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# The North American Reporting Center for Amphibian Malformations

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The North American Reporting Center for Amphibian Malformations was established to provide a conduit of information about, and a systematic data base on, malformed amphibians. This article describes the Reporting Center and the variety of features available at its Web site, presents an example of a summary analysis that can be conducted with its data, discusses caveats about the data, and makes recommendations about systematic surveys to better understand patterns and trends in the incidence of malformed amphibians.

INDEX DESCRIPTORS: amphibians, data base, deformities, malformations, World-Wide Web.

The issue of malformed amphibians has recently captured both scientific and public attention. Understanding the extent of the phenomenon had been hampered by the lack of a centralized data base on the occurrence of malformations in amphibians. The North American Reporting Center for Amphibian Malformations was established to consolidate observations in a data base so that scientists can search for patterns and trends in the type and incidence of malformations. The Reporting Center was activated in June 1997, following several months of discussions among federal and state agency staff, herpetologists, and other scientists. The Reporting Center uses the World-Wide Web (URL: <http://www.npwr.usgs.gov/narcam>) to facilitate the flow of information in two directions. First, scientists and the public can learn about the phenomenon, as well as where malformations have been found, the rates at which they were recorded, the species involved, and the types of malformations noted. Second, suspected or confirmed malformation observations can be reported to the Center. The Center can alert a responsible state or provincial agency or a nearby herpetologist for confirmation and further investigation, if appropriate. The purpose of this article is to describe the Reporting Center and to present some preliminary results from data stored there.

## THE REPORTING CENTER IN BRIEF

The Reporting Center includes a variety of information resources, as well as mechanisms to submit reports of malformed amphibians.

### Geographic Representation

The core feature of the Reporting Center is a map of the United States and Canada. Each county or census district for which we have one or more reports is highlighted. Different colors distinguish counties with confirmed records of malformed amphibians from those where amphibian monitoring was conducted, but no malformed animals were detected.

Selecting a state or province brings up a larger-scale map, on which individual counties are outlined. Counties are colored according to the categories described in the previous paragraph, but, in addition, counties with recent (since 1986) reports are distinguished from those with only historic (before 1986) reports.

By selecting a particular county or census district, the user re-

trieves a table summarizing the reports for that area. A separate summary is given for each visit to a field site and each species encountered; data include the month and year of the visit, common and scientific names of the species, the number of specimens examined that appeared normal, the number with malformations evident, and the types of malformations observed.

Only confirmed reports are included in the Web site. The coordinator of the Reporting Center determines on a case-by-case basis whether or not a report should be considered confirmed *prima facie*. Two reporting forms are available on the Web site for individuals with different levels of expertise. The technical form is used by biologists; those reports are treated as confirmed. Individuals without specific training in biology use the nontechnical reporting form. For nontechnical reports we ask the reporter if any photos of the animal were taken. If so, we request a copy, either through the mail when their film is developed, or scanned and sent digitally over the Internet. In other cases, the reports are forwarded to a biologist who has volunteered to serve as a verifier for a particular area. If the biologist gets the opportunity to verify the report, he or she replies to the Reporting Center, either confirming the report or not. Individuals reporting malformed animals who appear to be knowledgeable about the issue, such as indicated by using specific anatomical terms to describe the malformations, are telephoned to gain further insight. Many of these reports are considered confirmed after speaking with the individuals who may not be trained biologists, but clearly are interested and knowledgeable in biology. Unconfirmed reports are stored in a data base, but not presented on the Web site.

### Descriptive Information

Basic information about the issue of malformed amphibians is presented in non-technical terms, providing a layperson with a quick introduction to the topic. Alternative hypotheses about the causes of malformations are offered, as objectively as possible.

### Illustrations of Typical Malformations

A variety of malformations are illustrated with photographs provided by cooperators. These are intended to *exemplify the kinds of* malformations typically encountered, so that observers will know

Table 1. Number of sites included in analysis, and number with types of malformations reported.

State/Province	Number of sites			Number of sites with malformation type					
	Refuges	Other	Total	Missing	Extra	Eye	Jaw	Any	None
British Columbia	0	5	5	0	0	0	0	0	5
California	0	9	9	5	6	3	0	6	3
Connecticut	0	1	1	1	0	0	0	1	0
Delaware	2	1	3	1	0	0	0	1	2
Florida	0	1	1	0	1	0	0	1	0
Illinois	8	3	11	2	0	2	0	4	7
Indiana	3	1	4	1	0	0	0	1	3
Iowa	5	0	5	2	1	1	0	2	3
Kansas	2	0	2	0	0	0	0	0	2
Louisiana	2	0	2	0	1	0	0	1	1
Maine	9	2	11	4	1	2	0	5	6
Maryland	1	21	22	2	0	0	1	3	19
Massachusetts	0	5	5	1	2	1	0	4	1
Michigan	6	4	10	4	1	2	0	7	3
Minnesota	30	139	169	104	17	40	19	119	50
Mississippi	0	2	2	0	0	1	0	1	1
Missouri	14	0	14	4	0	0	0	4	10
Montana	0	1	1	1	0	0	0	1	0
Nebraska	3	0	3	0	0	0	0	0	3
Nevada	1	0	1	0	0	0	0	0	1
New Hampshire	2	6	8	6	0	2	0	6	2
New Jersey	3	0	3	1	0	0	0	1	2
New York	8	9	17	11	1	1	2	11	6
North Dakota	6	5	11	7	1	0	1	7	4
Ohio	2	4	6	4	2	1	1	5	1
Oklahoma	0	3	3	1	0	0	0	1	2
Ontario	0	1	1	1	0	0	1	1	0
Oregon	0	7	7	4	5	0	0	6	1
Quebec	0	19	19	9	0	0	0	9	10
South Carolina	1	0	1	1	0	1	0	1	0
South Dakota	10	4	14	6	0	2	1	8	6
Tennessee	0	1	1	1	1	0	0	1	0
Texas	0	1	1	0	0	0	0	0	1
Vermont	2	37	39	38	1	4	0	38	1
Virginia	3	0	3	1	0	1	0	2	1
Washington	0	6	6	3	4	3	1	5	1
West Virginia	0	1	1	0	1	0	0	1	0
Wisconsin	13	17	30	10	2	2	0	12	18
Total	136	316	452	236	48	69	27	276	176

what to look for. Included types are misshapen, extra, missing, or split limbs; cutaneous fusion; missing eye; and abnormal jaw.

### Species Identification Guide

The Reporting Center recently added an identification guide to help observers determine the species of amphibian they find. Included for a number of species and subspecies are one or more photographs, descriptions of key features, and information on its geographical range. We attempt to illustrate the variation in colors shown by certain species and to show ventral as well as dorsal views, to facilitate identification of specimens in the hand. The initial emphasis is on species most commonly reported to the Center.

### Sources of Additional Information

Visitors to the Web site can access other information on amphibian malformations. Pertinent articles from a number of newspapers

and magazines are posted, as are news releases and articles from newsletters such as *Froglog*. A searchable bibliography on malformed amphibians and related topics is available. Many entries were provided by Canadian Wildlife Service collaborators; other entries are added regularly. Also included are hot links to other Web site that deal with related issues.

### Technical Information

The Reporting Center provides certain kinds of information of a more technical nature. These include draft standard field forms for recording malformations, protocols developed by the U.S. Fish and Wildlife Service (FWS) for surveying malformed amphibians on national wildlife refuges, and a code of practice for amphibian fieldwork developed by the Declining Amphibian Populations Task Force. Information about the Amphibian Malformations Listserv is given, including instructions for joining it and an archive of past messages.

Table 2. Numbers of amphibians reported and percentage with malformations by state or province.

State/Province	Refuges			Other			Total		
	Number malformed	Number examined	Percent malformed	Number malformed	Number examined	Percent malformed	Number malformed	Number examined	Percent malformed
British Columbia		0		0	1142	0.0	0	1142	0.0
California		0		2183	12,663	17.2	2183	12,663	17.2
Connecticut		0		5	43	11.6	5	43	11.6
Delaware	0	200	0	91	115	79.1	91	315	28.9
Florida		0		1	51	2.0	1	51	2.0
Illinois	3	793	0.4	6	703	0.8	9	1496	0.6
Indiana	2	66	3.0	0	3500	0	2	3566	0
Iowa	9	504	1.8		0		9	504	1.8
Kansas	0	125	0		0		0	125	0
Louisiana	6	92	6.5		0		6	92	6.5
Maine	10	383	2.6	3	106	2.8	13	489	2.6
Maryland	0	96	0	3	2037	0.1	3	2133	0.1
Massachusetts		0		14	374	3.7	14	374	3.7
Michigan	4	626	0.6	19	1005	1.9	23	1631	1.4
Minnesota	48	2980	1.6	909	12,022	7.6	957	15,002	6.4
Mississippi		0		1	8682	0	1	8682	0
Missouri	16	887	1.8		0		16	887	1.8
Montana		0		1	12	8.3	1	12	8.3
Nebraska	0	170	0		0		0	170	0
Nevada	0	123	0		0		0	123	0
New Hampshire	2	56	3.6	11	415	2.6	13	471	2.8
New Jersey	1	177	0.6		0		1	177	0.6
New York	17	272	6.2	32	697	4.6	49	969	5.0
North Dakota	6	493	1.2	34	568	6.0	40	1061	3.8
Ohio	4	209	1.9	8	284	2.8	12	493	2.4
Oklahoma		0		2	579	0.3	2	579	0.3
Ontario		0		2	364	0.5	2	364	0.5
Oregon		0		84	455	18.5	84	455	18.5
Quebec		0		108	1100	9.8	108	1100	9.8
South Carolina	2	178	1.1		0		2	178	1.1
South Dakota	27	556	4.9	5	121	4.1	32	677	4.7
Tennessee		0		5	55	9.1	5	55	9.1
Texas		0		0	2089	0	0	2089	0
Vermont	9	235	3.8	237	2815	8.4	246	3050	8.1
Virginia	4	180	2.2		0		4	180	2.2
Washington		0		51	471	10.8	51	471	10.8
West Virginia		0		1	51	2.0	1	51	2.0
Wisconsin	4	752	0.5	36	1352	2.7	40	2104	1.9

The listserver was conceived and developed by the U.S. Geological Survey (USGS) Patuxent Wildlife Research Center.

#### Instructions for Submitting Reports

The Reporting Center allows submission of reports directly over the Internet. Two sets of instructions for doing so are provided. One set is for nonbiologists, for whom technical details are minimized. Requested information includes the observer's name and contact information, location and date of sighting, species of amphibian, its approximate size, description of the malformation, the number of

non-malformed amphibians encountered, and habitat description. Instructions for biologists are similar, except that they are asked more specifically to distinguish developmental malformations from possible injuries.

#### Acknowledgments Section

Here we thank individuals who assisted in the development of the Reporting Center by offering guidance, bibliographies, photographs, or other contributions, as well as the designers of the Web site and the Web authors.

Table 3. Species included in North American Reporting Center for Amphibian Malformations files, and number of sites with reports for each.

Species	Number of Sites
Northern leopard frog ( <i>Rana pipiens</i> )	352
Green frog ( <i>Rana clamitans melanota</i> )	142
Bullfrog ( <i>Rana catesbeiana</i> )	72
Wood frog ( <i>Rana sylvatica</i> )	65
American toad ( <i>Bufo americanus</i> )	61
Southern leopard frog ( <i>Rana utricularia</i> )	53
Mink frog ( <i>Rana septentrionalis</i> )	40
Gray treefrog ( <i>Hyla versicolor/chrysosecelis</i> )	28
Fowler's toad ( <i>Bufo woodhousii fowleri</i> )	24
Pacific treefrog ( <i>Hyla regilla</i> )	22
Spring peeper ( <i>Pseudacris crucifer</i> )	20
Pickerel frog ( <i>Rana palustris</i> )	15
Tiger salamander ( <i>Ambystoma tigrinum</i> )	12
Western toad ( <i>Bufo boreas</i> )	10
Chorus frog ( <i>Pseudacris triseriata</i> )	9
Northern cricket frog ( <i>Acris crepitans crepitans</i> )	9
Spotted salamander ( <i>Ambystoma maculatum</i> )	7
Rough-skinned newt ( <i>Taricha granulosa</i> )	7
Cascades frog ( <i>Rana cascadae</i> )	6
Blue-spotted salamander ( <i>Ambystoma laterale</i> )	6
Cricket frog ( <i>Acris crepitans</i> )	6
Green treefrog ( <i>Hyla cinerea</i> )	4
Canadian toad ( <i>Bufo hemiophrys</i> )	5
Northwestern salamander ( <i>Ambystoma gracile</i> )	5
Red-legged frog ( <i>Rana aurora</i> )	5
Long-toed salamander ( <i>Ambystoma macrodactylum</i> )	4
Eastern narrowmouth toad ( <i>Gastrophryne carolinensis</i> )	3
Eastern spadefoot toad ( <i>Scaphiopus holbrookii</i> )	3
Southern cricket frog ( <i>Acris gryllus</i> )	3
Woodhouse's toad ( <i>Bufo woodhousii</i> )	3
Barking treefrog ( <i>Hyla gratiosa</i> )	2
Blanchard's cricket frog ( <i>Acris crepitans blanchardi</i> )	2
Dusky gopher frog ( <i>Rana capito</i> )	2
Mississippi slimy salamander ( <i>Plethodon mississippi</i> )	2
Mole salamander ( <i>Ambystoma talpoideum</i> )	2
Ornate chorus frog ( <i>Pseudacris ornata</i> )	2
Pine woods treefrog ( <i>Hyla femoralis</i> )	2
Plains leopard frog ( <i>Rana blairi</i> )	2
Smallmouth salamander ( <i>Ambystoma texanum</i> )	2
Southern chorus frog ( <i>Pseudacris nigrata nigrata</i> )	2
Southern toad ( <i>Bufo terrestris</i> )	2
Upland chorus frog ( <i>Pseudacris triseriata feriarum</i> )	2
Red-spotted newt ( <i>Notophthalmus viridescens viridescens</i> )	2
Western redback salamander ( <i>Plethodon vehiculum</i> )	2
Great Plains narrowmouth toad ( <i>Gastrophryne olivacea</i> )	1
Jefferson salamander ( <i>Ambystoma jeffersonianum</i> )	1
Boreal toad ( <i>Bufo boreas boreas</i> )	1

Table 3. Continued.

Species	Number of Sites
Bronze frog ( <i>Rana clamitans clamitans</i> )	1
Clouded salamander ( <i>Aneides ferreus</i> )	1
Cope's gray tree frog ( <i>Hyla chrysosecelis</i> )	1
Couch's spadefoot ( <i>Scaphiopus couchii</i> )	1
Carpenter frog ( <i>Rana virgatipes</i> )	1
Eastern American toad ( <i>Bufo americanus americanus</i> )	1
Eastern green toad ( <i>Bufo debilis debilis</i> )	1
Eastern newt ( <i>Notophthalmus viridescens</i> )	1
Gulf Coast toad ( <i>Bufo valliceps</i> )	1
Marbled salamander ( <i>Ambystoma opacum</i> )	1
Northern redback salamander ( <i>Plethodon cinereus</i> )	1
Pig frog ( <i>Rana grylio</i> )	1
Rich Mountain salamander ( <i>Plethodon ouachitae</i> )	1
Rio Grande leopard frog ( <i>Rana berlandieri</i> )	1
Redback salamander ( <i>Plethodon cinereus</i> )	1
Silvery salamander ( <i>Ambystoma platineum</i> )	1
Southern redback salamander ( <i>Plethodon serratus</i> )	1
Spotted frog ( <i>Rana pretiosa</i> )	1
Squirrel treefrog ( <i>Hyla squirella</i> )	1
Texas toad ( <i>Bufo speciosus</i> )	1
Western (California) toad ( <i>Bufo boreas halophilus</i> )	1
Western chorus frog ( <i>Pseudacris triseriata triseriata</i> )	1

### What's New?

When the Web site is updated, the "What's New?" feature lists the changes that have been made. These include additional resources, new articles, and the like. Also listed are states and counties with new reports of malformed amphibians, or with negative reports. The data base is updated to reflect the latest reports about every two weeks during summer, and somewhat less frequently at other times of the year.

To facilitate reporting, the Reporting Center also has established a toll-free number (800-238-9801), which can be used to report observations of malformed amphibians or results of systematic surveys.

### AN EXAMPLE APPLICATION

As of September 1998, the Reporting Center contained more than 1300 reports, most (82%) of which represent frogs, with fewer toads (13%) and salamanders (5%). Malformed animals had been reported from 41 states and three Canadian provinces.

Most of the reports submitted to the Center were from opportunistic findings; that is, someone found a malformed amphibian and submitted a report of it. Such reports do not permit an assessment of the true incidence of malformations, for they are obviously biased toward sites with malformed animals, and often normal-appearing amphibians are not noted or recorded. There are at least two exceptions. First, the Minnesota Pollution Control Agency has conducted systematic surveys of anurans at various locations in that state. Second, the U.S. Fish and Wildlife Service conducted surveys at numerous wildlife refuge lands in its Northeast and Great Lakes re-

gions. Refuge managers in those regions were asked to sample two randomly chosen sites on each refuge, attempt to capture 100 or more frogs and toads at each site, and determine how many of them had malformations and what the types were. Refuge staff used protocols developed by FWS and USGS collaborators.

For the analysis presented here, we used only reports that included a substantial number of normal-appearing, as well as any malformed, amphibians. That restriction was made to reduce the effect of the opportunistic reporting of only malformed animals. Only reports of at least ten animals, all species combined, were included. Reports before 1986 were excluded, to better reflect the current situation.

The data base at present (September 1998) contains records of 452 sites that meet the criteria described above (Table 1). Of these, 136 were from the national wildlife refuge survey and 316 were from other sources. Of the states and provinces, Minnesota has by far the most reports, 169 in total. Vermont, with 39 reports, and Wisconsin, with 30, follow (Table 1). Of the types of malformations, missing limbs or digits were reported at more sites (236) than other types, followed by eye abnormalities (69), extra limbs or digits (48), and jaw deformities (27). One hundred and seventy-six (39%) of the sites had no observed malformed animals (Table 1). This rate differed between refuge sites (61% reporting no malformed animals) and non-refuge sites (29%).

The percentage of animals examined that had malformations varied widely among states and provinces (Table 2). Delaware, with 28.9% of 315 animals sampled showing malformations was highest by far. All malformed animals were bullfrog (see Table 3 for scientific names) tadpoles with missing appendages, from a single pond that also contained fish, so the possibility exists that they might have been injured, rather than malformed. In addition, regardless of the cause, the data reflect but a single site. Oregon had the next highest rate, 18.5%; most of the malformed animals were Pacific treefrogs with extra limbs. California, with a very large sample of more than 12,000 amphibians, had a high rate (17.2%), including large samples of long-toed salamanders, western toads, and Pacific treefrogs.

A number of species were involved in the reports examined (Table 3), although not all were included in the analysis, due to the criterion of having at least ten animals at a site. Most frequent were the northern leopard frog (352 reports) and green frog (142 reports).

## DISCUSSION

The results described here must be interpreted with caution, for several reasons. First, very few of the data were generated from randomly selected sites. Even the refuge data represent areas that receive conservation protection and should be less subject than most sites to some of the causes of malformations that have been proposed. Conversely, many reports were from sites that were surveyed because they were known to have malformed amphibians.

Second, the "true" rate of malformation should be based on very young animals, recent metamorphs, for example. If, as seems very likely, malformed animals are likely to die sooner than their normal cohorts, the incidence of malformations among populations of older animals will be biased low.

Third, despite carefully prescribed protocols and instructions, it

is not always easy to identify malformations with certainty. Missing limbs or digits may represent injuries, rather than malformations. While every effort was made to exclude likely injuries, it cannot be assured that all such reports were distinguished.

Fourth, the incidence of malformations can vary dramatically in space and time. Research by the Minnesota Pollution Control Agency has demonstrated that a site may harbor only normal-appearing amphibians on one occasion, but have amphibians with an elevated rate of malformations the very next year (J. Helgen, Minnesota Pollution Control Agency, pers. comm.).

Ideally, to gain a clearer understanding of the patterns and trends in the incidence of malformed amphibians, systematic surveys should be conducted in a variety of areas and repeated in time. Standardized protocols must be followed. Surveys timed to capture recent metamorphs are best, so that the incidence of malformations can be determined before any affected animals die. In some circumstances, surveys of larval amphibians can be used, although certain species are difficult to distinguish, especially by a nonherpetologist. In addition to conducting surveys specifically to evaluate malformations, it would be useful for scientists involved in capturing substantial numbers of amphibians to take note of any malformations that occur, and to report those data. Even if no malformed animals are encountered, the information can be used to evaluate the true extent of the problem.

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