Impact of Invasive Species on Ecosystem Services at Lake Tahoe

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A Community on Ecosystem Services (ACES)
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- **Ted Thayer** - Tahoe Regional Planning Agency (TRPA)-New AIS position
- **Steve Chilton** - US Fish and Wildlife Service- New AIS position
- **Lake Tahoe Aquatic Invasive Species Coordinating Committee**
  - Working Groups: (Aquatic plants, Asian Clam, Quagga/Zebra mussel)
Ecosystem Services at Lake Tahoe

- Watershed inputs and functions
- Food-Web Related Functions
- Fisheries and related income
- Water clarity, quality and aesthetic values
- Shoreline quality & aesthetic values
- Recreational and commercial boating
  - Bi-Season: Winter (Snow-related); Summer
- Property values (Entire Tahoe Basin)
- Related income and revenues from tourism
  - (Resorts, Rent, Retail, Taxes, Gambling, Transportation)
Forces Acting on Ecosystem Services at Lake Tahoe:

- Unique, deep alpine lake system spanning CA & NV
- Millions of seasonal boaters from western states & US-wide
- Replacement of natural marshes with dense urban development
- Introduction of several aquatic invasive species (AIS)
- Regulatory Agencies: From denial to action on AIS impacts
- Research expanding from water “clarity” to AIS and ecosystem
- “Basin Plan” adjustments to provide tools for responses to AIS
- Climate change: Water temperature, mixing, runoff, AIS/native species, people
Watershed inputs: 63 streams
Outflow via Lower Truckee River
Outstanding Natural Resource Water (ONRW) under the Clean Water Act (1972)
Establishment of lake trout

brown, rainbow, brook, lake trout

kokanee

crayfish

Tahoe Keys Built

bass spp.

Eurasian watermilfoil

Curlyleaf pondweed

1st Zebra mussel Interdiction on boat- prevented from launching Yikes!!

Asian clam Removal begun

R E S P O N S E S

extirpation of cutthroat trout & Daphnia spp.

USDA-ARS:Whole Lake Plant Surveys

AIS Working Group

ARS-TRCD Org. AIS Workshop

LTAIS Coordinating Committee; USFWS-Coordinator

AIS Plan Approved 2009, TRPA appts AIS coordinator

After Sudeep Chandra (Univ.Nev-Reno); modified and updated by Lars Anderson (USDA-ARS-Davis, CA)
Primary AIS of Concern in Basin

Invertebrates
Quagga mussel (*Dreissena bugensis*)
Zebra mussel (*D. polymorpha*)
New Zealand mudsnail (*Potamopyrgus antipodarum*)

* M. spicatum widely distributed 4 miles downstream from Truckee River Dam
  J. Appel, Plant Mangement 37: 1564.

3 “Rock Crib”
Apx. 1.4 Acres

South of Truckee River Dam
New Rectangular Patch:
Apx. 0.09 Acre

Additional individual plants

Sunnyside Marina:
Apx. 0.3 Acre

Homewood Marina:
Apx. 0.05 Acre
Obexer’s Boat Co.:
Apx. 0.5 Acre

Meeks Bay Marina:
Apx. 1.4 Acres

“Logan Shoals” Marina:
Apx. 0.62 Acres

Ski Run Marina:
Apx. .5 Acres
Ski Run (offshore population):
Apx. 2.4 Acres

East Tahoe Keys Marina:
Apx. 25 Acres
West T. Keys Marina:
Apx. 75 Acres

Lakeside Marina:
Apx. 0.75 Acres
Lakeside Offshore Area:
Apx. 10.5 Acres

Myriophyllum spicatum

Potamogeton crispus
Planned Invasive Aquatic Weed Management: 2011
Lakewide Nearshore Weed Treatment - 2011

Legend
- Shore Sections
- Treatment Sites

Draft - November 2010
Aquatic Invasive Species in Tahoe Basin

Aquatic plants:
Eurasian watermilfoil (*Myriophyllum spicatum*)
Curlyleaf pondweed (*Potamogeton crispus*)

Photo: Dan Thrift, Tahoe Daily Tribune

Ski Run Marina
Eurasian watermilfoil flowering-Lake Tahoe (Tallac Lagoon)
Colony of Curlyleaf Pondweed-
South Shore, Lake Tahoe (Sept. 2006)
Curlyleaf pondweed (*Potamogeton crispus*)

Turion: vegetative propagule - produced in spring; disperses in summer/fall...sprouts in fall-winter.
Status of Curlyleaf Pondweed (*Potamogeton crispus*)

- Areas Currently Infested by Curlyleaf pondweed
  - Shoreline: small patches
  - Ski Run: 6-8 acres
  - Lakeside Marina: 1 acre

Emerald Bay: NOT YET INFESTED

Fallen Leaf Lake: NOT YET INFESTED
Each flag is a GPS-referenced sample

Number Codes for Each Area Sampled

Eurasian watermilfoil

Number Codes for Each Area Sampled

Curlyleaf pondweed

Number Codes for Each Area Sampled

Elodea canadensis (Native)
Fleur du lac Marina
Fleur du lac Survey - Nov. 2009
(To be dredged in 2010)
Myriophyllum spicatum

Elodea canadensis
2006: “New” Infestation of *M. spicatum* (Between Truckee River and Sunnyside Marina: on California side)
Suspicious “rectangular” colony could be result of contaminated equipment used for dock repair?
Suggests need for “clean equipment” requirements
AIS in Lake Tahoe

Invertebrates

Asian clam (*Corbicula fluminea*)

24 mg L$^{-1}$ Ca near beds (*Chandra* et al.)
Can clams facilitate the invasion of other alien species?

Photo taken from Lake Mead
Didymosphenia geminata (“Didymo”/”Rock Snot”)

(Light microscopy: Lars Anderson; SEM: Sarah Kiemle)
AIS in Lake Tahoe

Warm water fishes:

Largemouth bass (*Micropterus salmoides*)
Brown bullhead catfish (*Ameiurus nebulosus*)
Black crappie (*Pomoxis nigromaculatus*)
Bluegill (*Lepomis macrochirus*)
Goldfish (*Carassius auratus*)
Current Status

Warmwater fishes are spreading around the lake but are still in low numbers and can be managed.

Climate change
- WT $\uparrow$ 0.13°C per year since 1992

Habitat:
- Eurasian Watermilfoil
- Curlyleaf pondweed
- New? *Egeria densa*?

Nonnative food source
- Crayfish

Nearshore N+P $\uparrow$
Nearshore water quality $\downarrow$
Native fish species $\downarrow$
- 10 fold $\downarrow$ since 1960’s

Stakeholders

- Lake Tahoe AIS Coordination Committee
  - Ensure Plan activities are consistent with agency policy and expand or modify policies and management strategies for AIS control
  - CDFG, CSLC, CTC, LRWQCB, NDOW, NDSL, TRCD, TRPA, TSC, USDA-ARS, USFWS, USFS, LTBMU
  - Provide Plan oversight and colleague review

- Lake Tahoe AIS Working Group
  - Mission: to protect the Lake Tahoe Basin from aquatic invasive species by education, research, prevention, early detection, rapid response, and control
  - CDFG, CDPR, CSLC, CTC, NDOW, TKPOA, TRPA, TRCD, TSC, UC Davis, UN Reno, USACE, USDA, USFWS
Key Roles of Two Multi-State Regulatory Agencies:

**TRPA** (Tahoe Regional Planning Agency)
1. Physical shoreline, littoral zone actions
2. Construction or placement of objects
3. Building permits, landscape alterations
4. >Now: AIS role

**LRWQCB** (Lahontan Regional Water Quality Control Board)
1. Federal Clean Water Act
2. Water quality (turbidity, contaminants, runoff, discharges, etc.)
3. TMDL’s (Total Maximum Daily Load)
4. NPDES permitting/ compliance
5. Now> AIS role (e.g. diver assisted hand removal & Turbidity, Bottom Barrier impacts (e.g. on bacterial populations); dye study approvals

*Basin Plan changes (Potential for aquatic pesticide uses)*
AIS Funding via SNPLMA
(Southern Nevada Public Land Management Act)

- Round 8 $450K
- Round 9 $500K
- Round 10 $985K
- Round 11 (requested): $3,221,000. (USFWS as sponsor)

Additional Funds via Boat Inspection fees/Sticker 2010) ((mainly to cover inspection/training costs)
Direct Costs Attributable to Aquatic Invasive Species at Lake Tahoe
(Costs to date)

- Historic (15 years) and Continuing Surveys and Management:
  - **Aquatic Plants**: $2.85 Million (includes “harvesting in Tahoe Keys= 75% of total over 15 year period)
  - **Asian Clams** (3 years): $700,000.

- **Launch Inspections**: (3 yr. total): $2.5 million
  (2009: 13,000 inspections; 2010: 8,000 inspections)

- **2010**: Total of 24,000 launches. 600 hot water decontaminations. 30% of inspections were done at the on-highway stations.
Prevention: Tahoe Boat Inspections

2009: 13,000 Boats Inspected
2010: 8,000 Boats Inspected
Dreissenid Mussels in the U.S.

Lake Tahoe Boat Traffic

Marion Wittmann (2007)
Current Control Methods

- Harvesting
- Hand-pulling
- Benthic barriers
- Diver-operated suction removal
- Electro-shocking (limited)

Future: Integrated Management

- Harvesting
- Hand-pulling
- Benthic barriers
- Diver-operated suction removal
- Electro-shocking (limited)
- **Systemic, selective herbicides**
Harvester Operating at Lake Tahoe
Use of Benthic Barriers in Emerald Bay
USDA-ARS Herbicide “Surrogate” Study-2011
(Rhodamine WT Dye)

- Lahontan RWQCB approved (May, 2010)
- 7 Sites have been identified
- Summer & fall treatments
- 2 public meetings held in preparation for dye application

Results will help establish protocols for future IPM approaches and to locate herbicide monitoring sites
HAS CLIMATE CHANGE BEEN OBSERVED AT LAKE TAHOE? YES.
HAS IT AFFECTED THE LAKE? YES.

Mean lake temperature increasing 0.15 °C/decade from 1970 - 2002

Coats (et al. 2006)
BY 2040, assuming progress in curtailing C-emissions worldwide

- Climate Change may have warmed Lake Tahoe by a further 0.5 – 1 °C
- Surface temperatures will have warmed by 2 – 4 °C
- Climate Change may be causing Lake Tahoe to stratify for decades at a time, leading to the lower half of the lake to become devoid of oxygen
Climate Change Impacts?
Increased Costs to Protect Ecosystem Services

- Earlier sprouting of plant propagules
- Maximum biomass achieved earlier
- More rapid P-cycling from plant to water column
- More rapid growth of clams, other inverts.
- New AIS establishment (e.g. *E. densa*)
- Spread of plants to deeper zones
- More rapid senescence in fall > depletion of DO
- Increased DIC >> increased photosynthesis
- Increased algal blooms
- Loss of lake clarity
- Altered runoff/ nutrient loading