THE IMPORTANCE OF TWO OF LUNDY'S TEMPORARY PONDS

by
ALAN ROWLAND
Mole Cottage, Chapel Close, Woodford, Morwenstow, Cornwall, EX23 9JR
e-mail: Morwenstow@btinternet.com

ABSTRACT

The species composition and habitats of two of Lundy's temporary ponds and their importance as reservoirs of short-lived and unique species is investigated. The type of temporary pond and the composition of species is further determined. Current management of these habitats is explored and their importance as habitats in both their wet and dry phases.

Keywords: *Lundy, Lentic water, freshwater invertebrates, autumnal pond, temporary pond*

INTRODUCTION

The plateau of Lundy is in effect a giant sponge which sits in a region that receives much rainfall throughout most of the year. After prolonged rain every hollow becomes a temporary pond and every permanent pond increases in depth considerably. The first Ordnance Survey maps of Lundy included five temporary ponds at the north east of the island (OS 1886) although between 20 and 25 were recorded after a particularly wet winter (pers. notes).

These north east temporary ponds are quite ephemeral and shallow, forming in slight depressions on bare granite and providing habitat for highly mobile and quick breeding species of Coleoptera and Diptera. There is an exception in Long Roost Pond which, unusually, contains water in its granite basin for considerable periods of the year.

Most permanent ponds occasionally dry up in years of prolonged drought (1976, 1981, 1995 and 2006) but in most years they can be relied on to hold water all year round (George, 2012).

The average number of rainy days throughout the year varies from 12.7 in June to 19.5 in December (Lundy Warden, pers. comm.).

At the southern end of Lundy there are two temporary ponds that have a regular periodicity: Government House Pond (GHP) and Kistvaen Pond (KP).

Definition of a Temporary Pond

A temporary pond is formed by water collecting in an isolated basin that has neither inlet nor outlet and from which water is entirely absent for part of the year (Wiggins *et al.*, 1980).

Brönmark and Hannson (1998) define two distinct types of temporary pond: Temporary Vernal or Temporary Autumnal ponds (see Box 1).

It is important to note that these definitions are not necessarily permanent. For example a particular pond could be vernal one year and autumnal in another year and occasionally, in a very wet year, permanent for that the whole twelve months. It is highly likely that species may in fact determine the designation of the pond (Wiggins *et al.*, 1980).

According to Brönmark and Hannson (1998) both KP and GHP are Temporary Autumnal Ponds with eight to nine month wet and three to four month dry periods; autumnal because the drought is terminated in autumn.

Box 1: Definition of Temporary Ponds

a) Temporary vernal pool
Fills in April from melting snow/rain, levels decline to none by June/July, remains dry until spring. Typically
3-4 months wet
8-9 months dry

b) Temporary autumnal pool
Has impermeable soils and has water into autumn. Typically
9 months wet
3 months dry

Despite this regular drying out, both types of temporary ponds are long-lived. Due to their annual dry phase, any build up of macrophytes dies off. Exposure to the elements means that any remains oxidise and disperse thus preventing the build up of silt. (Brönmark and Hansson, 1998)

Box 2: Species of Temporary Ponds

Group 1 Year round residents
Species that escape desiccation either by resistant stages or by burrowing into sediments.

Group 2 Spring recruits
Species that oviposit in water then spend the winter in aestivating in the dry basin or survive in another life stage.

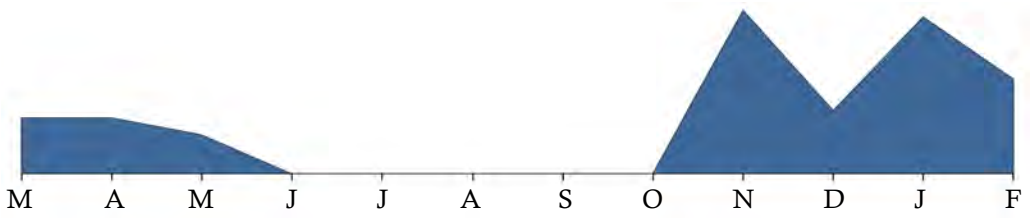
Group 3 Summer recruits
Species that oviposit in the dry basin then overwinter as eggs or larvae.

Group 4 Non-wintering migrants
Species that leave the pond before the dry phase and then spend time in a permanent pond before returning to breed in the spring.

Group 5 Terrestrial species

Figures 1 and 2 are adapted from Wiggins *et al*. (1980). The vertical scale in blue is the presence and relative depth of water against the horizontal axis of months from March to February. The year is shown in this arrangement to keep the seasons together: Spring (March/April/May); Summer (June/July/August); Autumn (September/October/November); Winter (December/January/February).

Figure 1: Government House Pond Depths (y axis) by month (x axis)



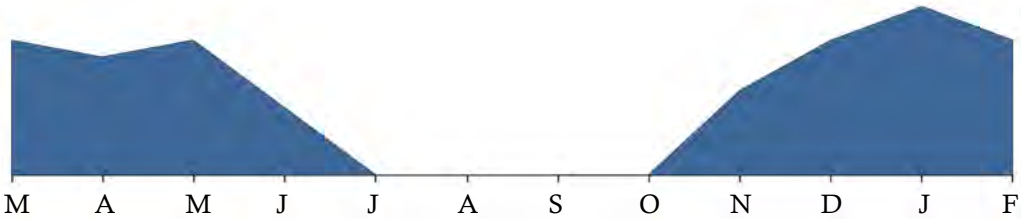
Records of water depths were commenced when Government House Pond was first surveyed in 2010 and continued irregularly until 2016 when records were made more regularly. The pond dries out from May to October/November when it stays wet usually around November through to April although occasionally, as in June 2017 and July 2012 some water was recorded. When it contains water it is around 0.3 to 0.5 metres in depth although this falls rapidly during periods of no rain when surveys are not undertaken. Figure 1 consolidates these depth readings which broadly conform to that of a Temporary Autumnal Pond.

GHP begins to fill around September/October when rainfall increases and continues to fill up to its maximum depth of around 0.5m. This continues until spring when rainfall and groundwater flow decreases until all water has drained or evaporated away at the end of May or beginning of June when the dry phase extends until autumn.

Plate 1: GHP Wet Phase showing the pond covered with *Lemna minor* November 2011

Plate 2: GHP Dry Phase albeit with a small amount of damp mud August 2019

Figure 2: Kistvaen Pond Depths (y axis) by month (x axis)



Depth records exist for Kistvaen Pond from April 2005 when the maximum depth in the western sub pond was as much as 0.35m. Records were made sporadically until 2017 when biotic and abiotic surveys were made on a much regular basis. The pond began to collect water between September and November and retained this at various depths until late May or early June when it dried out for the summer until rain began to collect again in autumn. Figure 2 consolidates these depth readings which broadly conform to that of a Temporary Autumnal Pond.

KP begins to fill in late autumn, around October, and continues to collect rain and ground water throughout the winter until it reaches maximum depth of up to 0.35m. The pond continues with this depth until late spring/early summer when water levels quickly fall leaving three isolated smaller ponds in the west, south and north-east areas when the pond enters its dry phase.

Plate 3: Kistvaen Pond
Wet Phase
February 2010

Plate 4: Kistvaen Pond
Dry Phase
August 2019

Plate 5: Aerial view of Kistvaen Pond showing the western, southern and north-eastern receding wet sub-ponds

Species of Temporary Ponds (see Box 2)

The species that inhabit temporary ponds can be separated into five groups. The strategies they have developed to inhabit this niche habitat defines them. In this paper the fifth group – invertebrate species that inhabit the dry phase – are not discussed although some exploration of the value of the habitats during this phase is made.

In addition to the various species that inhabit temporary ponds, there is also a succession of the species that comprise each group:

Group 1 comprises the permanent residents, those species that are not capable of active dispersal during the dry phase and have developed strategies to aestivate either as drought resistant cysts and eggs either as juveniles or adults. Typical species are Flatworms (Turbellaria), Segmented worms (Oligochaeta), Leeches (Hirudinea), the various planktonic Water Fleas, Copepods and Clam Shrimps (Crustacea), Freshwater Shrimps (Gammaridae), Water Slaters (Isopoda) and Snails, Limpets and Mussels (Mollusca).

Group 2 comprises those taxa that must reproduce in the pond before the water disappears then aestivate as eggs or larvae or, in the case of beetles, leave the pond as adults. They appear immediately after the pond begins to fill and typically have a 4-6 week life cycle. Typical species are Mayflies (Ephemeroptera), Beetles (Coleoptera), Caddis Flies (Trichoptera), True Flies (Diptera), Water Spiders and Mites (Acari).

Group 3, the summer recruits, do not need water for ovipositing and use the basin after the water has gone and overwinter as eggs or as larvae. They appear 2-5 weeks after water appears and typically have a 5-week life cycle and are predominantly Dragonflies and Damselflies (Odonata), Trichoptera, and Diptera.

Group 4, the non-wintering spring migrants, enter temporary ponds in spring about 10 weeks after water appears, breed, develop into adulthood then leave the pond for permanent water until water reappears. Typical species are Ephemeroptera, Odonata, True Bugs (Hemiptera), Coleoptera, Diptera, Acari and Frogs and Toads (Amphibia).

Group 5 species are the terrestrial species not covered in this paper (Williams, 2006, Wiggins *et al.*, 1980).

In summary, Drake (2001) describes the prerequisites for survival in temporary ponds as: an ability to reach maturity before it dries out; a mechanism to survive the dry period; and the ability to re-colonise. The two ponds in this paper are home to a subset of these species which are detailed more fully in the Results section.

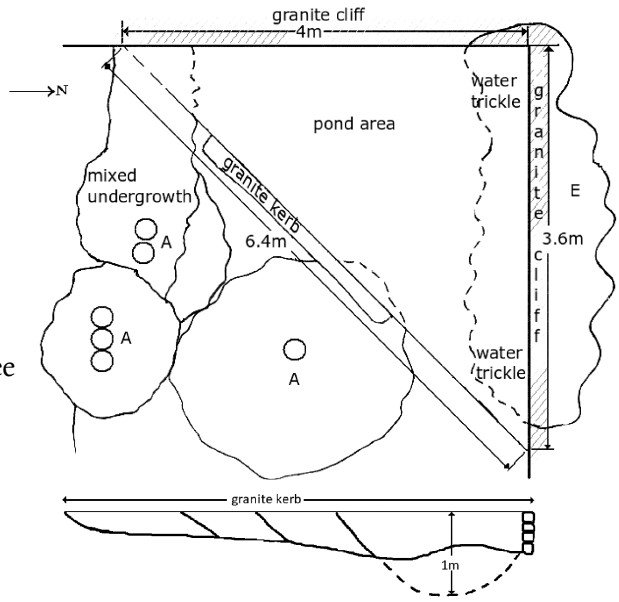
Descriptions of the Ponds

Government House Pond is located at Ordnance Survey Grid Reference SS 13808 44067, east of the Tavern, through the arched Trafalgar blue doorway leading to Government House where there is a sheltered area excavated from the rocks and protected by trees on the north side of the path.

The pool is triangular in shape and bounded on two sides by overhanging granite cliffs of up to 3m in height. The third side has a cut granite edging bordered by luxuriant undergrowth and grass. The northern cliff has a large shrub descending from it, Japanese Spindle tree *Euonymus japonicus*, from which much of the leaf debris originates. There are also Sycamore *Acer pseudoplatanus* on the south-eastern periphery. The pool has neither inlet nor outlet but is fed from visible, and audible, water seepage from the northern cliff, and presumably some rain water.

Figure 3: Government House Pond – plan and elevation along the granite kerb

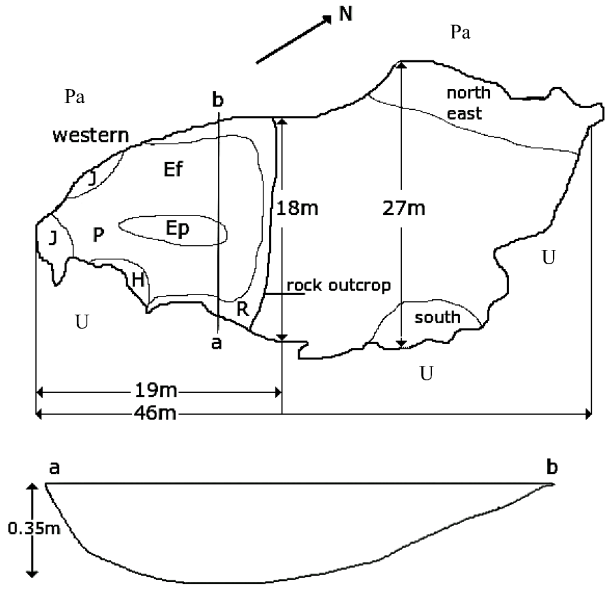
Key
A - *Acer pseudoplanatus* Sycamore
E - *Euonymus japonicus* Japanese spindle tree



Kistvaen Pond is located on the southern coast of Lundy, due east of Rocket Pole Pond at Ordnance Survey Grid Reference SS 1355 4369. It is a large shallow depression roughly oblong running east-west and measuring some 46.3m long by 27m wide. It too has neither inlet nor outlet and depends for its water on rain and to some extent ground water. It is bordered by Common Rush *Juncus effusus,* Western Gorse *Ulex galli* and Bracken *Pteridium aquilinum.*

Figure 4: Kistvaen Pond – plan and elevation across section a-b. Typical plants growing in the western sub-pond, one of three of the longest-lasting wet areas, are mapped. The rock outcrop that divides the depression is home to Chaffweed

Key
Ef - *Eleogeton fluitans*
Ep - *Eleocharis palustris*
H - *Hydrocotyle vulgaris*
J - *Juncus effusus*
P - *Potamogeton polygonifolias*
Pa - *Pteridium aquilinum*
R - *Ranunculus lingua*
U - *Ulex sp*



Origins and History

Government House Pond

This pond does not feature in Langham's 1969, otherwise comprehensive, listing of all Lundy's ponds and streams. It is first referred to as 'Pond in the Quarry' in the Heaven archives when Cecilia Heaven relates how she and her brother Walter, aged 9 and 5, played there:

> '… But the pond in the Quarry – now planted with trees, close to the site of the Iron Church – proved irresistible, and I can still vizualise Walter in his old velvet suit plunging in up to his waist!' (Heaven Archive, 1870).

It is also referred to by Langham (1993) in a later unpublished article where he mistakenly attributes the granite as slate in the 'Garden Quarry':

> 'Immediately through the "Gothic Gate", to the east, is a little "Garden Quarry" from which slate was dug and which, when abandoned, quickly filled with water to provide a sheltered pond beloved by dragonflies.'
>
> 'The "Old House" of Sir John Borlase Warren dates, we believe, from about 1775 and stands at what is the extreme head of Millcombe Valley. The large amount of stone required seems to have been quarried from what later became the hotel garden. There is no direct evidence of quarrying here but the sunken contours of the garden (although much modified and landscaped since) suggest that this site is the Old House's stone quarry. Immediately north of the modern Government House is an old quarry from which stone may have been quarried at this time.'

It may have developed as a pool naturally once the quarry had ceased use, but at some stage, there was a deliberate attempt to formalise the pond when the hypotenuse of its triangular shape was delineated by the placing of granite kerb stones along it.

Ternstrom (1999) locates and describes it in her gazetteer 'G343 Pond in the Quarry NGR 1380 4409'. Other than these references to its existence, no attempt has been made to survey or record the fauna and flora of this pond.

Reg Lo-vel (pers. comm.) recollected that there had always been a wet patch in the quarry adjacent to Government House, but could not remember any previous work being done there by Landmark Trust.

Dyke (1971) provided an illustration of the area which 'once sheltered a little church with a spire and bell … dedicated in 1885 … dismantled …. in 1896.' The foundations are clear and were reportedly used as foundation for a greenhouse, but at the time of writing '… has reverted back to nature and become a pleasant open space.' The Quarry and pond obviously predates all building works and was outside the Manor House grounds and apart from its recent excavation has remained undisturbed for much of its existence.

Kistvaen Pond

This pond, originally designated as Rocket Pole Temporary Pond 2 and more recently as Kistvaen Pond, is the large depression to the east of Rocket Pole Pond. It contains some water at some times of the year. At other times there is no water at all.

All winter it holds some water but dries out in late spring, around May remains dry until late autumn which is variably between October or November (Langham, 1969).

In light of Ternstrom's (2000) description of the site of this chambered tomb, it has been renamed from Langham's (1969) original designation, as one of the Rocket Pole complex of ponds, to Kistvaen Pond.

The whole area was originally excavated in 1852 and later in 1887 filled and altered to be much as it is seen today. It continues to be 'variously dry, marshy, or a pond'. It was measured at 242 feet long (Ternstrom, 2000) and is scheduled monument No. 27625.

METHODS

Abiotic

Both ponds have been surveyed occasionally from 2010 in the case of GHP and from 2005 in the case of KP. More regular surveys on both ponds commenced in 2016. Where equipment has allowed, Total Dissolved Solids, pH and depths have been recorded. Inputs for both are ground and rain water and output is evaporation.

Government House Pond:Total Dissolved Solids: 249 to 277 averaging 268, well within the definition of freshwater. pH between 6.3 (May) and 8.0 (Apr) with an average of 7.4. Maximum depth recorded was 0.29m with silt of up to an additional 0.15m in May.

Kistvaen Pond: Total Dissolved Solids: between 206 and 319 (Apr to June) with average of 251, well within the definition of freshwater. pH ranges between 5.9 (March) and 7.8 (June) with an average of 7. Maximum depth was reached in April at 0.44m. There is no silt in this weedy pond.

Despite the regular reduction in volume of water as the ponds dry out, pH and TDS remain within tolerable limits and for the whole of the wet periods these ponds fall within the definition of freshwater and do not restrict their flora and fauna in any way.

Biotics

Surveys have been carried out in most months of the year when there has been water in either of the ponds.

KP has been surveyed in every month with the exception of July, August and October

GHP has been surveyed in every month with the exception of January, June, August and October.

Government House Pond: The initial survey of this pond was made by request of the then Lundy Warden, Nicola Saunders and Lundy Ranger, Chris Flower (pers. comm. 2010). The pond was almost full of silt with only millimetres depth of water on the surface of the accumulated silt. The Conservation Team wanted advice on excavating the pond and returning it to being a body of water. Advice on how to do this was given but only after an initial survey was carried out. Due to the extremely shallow depth of water, the standard net method of surveying was not possible and water was scooped up into a container sampling all areas as well as some of the silt. The resulting mix was allowed to settle and species and abundance ascertained. Ten species were recorded and with the exception of three (*Carchesium, Hydra* and Freshwater Shrimp) all have since been recorded on frequent occasions.

Kistvaen Pond: Standard method surveying was carried out with standard hand net 250mm wide with 1mm mesh with 3 minutes sampling divided between all areas and habitats. Tables 2 and 3 of results includes surveys from April 2005 (George, pers. comm.).

In July 2019 both ponds were expected to be dry. In the event, GHP consisted of damp mud whereas KP had small but decreasing pools in the three areas where water remains for the longest period (Plate 5). These dried around the middle of the month. A stainless steel hand coring tool was used to extract cores of approximately 6cm in length and 1cm in diameter. In KP some areas were too close to bedrock to achieve this and lesser depths were extracted but GHP had sufficient soft silt to achieve this. One core was taken from dry areas adjacent to each of the three areas in KP and two from GHP. The five cores were re-hydrated with a few ml of cooled, but boiled, water and left to infuse for 24 hours.

Government House Pond core samples

Core 1: Damp and muddy with slightly wet surface. *Lumbriculus variegatus* × 5 (2 were partial worms only), Nematode × 1.

Core 2: Drier area with no surface water. *Lumbriculus variegatus* × 8 (two had chalky-white epidermis indicating they were about to aestivate).

Kistvaen Pond core samples

Core 1: North-eastern sub-pond - Nematode × 2.

Core 2: Southern sub-pond - Psychodid larva *Pericoma* sp × 2.

Core 3: Western sub-pond - Nematode worm × 1, *Staphylinidae* beetle larva × 1 (a common predator of Nematodes and Diptera larvae).

RESULTS

A total of 36 species occur in these two ponds: 20 in GHP and 24 in KP. There are only five species that are common to both ponds, Cyprididae, *Cyclops*, *Proasellus meridianus*, Chironomidae and Psychodidae, leaving a further 31 species. Of these, three have been found nowhere else on Lundy: *Phagocata vitta* in GHP and *Dalyellia viridis* and *Rhynchosostoma rostratum* in KP, all flatworms Platyhelminthes. The remaining species can be found in other ponds on the island although the three Mollusca species of GHP are restricted in their distribution, requiring calcium in the water to produce their shell. Water chemistry depends on whether water originates from precipitation or groundwater (van der Valk, 2006) and in this case much of it percolates through the surrounding cliff faces.

One example of *Dalyellia viridis* was found in Ackland's Moor Pond (Rowland, 2014) but this was an isolated example which must have been chance dispersal and has not been found in any subsequent surveys of this or other ponds.

The majority of species are mobile except for the worms, leeches and Isopoda. However their distribution is by means of resistant eggs dispersed by wind or animals.

Government House Pond has three species that were only found on a single occasion: *Carchesium*, *Cholorohydra viridissima* and a Gammaridae species. All three were found in the initial survey of GHP before the accumulated silt was removed and have not, so far, re-colonised. Although *Gammarus duebeni* has been found in Pyramid and Punchbowl streams (Long, 1994), it has not been found in a water body on Lundy since and may have been a misidentified species. The other two species are not uncommon in other Lundy waters. Tipulidae larvae have been found on two occasions; one was recovered in 2018 as a pupa and reared to adulthood. *Philidorea ferruginea* and may be classed either as a freshwater or a terrestrial species.

KP pond has three species that have only been found once: *Polycelis nigra* and *Helobdella stagnalis* which occur in abundance in other ponds. A Tipulidae which was found towards the end of a wet period in 2018 as a pupa was reared to adulthood *Tipula oloracea* and may be classed either as a freshwater or a terrestrial species.

Carchesium and *Hydra* species have not been recovered in GHP and are not typical species of temporary ponds. They are unable to disperse without a host. Both depend on submerged substrates such as roots, aquatic plants, pilings and in the case of *Carchesium* the shells of snails on which they anchor. Thus, they may not return without introduction from other water bodies on the island.

Platyhelminthes: Flatworms (Group 1)

Three species have been recorded in KP and one in GHP. *Polycellis nigra, Dalyellia viridis* and *Rhynchosostoma rostratum* in KP and *Phagocata vitta* in GHP. *P. nigra* is ubiquitous, but the other two species have not been found in any other of Lundy's waters.

All Platyhelminthes lay eggs in cocoons and can regenerate from being cut into several pieces. Fragmentation can be induced by high temperatures which caused them to secrete slime which hardens into a cyst to resist desiccation. Regeneration of .*P vitta* can take up to 10 days once the basin becomes flooded, although *D. viridis* may take 25-40 days to accomplish this (Wiggins *et al*., 1980).

Nematoda

Nematodes are adapted to survive in the moist substrate. These have been found in both ponds.

Annelida: true worms and leeches (Group 1)

Representative of both families have been found in both ponds*, Lumbriculus variegatus, and Helobdella stagnalis*, although *H. stagnalis* has been found only once in each. Both are common on Lundy. Leeches are known to be able to survive the dry phase by secreting a protective mucous layer after burrowing into the moist substrate. *H. stagnalis* reproduce by fragmentation after encystment although they are thought by (Cook, 1971) to survive as adults in a drought-resistant cyst.

Chelicerata: spiders and mites (Group 4)

Hydracarina sp. have been found in KP and feed on Hemiptera and Coleoptera which appear at the same time as those species. They are not uncommon in Lundy's other freshwaters.

Mollusca: snails, limpets and mussels (Group 1)

Species of this Phylum were only found in GHP represented by *Hydrobia (Potamopyrgus) jenkinsi, Pisidium personatum* and *Galba truncatula*.

H. jenkinsi has been previously recorded in all streams that were surveyed by Long (1994) but are expanding their range into ponds. Similarly, *P. personatum* has been found in most streams and some ponds (Long, 1994, Clabburn, 1994, George & MacHardy, 2004). *G. truncatula* has only been recorded in Quarter Wall Pond North (George & Sheridan, 1987) so this is a useful additional habitat.

Mollusca need calcium to produce their shell which would indicate that KP is deficient in calcium whilst GHP is not. *H. jenkinsi* is an operculate snail in that it has a horny plate with which it can seal itself into its shell producing an epiphragm which reduces moisture loss and enables the species to survive long periods without water.

Table 1: Species that occur in Government House Pond with an indication of abundance, the group to which they belong and in which season they can be found.
* denotes a not counted presence and *1 a single occurrence.
Abundance: 5>500; 4=200-499; 3=50-199; 2=5-49; 1<5

Name	Spring (M/A/M)	Summer (J/J/A)	Autumn (S/O/N)	Winter (D/J/F)	Group
PROTOZOA: Periticha: *Carchesium* sp.		*	*		n/a
CNIDARIA: Hydra *Chlorohydra viridissima* (Pallas)		*1			n/a
PLATYHELMINTHES: Flatworms *Phagocata vitta* (Duges)			3	3	1
NEMATODA: *Nematode* worm		1		2	
ANNELIDA: true worms and leeches					
Oligochaeta *Lumbriculus variegatus* (Muller)	3	2	2	3	
Hirudinea *Helobdella stagnalis* (L.)			*1		
MOLLUSCA: snails, limpets and mussels					
Hydrobia (Potamopyrgus) jenkinsi (Smith)		2	3	3	
Pisidium personatum (Malm)	3	2	2	4	
Galba truncatula (Muller)	1	2		2	
CRUSTACEA: shelled arthropods					
Copepoda: *Cyclops* sp		*	*	*	
Ostracoda: Family *Cypridida*e sp.	2			1	
Isopoda *Proasellus meridianus* (Racovitza)		3	3	3	
Amphipoda Family *Gammaridae* sp.		*1			
INSECTA: insects					3
Trichoptera Caddis flies *Notidobia ciliaris l*arva (L)				1	
Diptera: two-winged flies					2
Ceratopogonidae sp. larva				2	
Dixidae sp. larva				1	
Chironomidae larva	2		2	2	
Culicidae sp. larva				*	
Tipulidae Philidorea ferruginea (Meigen)			1	1	
Psychodinae Pericomini sp.				2	
Total=20 species including 3 singles	5	10	10	16	

Table 2: Species that occur in Kistvaen Pond with an indication of abundance, the group to which they belong and in which season they can be found.
* denotes a not counted presence and *1 a single occurrence.
Abundance: 5>500; 4=200-499; 3=50-199; 2=5-49; 1<5

Name	Spring (M/A/M)	Summer (J/J/A)	Autumn (S/O/N)	Winter (D/J/F)	Group
PLATYHELMINTHES: Flatworms					
Polycellis nigra (Muller)			*1		
Dalyellia viridis (Shaw)	2			1	
*Rhynchosostoma rostratum (*Muller)	1			2	
NEMATODA: *Nematode* worm				1	1
ANNELIDA: true worms and leeches					
Oligochaeta *Lumbriculus variegatus* (Muller)	1	1		1	
Hirudinea *Helobdella stagnalis* (L)			*1		
CHELICERATA: spiders and mites *Hydracarina sp*	1			1	4
CRUSTACEA: shelled arthropods					
Cladocera:					
Simocephalus vetulus (Muller)	4	4	*	*	
Chydorus sphaericus (Muller)	5				
Ostracoda: Family Cyprididae	2			1	1
Copepoda:					
Cyclops sp.	3	1	1	1	
Harpaticoidea	2				
Isopoda *Proasellus meridianus* (Racovitza)		3	2	2	
INSECTA: insects					
Ephemeroptera: *Cloeon dipterum* (L.)		1	1		
Collembola					2
Podura aquatic (L.)	1			1	
Isotomurus palustris (Muller)	1				
Hemiptera:					
*Corixia panzeri (*Fieber)	1	3			
Gerris sp.	1	2			
*Notonecta viridis (*Delcourt)		1			4
Coleoptera:					
Dytiscid sp.	2	2	1	2	
Colymbetes fuscus (L.)		*1			
Diptera: two-winged flies					
Chironomid sp.		2		1	
Psychodidae sp.	1				2
Tipulidae *Tipula oleracea* (L.)			*1		
Total=24 species including 4 singles	15	11	8	12	

No males have yet been found, but the females can contain 30-40 fully developed young within her shell making them ideally suited to survive the dry phase of a temporary pond.

Galba truncatula in an aquatic pulmonate which can breathe air and survive out of water for between 6 weeks and 4 months in its aestivated state.

Pisidium personatum can survive for up to 8 or 9 months in damp leaves.

Chelicerata: spiders and mites (Group 4)

Hydracarina sp. have been found in KP and feed on Hemiptera and Coleoptera which appear at the same time as those species. They are not uncommon in Lundy's other freshwaters.

Mollusca: snails, limpets and mussels (Group 1)

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Mollusca need calcium to produce their shell which would indicate that KP is deficient in calcium whilst GHP is not. *H. jenkinsi* is an operculate snail in that it has a horny plate with which it can seal itself into its shell producing an epiphragm which reduces moisture loss and enables the species to survive long periods without water. No males have yet been found, but the females can contain 30-40 fully developed young within her shell making them ideally suited to survive the dry phase of a temporary pond.

Galba truncatula in an aquatic pulmonate which can breathe air and survive out of water for between 6 weeks and 4 months in its aestivated state.

Pisidium personatum can survive for up to 8 or 9 months in damp leaves.

Crustacea: shelled arthropods (Group 1)

Cladocera

The water fleas *Simocephalus vetulus* and *Chydorus sphaericus* were only found in KP.

Copepoda

Cyclops sp. were found in both ponds.

Both these plankton species have been recorded since freshwater records began when Galliford began surveying (1954). Eggs can only survive as encysted eggs in bottom sediments or dry mud but have been reactivated after up to three (Wiggins *et al.*, 1980).

Cladocera can produce eggs parthenogenetically or at certain times of the year by male fertilisation. These eggs are kept in the brood chamber of the female until the ephippium is shed when she moults. These eggs are hard and thick and can remain dormant through drying and freezing until suitable conditions for development occur make them ideally suited to temporary ponds.

Harpaticoidea were found in KP only.

Ostracoda (Group 1)

Family *Cypridida*e were found in both ponds.

Eggs are highly resistant to desiccation having double-walled chitinous shells. They may have several generations a year. In temporary ponds this is restricted to one generation when diapause eggs are triggered to hatch when the pond floods.

Isopoda (Group 1)

Proasellus meridianus was found in both ponds. This is a ubiquitous species found in most of Lundy's waters. It is highly likely that this species aestivates in the ground once water has all evaporated. Adults reappear immediately after water begins to collect in the pond.

Insecta: insects (Group 2)

Ephemeroptera:

Cloeon dipterum was only found in KP; this species is common in the ponds of Lundy.

Collembola

Podura aquatic and *Isotomurus palustris* were only found in KP but these not uncommon species are probably under-recorded.

Trichoptera Caddis flies

Notidobia ciliaris larva was only found in GHP and not recorded on Lundy previously.

Insecta: insects (Group 4)

Hemiptera

Corixia panzeri was only found in KP but Corixids can be found in most other open ponds on Lundy.

Gerris sp. only found in KP which is a highly mobile species that will locate any suitable body of water and can be found widely elsewhere on Lundy.

Notonecta viridis was only found in KP, another highly mobile species that will locate any suitable body of water and can be found widely elsewhere on Lundy.

Coleoptera

Dytiscidae sp. were only found in KP both as larvae of various sizes and adults. *Dytiscidae* are a highly mobile species that will locate any suitable body of water and can be found widely on Lundy.

The most abundant larvae and adults were 3-4mm diving beetles of *Hydrophorus* sp. However occasionally much larger larvae are seen, probably of *Colymbetes fuscus*, an adult of which has been recorded on one occasion.

Diptera: two-winged flies (Group 2)

Chironomidae, *Psychodidae* and *Tipulidae* species have been found in both ponds. GHP is also host to *Ceratopogonidae*, *Dixidae* and *Culicidae* larvae.

Long (1994) recorded some of these families in the streams of Lundy that he surveyed, but despite there being little or no other records, there is no reason to believe the records of *Diptera* found in these ponds are unique.

Larvae of most *Diptera* are air breathers and therefore restricted to shallow waters; either margins or very shallow ponds. Although mosquito larvae (*Culicidae*) break this rule being able to swim, they are at greater risk in open water and so tend to favour shallow pond margins. Rat-tailed larvae (*Syrphidae*) have telescopic posterior spiracles so they can live in sediments several centimetres under water. *Eristalis*, *Holophilus* spp. are known to inhabit sites that are dry in summer. They have been seen in KP but on only one occasion by casual observation. Dipteral larvae are able to survive freezing in pond margin sediments (Drake, 2001). Mosquitoes are known to lay eggs in dry places that will be later submerged.

Diptera are highly mobile and able to colonise new sites with a long flight periods and short life-cycles. It is no surprise that both ponds are hosts to a range of Diptera species.

DISCUSSION

No comprehensive survey of either flora or fauna of the dry phase had been attempted, but a list of plants and vertebrates observed during the dry phase is worth recording.

During its dry phase, GHP is dry or at best damp mud with only ruderal plants invading from the periphery. Typically, nettles, brambles hogweed and dock stray across the area, but nothing really can achieve full succession as the regular refilling of water inhibits this. The pond is heavily shaded by shrubs and trees which may also inhibit growth.

The damp rock face on the northern edge where water can be heard and seen trickling during the wet phase does bear abundant growth of a Liverwort, Bifid Crestwort *Lophocolea bidentata* and on occasion the water surface has been covered with Lesser Duckweed *Lemna minor*.

In contrast, KP has a regular dry phase flora, when the area becomes completely grassed over with Rushes and Sedges remaining. The margins of the drying pond attract Greater Spearwort *Ranunculus lingua* whilst Marsh Pennywort *Hydrocotyle vulgaris*, Bog Pimpernel *Anagallis tenella* and Tormentil *Potentilla erecta* spread across the drying sward. Once the area is as completely dry as is possible on Lundy, Chaffweed *Cenunculus minimus* becomes established (pers. comm. Andrew Cleave). All these plants can survive inundation during winter and the dry summer phase.

Fungi are also to be found during the dry phase in the basin of KP. Scarlet Waxcaps *Hygrocybe coccinea* can be seen and the Sphagnum Brownie *Hypholoma elongatum* was seen for only the second time on Lundy in 2013. This species is known to like wet conditions and can obviously tolerate complete immersion during the winter (John Hedger, pers. comm.).

During its wet phase, KP should attract waders, but the shallow depth of mud overlying the bedrock is not conducive to there being a large number of invertebrates on which they could feed. It is exposed on the south coast with almost no cover in which to shelter from patrolling gulls and Peregrines *Falco peregrinus*. The usual range of common birds are seen, typically Meadow Pipit *Anthus pratensis*, Skylark *Alauda arvensis*, Pied Wagtail *Motacilla alba*, Wren *Troglodytes troglodytes* and warblers. More unusual species have occasionally been seen such as Dunlin *Calidris alpina*, fairly regularly, and Semipalmated Sandpiper *Calidris pusilla* in 1980 and Pectoral Sandpiper *Calidris melanotos* in 1985, both Lundy rarities (Tim Davis, pers. comm.).

KP continues to thrive in both its dry and wet phases. It provides a valuable resource to spring and autumn migrant birds and one of the few places where Chaffweed can be reliably found. It too has flatworm species unique to Lundy ponds in *Dalyelia viridis* and *Rhynchosostoma rostratum*.

Hover flies *Syrphidae* are common on Lundy. An early informal survey of KP recorded many Syrphidae larvae, rat-tailed maggots, but subsequent surveys have not recovered any examples. The larvae are known to prefer dirty and polluted waters. KP would seem to no longer be a suitable habitat.

Both these ponds whilst temporary are long-lived, GHP since at least 1870 and KP since 1852, and provide special habitats particularly for flora as well as freshwater fauna.

CONCLUSION

Compared to permanent ponds, temporary ponds are host to a smaller number of species which may be less common that those in permanent ponds. They also provide habitats for more common species that disperse from more permanent ponds once they have attained adulthood. Temporary pond specific species typically have a short life cycle – although any extended wet season allows predators to migrate into temporary ponds to take advantage of this life. This can be seen in KP when surveys late in the wet phase finds ranging Coleoptera and Hemiptera, Heteroptera taking advantage of the abundant prey in its waters. GHP has not attracted these predators but does provide an additional valuable habitat to molluscs and to the flatworm *Phagocata vitta* that has not previously been recorded on Lundy.

In 2010 GHP had completely filled in with only a few millimetre deep puddles on an infilling of mud and debris. The Lundy Conservation Team asked for advice on restoring GHP. It would appear that clearing out the silt was not a disastrous decision since almost all species have returned. It is one of the few ponds in which Mollusca occur and is an additional reservoir of this family. The difference in fauna of the two ponds can be accounted for by the substratum and cover. GHP is bounded by granite cliffs and heavily shaded by overhanging trees making it less obvious to flying insects than the open weedy location of KP.

In late autumn, both ponds benefit from increased rainfall and begin to fill. This stimulates the aestivated adults of group 1 species to emerge into the water where they complete their life cycle in a staggered sequence. Group 2 species having mated then see this newly formed water body as an attractive place in which to lay their eggs. They are followed by Group 3 species which have been dormant and are now ready to either hatch from or develop into adults from larvae. Group 4 species identify these bodies of water teeming with life as potential hunting grounds until summer dries it up and the cycle repeats.

These two temporary ponds have survived since 1852 and at least 1870 with minimal intervention. The original deepening of KP carried out by destruction of the Kistvaen (Ternstrom, 2000) gave it its current shape and depth. Any attempt to deepen it, for example to make it more attractive to waders, is impractical as the bedrock is mere centimetres below the soil level and would never retain water longer than it does now. The excavation and subsequent natural filling of GHP proved to be successful with almost all species returned. Originally it was thought that the excavation had caused it to leak, but subsequent surveys proved this to be a temporary pond which has its wet and dry phases.

Both ponds are doing well providing a home attractive to species that depend on temporary waters and benign neglect should continue to ensure their future.

ACKNOWLEDGEMENTS

Thanks to Jenny George and Brenda McCarthy Stone for permission to use their early survey data and mapping information on Kistvaen Pond; to Dean Woodfin Jones, Lundy Warden, for his help in obtaining a licence from Natural England to survey

ponds and to take core samples from Kistvaen Pond and Government House Ponds; and to my colleagues in the Lundy Field Society, Andrew Cleave, John Hedger, Tim Davis and Tim Jones for searching their databases for plants, fungi and birds that are part of Kistvaen Pond's flora and fauna.

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