Preliminary Assessment of Breeding-Site Occurrence, Microhabitat, and Sampling of Western Toads in Glacier Bay

Sanjay Pyare[1,4], Robert E. Christensen III[2], and Michael J. Adams[3]

Abstract. To investigate the potential for future monitoring of western toads (*Bufo boreas*) in Glacier Bay, we: (1) conducted a preliminary assessment of breeding-site occurrence; (2) evaluated microhabitat associations of toad occurrence; and (3) investigated sampling designs appropriate for situations in which breeding-site occupancy is low. We observed low breeding-site encounter rates (0.04; n=94). Microhabitat comparisons between occupied and putatively unoccupied sites did not reveal clear differences, but sample size available for this analysis was relatively low. Initial GIS-based simulations suggest that sampling designs composed of grid cells that are 0.0625 km^2 (250×250 m) to 0.25 km^2 (500×500 m), and cover at least 60 percent of an area of interest, may be effective approaches for estimating occupancy at scales larger than individual wetlands. To monitor toads in low-occupancy landscapes, we recommend the use of a monitoring design that (1) establishes trends in higher-occupancy breeding-site types, while documenting simple occurrence in lower-occupancy sites; and (2) sampling at appropriately large spatial scales, (e.g. sub-watersheds, watersheds, rather than individual wetlands).

Introduction

Anecdotal records of western toads (*Bufo boreas*) in Southeast Alaska suggest that they may have undergone declines in some locales during the last 10–20 years (Carstensen and others, 2003). Quantitative, baseline estimates of existing population levels and distribution, however, are not available to meet future monitoring needs for the species. A promising method for meeting inventory and monitoring needs over large and complex landscapes like Glacier Bay National Park (GLBA) is through estimation of site occupancy rates (Mackenzie and others, 2002). Recent developments in occupancy-based estimation have resulted in statistically robust methods to assess changes in amphibian distribution and identify areas where conservation action is imperative. When breeding-site occupancy is low (<0.10), however, ascertaining trends is difficult. Two possible means to overcome this challenge are to emphasize sampling in higher-occupancy breeding habitats and (or) to sample units of landscapes that are larger than individual breeding sites (e.g. watersheds, grid cells). To explore the potential for western toad monitoring in Glacier Bay landscapes, we conducted a preliminary study focused on the following questions:

1. What are breeding-site encounter rates for toads in lower GLBA?
2. What microhabitat characteristics are associated with breeding sites?
3. What spatial scales are appropriate for future toad monitoring in GLBA?

[1] University of Alaska Southeast, 11120 Glacier Hwy, Juneau, AK 99801

[2] SEAWEAD, 3845 N. Douglas Hwy, Juneau, AK 99801

[3] U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331

[4] Corresponding author: sanjay.pyare@uas.alaska.edu, 907-796-6007

Methods

We used 30 m pixel satellite, 2 m pixel B/W digital orthophoto imagery, and 0.6 m pixel, color infra-red “Coastwalker” imagery to identify four general areas with an abundance of wetlands in lower GLBA: Taylor Bay, Ripple Cove, Berg Bay, and Bartlett Cove. These areas overlapped with high-density wetland clusters (e.g. hotspots) in the region (Christensen and others, 2004). We generated walking-survey routes in these four areas to maximize the number and diversity of potential breeding sites we could access in a single visit. We also opportunistically visited a small number of wetlands in two nearby outlying areas: Gustavus and Chichagof Island. We conducted surveys at wetlands by visually searching shorelines and shallower margins for evidence of breeding (egg masses, larvae). We measured 10 microhabitat variables at all sites with eggs and larvae and a select number of sites with no signs of breeding. To investigate the utility of alternate sampling designs when occupancy at the scale of individual wetlands was hypothetically low, we also conducted spatially-explicit simulations using larger scale sampling units (i.e. grid cells) of varying sizes. We used ArcGIS 8.x and Arcview 3.x with the Animal Movement Extension to simulate a random distribution of ponds using a wetland occupancy rate of 0.1, overlaid a grid cell-based sampling design that varied with respect to grid cell size and proportion of grid cells surveyed, and derived grid-cell based occurrence rates for each design. We ran five iterations for four grid cell sizes ranging from 0.1 to 1 km on a side; and 10 iterations of each sample-size ranging from 10 to 90 percent of grid cells surveyed, in 10 percent increments. Although detection probability for toad breeding sites is approximately 0.85 (S. Pyare, University of Alaska Southeast, personal commun.), we did not incorporate this term into these preliminary simulations.

Results

The breeding-site encounter rate was less than 5 percent (4 of 94 ponds surveyed); an uncorrected estimate that assumes detection error is negligible. We found general evidence of toad occurrence at 9 percent (8) of these wetlands. We measured and compared 10 microhabitat variables at 23 wetlands (table 1). Breeding sites ranged in size from uplifted tidal ponds less than 1 m^2 to large wetland complexes greater than 9 km^2 (http://www.seawead.org/tidings.html). Few significant microhabitat differences were determined between wetlands at which toads were and were not detected. Floating vegetation was significantly less at sites with eggs and (or) larvae present. Solar exposure (i.e., mean distance to forest cover in three directions) was nearly significant ($p < 0.07$) at sites with breeding activity. In addition, 3 of 4 breeding sites and 7 of 8 sites with general evidence of toad activity were associated with disturbance phenomena such as uplift, glacial recession, and anthropogenic modification.

GIS-based simulations of ponds in the lower GLBA landscape suggested that when occupancy at the scale of individual breeding sites is low (<0.10), grid cells that were at least 250×250 m (0.0625 km^2) consistent yielded encounter rates less than 0.15 (fig. 1). Increasing cell size resulted in higher encounter rates, but variability of estimates increased, particularly when cells approached 1×1 km in size. Using 250×250 m grid cells, simulations also suggested that encounter rates tended to stabilize when at least 60 percent of cells in a study area had been surveyed (fig. 2).

Discussion and Conclusions

These preliminary surveys suggest that western-toad breeding sites are sparsely distributed at large scales of analysis in GLBA: even if we adjusted our "observed" encounter rates with modest detection-error estimates documented elsewhere (Mackenzie and others, 2002; Bailey and others, 2004), "true" occupancy rates in the region

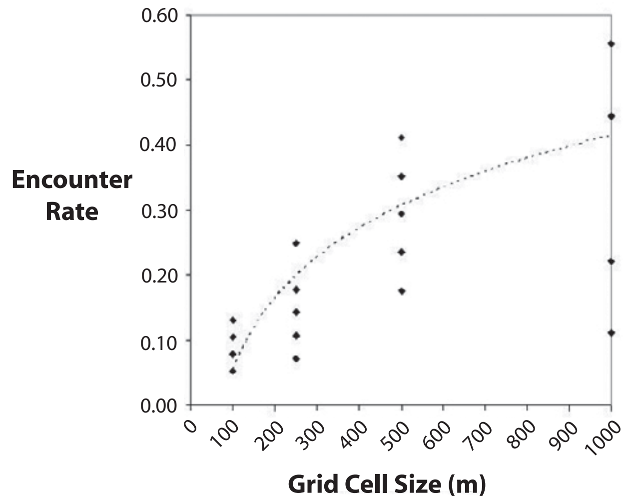

Figure 1. Effects of variation in the size of sampling units (0.01 – 1 km) on encounter rates of western toads in the lower Glacier Bay region. Five iterations were run for each grid cell size. We assumed negligible detection error and maintained "true" occupancy rates at 0.1 for all simulations.

Table 1. Summary of 10 habitat variables that were evaluated at 23 potential breeding sites in the lower Glacier Bay area, June 2004.

[Results from the one successional variable we evaluated are provided in text]

Habitat Variable	Occupied (n=4) Mean (SD)	Unoccupied (n=19) Mean (SD)	Occupied, all stages (n=8) Mean (SD)
Area (m^2)	5,182.50 (3,901.18)	9,942.37 (18,535.8)	12,216.88 (12,216.88)
Depth (dm)	4.63 (3.95)	4.03 (2.73)	4.95 (4.95)
Organic depth (dm)	2.00 (2.16)	2.82 (2.75)	2.25 (2.25)
Solar exposure (m)[1]	197.50 (118.42)	37.58 (39.10)	105.88 (105.88)
Percent emerging vegetation	55.00 (36.97)	59.48 (38.51)	59.71 (59.71)
Percent floating vegetation[2]	0.33 (0.58)	36.89 (39.30)	35.00 (35.00)
Percent submerged vegetation	56.65 (51.32)	38.33 (49.16)	40.00 (40.00)
Water temperature (°C)	22.75 (2.21)	20.79 (3.53)	23.14 (23.14)
pH	7.17 (1.00)	6.52 (1.12)	7.30 (7.30)
Percent DO	9.25 (1.50)	9.10 (2.14)	9.71 (9.71)

[1]Denotes means are nearly significantly different ($p<0.07$).

[2]Denotes means are significantly different between occupied and unoccupied breeding sites ($p<0.05$, 2-tailed *t*-test).

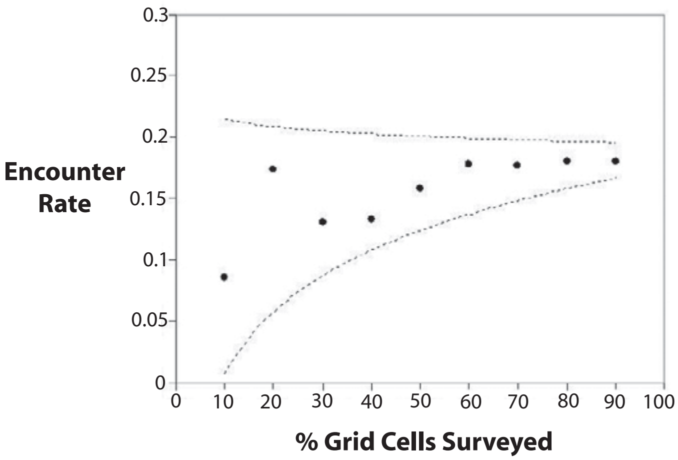

Figure 2. Simulated effects of varying the percentage of 0.0625 km^2 (250×250 m) grid cells surveyed (e.g. sample size) on encounter rates for western toads in the lower Glacier Bay region. Ten iterations were run for each 10 percent increase in area covered. We assumed negligible detection error and maintained "true" occupancy rates at 0.1 for all simulations. Dashed lines represent upper and lower 95-percent confidence intervals.

probably do not exceed 10 percent. Given the lack of a quantitative, historical baseline, it is not clear if this putative low-occupancy situation has resulted from the type of large-scale declines that have occurred elsewhere during the last 20+ years. Even if such declines have occurred in GLBA, an interesting subject for future research is the ultimate effect of newly emerging, post-glacial landscapes in upper GLBA, and the potential for colonization of these novel habitats by toads (Anderson, 2004).

We made few assumptions about "optimal" areas in which to survey for breeding sites in lower GLBA. This is because little information is available about toad distribution in the region and the variability in breeding-site characteristics observed throughout the species' range (M. Adams, oral commun.). However, breeding sites probably are patchy in distribution in GLBA and, to increase efficiency of future inventory and monitoring efforts, some refinement and (or) narrowing of monitoring areas may be necessary. For instance, solar exposure, a potentially important microhabitat variable in our assessment, is interpretable with most existing imagery and could be used to identify zones with putatively higher occupancy rates. Sampling procedures that are biased towards higher occupancy habitats probably would not result in a loss of area or toad populations to monitor, given the size and extent of GLBA. We do not, however, recommend completely eliminating more marginal sites from consideration. Although marginal breeding sites may result in occupancy rates too low for effective monitoring, these types of sites potentially can be more abundant on landscapes than high-occupancy habitats and, because these sites are inherently marginal, may represent sites where toad population may be particularly sensitive.

Although individual wetlands represent an ecologically relevant scales for toads, this fine scale of analysis may not be optimal in GLBA for detecting the type of broad declines that have been documented elsewhere. Our GIS simulations were simple and will require additional refinement through, for instance, incorporation of detection error and non-random toad distributions. These simulations, however, suggest that when occupancy is inherently low at the scale of individual wetlands, encounter rates measured at larger scales may have greater utility for monitoring. We do caution that when using sampling units that are too large (e.g. 1×1 km grid cells), statistical power to detect changes in occupancy may be limited and may result in inconsistent estimates of occupancy. Our simulations also demonstrate the utility of grid cells, which represent a standard type of landscape unit that can be used to sample across diverse types of potential breeding sites, (e.g. palustrine, riverine, etc.).

Management Implications

Although there is a significant ongoing debate about the cause(s) of global amphibian declines, there is now a virtual consensus among scientists that the status of amphibians is closely tied to ecological integrity of systems. In lower GLBA, anecdotal reports from local residents suggest western toads are not observed as frequently as they were historically. Furthermore, this preliminary survey effort yielded findings that are consistent with the notion that overall in GLBA, toads are and (or) have become patchy in distribution and uncommon. Given their current possible status, as well as their association with ecological processes in terrestrial and freshwater aquatic systems, we recommend that western toads receive considerations in forthcoming inventory and monitoring efforts in GLBA. To accomplish this, our findings suggest that an occupancy-based inventory and monitoring design for toad populations in GLBA likely would be effective if (1) trends were established in higher-occupancy breeding-site types, while at least documenting simple occurrence in lower-occupancy sites; and (2) sampling occurred at appropriately large spatial scales, (e.g. sub-watersheds, watersheds, rather than individual wetlands). This type of monitoring design currently is being employed in an ongoing assessment of western toad in other parts of Southeast Alaska, and similar efforts in GLBA would contribute to an understanding of the causes for western-toad distribution changes in the region.

Acknowledgments

We received funding and support from the National Park Foundation, Glacier Bay National Park, SEAWEAD, the Denver Zoological Foundation, Discovery Southeast, and the U.S. Geological Survey. We would like to specifically thank R. Carstensen, B. Anderson, C. Van Dyke, S. Boudreau, and B. Eichenlaub for their assistance and helpful comments.

References Cited

Anderson, B., 2004, An opportunistic amphibian inventory in Alaska's national parks, 2001–2003, Final Report: National Park Service, Alaska Region, Anchorage, Alaska,

Bailey, L., Simons, T.R., and Pollock, K.H., 2004, Estimating site occupancy and species detection probability parameters for terrestrial salamanders: Ecological Applications, v. 14, no. 3, p. 692-702.

Carstensen, R., Willson, M., and Armstrong, B., 2003, Habitat use of amphibians in northern Southeast Alaska: Report to Alaska Department of Fish and Game, Discovery Southeast, Available at: http://www.discoverysoutheast.org/pdf/reports/amphib-report-low-res.pdf

Christensen, B., S. Pyare, R. Carstensen, and M.J. Adams. 2004. A multi-scale approach to monitoring-site selection for western toads in Glacier Bay. Poster presented at the Glacier Bay Science Symposium, Oct. 26-29 2004. Juneau Alaska, 77 p., at: http://www.seawead.org/amphibs/seawead_amphib_poster.pdf

Mackenzie, D., Nichols, J.D., Lachman, G.B., Droege, S., Royle, J.A., and Langtimm, C.A., 2002, Estimating site occupancy when detection probabilities are less than one: Ecology, v. 83, no. 8, p. 2248-2255.

Suggested Citation

Pyare, S., Christensen, R.E., III, and Adams, M.J., 2007, Preliminary assessment of breeding site occurrence, microhabitat, and sampling of western toads in Glacier Bay, *in* Piatt, J.F., and Gende, S.M., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S. Geological Survey Scientific Investigations Report 2007-5047, p. 16-19.

A pond in a muskeg meadow, dappled with orchids and lilies. (Photograph by Bill Eichenlaub, National Park Service.)