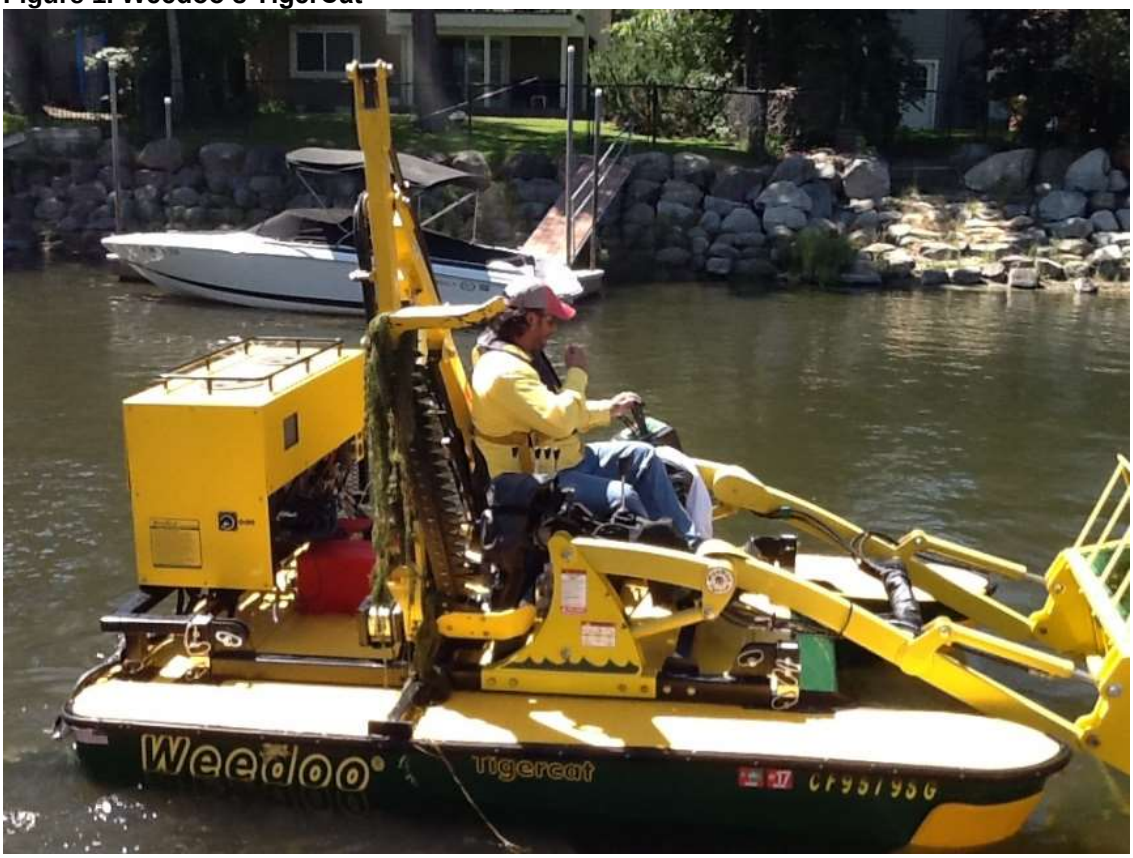


Figure 2. ELASTEC's Omni Cat

In 2017, the TKPOA continued the Harvesting and Fragment Collection Program through the evaluation of stationary dock mounted or free-floating skimmers that could potentially be used in the lagoons to collect surface floating fragments. These skimmers are termed either 'active' or 'passive.'

1.2 Active Skimmers

Active skimmers are equipment that require the expenditure of energy to collect debris and include either free-floating or dock mounted skimmers. Active skimmers use the creation of a vortex or vacuum driven aeration to filter water. There are a variety of pool or pond active skimmers available for purchase. However, with the size of the Tahoe Keys lagoons, a larger skimmer system is required. Due to the need for a larger system, three different skimmers were evaluated for potential use in the Tahoe Keys lagoons: Marina Trash Skimmer, Seabin, and ProSkimmer System.

1.2.1 Marina Trash Skimmer

The Marina Trash Skimmer (MTS) (Figures 3 and 4) is a dock mounted, pump driven skimmer that can be run 24/7 using little electricity. It is produced by Marina Accessories, a Bellingham, WA based company. The skimmer is mounted on a dock system and floats on the water. The main tank of the MTS, ½" thick Roto-Molded LLDPE + Regrind, is approximately 6'2" L by 4'3" W by 5'1" H.

Figure 3. Marina Trash Skimmer Schematics

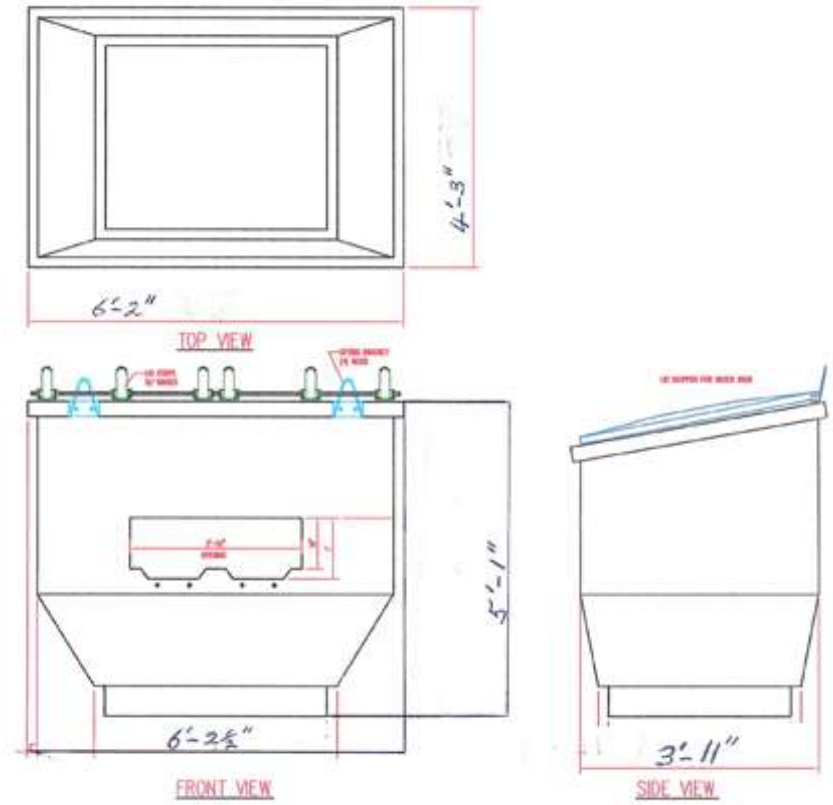


Figure 4. Marina Trash Skimmer – Port of San Diego

This skimmer design requires a vacuum driven aerator with a ¾ HP 120 Volt motor to force water to flow into the containment area where debris is captured.

In 2011, a report evaluating the effectiveness of the MTS in the Port of San Diego deemed the installation of four devices a success due to the amount of debris collected as well as the observable improvement in water quality. The study occurred over the course of eight months at four locations including: Pier 32, Point Loma Marina, Cabrillo Isle Marina, and Half Moon Marina. Here it was found that each MTS collects an average of 45 gallons of debris per day, filtering debris and oil residue at an estimated rate of 300 gallons of water per minute and a maximum capacity of 20 lbs (AMEC 2011; Sifuentes 2015).

Advantages

Overall the design of the MTS is simple and reportedly easy to install and operate. The tank size capacity could allow for reduction in TKPOA skimming boat operations and may aid in collecting fragments that would otherwise become trapped by docks in the lagoons. Strategic placement of these skimmers could greatly improve fragment collection in heavy fragment areas.

The MTS has also been noted to oxygenate the water column through the churning motion created due to the vacuum driven aeration (Sifuentes 2015). The oil/particulate filter, an optional addition to the MTS, could filter oil residue and algae from the surface of the water column.

Disadvantages

While the skimmer has a relatively simple design, its larger size could impair boat usage at the dock it is mounted to. Furthermore, the requirement of a 30A 120V GFIC breaker for power input to drive the vacuum driven aeration presents limits to mounting locations without power supply. Multiple MTS systems would be required to successfully collect fragments from an area, where there is a high distribution of docks impairing water flow. According to the manufacturer, maintenance of the MTS is required daily or every other day, to clean the filter and remove collected debris. An automatic shut off mechanism is initiated if the tank becomes full or if the filter becomes clogged. Finally, removal of each unit would likely be required prior to winter and below freezing temperatures to prevent damage to the unit from ice formation.

1.2.2 Seabin

A second model of active skimmer to be considered for the Tahoe Keys lagoons is the Seabin, a pump-driven debris skimmer shaped similarly to a trash bin that can be continuously operated. The Seabin is a relatively new technology, only recently made available for purchase in mid-2017. This technology was designed for any waterbody with a relatively calm environment (including marinas, yacht clubs, and ports) where waves or water movement will not impact the mode of debris collection.

The Seabin (Figures 5) is attached to individual docks or other structures with the lip of the bin placed along the water's surface. It is plumbed to a water pump on the dock. Water and debris are drawn into the Seabin where a mesh catch bag, made of recycled plastic, can collect up to 12 kg (roughly 26 lbs) of material. The system is powered by a submersible water pump that requires either 110V or 220V to run.

Figure 5. The Seabin Skimming System

In 2015-2016, a pilot study was conducted at La Grande-Motte Port in France. Following the pilot study, version 5 (the most recent prototype) of the Seabin was created and the product was marketed with the ability to purchase units in 17 countries starting in mid-2017. The Seabin is currently being used in the Balearic Islands and Mallorca, Spain (Klein 2016). As of October 2017, a Seabin unit was installed at the Portsmouth harbor in the United Kingdom (UK), the first Seabin in the UK (Brian 2017).

Advantages

The design of the Seabin appears relatively simple. Transportation of the unit, as well as its installation to and removal from a dock, is reportedly easy, due in part to its smaller size. The Seabin filters debris from the surface of the water column, filtering surface oils and detergents as part of the process. Changing the catch bag to remove collected debris is also reportedly a simple process.

The system has two energy options, one requiring either 110V or 220V power to collect debris and the second involving a solar powered unit. The solar powered unit is offered in only a few locations. Solar power would reduce the cost of use per day and permits installation in locations without electrical power supplies.

Disadvantages

The Seabin is a new technology that, similar to the Marina Trash Bin, has not been tested specifically for collection of aquatic weeds or floating aquatic weed fragments. At this time, there are no studies currently available on the efficiency of debris collection in marinas. Furthermore, the smaller size and smaller storage capacity requires daily (recommended by manufacturer twice daily) maintenance. Due to the necessity of an electrical connection (if solar unit is not available) and a stationary surface for mounting, the locations at which the Seabin can be placed may be limited. Additionally, if the system is mounted on a dock, the placement could potentially infringe upon homeowner usage. Finally, removal of each unit would likely be required prior to winter and freezing temperatures to prevent damage to the unit from ice formation.

1.2.3 ProSkimmer System

The ProSkimmer System (Figures 6 and 7), a filtration system produced by ProSkim, is composed of two parts: a floating in-water collection unit and an onshore filtration unit. The in-water unit is connected to the on-shore unit by a 25-ft long 2-inch diameter connector hose. Water is drawn towards and into the floating unit through the creation of a vortex by the stainless steel pump and moved through the hose to the onshore filtration unit. Debris is collected onshore while the cleaned, aerated water returns to the pond, lagoon, or lake via two return hoses.

Figure 6. The ProSkimmer System – Floating Collection Unit

Figure 7. The ProSkimmer System – Onshore Filtration Unit

Advantages

The ProSkimmer System also appears to have a straight forward and relatively easy set up that allows for the aeration of water while filtering out weed fragments and scum. This system can be used in dead end coves, near docks, and in narrow channels where there are adequate mounting and electrical hook-up options. The floating filtration unit is relatively small in comparison to other floating systems and draws from the top 18 inches of water. The system reportedly is most often utilized for short term (day-by-day) use, which could include a cove location following harvesting operations to collect fragments.

On-shore collection of fragments is conducted through the built-in ramp of the filter. Increasing the angle and placing the filter atop of either a tarp or trailer would allow for the collection of a vast amount of fragments with limited manual labor.

Disadvantages

The ProSkimmer System requires both access to electricity and enough shoreline to set up the on-shore filtration unit. Hose length, approximately 25 ft, would further limit placement of the system. The floating unit would need to be anchored or adequately marked when placed in an area with boat traffic to protect the unit from potential damage. Multiple ProSkimmer Systems would be required to fully collect fragments, especially if there happen to be a high number of docks, which could impair surface water flow of fragments to the units. Finally, continuous use of the system is not recommended due to its limited filtration capacity and therefore requires day-to-day set up rather than constant skimming in an area.

1.3 Passive Skimmers

Passive skimmers are free-floating or dock mounted structures that collect fragments without the outward expenditure of energy, where natural water movement or wave action lead to the collection of debris. Currently, there are few passive skimmers readily available for purchase. Furthermore, due to the lack of water flow in the Tahoe Keys lagoons, there are few designs that could work in dead end areas or narrow channels. However, the TKPOA could consider testing a passive skimmer, using two general designs. These designs include a passive debris collector (PDC) and an anchored boom with door flaps.

1.3.1 Passive Debris Collector

The passive debris collector (PDC) is a large floating bin with a central collection basket that is anchored to the bottom of a waterway, facing upstream. Trash and debris floating along the surface, moving with the flow of water, are collected when water moves through the collecting basket of the PDC and becomes trapped by mesh (made from either fabric or metal). A PDC is currently used in the UK, specifically along the Thames in England. The UK PDC is large, barge sized, and collects large amounts of trash and debris as water flows down the river.

Figure 8. Passive Debris Collector, UK

It is possible that TKPOA could consider a smaller version of the UK PDC that could be anchored in navigation channels or open water areas (possibly where there are prevailing winds) to collect fragments from the surface of the water.

Advantages

This skimmer design is fairly simple and may be easy to design and construct a prototype version. It does not require the expenditure of energy to collect the fragments floating along the surface of the water. As such, it is not limited to areas where electricity access is available.

Disadvantages

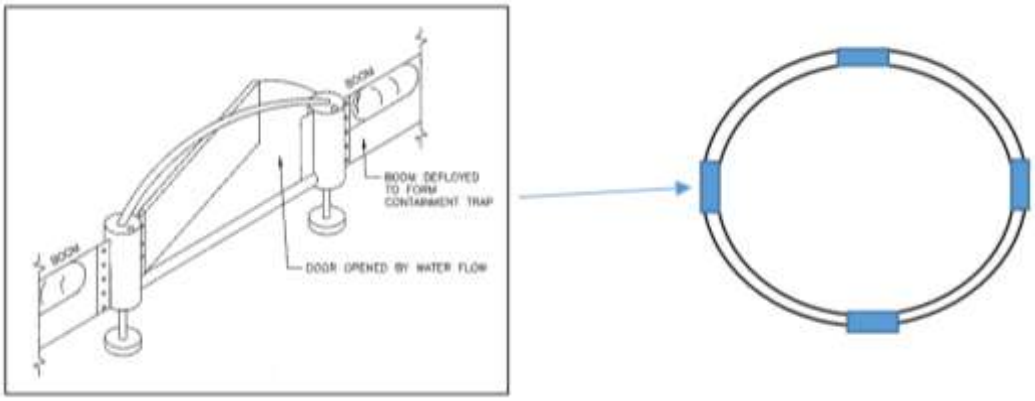
While the design is relatively simple, the limited water movement in the Tahoe Keys lagoons would inhibit its usefulness in most areas, especially dead-end coves and near docks. The size of the skimmer would have to be determined based on navigation of boats in the channels and ease of removal of collected fragments. To prevent loss of fragments once collected, a flap of some kind would need to be placed at the collection basket's opening.

1.3.2 Anchored Boom with Door Flaps

US patent 20110198302 describes the specifics for a hinged door that is opened by water flow. This door is attached to flexible boom material that creates an enclosure to trap debris. TKPOA could configure a circle of boom material with a few hinged doors, either configured as shown in the patent (Figure 9) or similar to a built-in pool skimmer flap, evenly spaced around the circle. The doors should be manufactured such that they open inwards, preventing the escape of collected fragments and debris.

An interchangeable mesh fabric could be attached to the base of the circle to collect fragments as they sink. To remove the fragments, this mesh should be able to be removed from the boom. TKPOA skimmer crews could remove surface fragments using a pool skimmer net.

Figure 9. Diagram of Anchored Boom with Door Flaps



The circular boom could be anchored to the bottom substrate of the water column in open water areas, where there is enough room to allow boats to navigate around the passive skimmer and where there is water movement (flow) from boat traffic or baroclinic or barotropic forces.

Advantages

This skimmer design does not require the expenditure of energy for the collection of debris. As such, it is not limited to areas where electricity access is available.

Disadvantages

Limited water movement in the Tahoe Keys lagoons would inhibit its usefulness in most areas, especially dead-end coves and near docks. The design of this skimmer system is more complex than that of the PDC. Configuration of the flaps on the boom material, and further addition of the bottom mesh collecting material, could present a problem. As fragments are known to float for a certain period of time and then sink, the mesh bottom is required, however, cleaning of mesh presents a problem. Furthermore, fragments could become tangled and caught on the outside of the mesh.

2.0 DISCUSSION

Both active and passive skimmers are capable of successfully collecting the fragments floating along the surface of the lagoons. The five skimmer designs included in the literature evaluation are subtly different with respect to debris collection, with various strengths and weaknesses. The assessment of machines with various strengths was intentional and was meant to identify a version of skimmer that could work better for the collection of fragments and reduction of macrophyte spread in and out of the Tahoe Keys lagoons. A comparison of the active and passive skimmer types is presented in Table 1 (below).

Table 1. Comparison of Active and Passive Skimmer Design Concepts

	Active Skimmers			Passive Skimmers	
Skimmer System	Marina Trash Skimmer (MTS)	Seabin	ProSkimmer	Passive Debris Collector	Anchored Boom with Door Flaps
Estimated cost per unit	$9,600	$3,825	$7,560	N/A	N/A
Operation Considerations	•Mounted on dock near power source •Cleaning of collection bin daily	•Mounted on dock near power source or mounted on buoy (solar powered) •Cleaning of bin multiple times daily depending on location and amount of fragments	•Set up on land near power source •Floating unit can only reach 25 feet from land unit •Anchor and demarcate floating unit to allow boat navigation •Use of tarp or trailer to haul collected material from site	•Water movement required to collect debris •PDC size will vary based on channel size and boat navigation needs	•Water movement required to collect debris •Potential to clean of collection mesh daily or every other day
Notes	•Dock mounted •Filtration of 300 gal/min •Requires 120 V / 230V	•Dock/pontoon mounted • 26 lbs capacity • Requires 110 V/ 220 V •Solar power option available	•Combination of free-floating and mounted •Unlimited Capacity	•Free-floating •Capacity to be determined	•Free-floating •Capacity to be determined
Supplier	Marina Accessories	Seabin Project	ProSkim®	N/A	N/A

2.1 Active Skimmers

All three of the active skimmers discussed have the ability to collect debris as well as oil and detergents within the water. Installation locations for all three are limited to areas with access to electricity, not including the solar powered option for the Seabin. Of the three skimmers, the Seabin and the ProSkimmer are perhaps the most feasible for the Tahoe Keys lagoons for the reasons discussed below.

The Seabin is relatively compact and has the option for more flexible placement throughout the lagoons, given the option for a solar-powered unit. If solar-powered versions were purchased and then attached to pontoons or buoys and distributed throughout the area in the Main Lagoon dedicated to the Boat Back-up Station, aquatic plant fragments dislodged from boat propellers would be collected thereby reducing the need for TKPOA skimmer boats to frequently skim the area. Little maintenance is required for the system and changing/emptying of the catch bag (recommended twice daily) is reportedly easy due to the simple design. At this time, the TKPOA is in the process of purchasing two Seabins to test in the Main lagoon during 2018.

The floating filtration unit of the ProSkimmer System is the smallest in comparison to the other designs and the connecting hose to the on-shore unit permits movement of the floating filter, making it possible to skim dead end coves, near docks, and in navigation channels. The system has a nearly unlimited capacity for finer materials such as plant fragments, as collected material is moved ashore through the connection hose and can be deposited on tarps or directly onto a trailer.

The system is reportedly most often utilized for short term (day-by-day) use. As such, this system could be used in a cove following harvesting operations to collect fragments that begin floating one to two hours following completion of harvesting in that area. Additionally, on-shore collection of fragments appears straightforward using the built-in ramp of the filter. Increasing the angle and placing the filter atop of either a tarp or trailer may allow for the collection of large amounts of fragments without much manual labor.

2.2 Passive Skimmers

Passive skimmers are ideally the preferred means of fragment collection, as no energy input is required and capacity size could be altered for different locations throughout the lagoons. However, with the limited water movement and amount of boat navigation found within the Tahoe Keys lagoons, the passive collection of fragments may be problematic. Of the two potential designs, the PDC appears the most feasible for the Tahoe Keys as the concept of the collection basket would likely be easier to implement and maintain.

3.0 CONCLUSION AND RECOMMENDATION

The goals of fragment collection are important when considering whether any of the five skimmer systems could improve collection of plant fragments in the Tahoe Keys lagoons. Firstly, minimizing the spread of invasive weeds out into Lake Tahoe is a prime interest. Collection of fragments in the channels and prevention of escape into the lake proper is a key target of fragment collection. The second goal of the program is the reduction of fragment spread in the lagoons. Reducing spread inside the Keys will help lead to a reduction of and also help control the aquatic weeds. Lastly, improving collection and control within the Tahoe Keys waterways will help restore aesthetic and recreation values. The five skimmer designs addressed in this literature evaluation are subtly different with respect to debris collection, with various strengths and weaknesses. For the skimmers presented, characteristics important for potential use in the Tahoe Keys lagoons include: requirement of energy input and ability to collect fragments with limited water movement, unit size, overall storage capacity, frequency of required maintenance, and ease of cleaning or removing debris.

Active skimmers appear capable of successfully collecting fragments floating along the surface of the lagoons. All three of the active skimmers discussed (including the MTS, Seabin, and ProSkimmer System) reportedly have the ability to collect debris as well as oil and detergents within the water. Installation locations for all three are limited to areas with access to electricity, not including the solar powered option for the Seabin, and require either docks or pontoons for placement of the skimmer components.

Passive skimmers are not readily available for purchase. Most passive skimmers are designed for pond or pool maintenance and are therefore too small for the Tahoe Keys lagoons. The two designs in this evaluation incorporate patents and current designs. Passive skimmers would be the preferred means of fragment collection, as no energy input is required. Capacities could be altered for different locations throughout the lagoons. Of the two potential designs, the PDC appears the most feasible for the Tahoe Keys as the concept of the collection basket would appear to be easier to implement and maintain. However, with the limited water movement found in the Tahoe Keys lagoons, their effectiveness would be limited for collecting fragments.

Both the Seabin and the ProSkimmer System would be expected to benefit the fragment collection activities of the TKPOA, particularly in dead end coves. However, if only one system can be purchased at this time, then it is recommended that the Seabin solar powered system would be the most beneficial for the Tahoe Keys lagoons. The overall need of the TKPOA for constant skimming of dock areas and the Boat Back-up Station would best be met by the Seabin, especially solar powered units. The solar powered Seabin skimmer may be most cost-effective for the Tahoe Keys lagoons due to its compact design and ability to be placed nearly anywhere throughout the lagoons.

4.0 LIST OF PREPARERS

The following individuals prepared the text presented in this report.

Name	Education	Role
Rick A. Lind	M.A. Geography (Water Resources) UC Davis B.A. Geography (Natural Resources) CSU Sacramento	Principal-in-Charge
Krystle Heaney	B.A. Geography (Physical) CSU Sacramento	Contributing Author
Kristen Hunter	B.S. Biology UC Davis	Primary Author
Rayann La France	B.S. Criminal Justice CSU Sacramento	Document Editing, Formatting

5.0 ABBREVIATIONS AND ACRONYMS

CTC	California Tahoe Conservancy
IMP	Integrated Management Plan
Lbs	Pounds
LRWQCB	Lahontan Regional Water Quality Control Board's
MTS	Marina Trash Skimmer
NPS Plan	Nonpoint Source Plan for Water Quality
PDC	Passive Debris Collector
TKB&HA	Tahoe Keys Beach and Harbor Association
TKPOA	Tahoe Keys Property Owners Association
UK	United Kingdom
WDRs	Waste Discharge Requirements
V	Volts

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