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THE NATTERJACK TOAD *Bufo calamita* IN IRELAND: current status and conservation requirements

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EXECUTIVE SUMMARY

- The status and conservation prospects of natterjack toads in Ireland are reviewed using information from published sources, knowledgeable naturalists and personal visits.

- Natterjack toad biology is summarised including habitat requirements, international status and the history of the species in Ireland.

- The current status of natterjacks in Ireland is described with reference to historical status, and with details of the ten surviving populations together with two recently introduced populations.

- Recommendations for natterjack toad conservation in Ireland are made including general measures (site protection, monitoring and survey), practical measures for all the native and introduced populations, and an overall strategy for achieving favourable conservation status.

- Future research requirements relevant to natterjack toad conservation in Ireland are addressed.

- Priorities for natterjack toad conservation in Ireland are identified.

Contents

Report outline

Objectives of contract

There were three main objectives:
(1) To provide a summary of the present status of the natterjack toad in Ireland.
(2) To propose practical measures to secure favourable conservation status of natterjacks in Ireland for the foreseeable future, including reference to existing sites and possible translocations.
(3) To highlight aspects of natterjack ecology requiring further research.

Methods employed

Three main approaches were used to address the contract objectives:
(1) A literature search was carried out on published information about natterjacks in Ireland.
(2) Information was obtained from people (especially rangers from the National Parks & Wildlife Service and herpetologists) having direct knowledge and experience of natterjacks in Ireland.
(3) Personal visits were made to all Irish natterjack sites in spring 2002 for up to date assessment, supplementing observations from several previous visits made since 1974.

Background information

Natterjack toad biology

The natterjack toad has the smallest biogeographical range of the three *Bufo* species found in Europe. Nevertheless it occurs from Iberia in the south-west as far as the Baltic coast in the east of the continent, and is the only toad found in Ireland (Gasc 1997). Juveniles and adults live in burrows of their own making, or under debris, from which they emerge at night in the summer months to feed on invertebrates. Hibernation is also usually in burrows. In spring, mostly during April and May, adults congregate in the shallow margins of ponds to breed. Males call loudly to attract females, each of which lays a single string of spawn containing 1000-7000 eggs depending on her size. Fertilisation is external, as is true of almost all anuran amphibians (frogs and toads). Eggs usually hatch within 10 days, depending on temperature, and the black larvae grow rapidly to a maximum size of around 25 mm. These tadpoles feed on algae and detritus, or on dead animals in the ponds. Metamorphosis into toadlets can occur within 4 weeks of egg laying in very hot weather, but 6-8 weeks is more usual. It normally takes at least three years to reach sexual maturity. Natterjacks commonly live to an age of 7-8 years, and occasionally reach their teens.

Important mortality factors for natterjacks include fungal infection of spawn, especially in cold weather, and invertebrate predation of tadpoles. Dragonfly nymphs are particularly efficient killers, but dytiscid water beetles (adults and larvae) and back-swimmer water boatmen also take a toll. Where large numbers of common frog tadpoles occur there may be predation of natterjack spawn and of hatchling larvae, and growth inhibition of natterjack tadpoles. Mortality of tadpoles from predation is especially high in cool springs, but in warm weather early desiccation of ponds can also be catastrophic. Juvenile and adult natterjacks have few known predators, especially in Ireland where snakes are absent. Glands in the skin produce a range of toxins rendering natterjacks unpalatable to many animals that readily take frogs. However, crows, gulls and rats may kill them occasionally. A more complete account of natterjack biology can be found in Beebee & Griffiths (2000).

Habitat requirements

Natterjacks are associated throughout their range with relatively open (unforested) habitats and shallow ponds. Sand and gravel pits, coastal sand dunes and marshes, and lowland heaths all constitute potential natterjack habitat in northern Europe. Sandy soils are particularly favoured because they often support low-growing vegetation and are easy to burrow in. Shallow ponds are often temporary, and thus have relatively few tadpole predators and competitors. A common factor is temperature; open sandy habitats and shallow ponds are warm habitats in spring and summer, and natterjacks are adapted to relatively high temperatures at all stages of their life cycle. Water quality in breeding ponds is important. There should be little or no organic pollution, a pH above 5 (preferably above 6), and a salinity less than 15% of seawater.

In Ireland, natterjacks occur in coastal dunes, lowland heath-bog systems and in wet fields near the sea. Some of both the aquatic and terrestrial habitats in the bogs and fields include denser vegetation than is normally encountered at natterjack sites in Britain. Another unusual habitat feature in Ireland is the use for breeding of large, permanent ponds (Loughs Gill, Nambrackdarrig and Yganavan). These loughs do however have shallow margins, and support fish populations that presumably control invertebrate predators of tadpoles. *Bufo* tadpoles are distasteful to most fish species and thus can thrive in fishponds.

International status

Natterjack toads were considered vulnerable under the Bern Convention of 1979, and were listed on the EU Habitats and Species Directive of 1992. Following evidence of severe declines during the early 20th century, natterjacks first received formal protection in England in 1975, enhanced under the Wildlife & Countryside Act of 1981, and again under the Conservation Regulations of 1994. By the early 1990s more than 80% of British natterjack sites also enjoyed habitat protection as nature reserves and/or Sites of Special Scientific Interest. Most other countries now offer similar levels of legal protection to natterjacks. Generally speaking *Bufo calamita* remains fairly common and widespread over much of its distribution in south-west and central Europe, but has declined substantially at its range margins in northern France, Ireland, Britain, Belgium, Sweden and Estonia.

History of natterjacks in Ireland

Natterjack toads were first noticed in Ireland in 1805, at Callanafersy in Castlemaine Harbour at the head of Dingle Bay, and subsequently reported by Mackay (1836). It quickly became clear that natterjacks were widely distributed around Castlemaine Harbour between Inch in the north and Rosbeigh in the south, though always close to the sea. A delightful account of their presence in this area is given by Ward (1864). Later records, often rather vague, indicated the presence of natterjacks at other sites around the Iveragh (Waterville) peninsula. These were Ballycarbery near Cahirsiveen, and Coomakista and Caherdaniel further south (Dover 1877; Macdougald 1942). Only as recently as the 1960s were the toads discovered on the north side of the Dingle peninsula between Fermoyle and Castlegregory (Gresson & O'Dubhda 1971). No populations have been discovered outside these areas of county Kerry, and in recent decades natterjacks have been confined to some sites around Castlemaine Harbour and to the Fermoyle-Castlegregory district (Korky 1999). There has evidently been a decline in the Castlemaine Harbour area and local extinctions elsewhere on the Iveragh peninsula over the past hundred years or so. Most recently

(during the 1990s) natterjacks have been successfully reintroduced to Caherdaniel and introduced to a dune site in south-east Ireland (The Raven, County Wexford). Natterjacks were protected by law in Ireland under the Wildlife Act of 1976, and several areas in which they occur were scheduled as Areas of Scientific Interest (ASIs). More recently this designation has been superceded and virtually all habitat used by the toads was in the process of registration as Special Areas of Conservation (SACs) in 2002.

The origins of natterjack toads in south-west Ireland have been widely debated. Unfortunately there is no fossil record. Either they colonised the area naturally or they were introduced, presumably accidentally, by man. Within historical times there was a thriving sea trade between Kerry and Iberia, where natterjacks are abundant, and toads could have been imported with sand ballast discharged from ships in Dingle Bay. However, natterjacks are one member of the so-called "Lusitanian" biota, a small number of plant and animal species found in this corner of Ireland and in the Iberian peninsula but usually (though not in the case of the natterjack) only occasionally at other localities in between. Genetic analysis clearly showed that Irish natterjacks are closely related to those in western England, but very distantly related to those in Iberia (Beebee & Rowe 2000). Recent import from Iberia in ballast is not compatible with the genetic data. On balance it seems most likely that natterjacks are true natives of Ireland and colonised the country naturally after the last glaciation, which finally ended about 11,000 years ago. Exactly how the Lusitanian biota accomplished this colonisation, perhaps from relatively local refugia when sea levels were lower, remains to be determined.

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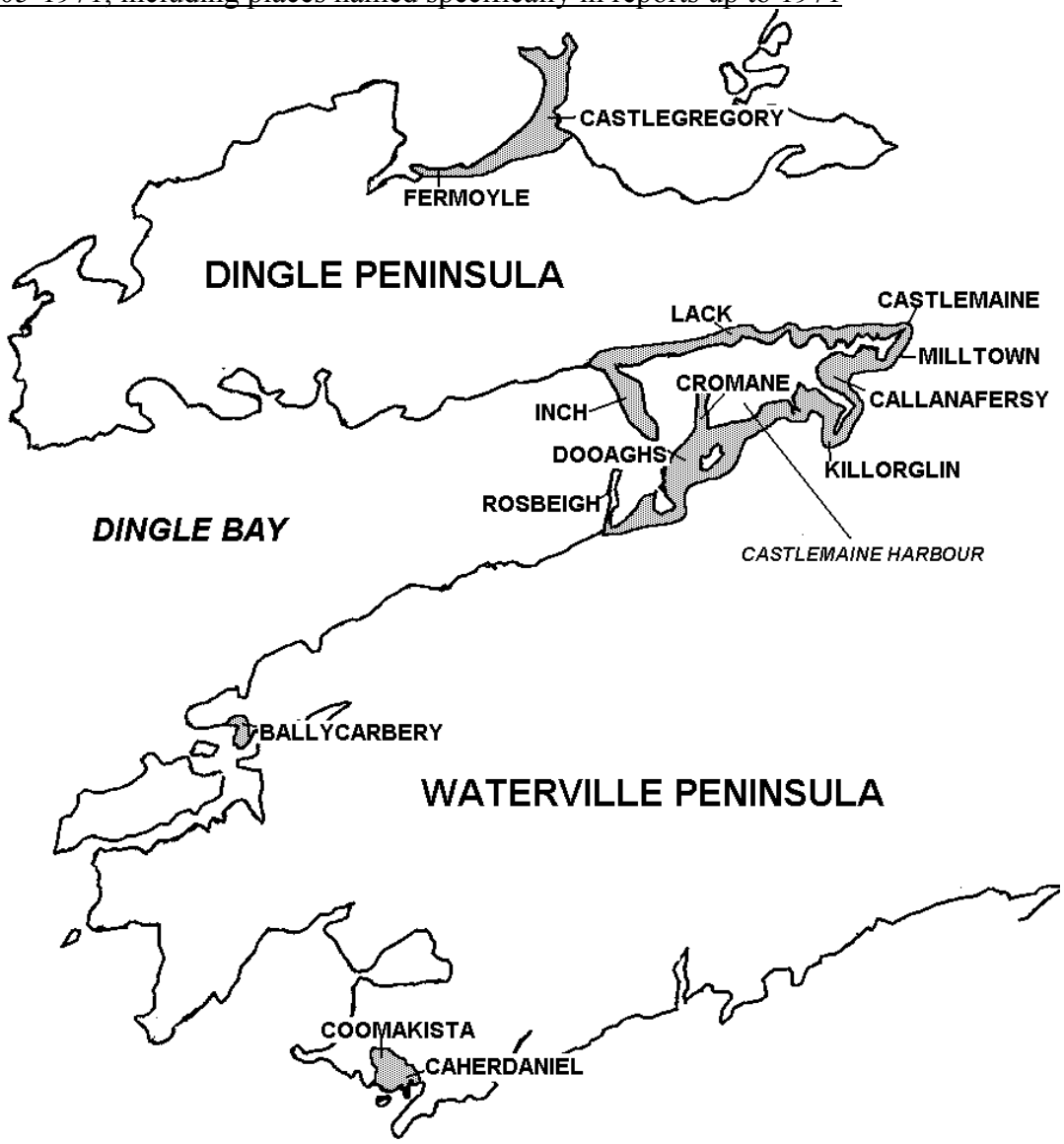
Present status of natterjacks in Ireland

Past and present distribution

Localities where natterjacks have been recorded in Ireland since their discovery in 1805 are shown in Figure 1.

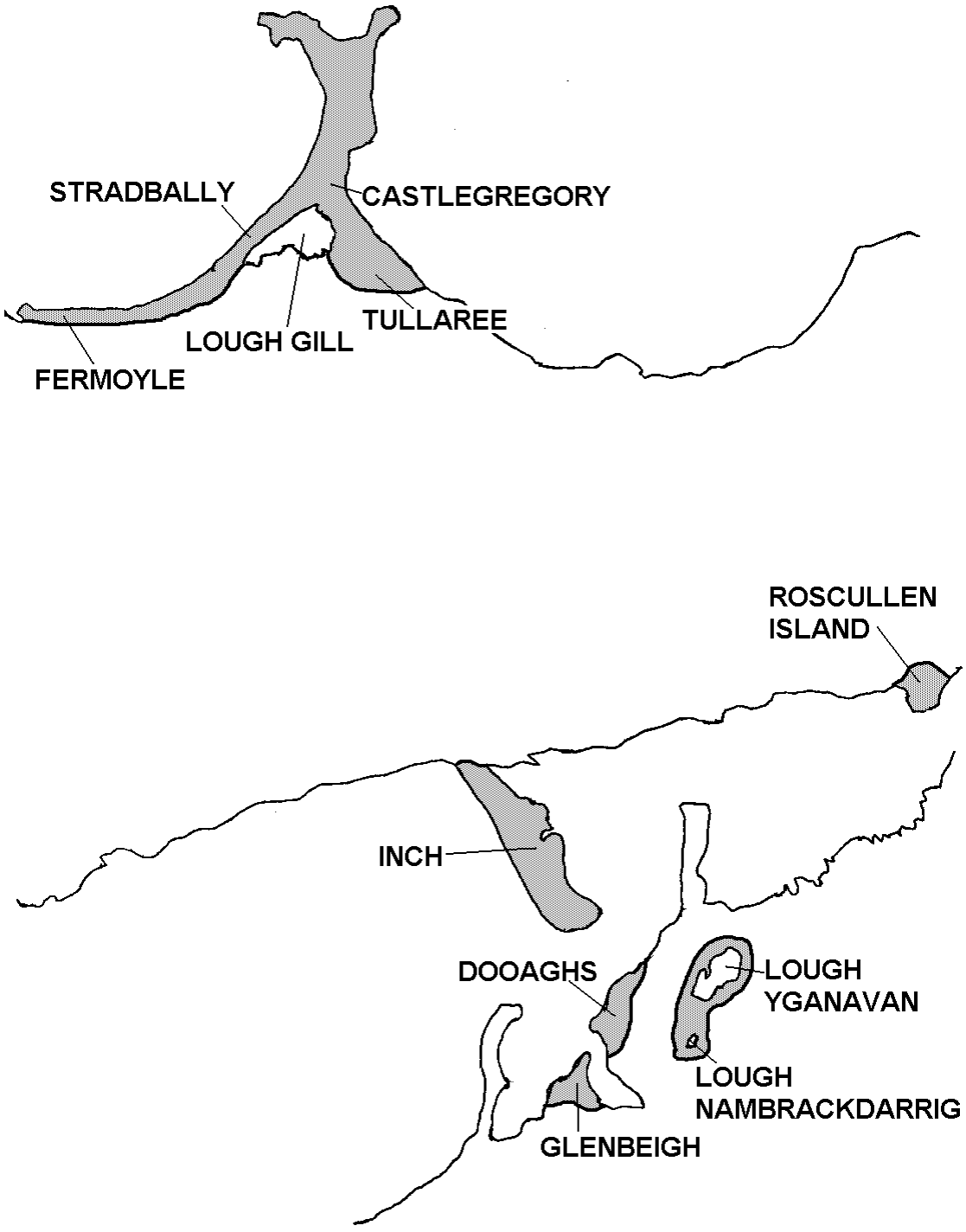
Figure 1. Areas (shaded) in County Kerry where natterjacks were recorded between 1805-1971, including places named specifically in reports up to 1971



I----------I = 10 km

Sites with natterjacks in 2002, including recent translocations, are shown in Figures 2 and 3.

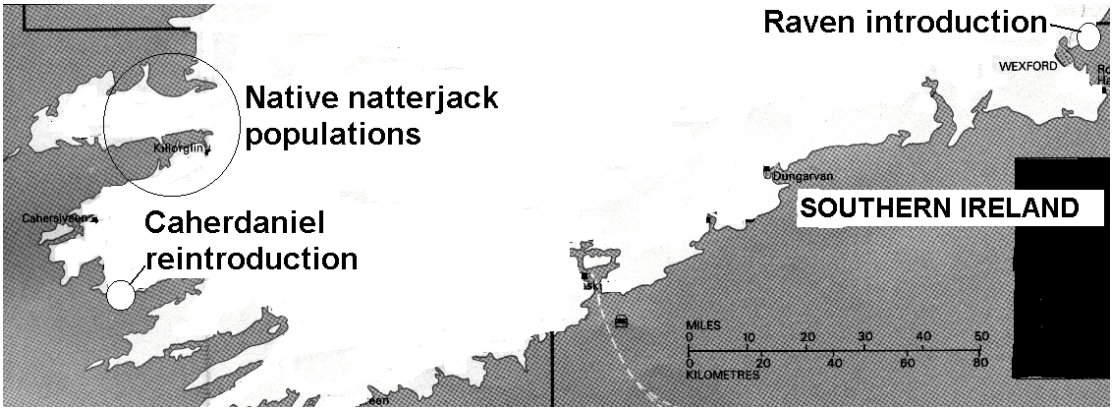
Figure 2. Approximate distribution of native natterjack toad sites in Kerry (shaded) 1971-2002.



No sites have been lost since the first recent survey of natterjacks in Ireland (Gresson & O'Dubhda 1974), and two (Lough Nambrackdarrig and Roscullen Island) have been discovered since that time. Nevertheless, there has clearly been a substantial range contraction around Castlemaine Harbour since the nineteenth century, and both the outlying populations (Ballycarberry and Coomakista/Caherdaniel) also went extinct sometime before 1974. At both Ballycarberry and Caherdaniel natterjacks were present within living memory, and according to local people disappeared after breeding ponds were drained during the past 50 years. Although no comparable information is available for Castlemaine Harbour, it may well be that the range contraction occurred there over a similar period and for the same reason. Certainly the mid twentieth century was the time of major natterjack declines and extinctions in Britain, largely as a result of agricultural improvements. It would seem that, since the nineteenth century, natterjacks have disappeared from around half of their historical range in Ireland.

By way of partial compensation, there have been two successful establishments of new natterjack populations since 1990. One was at Caherdaniel, and thus a reintroduction. The second was at the Raven Dunes, County Wexford, in south-east Ireland (Figure 3). This is an area distant by some 200 km from the Kerry sites with historical natterjack records.

Figure 3. Natterjack translocation sites in Ireland



Extant native populations

Natterjacks occur in Kerry at multiple sites which vary a lot in how discrete they are. Probably all those on the north Dingle coast (Fermoyle, Stradbally, Lough Gill/Castlegregory and Tullaree) are contiguous with respect to toad population structure (i.e. can be considered as a single metapopulation). The same may apply to Loughs Yganavan and Nambrackdarrig, and perhaps to Glenbeigh and Dooaghs (= Dooks). Inch and Roscullen Island are certainly the most isolated sites, aside from the recent translocations. For convenience the status of natterjacks is assessed below separately for each of the 10 sites listed above, though the likely continuity of some with their neighbours should be borne in mind throughout. Natterjacks occasionally wander 1 km or more from their breeding sites, and evidently can cross streams and rivers as well as mud and sand flats in estuaries at low tide. The latter movements are probably quite rare, but may be important in maintaining marginal populations as well as in colonising newly available habitats.

With one exception, a mark-recapture study at a pond near Castlegregory in 1982, there have been no formal scientific attempts to assess natterjack population

sizes in Ireland. However, there have been many and repeated visits to the sites and some attempts to assess population sizes by counting numbers of adults (mostly males) assembled at breeding sites, and numbers of spawn strings. Since each female usually lays a single string each year, this represents the simplest method for estimating female numbers. The most comprehensive reviews of Irish natterjack populations undertaken thus far were by Gibbons (1981), McCarthy & Gibbons (1982) and McCarthy *et al*. (1983). Toad or spawn counts can certainly be used as minimum estimates of population size, but of course the actual numbers of animals are likely to be greater than these estimates by some unknown amount. The numbers given below for each site are a sample of observations made over the past 30 years or so. They are all I have managed to find, but there are probably others in naturalists' notebooks (especially from the 1980s) that have not come to light. Most recently a series of site visits by Buckley (1996-2000) has provided additional information. In most cases the numbers represent counts made on a single visit, but occasionally (especially at Stradbally/ Castlegregory) they represent the peak numbers recorded at multiple ponds over a few days during the course of a season.

Site maps for all the areas discussed below are given in **Appendix 1**.

Fermoyle

Site description: c. 50 ha of coastal dunes and low-lying fields, sometimes grazed, together with a sea defence bank. Discovered as a natterjack site in the early 1970s. A small stream drains from east to west, the estuary area of which formerly flooded to provide a natterjack breeding area. Coastal erosion has increased tidal inundation which, together with deliberate drainage since 1981, has eliminated this habitat. An artificial pond was created recently at the eastern end of the site, immediately behind the sea defence bank, to provide a replacement breeding site.

Natterjack records:

Year	**Adults seen**	**Spawn strings or tadpoles**
1970	8	
1972/3		Few tadpoles in stream edge
1975	24	
1979	29	
1981	"Some" males seen	Small numbers of toadlets seen.
1982	Chorus heard	
1983	30	Spawn & tadpoles seen
1990	3	
1993	5	1 spawn string + tadpoles
1996	9	12 spawn strings
1997	3	14 spawn strings

Status summary: A westerly outlier of the main Magherabeg natterjack population, and connected to it by habitat suitable for natterjacks. Never a large population, but potentially viable in its own right if suitable breeding sites can be maintained and restored.

Stradbally

Site description: c.20-25 ha of coastal dunes, between the western end of Lough Gill and Brandon Bay, that were developed as a golf course in the early 1990s. There are

four substantial (permanent) ponds and an interconnecting ditch to Lough Gill, all made for the golf course and subsequently used by natterjacks for breeding. Stradbally is part of the Magherabeg dune complex discovered to support natterjacks in the late 1960s.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1991	228	Much spawn & tadpoles
1992	293	Much spawn & tadpoles
1993	216	59 spawn strings
1994	246	>82 spawn strings
1995	155	56 spawn strings
1996	70	182 spawn strings
1997	Many adults	1000s of tadpoles
2002		10000s of tadpoles

Status summary: Successful breeding area for natterjacks and an important part of the Magherabeg metapopulation.

Castlegregory-Lough Gill

Site description: c. 500 ha of dune peninsula (Magherabeg) to the north of Castlegregory, together with the very shallow (less than 1 m maximum depth) Lough Gill that extends over c. 150 ha. Up to c.25 ponds form in slack basins, depending on rainfall each year. They vary between very temporary to virtually permanent (Lough Naparka). Natterjacks were discovered in the late 1960s and breed in these pools and in Lough Gill, especially along its north-eastern shore. Trout occur in Lough Gill. There have been pollution incidents in Lough Naparka (fertiliser run-off) and Lough Gill (industrial) but no permanent damage. The area is lightly grazed, mostly by cattle. Sea buckthorn (*Hippophae rhamnoides*) scrub has become established and is spreading widely along the western side of the Magherabeg peninsula, posing a serious threat to dune biota.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1970	Many in Lough Gill	Much spawn & many tadpoles in Lough Gill
1971-1973	Many in Lough Gill	Spawn & tadpoles along north & east shores of Lough Gill
1975	Very many in Lough Gill	Much spawn & many tadpoles in Lough Gill
1976-1978	4 (Magherabeg dunes), many in Lough Gill	
1979	1 in dunes, 9 at Lough Gill	
1981		Tadpoles in 21 ponds in dunes + Lough Gill (the main site)
1982	Chorus in NW Lough Gill. MR* estimate of 448-784 in pond 23. 98	Tadpoles in 14 dune ponds. Spawn in Lough Gill.

	in pond 1 (Naparka) 277 toads measured	
1983	Several hundred adults estimated as present	15 sites used for breeding, of which Lough Gill was of foremost importance
1990	4 in Lough Gill	
1993	330 in 9 dune ponds, 18 in Lough Gill	126 spawn strings & many tadpoles in dune ponds. 3 spawn strings in Lough Gill.
1995	2,423 in 15 ponds	111 spawn strings
1996	62 in 7 ponds + many in Lough Gill	199 spawn strings
1997	Some in pond 1 (Naparka)	>61 spawn strings & "huge numbers" of tadpoles in ponds 1, 9 & 14.
2002		1 spawn string in Lough Gill. 87 strings in pond 1, 10000s tadpoles in several dune ponds

*MR = mark-recapture

Status summary: One of the two most important areas for natterjacks in Ireland, supporting thousands of toads breeding in multiple ponds. Considered by McCarthy *et al*. (1983) to sustain about two thirds of Irish natterjacks. Should be considered together with Stradbally as the focal area for natterjacks on the north Dingle coast.

Tullaree

Site description: c. 10 ha of heath and bog about 1.5 km south-east of Castlegregory, with 3-4 small, shallow pools used for breeding by natterjacks. The toads were discovered at Tullaree in 1983. Two small pools were mechanically deepened in 1999 to maintain availability of breeding water in late spring.

Natterjack records:

Year	**Adults seen**	**Spawn strings or tadpoles**
1983	<25 estimated	
1995	6	
1996	5	
2002		100s tadpoles

Status summary: Apparently a minor easterly offshoot of the Magherabeg metapopulation. Probably supports a small toad population in its own right, but it is not known how often breeding succeeds at Tullaree or whether toadlets survive to return as adults.

Inch

Site description: c. 400 ha of dune peninsula separating Castlemaine Harbour from Dingle Bay. The dune habitat is in excellent condition and lightly grazed by both cattle and sheep. Two main areas of mixed salt and fresh marsh occur on the eastern side of the dunes. Very small sections of this marsh are suitable for, and are used by natterjacks. In exceptionally wet years, shallow pools form elsewhere on the dunes

particularly at the north end. Long known (since the early nineteenth century) as a natterjack toad site.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1971	1	
1975	3	Tadpoles + 30 toadlets
1976-1978	"Toads seen"	
1979	26	12 toadlets
1981		Larvae in 5 pools on east side of peninsula
1983	<100 toads estimated	Evidence of breeding in 6 sites
1990	1	
1996	3	10 spawn strings, 1000s-100000s tadpoles
1997		24 spawn strings in ditch
1998	1	2 spawn strings
2000	1	34 spawn strings in two separate marsh areas (east side)
2002		16 spawn strings in two marsh areas

Status summary: Currently this is probably a small population with just tens or low hundreds of toads, strictly limited by the small amount of freshwater available for breeding. Historical accounts infer that the natterjack population used to be larger, presumably because there were formerly more ponds. Some of the eastern marshes have been deliberately drained (pre-1983). Certainly there is the potential for a much bigger population given the excellent state and extent of dune habitat.

Roscullen Island

Site description: c. 50 ha of wet cattle and sheep-grazed meadows extending north to the Inch-Castlemaine road, with deep peripheral ditches, shallow central ditches, flooded fields and a central shallow pool/bog. Natterjacks breed in some or all of these according to conditions in a particular season. Adult toads wander north of the main road from this site, which was "rediscovered" in the 1990s. It is however in a general area (the margin of Castlemaine Harbour) first noted for natterjacks nearly 200 years ago.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1996	54 males	1000s tadpoles in ditch
1998	5	1000s tadpoles
2002		1000s tadpoles in pool

Status summary: Probably a small or moderately sized population (tens to hundreds of adults) which, like Inch, is separated by several kilometres from its nearest neighbour. This is an important relic of the originally much wider distribution of natterjacks at the eastern end of Castlemaine Harbour.

Lough Yganavan
Site description: Shallow lough with much open water, some 60 ha in extent, surrounded by bog, rough ground and mixed farming. Trout are present. The southern end is a nature reserve, and natterjacks breed all round the lough. Discovered as a natterjack site in the early 1970s.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1973	4 at eastern end	
1975		Many tadpoles along southern and eastern shores (30/square metre)
1979	156 around all shores	
1981		5 areas with larvae, at various places around shoreline
1983	Several hundred toads	Breeding at various locations around Lough
1990	1 (north bank)	
1996	"Thunderous" chorus, 16 seen.	1000s tadpoles
1997	Numerous adults	100000s tadpoles
1998	4	1000s tadpoles
2002		1000s tadpoles, north & west shores

Status summary: Undoubtedly one of the two most important natterjack sites in Ireland, supporting probably thousands of toads that use terrestrial habitat all around the Lough margins. Described by McCarthy et al. (1983) as the premier breeding site on the Iveragh peninsula. Very likely forms part of a metapopulation with Lough Nambrackdarrig, perhaps even with occasional contacts to Dooaghs and Glenbeigh.

Lough Nambrackdarrig
Site description: Small (< 5 ha) and well vegetated shallow lough surrounded by bog and pasture. A nature reserve. Discovered as a natterjack site in the late 1970s.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1975	5 (NE edge)	
1979	10	
1983	c. 80 adults	Spawn & tadpoles seen
1996	Much calling, 2 seen	100000s tadpoles
1997	>7	100000s tadpoles
1998	3	Many tadpoles
2002		100s/1000s tadpoles

Status summary: A relatively small site perhaps supporting a few hundred natterjacks in its own right, but probably also part of a metapopulation with Lough Yganavan.

Dooaghs
Site description: c. 100 ha of golf course (mostly) and commonage at the entrance to Castlemaine Harbour. Sandy habitat with some scrub, rather more open on the commonage where grazing occurs. Three ponds on the golf course, two temporary pools on the commonage and a further pond in a wet, cattle-grazed field east of the commonage (owned by the golf course) are used by natterjacks for breeding. The golf course ponds have recently been improved deliberately for the toads. Castlemaine Harbour has been known for natterjacks since the early nineteenth century, though specific records for Dooaghs date only from the 1940s.

Natterjack records:

Year	**Adults seen**	**Spawn strings or tadpoles**
1971	6 at east end of site	
1975	2 toads on and 29 toads off golf course	
1976-1978	Toads seen	
1979	33 (off golf course)	
1983	c.60 adults	Spawn and tadpoles seen
1990	2 (off golf course)	
1996	1 toad, much calling on golf course	Tadpoles in golf course pond
1997		1 spawn string in commonage pond, 1000s tadpoles in golf course pond
1998	2 on golf course, 7 on commonage	Some tadpoles in commonage ponds
2002		1000/10000s tadpoles in 2 golf course, 2 commonage and eastern pond.

Status summary: A moderately sized and viable metapopulation of probably a few hundred natterjacks using ponds on the commonage and the golf course, both of which habitats are important. May interconnect with Glenbeigh, and perhaps even with Loughs Yganavan/Nambrackdarrig.

Glenbeigh
Site description: c. 100 ha of mixed urban development, pasture and commonage forming a peninsula in Rosbeigh Creek. Natterjacks have bred recently in three areas: (1) near the sea in a marshy area on the north-west coast, (2) in a shallow pool on cattle-grazed commonage near Reennanallagane, and (3) in several small pools in and around a disused quarry on the eastern side of the peninsula. The northern site has suffered increasing saline inundations rendering the breeding pools unusable, and the quarry ponds have become heavily overgrown with trees and scrub in recent years. Glenbeigh forms part of the Castlemaine harbour ring where natterjacks were first seen nearly 200 years ago, and was “rediscovered” in the early 1970s.

Natterjack records:

Year	Adults seen	Spawn strings or tadpoles
1971	6 adults near quarry, 10 juveniles at north end	
1975	1 (north end)	
1979	17 (north end)	
1983	30 adults at north end, >100 in commonage pond	Very many tadpoles in commonage pond
1990	4 (north end) + 2 (quarry)	
1996	1 in quarry	Tadpoles in commonage pond, 100000s tadpoles in quarry
1997	2 (north end)	10 spawn strings + 10000s tadpoles in commonage pond; 9 spawn strings + 10s of tadpoles in quarry.
1998	2 (north end) + 2 (quarry)	2 spawn strings + 10s tadpoles in commonage pond, 8 spawn strings in quarry.
2002		100s/1000s tadpoles in commonage pond, 100000s hatching tadpoles in shallow quarry pools.

Status summary: An area with several dispersed breeding sites probably supporting tens or low hundreds of natterjacks. It seems very likely that the three breeding areas can be considered a single metapopulation. Currently precarious due to deterioration of both the north coast and quarry breeding areas.

Overview of extant native populations

Irish natterjack populations can be grouped into three main categories:

- Large and thriving metapopulations. There are two of these: (1) Fermoyle/ Stradbally/Castelegregory-Lough Gill/Tullaree; and (2) Yganavan/ Nambrackdarrig), each supporting thousands of toads.
- Small metapopulations. There are two of these: (1) Dooaghs; and (2) Glenbeigh, each with probably a few hundred toads. One (Dooaghs) is thriving, the other (Glenbeigh) is at risk.
- Small isolated populations. There are also two of these: (1) Inch; and (2) Roscullen Island. One (Inch) is in particular need of conservation support.

Natterjacks are not under immediate threat of extinction in Ireland at the present time, but survive in an area much reduced from their recent historical distribution. Population size must therefore be lower than in former times, and in many cases there are now substantial distances between breeding sites. This increased fragmentation and isolation of toad populations increases the long term risks of further local extinctions with little chance of natural recolonisation. Small and/or isolated

populations may die out as a result of human interference and/or short-term climate variation, perhaps exacerbated by inbreeding depression. Populations in the second and especially the third categories listed above are vulnerable to these threats. McCarthy *et al* (1983) estimated that the total Irish natterjack population (adults) was probably in the range 3,000 - 10,000, and I concur with this educated guess.

Translocations
Two new natterjack populations have been initiated by translocation since 1990, in both cases using spawn from Stradbally and Castlegregory ponds. Site maps are given in Appendix 2.

Caherdaniel
Site description: c. 5-10 ha of dune peninsula extending southwards into Derrynane Bay some 2 km south-west of Caherdaniel. Excellent terrestrial habitat with light grazing, but now without any natural pools. A historic natterjack site (reported in the 1940s), the toads went extinct sometime between then and the early 1970s. Two artificial ponds were created in the early 1990s at the start of a natterjack reintroduction to the Caherdaniel dunes.

Natterjack records:

Year	**No. spawn strings introduced**	**Adults seen**	**Spawn strings or tadpoles produced on site**
1992	16		
1993	14		
1994	>63		
1995	28		6 spawn strings laid
2002			1000s tadpoles in 2 ponds

Status summary: This translocation has proved successful and a self-sustaining population is established. It is likely that the amount of breeding water available at Caherdaniel limits toad population size on the dunes. There are probably at least tens, maybe low hundreds of adult natterjacks at Caherdaniel now.

Raven
Site description: Large (c. 250 ha) belt of coastal dunes at the northern entrance of Wexford Harbour. Mostly forested, though small areas of open dune occur on this nature reserve especially around the southern end. About 12 ponds potentially suitable for natterjacks are present, all artificial and mostly around the southern tip of the dune system. Most are in small clearings, though three are in larger areas of open dune. They were the recipients of natterjack spawn in a translocation that started in the early 1990s.

Natterjack records:

Year	No. spawn strings introduced	Adults seen	Spawn strings or tadpoles produced on site
1991	16		
1992	51		
1993	14		
1995	60		
1996	40		
1997	24		
2000	66		
2001			12 spawn strings in 4 ponds (1, 2, 3 & 9); later 100s tadpoles in 6 ponds
2002			1000s tadpoles in 6 ponds

Status summary: A translocation that has probably been successful. However, because large spawn imports continued for a long time, and until as recently as 2000, it is not yet possible to be certain that a self-sustaining population is established. This will only be clear when several years have elapsed with no support from external spawn input. It seems likely, though, that a viable population of at least tens of natterjacks exists on the Raven.

Overview of translocations

Both of the natterjack translocations carried out in Ireland since 1990 have proved successful. There was an element of "overkill" in the method used, since it should be possible to carry out translocations using far fewer spawn strings and over just 2-3 years rather than 4-9. The advantage of a shorter time period of translocations, in particular, is that success or failure is more quickly detected. The Caherdaniel translocation made good biogeographic sense (the area was an old natterjack site) and habitat quality is high there. The Raven is perhaps more questionable. It is nowhere near the historical range of natterjacks, and habitat quality (due to aforestation) is relatively poor over most of the site. It has the advantage of being a state-owned nature reserve, and of course habitat quality can always be improved. However, there are further sites within the historical range in Kerry where reintroductions could be attempted, and which arguably should have higher priority than introductions to completely new areas.

Practical measures for natterjack conservation

Three areas of activity are relevant to future natterjack conservation in Ireland. Firstly there are wide-ranging issues that will have long-term implications for all populations, notably site protection, monitoring and further survey. Secondly the appropriate management needed to protect individual sites must be considered. Finally, a broader strategy to safeguard natterjacks by improving metapopulation connectivities and restoring overall population size using translocations is proposed.

General: site protection, monitoring and further survey

Site protection

- **SAC status**. Statutory site protection should be adequate for all natterjack sites in Ireland as SAC status is confirmed. It will be important to ensure that SAC boundaries include all breeding areas and surrounding terrestrial habitats as currently anticipated. It is also desirable, however, that SAC boundaries are extended in future to include areas between some of the natterjack sites in order to protect continuity and thus maintain metapopulation structures. This particularly applies to land between Loughs Yganavan and Nambrackdarrig, and to other areas between these loughs, Dooaghs and Glenbeigh.

- **Nature reserves**. Statutory protection as SAC is welcome because it should prevents further losses from development or damaging activities, but nature reserve status should also be promoted for the most important sites. Top priorities for reserve status should be the Castlegregory dunes including Lough Gill, Inch dunes, and Lough Yganavan including the surrounding terrestrial habitat. At present only part of Lough Yganavan and Lough Nambrackdarrig are nature reserves, and this status (aquatic habitat only) does not seem to confer any obvious advantage. Being a nature reserve should attract some level of extra resources, e.g. for wardening and management.

Monitoring

- **Justification and Protocol**. A high priority should be the increased monitoring of natterjack toad populations to provide warning of declines that might result in further extinctions, and to assess the success of management and translocations. The most important aspects of monitoring are: (a) recording numbers of spawn strings to produce a cumulative total for each site every year, as a measure of population size; and (b) recording the presence of toadlets around each pond every year, as a measure of breeding success. Trends in these measures provide invaluable information about population status and forewarn of problems that might otherwise go unnoticed. In Britain this information is compiled annually into a national natterjack site register (Beebee & Buckley 2000). If comparable information was available for Ireland, it could (if desired) be incorporated into a comprehensive site register for Britain and Ireland by the UK's Herpetological Conservation Trust (HCT).

- **Practicalities**. **PRIORITY** Over the past 20 years monitoring has been carried out mostly by rangers of the National Parks & Wildlife Service. This has provided valuable information, but rangers have many other duties and are responsible for large areas, and clearly have insufficient time to monitor natterjack populations systematically. Monitoring should be an intensive job requiring a full-time employee, but only for four months of the year (April-

July inclusive). Every site needs to be visited at least once every 8-10 days to obtain accurate overall counts of spawn strings. Toadlets emerge in June/July and ponds need regular visits at this time to assess output within an order of magnitude (none, tens, hundreds etc). Monitoring the native populations and the Caherdaniel reintroduction site could be accomplished by a single person, though the Raven site would need separate attention by local personnel.

Further survey

- **Justification**. The Roscullen Island natterjack population was not discovered until the mid 1990s, despite rumours of toads in the area some 20 years earlier (Gresson & O'Dubhda 1974). Natterjacks can sometimes be hard to locate, especially when breeding sites are small or only used intermittently. It remains possible that undiscovered populations occur around Castlemaine Harbour. In recent years there have, for example, been consistent reports from reliable observers of toads near Killorglin. It is highly desirable to ensure that any remaining unknown populations are found, or that there can be high confidence that the distribution of natterjacks is fully known, as soon as possible.

- **Practicalities**. Survey should continue on an *ad hoc* basis by rangers, local enthusiasts, visiting herpetologists and/or the person employed primarily for monitoring known sites. It should, however, be actively promoted by the National Parks & Wildlife Service and planned such that particular areas are investigated thoroughly in a systematic way.

Site-specific measures

Although most of the recommendations listed below are specifically for natterjacks, they are framed according to two underlying principles: (1) Habitat rather than species should be the main focus of conservation work; and (2) *Status quo* is usually the default option and intervention of any kind should be fully justified. Both of these principles mitigate against developments such as golf courses. However benign such developments may appear, they inevitably reduce habitat pristinity and are unpredictable with respect to long-term consequences.

Fermoyle

Fermoyle natterjacks are at risk from natural processes that have eroded the coastline and inundated previous breeding pools with saltwater, and from improved land drainage. The prospects of the site could be improved in three ways:

- **New pools eastwards**. **PRIORITY** A series of 3-4 shallow pools should be created immediately inland of the coastal bank, perhaps at 500 m intervals, between Fermoyle itself and Stradbally. This would enhance connectivity of the north Dingle metapopulation as well as providing a choice of breeding sites in an area currently sustaining only a single, recently excavated pool.
- **Reflooding**. The area previously flooded by the stream could be reflooded by appropriate engineering, perhaps involving new sluices at the seaward outflow.
- **New pools westwards**. The prospect exists for creating pools at Drom, in dunes immediately west of Fermoyle. This would probably require an introduction of natterjacks, and is thus considered separately in the next section.

Stradbally
No conservation measures are required at this site. In future it may be necessary to dredge vegetation from the ponds, and to ensure the continued presence of fish.

Castlegregory-Lough Gill
This area supports large numbers of natterjacks and the population is not immediately under threat. However, some actions are required:

- **Sea Buckthorn**. . **PRIORITY** There is now a very extensive stand of sea buckthorn (*Hippophae rhamnoides*) on the western side of the Magherabeg dune peninsula, and this continues to spread. The problem of this invasive alien plant at Castlegregory has been noted before (Beebee 1991). Sea buckthorn has a eutrophicating effect (it is a nitrogen-fixer) with serious long term implications for both flora and fauna on these dunes. Eradication should be the objective. This will be expensive, but methods for removing buckthorn have been developed and implemented effectively elsewhere. Machines designed to uproot buckthorn and transport it to burn sites were used in dune regeneration at Merseyside, England as part of the UK natterjack toad recovery programme (Beebee & Denton 1997).
- **Water table monitoring**. There is concern that some previous temporary ponds no longer form, perhaps because of a long-term drop in the water table. There is no immediate cause for concern (multiple breeding pools are still available, including Lough Gill) but a water table monitoring regime should be established to investigate this issue.
- **Pollution monitoring**. In the past both Lough Gill and Lough Naparka have suffered from pollution, and it is important that further such incidents are avoided.
- **Grazing regime**. It is important that grazing is maintained on the dunes, but also that addition of supplementary feed in winter is controlled. This could otherwise lead to pollution of freshwater habitats as well as changes in nutrient status, and thus biological communities, on the dunes.

Tullaree
No action apart from monitoring is required at this site.

Inch
This superb dune peninsula has long been known as a natterjack toad site. However, although the terrestrial habitat is excellent, the status of natterjacks is precarious because of the very limited amount of freshwater. Action is needed to safeguard natterjacks on Inch.

- **Pond creation**. **PRIORITY** At least 5 scrapes should be created wherever suitable sites can be found within the dune system. Such sites certainly exist along the upper edges of (mainly) saltmarshes on the eastern side, and freshwater habitats water might be created just by blocking or infilling some of the drainage ditches. Sites should of course be chosen such that there is minimal impact on dune flora.
- **Site purchase**. **PRIORITY if work cannot be agreed with landowner** Because of its significance as a large, pristine dune system every effort should be made to purchase Inch as a nature reserve. This could be done by government and/or by voluntary organisations. Because the current landowner

is not sympathetic towards conservation, all else may hinge on purchase of the site.

Roscullen Island
Like Inch, this is a very isolated natterjack population. It is also important as the last remnant population at the eastern end of Castlemaine Harbour. The main threats are drainage (ditch improvements) and the rather low intensity of grazing. Action is desirable to improve the prospects of toads at this site.

- **Extra breeding sites**. At present the toads seem to rely mainly on a single area of marsh/shallow pond for breeding. The creation of at least two more, similar ponds elsewhere on the peninsula would be relatively cheap and should help safeguard the population.
- **Drainage control**. Deepening the drainage ditches should be stopped, and efforts should be made to ensure that current water levels are maintained.
- **Grazing regime**. The landowners should be encouraged to graze at least as intensively as at present and preferably more intensively in the fields around and north of the breeding area.

Lough Yganavan
This very important breeding site continues to support a large natterjack population. No major conservation action is required. However, it will be important to ensure that land use remains non-intensive around the lough, minimising pollution risks, and that grazing regimes are at least maintained and, if possible, intensified. Some of the peripheral vegetation has become ranker than desirable for natterjacks. There should be no further developments (house building etc).

Lough Nambrackdarrig
There is some concern that grazing intensity has reduced substantially around the northern side of the lough, which is where most terrestrial habitat for natterjacks exists. As with lough Yganavan, it will be important to make sure that surrounding agriculture remains non-intensive and that grazing regimes are maintained to provide good terrestrial habitat for natterjacks.

Dooaghs
No major conservation action is required either on the commonage or the golf course areas of this natterjack site. It will be important to maintain all the ponds in good condition, and some scrub clearance would improve the terrestrial habitat on the golf course (Buckley 2000) though this is not an urgent priority. Terrestrial habitat on the commonage should be maintained by grazing in its current excellent state, and grazing should also be maintained in the field around the easternmost pond that is owned by the golf course.

Glenbeigh
The future of natterjacks in the Glenbeigh area looks precarious because two of the three breeding sites are damaged or in poor condition. Action is certainly required here.

- **North-western (coastal) breeding site**. **PRIORITY** Repeated tidal inundations through a damaged sluice have made the adjacent marsh at this site too saline for natterjack reproduction. Unless the sluice is properly repaired and maintained, this breeding area will be completely lost.

- **Commonage (central) breeding site**. This area with its single shallow pond does not require any action other than the maintenance of grazing regimes at their current level.
- **South-eastern (quarry) breeding site**. **PRIORITY** Both main ponds in the old quarry are now overgrown while other pools around the quarry are extremely ephemeral. Purchase of the quarry site should be considered (the owner is unsympathetic to conservation) if action depends on this. Both the original main quarry pools should be opened up by removal of scrub and dumped rubbish, and thus restored as toad breeding sites. More general scrub control and the introduction of grazing in the quarry area are also highly desirable.

In addition, it will be important to prevent further building in the Glenbeigh area where new houses have, over recent years, reduced the overall extent of habitat particularly near the northern breeding site.

Caherdaniel (translocation site)
This site has excellent terrestrial habitat and currently two breeding ponds. Because it is isolated from other populations, and likely to remain so, it will be important to generate a large population size for long-term viability. This will be best achieved by increasing the number of breeding ponds. A target of three more ponds should be considered, with each at least as large as the existing ones and spread as widely as possible across the site. Wet meadow at the northerly dune edge, possibly where the pool used by the original population existed, has already been identified as one potential new pond site.

Raven (translocation site)
This translocation site in Wexford has some 14 ponds, six of which are used for breeding by natterjacks. Five of these are near the southern end of the dune peninsula, but are separated from each other by unsuitable terrestrial habitat (mostly forest). The prospects of this population could be improved by opening up the dunes in this area, i.e. by extensive tree clearance, thus facilitating toad movements between the ponds. A grazing regime with domestic animals should be introduced to prevent forest regeneration, and this would have general beneficial effects on dune biota.

Options for enhancing long-term conservation status
The current status of natterjacks in Ireland is both reduced and more fragmented than was the case a century ago. While ensuring the future of surviving sites (as outlined in the previous section) should be the first priority, long-term safeguard will be best assured by increasing the overall toad population size and by increasing connectivity between existing sites. Three options are identified for such a strategy.

- **1. Full range restoration**. Undoubtedly the ideal way of achieving both population increase and connectivity would be to restore continuity of range around Castlemaine Harbour, i.e. the recent historical distribution. This should certainly be considered as a long-term objective, but is likely to be difficult. Many different landowners will be involved, and it is not clear how easy it will be to restore breeding sites in areas where there has been extensive drainage.

- **2. Widespread translocations**. A second option is to translocate natterjacks to new sites anywhere in Ireland that suitable habitat can be found, notably on coastal dune systems around the country. This requires that the whole of Ireland is adopted as a single biogeographical unit, and that historical range is considered an irrelevance. It greatly increases the scope for population size increases, but does not help with connectivity; indeed it creates multiple isolated populations with no chance of connectivity to others. It also makes national monitoring more complex since very dispersed sites will require several people to monitor them.

- **3. Site improvement and local translocations**. A compromise option is to improve connectivity between and/or extend existing sites, while translocating natterjacks to new sites but only where these are close to the historical distribution area. This would serve to increase population size and have some benefits for population connectivity, though some of the new populations would probably remain isolated. They would, however, all be within the range of a single monitor. This option is outlined more fully below.

A strategy for achieving favourable conservation status
To improve the long term prospects of natterjacks in Ireland, two types of action should be considered: improving connectivity of existing sites and translocations to establish new populations.

Connectivity of sites
There are three areas where improvements of connectivity would be valuable. These are listed in decreasing order of importance.

- **Inch-Roscullen Island**. These are currently the two most isolated natterjack populations in Ireland. They could be connected by creating a series of shallow pools along the northern edge of Castlemaine Harbour. This would require a minimum of ten ponds at approximately 1 km intervals. Clearly this would need the cooperation of multiple landowners, but pond creation is not inherently very expensive. When complete, the operation would be an important safeguard for two existing populations and make a substantial contribution to historical range restoration.

- **Fermoyle-Stradbally**. As indicated earlier under conservation options for the Fermoyle site, linking Fermoyle to the main natterjack population of the Magherabeg peninsula is highly desirable. The creation of 3-4 pools would achieve this objective.

- **Yganavan/Nambrackdarrig/Dooaghs/Glenbeigh**. These natterjack populations are already in fairly close proximity. Judicious addition of a few (perhaps 5) ponds at intervening locations, if suitable sites could be found, would convert this complex into a single metapopulation. This in turn would buffer natterjacks against local, hopefully temporary disasters such as currently threaten some of the Glenbeigh sites.

In all of these cases the best policy would be to create ponds and then give natterjacks the opportunity to colonise them naturally. Indeed, interesting information

could be obtained from such an operation. However, if the process is unduly slow and ponds nearest to the existing populations are not colonised within five years, spawn could be introduced as per translocations (see below). This may well be necessary in an Inch-Roscullen Island link, since neither of these populations seems likely to be large. Any such translocation should always use spawn from the nearest population to maintain the genetic profile of the area.

Translocations

There are three sites where natterjacks should be translocated with relatively high priority because they would help to restore, or in one case sustain, the historical range. These are listed below in decreasing order of importance.

- **Rosbeigh dunes** (SAC). There is scope on this extensive dune peninsula to re-establish a substantial natterjack population. Rosbeigh is well documented as a historical site and previously formed the southernmost end of the Castlemaine Harbour range. There are currently no suitable breeding ponds, and it is presumed that loss of these in the now just damp slacks caused the natterjack extinction. Creation of several (at least three, preferably five) ponds among the extensive slack basins would be a prerequisite of any natterjack reintroduction.

- **Ballycarbery**. This is an isolated site at the north-westerly end of the Iveragh peninsula. It was, however, a recent natterjack site and there is scope to create ponds in sandy fields near the coast. Like Rosbeigh, it seems that pond loss was responsible for natterjack extinction so pond restoration (at least three) is again an essential prerequisite. The benefit of carrying out this translocation is that together with Caherdaniel (already accomplished) it would complete restoration of the historical range in outlier areas of the Iveragh peninsula.

- **Drom dunes** (SAC). These dunes immediately west of Fermoyle are not suffering from coastal erosion and there are areas where freshwater pools could be created. At present there are no pools on the dunes, so at least two should be made prior to a translocation. Its proximity to Fermoyle makes this translocation an attractive option for safeguarding the western end of the north Dingle Bay natterjack metapopulation.

In addition to these sites, at least two other areas in Kerry could be subject to natterjack translocations. Neither are historical sites but both are relatively close to the recent range. Both are SACs, and both lie to the north of the Dingle peninsula. The Ballyheige dunes form an extensive system up to 2-3 km wide and 8 km long north-west of Tralee. At present there are probably no suitable breeding ponds, and extensive survey to check this out, probably followed by pond creation, would be necessary prior to any natterjack introduction. Further north still, between Ballybunnion and the Shannon estuary, is another smaller dune system. Damp slacks and a stream exist, so pond creation would probably be straightforward. However, in my opinion both of these areas should be of low priority relative to the three listed above. They lie outside the historical range and populations could never be connected to each other or to existing populations. They could however be considered if serious difficulties arise with the higher priority sites.

Procedures for natterjack translocations

In both Britain and Ireland natterjack populations have been successfully established by translocation of spawn into recipient ponds, and this continues to be the recommended practice (Beebee & Denton 1997). It is important to maximise the genetic diversity of the translocated stock, and this is best done by moving short sections of several spawn strings rather than a small number of complete strings. Sections of strings are easily obtained by cutting with scissors between eggs. The equivalent of at least two full strings, but made up from sections of at least eight, is recommended for each recipient pond in a particular year. It is important to monitor development and record successful toadlet production to ensure that the recipient pond is satisfactory. Providing it is, and barring disasters where there is no toadlet production, translocation should be continued for no more than two consecutive years altogether (i.e. the spawn transfer should be repeated just one more time). Continuing for further years confuses assessment of whether a viable new population has become established. All being well, adult natterjacks should return to breed three years after the first toadlets are produced and after that the new population should be self-sustaining.

Future research requirements

Irish natterjacks are in most respects similar with respect to behaviour and ecology to those elsewhere in northern Europe. However, there are some interesting features of *Bufo calamita* in Kerry that could be of evolutionary significance and of relevance to practical conservation. Isolated populations at range edges, the situation of all natterjacks in Ireland, are subject to unusual selection pressures and may show important local adaptations. Two aspects stand out.

Breeding ecology

Natterjacks in Kerry breed successfully in large, permanent lakes (Yganavan, Gill, Nambrackdarrig) as well as in shallow temporary pools. Lake breeding is extremely unusual for natterjacks in northern Europe, and (for example) happens nowhere in Britain. It may be that natterjacks can exploit lakes by extending their breeding season, and/or by extending the larval growth period to benefit from aquatic resources. It would therefore be interesting to compare reproductive biologies, including larval survival rates, in lakes and the more typical temporary pond habitats. This would provide valuable information relevant to future pond construction, because it may not be as necessary as it is in Britain to ensure that ponds dry out in summer. It would also indicate the importance of Lough Gill and the Stradbally permanent ponds relative to the temporary slacks for overall population viability on the Magherabeg peninsula.

Terrestrial ecology

Natterjacks in Ireland appear to cope with ranker terrestrial habitat structures than do toads in Britain. This is particularly obvious at sites such as Tullaree and Roscullen Island. It would be interesting to know how this tolerance is achieved, particularly by toadlets. It may be that toadlet mortality is just as high in dense vegetation as it is in Britain, but larval survival is so high that this does not affect population viability. Alternatively, natterjacks may be in some way better adapted to cope with rank ground flora in Ireland. Experimental comparisons would be interesting, and of considerable relevance to conservation management. Understanding this aspect of natterjack ecology would clarify grazing requirements on terrestrial habitats.

Top priorities

Among the conservation recommendations listed above, the following are considered especially urgent and important:

General

- **Instigate a systematic monitoring regime** with a full-time employee available for one third of each year (April-July).

Site-specific

- **Inch and Glenbeigh**: Carry out measures for breeding site creation/restoration.
- **Magherabeg dunes**: Commence buckthorn removal**.**

Strategic

- **Rosbeigh**: Initiate a translocation.

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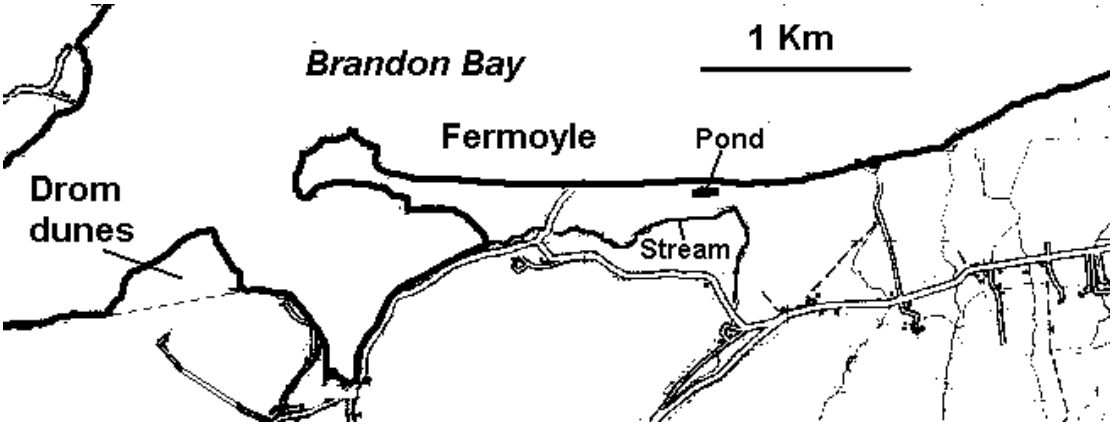
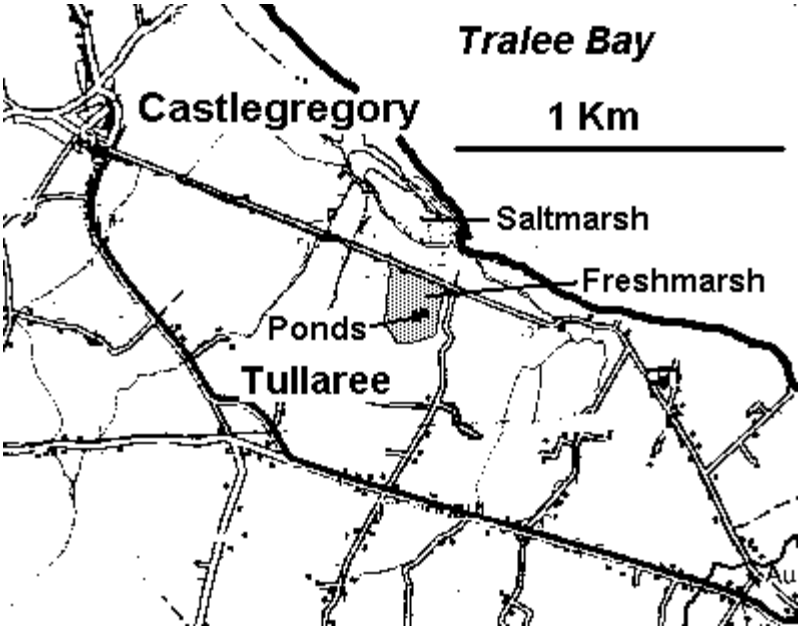
Appendix 1: Maps of sites with native populations

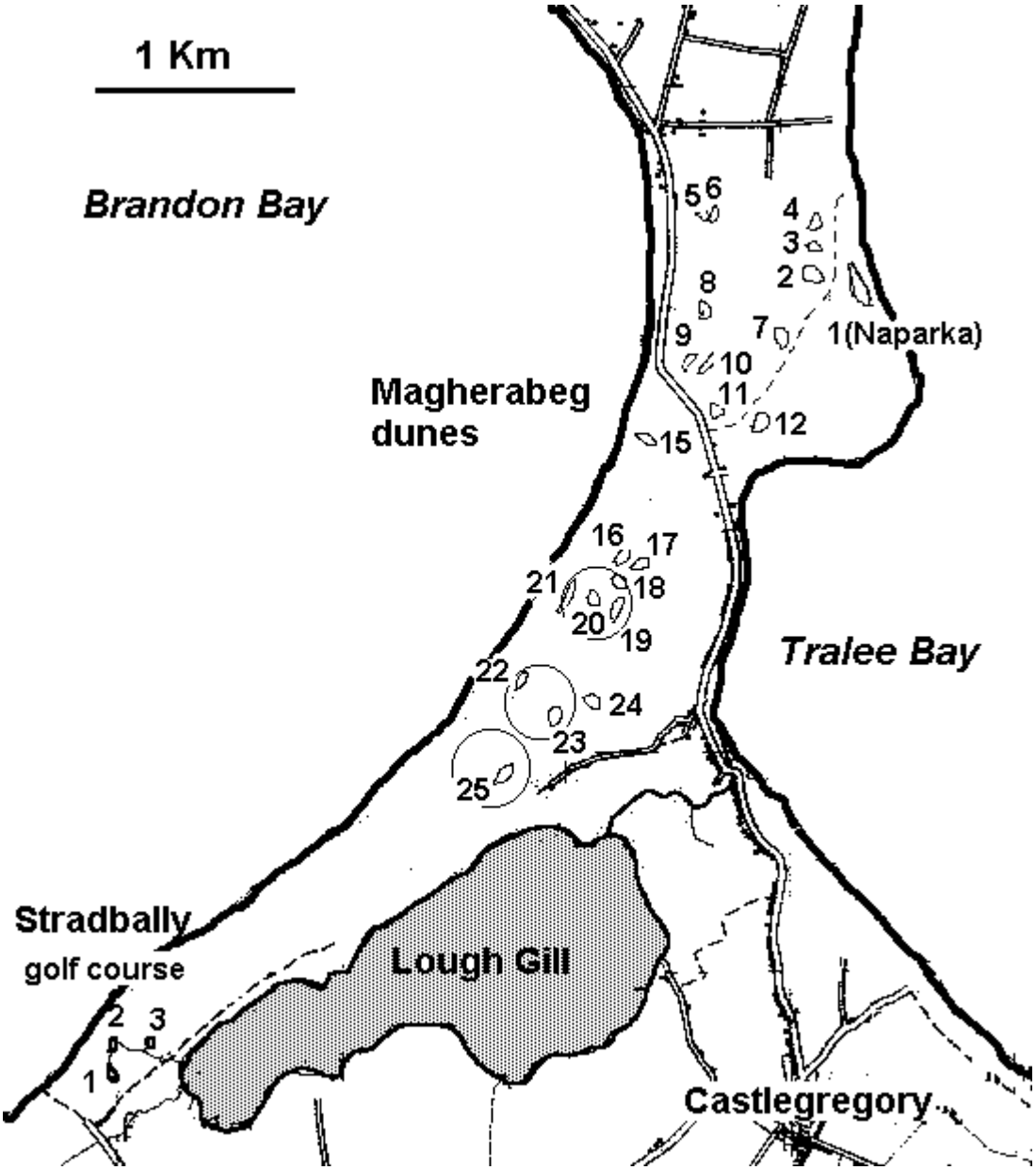
Fermoyle



Tullaree

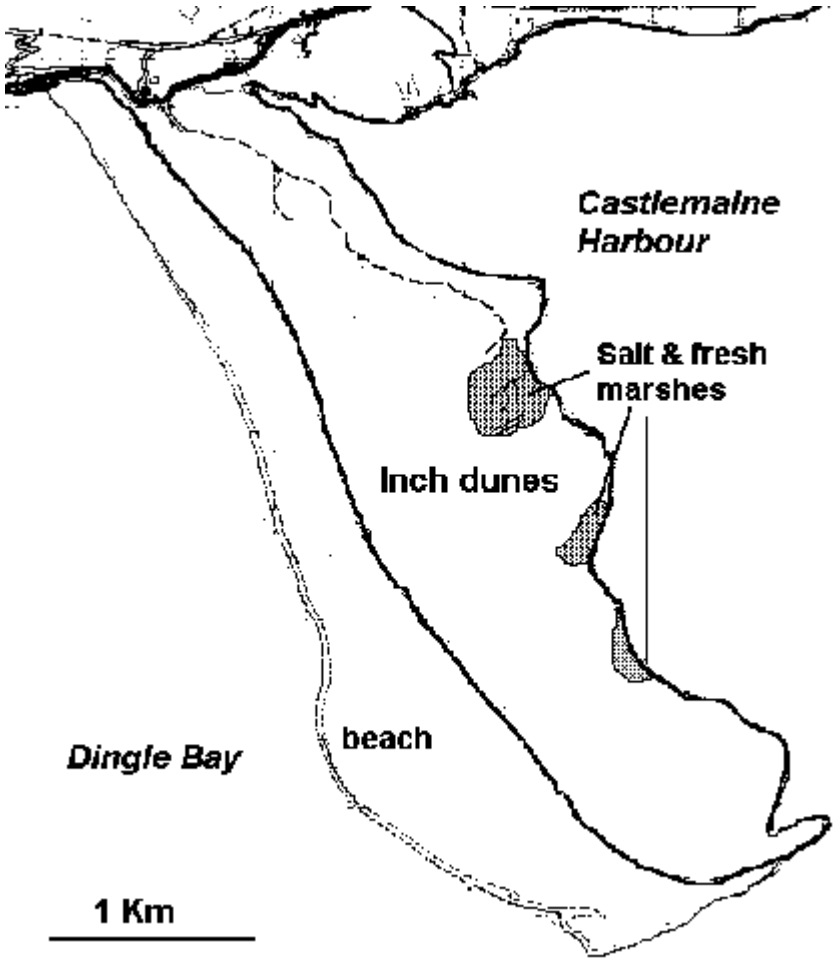


Castlegregory

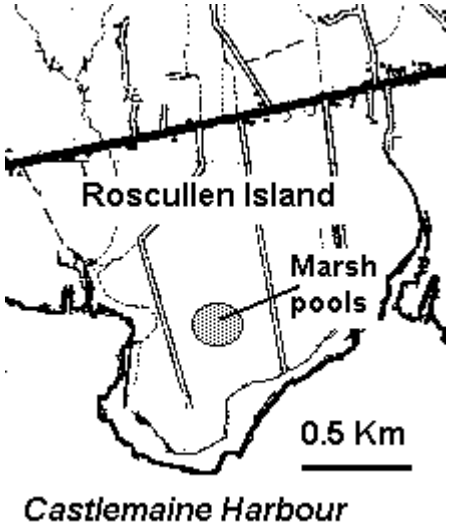


Ponds are numbered as in recent monitoring reports.

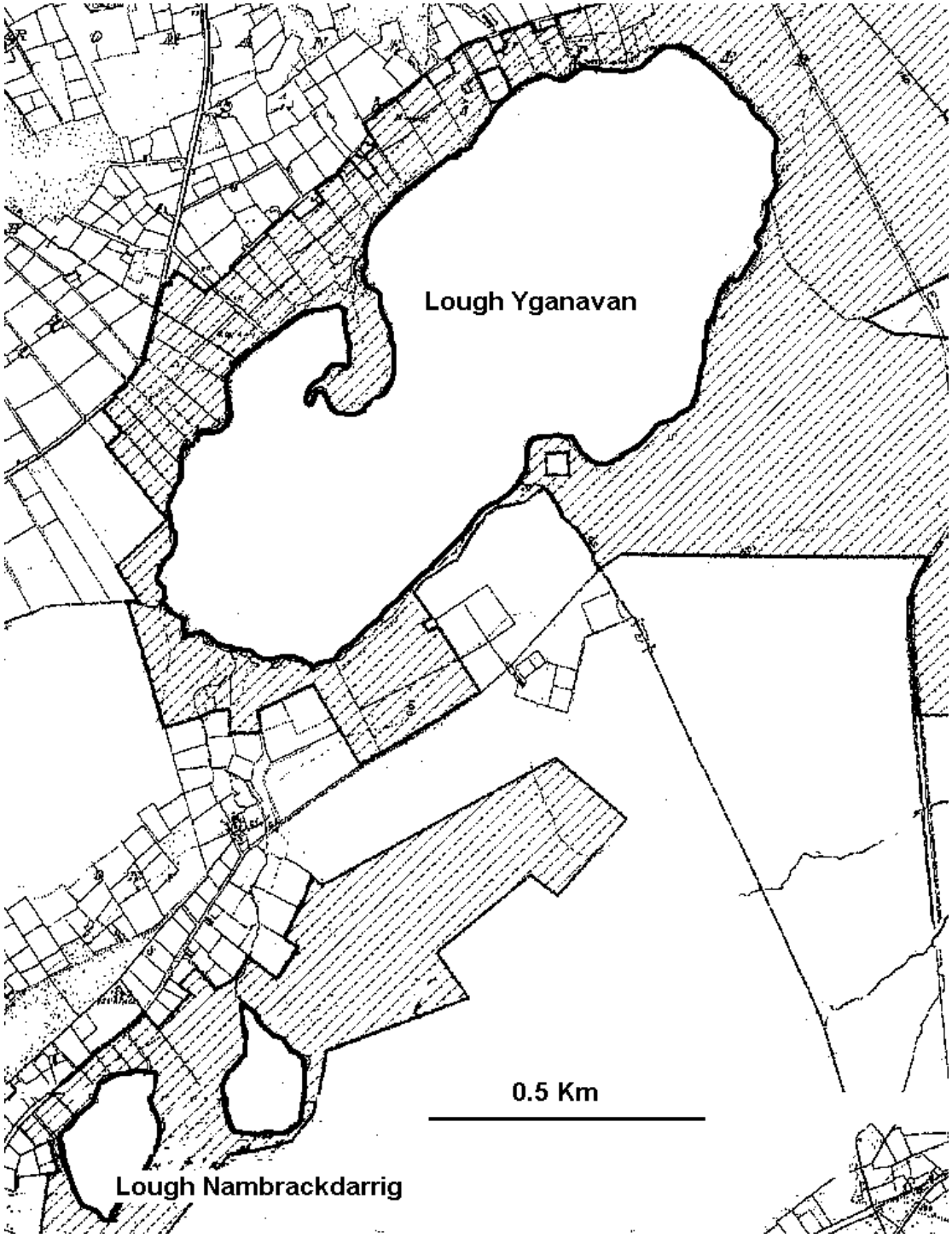
Inch



Roscullen Island

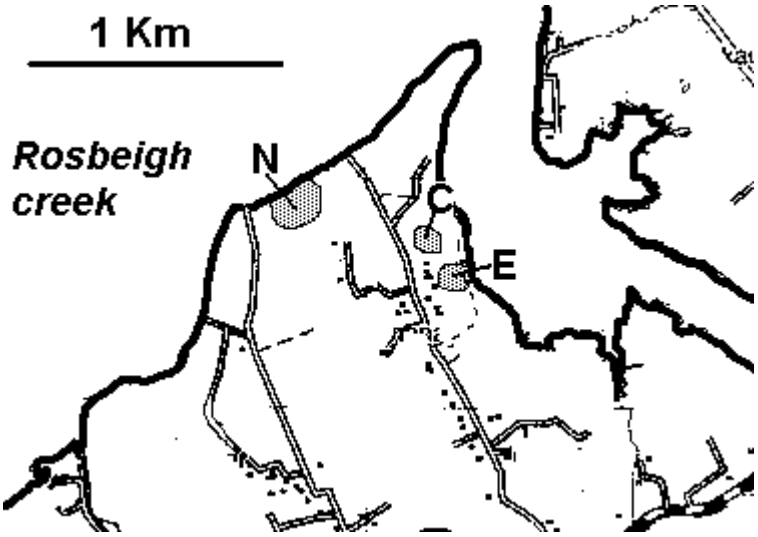


Loughs Yganavan and Nambrackdarrig



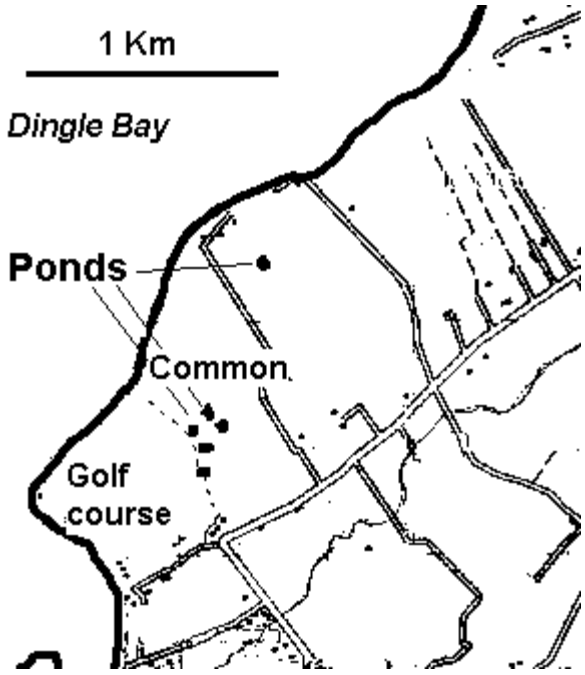
Areas shaded with oblique lines are (together with the loughs) in SACs.

Glenbeigh



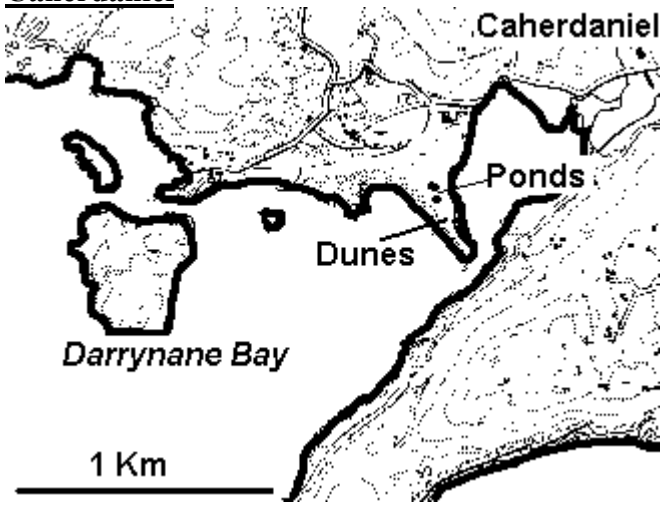
N = northern site (coastal marsh); C = central site (shallow pond); E = Eastern site (old quarry and environs)

Dooaghs



Appendix 2: Maps of sites with translocated populations

Caherdaniel



Raven