Groundwater inputs to the coastal zone of South Galway and Clare, west coast of Ireland

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Introduction

Submarine groundwater discharge (SGD) is now recognised as a significant source of nutrients and contaminants to coastal waters(1-6). In some regions, the magnitude of fluxes from SGD are comparable to riverine fluxes. So far however, they are not taken account of when measuring fluxes to coastal waters under the EU Water Framework Directive. This poster presents results from an on-going study of SGD along the west coast of Ireland by researchers at NUI, Galway, funded by a Millennium grant from NUI, Galway and subsequently by the Geological Survey of Ireland (GSI) under the Griffiths Programme.

Kinvarra bay is surrounded and underlain by the Burren karst limestone(7). There are no surface water flows into the bay, due to the porous nature of the karst and the thinness of the soil cover in the area (Fig. 1, box outlines Kinvarra Bay) The poster background shows the Burren hills, and in the foreground, rafts and boats belonging to local fisherman Rainier Krause, who very kindly gave us permission to use them for our study in the bay.

Methods

Two Microcat conductivity-temperature-depth loggers were placed in Kinvarra bay from Nov 2006 to Jul 2007, recording at 10 minute intervals. Each was hung 1m below a floating raft placed in the bay for rope mussel cultivation. As the rafts rise and fall with the tide, the Microcats were maintained at ~1m depth at all times (Fig.1a-c). They were recovered approximately once a month, downloaded, and returned to the water. Discharge rates were calculated using the tidal prism method (see below). Samples of water from 2 groundwater resurgences flowing directly into the bay were taken over the winter and analysed for nitrite, nitrate and phosphate using a flow injection analyser (Lachat FIA QC8000). Nutrient fluxes were calculated as discharge x concentration. (Table 1). Effective rainfall data are from NUI Galway, northwest of Kinvarra, and from Mellowes College, Athenry, inland in the catchment.

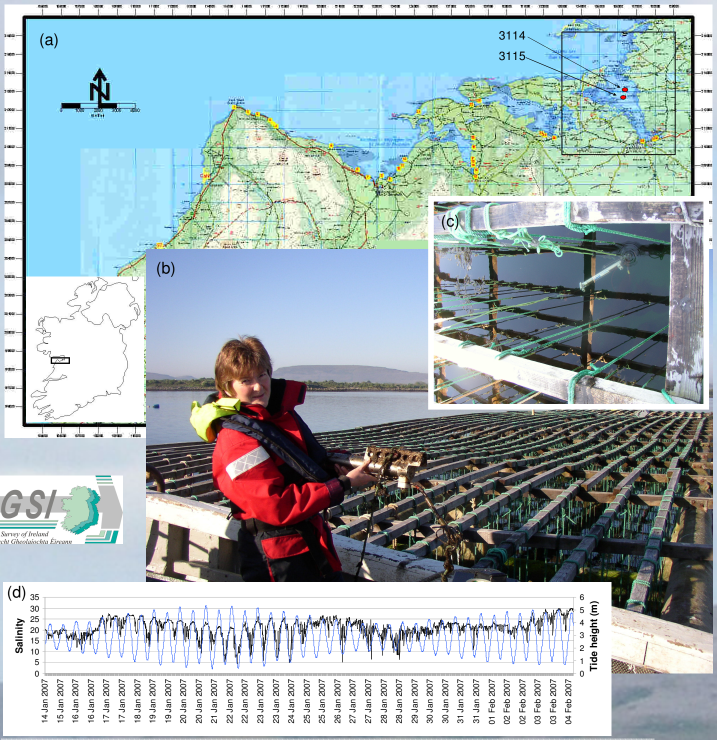

Fig. 1 (a) Location map of known groundwater resurgences on the southern Galway Bay coastline. Box outlines Kinvarra Bay, with Microcat positions
(b) Microcat being deployed from a raft for rope- mussel aquaculture
(c) Downward looking view of Microcat hanging ~1m below the water surface
(d) Example of correspondence between tide height and salinity

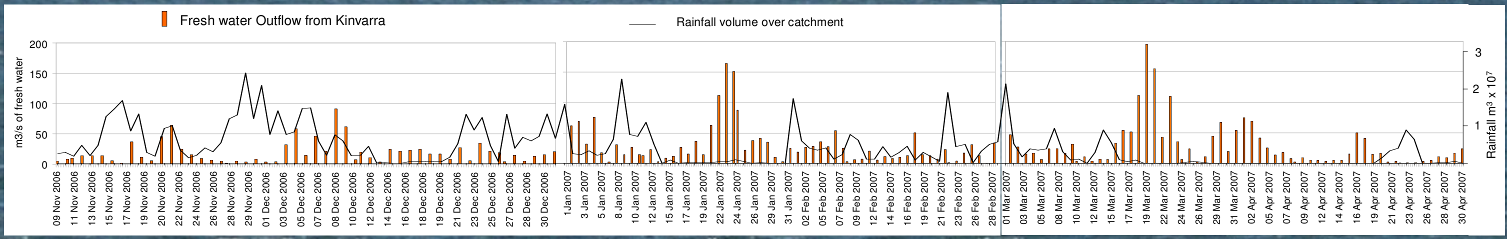

Fig. 2 Calculated fresh water outflow per day (2 ebb tides) from Kinvarra Bay (columns). Daily rainfall volumes calculated from stations at NUI Galway and Athenry (black line).

Calculation of discharge using the Tidal Prism

Data from Microcat 3115 was used to calculate the fresh water outflow from the bay, using the tidal prism method, where Vprism = Area x height

Vprism = vol of water removed from the bay on a falling tide in m3
Area = the surface area of the bay in m2
Height = the height difference between high tide and low tide in m
Proportion of fresh water in the tidal prism = 1- Sprism/Ssea

The salinity observed at high tide on each tidal cycle (Fig. 1d) is taken to represent the salinity of seawater entering the bay from outside, **Ssea**. This takes into account that some of the outgoing brackish water will be returned on the incoming tide. The average of high and subsequent low tide salinity values is taken to be the salinity of the tidal prism, **Sprism**. The volume of fresh water removed on each ebb tide is then calculated and each pair of tides for a day is summed, then divided by 86400 to get an average flow in $m^3 s^{-1}$ for each day. For other methods of calculating submarine groundwater discharge see (8).

Table 1: N and P concentrations and loads from the two principal known resurgences in Kinvarra Bay. The loads are calculated from their averaged concentrations. Between them, these resurgences account for a discharge of ~10m³/s.

Table 1		Castle	Arch	Average	Castle	Arch	Average
	Flow	(NO_2+NO_3)-N	(NO_2+NO_3)-N	(NO_2+NO_3)-N	PO_4-P	PO_4-P	PO_4-P
Date	m^3/s	µg/L	µg/L	kg/d	µg/L	µg/L	kg/d
09/11/2006	8	3377	1166	1579	10.9	30.7	14
21/11/2006	64	5478	2442	22050	20.7	18.2	108
21/12/2007	27	3100	938	4754	5.51	9.04	17
10/01/2007	15	2900	1080	2562	5.7	8.74	9
18/01/2007	37	2870	1020	6180	7.89	9.86	28
25/01/2007	22	2680	1050	3605	6.27	8.72	14
31/01/2007	25	2520	722	3534	4.96	9.19	15

Results

Due to natural storage in the catchment in turloughs and subsurface, the restricted nature of groundwater outflow, and the range of conduits active at different water table levels, the daily volumes of fresh water discharge do not closely follow the rainfall pattern. Rainfall minus evaporation data give an expected average discharge from the catchment of ~30$m^3 s^{-1}$. About 8$m^3 s^{-1}$ are accounted for by man-made surface rivers entering the sea in the northern end of the catchment. The average discharge calculated by the tidal prism method for Kinvarra Bay for Nov-June is 22$m^3 s^{-1}$. This indicates that the bay is the focal point for a significant proportion of the total discharge from the catchment, and will therefore bear the brunt of any nutrient or contaminant input. The nutrient concentrations measured so far indicate that the load of Nitrogen (as NO_2 and NO_3) entering the bay (and exiting it in winter) is of the order of several tonnes per day, while the Phosphate load is a few tens of kg per day. Related work indicates that ammoniacal-N loads are comparable to the oxidised nitrogen loads.

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