# AN ASSESSMENT OF WATER QUALITY DATA FROM KILKIERAN BAY, CO. GALWAY

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## ABSTRACT

A programme monitoring water quality was carried out at 11 sites in Kilkieran Bay, Co. Galway from 1984 to the 1998, for the most part. Continuous monthly readings were recorded at 5 of these sites. Three sites were sampled for temperature, salinity, nitrate, nitrite and phosphate. Three replicate samples were taken at each sampling event. While salinity remained relatively stable throughout, temperature varied considerably between winter and summer months (e.g. Lettercallow, 3.5-18.5ºC), at each of the sites. Nutrient levels were highest in winter months at all sites. The innermost sites tended to have lower salinities and lower nutrient levels. However, there were no statistical differences in nutrient levels among the sites and from year to year. These findings suggest that there was no appreciable increase (or decrease) in nutrient loading within Kilkieran Bay. It is recommended that sampling within the bay is defined according to the broad geographic regions outlined and that intensive sampling was not necessary.

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## INTRODUCTION

The annual production of farmed salmon in Ireland has risen from 21 tonnes in 1980 to an annual harvest of approximately 14,025 tonnes in 1996. As part of the operational Programme for Fisheries, the government had targeted 2,000 sustainable jobs with £90m per annum increase in exports by 1999.

Salmon production in Kilkieran Bay has evolved since the early 1980's. The bay itself supports a mixture of aquaculture activities including salmon, shellfish cultivation, seaweed harvesting, wild shellfish management and small inshore fishing activities. It also includes areas of special scientific interest, which are to be proposed as National Heritage Areas (NHA) by the National Parks and Wildlife Service. Thus, there is a wide variety of maritime interests in the Kilkieran Bay area.

During the early years of salmon farming in Kilkieran Bay there was continuous production with overlapping generations, which lead to higher biomasses than licensed tonnages. However, a system of 'Single Bay Management' practice has been widely adopted in the bay involving fallowing, single generation sites, agreement on stocking and synchronisation of lice treatments and harvesting programmes.

Licensed tonnages permit a production of 4,000 tonnes to be produced in the greater Kilkieran Bay area on an annual basis. However, because of such factors as economic viability, the requirement to fallow and the need to prevent overlapping generations, many sites have written permission from the Department of the Marine to double their licensing tonnage and produce fish every alternative year. This results in the possibility of exceeding the licensed tonnages in a given year while reducing the production tonnage below that of the licence permits in alternative years. In addition, a number of the smaller farms have been given permission by the Department of the Marine for a further 50 tonnes production capability on an annual basis. However, these additional tonnages do not generate a significant increase in tonnages in the Kilkieran Bay as a whole.

Currently there are 8 licensed salmon farm operators in Kilkieran Bay with sites ranging from inshore areas in the inner bay region to offshore sites such as Namacken Rocks. In effect, the 8 fish farm companies operate 17 sites, which vary in classification from fallow/smolt, production, harvest, to combinations of the above sites. The overall production of salmon in the 1995/1996 cycle was estimated to be 3,602 tonnes.

Intensive fish farming generates organic and inorganic wastes, which are released into the marine environment. In general, the recipient for the soluble waste is the water column and the recipient for the particulate organic waste is the sea bed or benthic environment.

Any measurable increase in the concentration of a dissolved nutrient has been defined as hypernutrification and any increase in primary production resulting from hypernutrification has been termed eutrophication (ICES, 1984).

Inorganic nitrogen cycle in the marine environment follows a path from ammonia through nitrite to nitrate due to oxidisation. In spring, algal growth utilises the nitrate and levels fall dramatically from late March onwards. Often in the summer months nitrate in the water column is depleted and is then a factor limiting algal growth.

When dead algal cells sink to the sea floor, they are degraded and nitrate is re-introduced to the water column through the above-mentioned cycle. In late autumn the levels of nitrate in the water start to climb as algal growths diminish and vertical mixing occurs. Nitrate also enters the marine environment in freshwater runoff from the land.

The release of soluble nitrogenous waste from fish farms could therefore stimulate phytoplankton growth when nitrogen is limiting growth. The potential for fish farming to bring about nutrient enrichment was reviewed by Gowen (1990). In general, the size of the farm and husbandry practice will determine the total amount of dissolved nitrogenous waste released by a farm but physical oceanographic processes such as the flushing rate of coastal embayments will determine whether or not eutrophication will occur.

The levels of phosphate in the marine environment show a similar cycle to that of nitrate. However, phosphate is not usually depleted by algal growth and is, therefore, not a limiting factor. Nutrient-rich, offshore water may enter bays such as Kilkieran Bay in times of low freshwater input, i.e. dry spells. This would be the usual cause of increased phosphate levels in inshore waters. Other sources are agricultural runoff and sewerage.

Data collected as part of a monitoring programme water quality at salmon farms in Kilkieran Bay, Co. Galway was assessed by Gowen (1990). Analysis of the data was undertaken to determine whether there was any evidence that activities of fish farms had resulted in a change in the water quality of the water bodies in which they were located. The report concluded (Gowan 1990) that fish farming in Kilkieran caused no detectable changes in summer levels of dissolved oxygen, summer levels of phytoplankton biomass or in winter levels of dissolved inorganic nutrients.

Since the original environmental monitoring programme was implemented, the analysis of water quality parameters has been ongoing at a number of fish farm sites including those in Kilkieran Bay. The goals of the report are to:

1. Collate these ongoing monitoring efforts,
2. Assess the data statistically for any temporal or spatial trends and
3. Discuss the results with reference to fish farming activity in the bay.

## STUDY AREA

Kilkieran Bay is located in south west Connemara on the west coast of Ireland. It is almost 12km long and encompasses approximately 5,800ha comprising four major basins, the most northerly Leckin Basin, Roskeeda Bay, the outer Kilkieran Basin, Camus Bay at the eastern end of Gurraig Sound and Casheen Bay. The main channel connecting these basins runs along the western side of the bay with a single major outlet between Birmore and Dinish Island to the south.

Geologically, the bay is situated near the western end of the main Galway Granite batholith and has some minor intrusions of acidic rock. Glacial features include moraine material near Kilkieran village; more important are the roches moutonnées, which show the southerly movement of the ice. Minor coastal features, such as reefs and gullies in the rocky shores, small embayments, *etc*., are joint controlled, as are the slope and orientation of many offshore rocks. Some geographical features, *e.g.* the long axis of the bays, may similarly reflect joint or possibly fault control.

No large rivers flow into the bay but the hinterland holds a quantity of small lakes many of which feed into the bay by means of small local streams. Salinities are generally between 30 - 35S, but during prolonged rainfall, freshwater run off from surrounding land can reduce surface salinities in the inner reaches of the bay to 26-27S (Wilson, 1987).

The volume of water at low water in the inner bay, that is the area contained by a line drawn between Birmore and Dinish Islands, is estimated as $2.61 \times 10^8 m^3$. The tidal prism increases this by about 50% at mean high water. Mean spring and neap tidal ranges are *c.* 4m and 2m, respectively. Depths are generally between 2-10m, with the bottom gently shelving to 25m at the mouth. There are a number of deeper holes located within the bay, the deepest, at depths of *c.* 40m are located between Ardmore Point and Illaunmaan and in the Gurraig Sound. In general, current movement in the bay is related to the topography of each channel and embayment. The waters of the extensive inner reaches of the bay are renewed by tidal movement through a series of narrow and steep-sided channels such as Gurraig Sound, which have strong linear currents for much of the tidal cycle. In the outer bay, current movement is generally weaker, the extent of movement again dependent on the hydrodynamic processes particular to each bay. However, the outer region is exposed to the prevailing south-westerly winds and experiences pronounced turbulence in stormy weather. This movement is reflected in the deposit substrates on the sea floor, which show marked effects of oscillating water movement in the form of ripples and dunes.

Hydrographically, Kilkieran Bay can be divided into an upper and lower bay with the dividing line being between Lettermore Island on the east and the area of Kilkieran Point to the west. The upper bay water is typically colder and less saline in the winter months than the lower bay water. The seasonal temperature range is more extreme inshore than off-shore and occasionally very low temperatures of around 2°C have been recorded from the upper reaches of Kilkieran Bay in winter. Off-shore winter temperatures are more stable and higher at around 8°C. In late March, water temperatures increase at the surface and the temperature of the shallow bays rises faster than that of the deeper waters. As this heating continues, the surface layer becomes warmer relative to deeper waters and a vertical temperature difference of 4-6°C occurs beyond the Skerd Rocks. The deep colder water occasionally extends into the entrances of the bay. From July onwards the vertical temperature differences decrease as the bottom water warms up and the colder water retreats further off-shore. Seasonal maximum temperatures occur in August and vary from 15-18°C off-shore and are warmer inshore (Roden *et al.*, 1987). Large temperature differences between the upper and lower bay indicates slower water exchange.

In general, Kilkieran Bay is a poorly mixed bay with lower nutrient levels and lower salinities in the northern part of the bay as described above and higher salinity, more nutrient rich water in the south.

## SAMPLING, ANALYSIS & DATA INTERPRETATION

A full list of the sampling locations and the years in which they were sampled are presented in Table 1. The raw data collected at each site are available from the Marine Data Centre. Of the 11 locations sampled only five returned sufficient data for the calculation of winter means according to Gowen (1990). The five sites can be divided into three located in the more open waters of Kilkieran Bay and two located in semi-enclosed bays. These areas are:

1) Ardmore Bay, located on the south western end of Kilkieran Bay where salmon farming has been ongoing since 1984.
2) Casheen Bay where samples were taken to the north of the salmon farm location.
3) Between Illaunmaan and Illauneeragh with the former island name used as the station name.
4) Knock Bay where salmon farming has been ongoing since the late 1980's.
5) Lettercallow Bay where salmon farming has been ongoing since the mid 1980's.

| SAMPLING LOCATION | DATES SAMPLED |
|---|---|
| Ardmore Bay | 1984 - 98 |
| Illaunmaan | 1984 - 89 |
| Namacken Rocks | 1990 - 97 |
| Illauneeragh | 1986, 88 - 94 |
| Lettercallow Bay | 1986 - 92 |
| Knock Bay | 1987 - 92 |
| Casheen Bay | 1986 - 94, 96 - 98 |
| Inner Casheen Bay | 1990 - 97 |
| Inishbarra | 1996 - 98 |
| Gurraig Sound | 1986 - 90 |
| Annaghavaan | 1986 - 90 |

**Table 1.** Sampling was carried out biweekly during warmer months (April-September) and monthly thereafter.

The variables measured in the present study were: temperature (°C), salinity (S), nitrate ($NO_3$), nitrite ($NO_2$) and phosphate ($PO_4$). Samples taken at depth were retrieved using a National Institute of Oceanography (N.I.O.) sampling bottle. Temperature readings were taken using a mercury thermometer and salinity using a salinity bridge. Nutrient samples were analysed by the Central Marine Services Unit at the National University of Ireland, Galway according to methods outlined by Strickland & Parsons (1972).

The statistical technique used to assess any temporal changes and spatial differences in dissolved inorganic nutrients was analysis of variance (ANOVA) combined with *post hoc* Tukey tests to highlight differences, if necessary.

Comparison of nutrient levels from different depths at the same station showed there were no major statistical differences in the overall trend between depths (see Figure 1, for example). Therefore, data on nutrient concentrations in samples from different depths were combined before analysis.
With respect to dissolved inorganic nutrients in inshore coastal waters, it was concluded that there were no grounds for assuming changes in any of these variables in a given year would influence the level in subsequent years (Gowen, 1990).

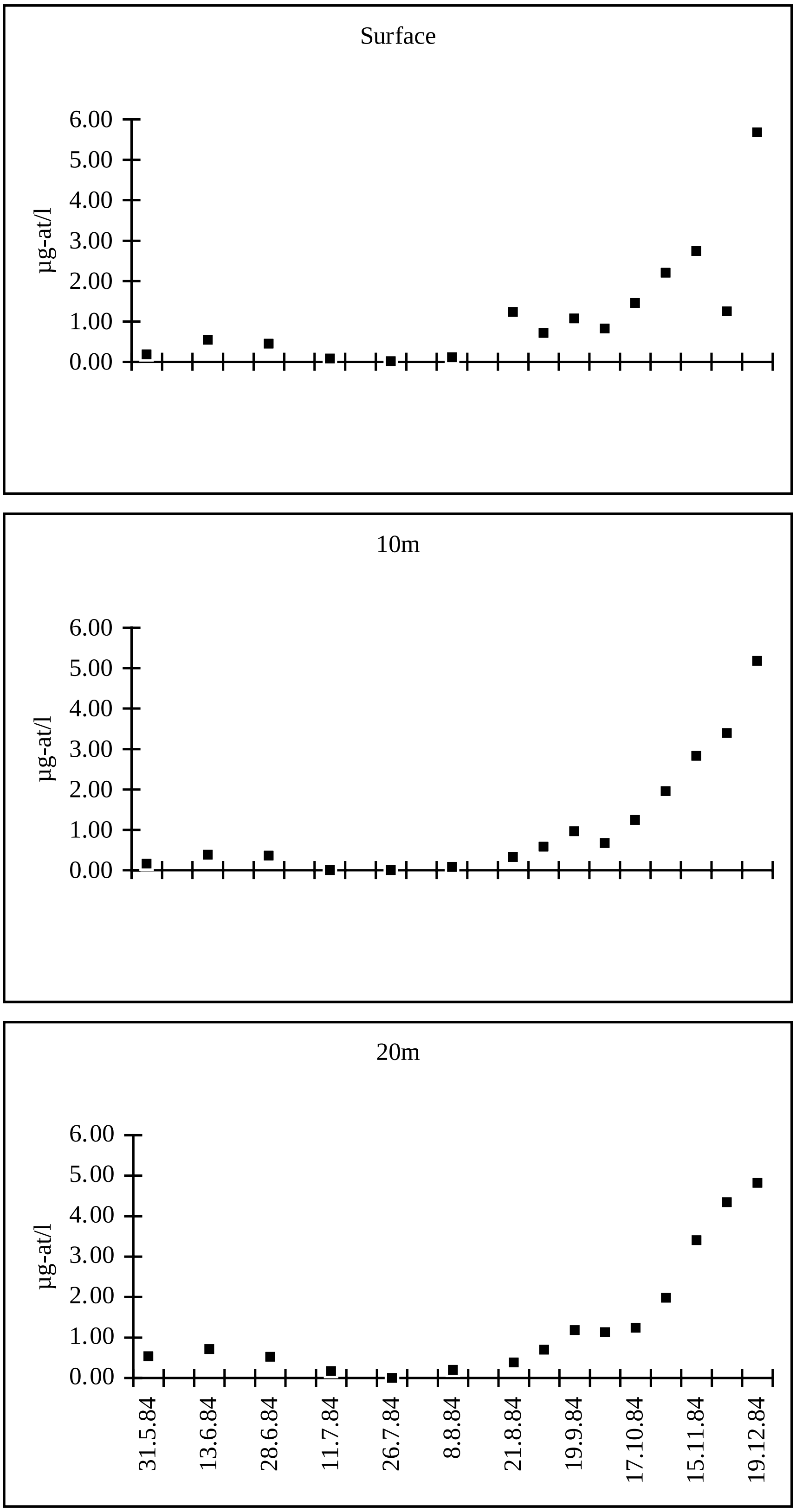


Figure 1. Example of comparison of concentrations of nitrate from three depths at Ardmore Bay in 1984.

Furthermore, analysis of variance assumes that the population or sample variance is independent of the population or sample mean. Where this is not the case, and variance increases with the size of the mean, logarithmic transformation of the data is necessary prior to analysis. With respect to nutrients, the need to log transform the data was assessed as follows: the data were separated into winter values for all nitrate (hereafter, this term refers to nitrate plus nitrite) and phosphate values for five stations. As previously mentioned, the five stations were chosen because of the availability of winter data according to Gowen (1990), i.e. from day 289 - 67 (Oct. 16$^{th}$-Mar. 8$^{th}$). The mean and variance for each data set was calculated and plotted graphically and the correlation coefficients (r) calculated, see Table 2. At three sites, Illaunmaan, Lettercallow and Casheen, the correlation was significant indicating that the variance increases proportionally with the mean. It was therefore concluded that logarithmic transformation of the nutrient data was necessary.

| **Site** | **r ($NO_3$+)** | **r ($PO_4$)** |
|---|---|---|
| Ardmore | 0.54 | 0.77 |
| Illaunmaan | 0.70 | 0.88 |
| Lettercallow | 0.71 | 0.69 |
| Knock | 0.19 | 0.043 |
| Casheen | 0.89 | 0.085 |

**Table 2.** Correlation coefficients estimated from the calculated variance associated with the mean.

# RESULTS

Nutrient results showed typical seasonal trends with higher values measured in winter and lower levels recorded during the summer months (Figs 2-10 in Appendix 1). During the winter there is little phytoplankton growth and regeneration of nutrients from sediments and the possible resupply of nutrients from deep, off-shore water result in nutrient levels reaching their annual maximum. Once the winter maximum has been reached there are generally only small fluctuations in the concentrations of nutrients in the winter. The data presented graphically includes those years for which the most complete annual cycle is available. For example, in the case of Lettercallow Bay, nutrients were measured in 1992. However, only three months data are available and thus are not presented.

Phosphate values did not vary as much as nitrate but the annual minimum values occurred similarly in the months of June and July with the exception of Casheen Bay where high concentrations were recorded in August of 1988 and March and April of 1989 and on one date in 1993 in Ardmore Bay.

The temperature and salinity are graphically presented for the five stations in Appendix 2. In general, salinities ranged from 30-35S and temperature ranged from 3.5°C (Lettercallow, 13.02.91) to 18.5°C. There were few differences between samples taken at the surface and those taken at depth indicating some degree of vertical mixing at the sites sampled in Kilkieran Bay.

## Temporal variation

After calculation of the winter means, the data were analysed to identify possible temporal changes. Temporal trends in the winter concentrations of both nitrate and phosphate are presented in Table 3.

The temporal variation at each location showed no significant statistical changes in the level of inorganic nitrate over time.

| | **Nitrate** | | **Phosphate** | |
|---|---|---|---|---|
| | F | p | F | p |
| Ardmore | 0.496 | 0.071 | 0.315 | 0.273 |
| Lettercallow | 0.712 | 0.183 | 0.700 | 0.195 |
| Illaunmaan | 0.596 | 0.295 | 0.022 | 0.972 |
| Knock | 0.085 | 0.085 | 0.779 | 0.126 |
| Casheen | 0.366 | 0.549 | 0.132 | 0.833 |

**Table 3.** Results of temporal analysis of mean winter data from five sites in Kilkieran Bay.

## Spatial variation

The log transformed concentrations for nitrate were compared by ANOVA to test for spatial variation. Each of the sites was compared against each other in a matrix comparison table and the spatial relationships were calculated, as presented in Table 4.
Certain sites had some substantial differences in nitrate levels, i.e. that of Lettercallow Bay with Ardmore Bay and Lettercallow Bay with Illaunmaan. In both cases the outer sites had higher concentrations of nitrate. A Bonferroni correction was utilised to allow for the number of comparisons made (i.e. 10). Therefore a significance level p=*0.005* was

selected. However, comparisons of nutrient levels did not yield any significant differences between the sites (see Table 4).

Of the water quality data available on Kilkieran Bay only one site could be compared with data collected outside the present study. Levels of nitrate (+ nitrite) recorded in the vicinity of Illaunmaan were 6.56µg-at/l in March 1978 and 6.21µg-at/l in March 1979. These levels compare similarly with data assessed in the present report from the same area, with levels of nitrate in March recorded as follows: 1985 - 6.6µg-at/l; 1986-5.08µg-at/l; 1987-4.67µg-at/l and 1988-3.07µg-at/l.

| **Comparison Sites** | **Nitrate** | **Phosphate** |
|---|---|---|
| Ardmore / Casheen | 0.757 | 1.000 |
| Ardmore / Illaunmaan | 0.992 | 0.996 |
| Ardmore / Knock | 0.147 | 1.000 |
| Ardmore / Lettercallow | 0.026 | 0.996 |
| Casheen / Illaunmaan | 0.522 | 0.949 |
| Casheen / Knock | 0.644 | 0.999 |
| Casheen / Lettercallow | 0.158 | 0.981 |
| Illaunmaan / Knock | 0.077 | 0.877 |
| Illaunmaan / Lettercallow | 0.013 | 0.725 |
| Knock / Lettercallow | 0.782 | 0.998 |

**Table 4.** ANOVA probabilities for inter-site comparison in Kilkieran Bay.

## DISCUSSION

There are many factors that may contribute to and regulate the concentration of inorganic nutrients in a given bay. Many of these variables, e.g. oceanographic processes, tidal state, prevailing wind, and freshwater runoff have been considered by various authors: Dooley, 1973; Roden, 1984; Morin *et al.*, 1985; Roden *et al.*, 1987; Gowen, 1990; Roden, 1994 and Roden & Raine, 1994.

As previously mentioned, Kilkieran Bay can be divided into two hydrographically different regions. The inner bay to the north of a line running from Lettermore to Kilkieran Point and the outer bay encompassing Namacken Rocks. The inner bay is generally characterised by lower salinities and lower nutrient concentrations while the opposite may be said of the outer bay (R. Raine, pers. comm.). The majority of sites examined in the present study are located in this outer area. According to Roden *et al.* (1987), the outer bays such as Knock and Casheen have a higher plankton concentration, a smaller range of temperature and salinity and better water circulation than the inner bays. Consequently, in a report to the National Board for Science and Technology (*loc. cit.*) is was suggested that cage fish culture and bivalve culture were more suited to this area.

Data from the present report show that there were no significant increases in inorganic nutrients that can be attributed to anything other than normal annual cycles. According to Roden & Raine, (1994) algal blooms require a source of inorganic nutrients. The blooms are largest at depth and diminish in concentration shorewards, so a nutrient source in terrestrial runoff is unlikely. Furthermore, Connemara is a region of oligotrophic bogland with little or no intensive agriculture or large towns or villages. A possible source is the nutrient-rich deep water below the summer thermocline. The fact that diatom blooms diminish when the nutrient-rich water retreats during summer supports this theory.

The differences between concentrations of nitrate in Lettercallow Bay and both Ardmore and Illaunmaan may be explained by the semi-enclosed nature of Lettercallow Bay resulting in lower concentrations than the outer sites. These outer sites may be experiencing an exchange of nutrients from the colder more nutrient-rich water, which is known to occur in the vicinity of Golam Head.

Given that the seasonal cycle of nutrients at each sampling station was typical of north temperate coastal waters and that no significant trends in the temporal level of nutrients were observed. It can be concluded that there is no indication that fish farming in Kilkieran Bay has caused any detectable change in the levels of inorganic nutrients. Comparison of 'pre-salmon farming' data and 'post-salmon farming' data from one site in Kilkieran Bay indicates that the levels are similar in concentration.

Results from other studies (Ervik et al., 1985 from N.C.C., 1989; Weston, 1986 from N.C.C., 1989; Gowen & Bradbury, 1987 and E.A.O., 1997) all report similar undetectable increases in dissolved nitrate from marine salmon farms.

## RECOMMENDATIONS

In general, the majority of salmon farming sites in Ireland are positioned in semi-exposed to exposed locations where tidal flushing and wind/wave induced surge are large. Given these considerable volumes of water and the concentrations of nutrients produced by fish farms, it is not surprising that there is no significant impact on water quality in Kilkieran Bay. However, the Scottish Environmental Protection Agency (SEPA) have indicated that elevated levels of dissolved organic nutrients in inshore, less exposed areas may have an effect on water quality (Anon., 1997). For this reason a limited water quality monitoring programme was recommended in Scotland taking into account farm biomass and hydrography of the site location. It must be pointed out, however, that water quality programmes will vary depending on the goals outlined for setting up such programmes. On the one hand, detection of farfield environmental effects will require monitoring of one set of parameters, while background water parameters required for various husbandry practices will need a further set of parameters to be monitored. Similarly the frequency of these sampling programmes will be guided by the specific goals of each monitoring programme.

As no significant impact on water quality could be discerned in Kilkieran Bay from the data assessed (1984-1998), it would appear that regular high intensity water quality monitoring is not required. However, if a water quality-monitoring programme is to continue, the following recommendations are suggested:

- Kilkieran Bay has been shown to operate as two distinct areas. It is recommended that one sampling station in each area be used as a monitoring location along with a third located in Lettercallow Bay.
- Parameters to be monitored are nitrate, nitrite and chlorophyll *a*.
- In specific locations it may be in the interest of the aquaculture operation to monitor parameters such as temperature, dissolved oxygen and toxic microalgae.

## ACKNOWLEDGEMENTS

The authors wish to thank Dr. Cillian Roden, Dr. Robin Raine and Mr. Duncan Browne for their help in collating water quality data and their advice in the production of this report.

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## APPENDIX 1

Seasonal Cycles of Dissolved Nutrients for five sites in Kilkieran Bay

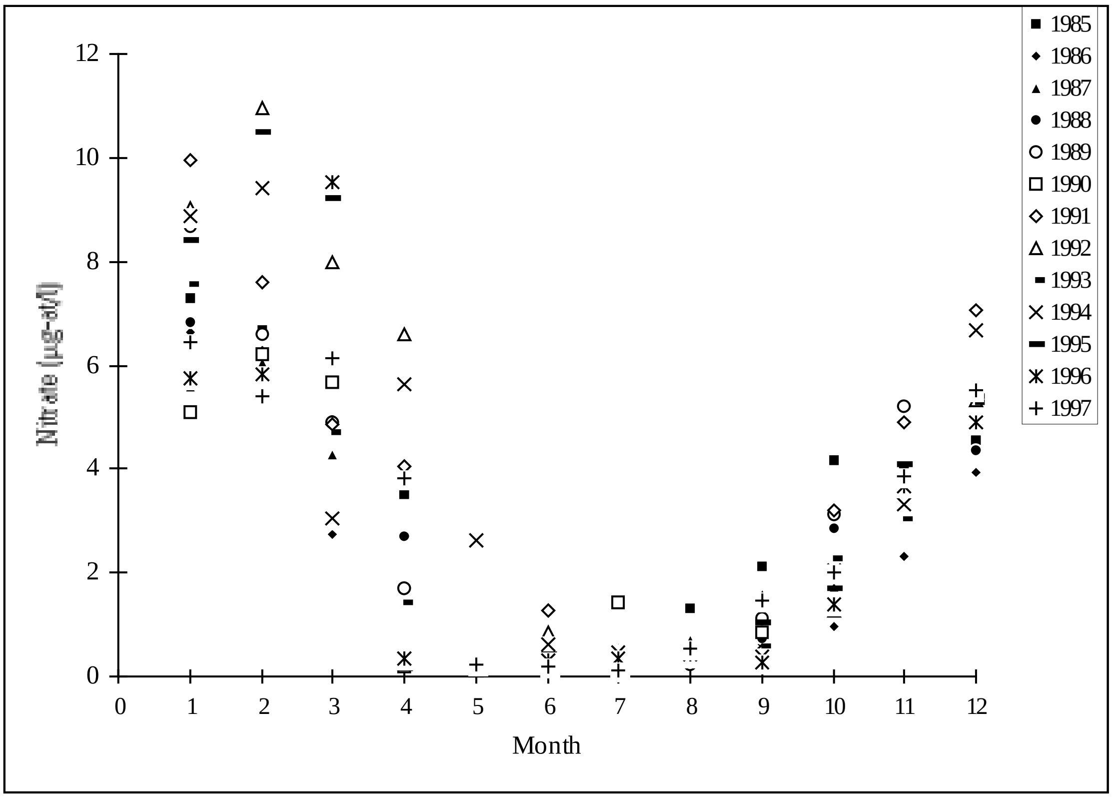



**Figure 2.** The seasonal cycle of dissolved inorganic nitrate (+ nitrite) in Ardmore Bay.

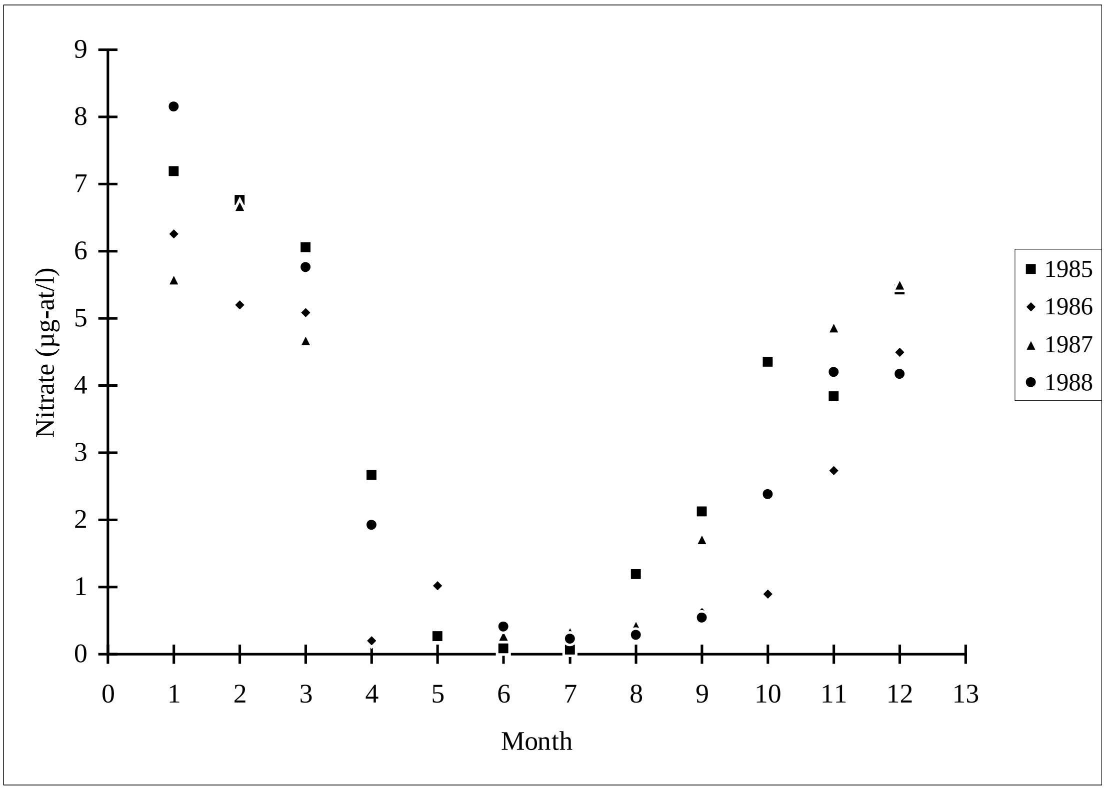



**Figure 3.** The seasonal cycle of dissolved inorganic nitrate (+ nitrite) in Illaunmaan Bay.

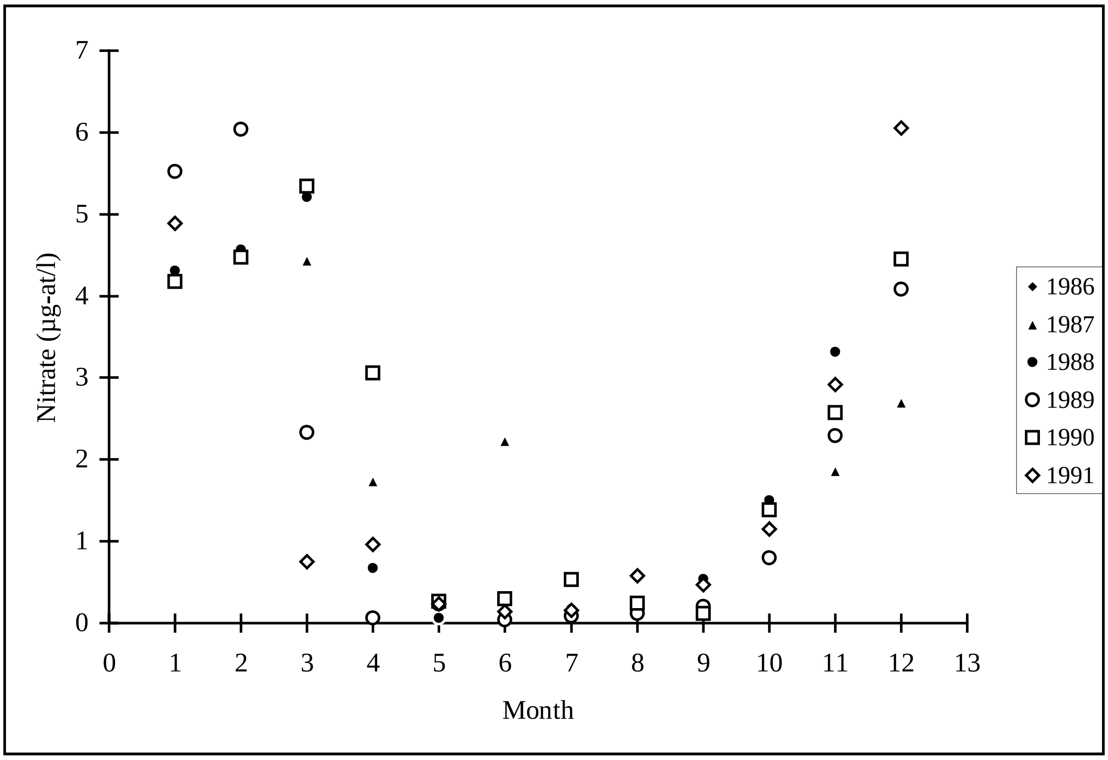



**Figure 4.** The seasonal cycle of dissolved inorganic nitrate (+ nitrite) in Lettercallow Bay.

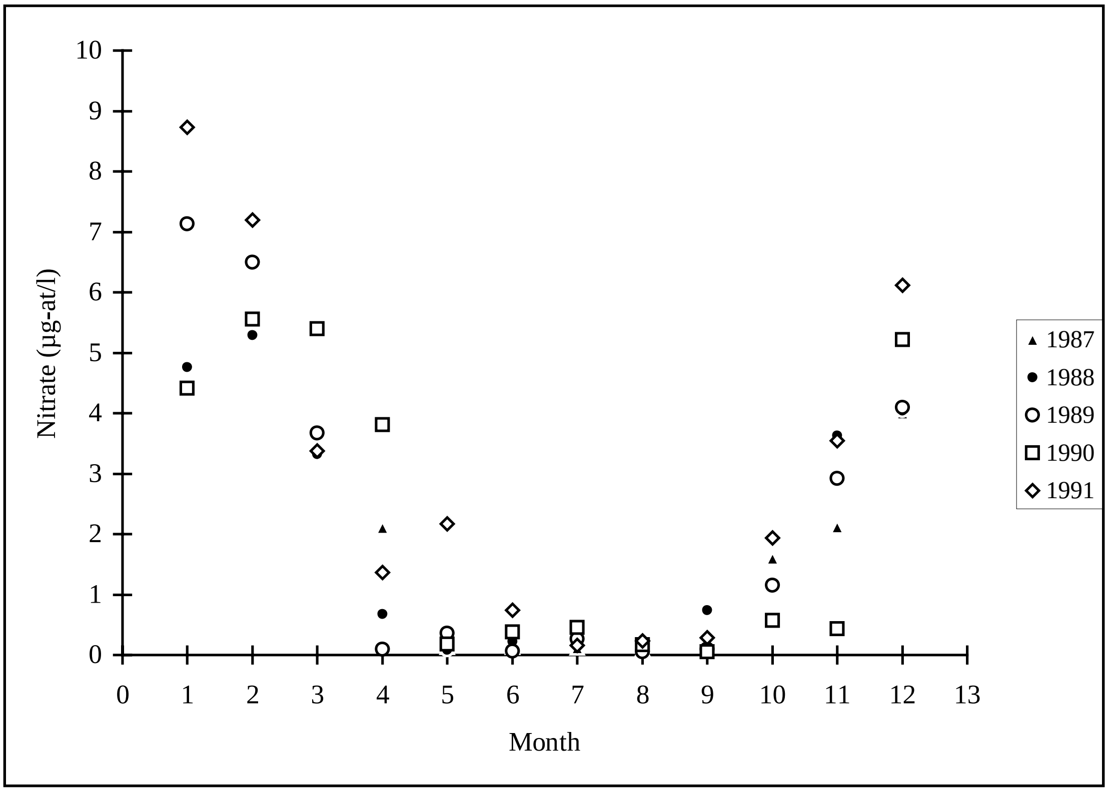



**Figure 5.** The seasonal cycle of dissolved inorganic nitrate (+ nitrite) in Knock Bay.

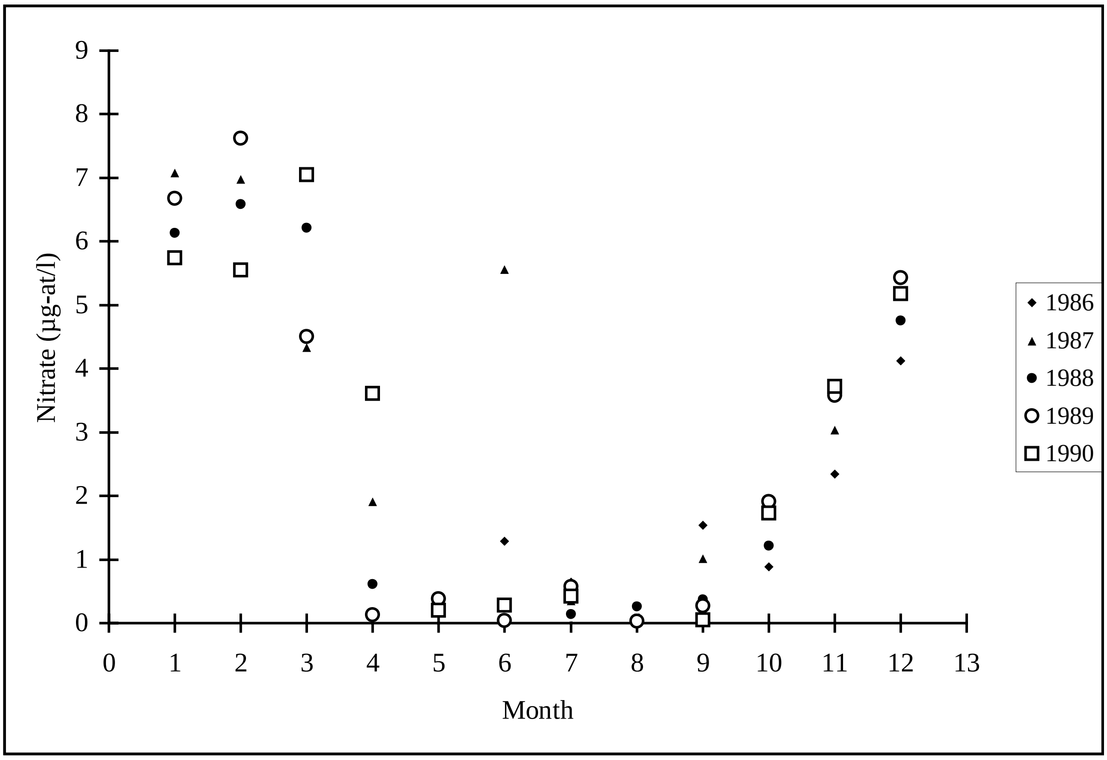



**Figure 6.** The seasonal cycle of dissolved inorganic nitrate (+ nitrite) in Casheen Bay.

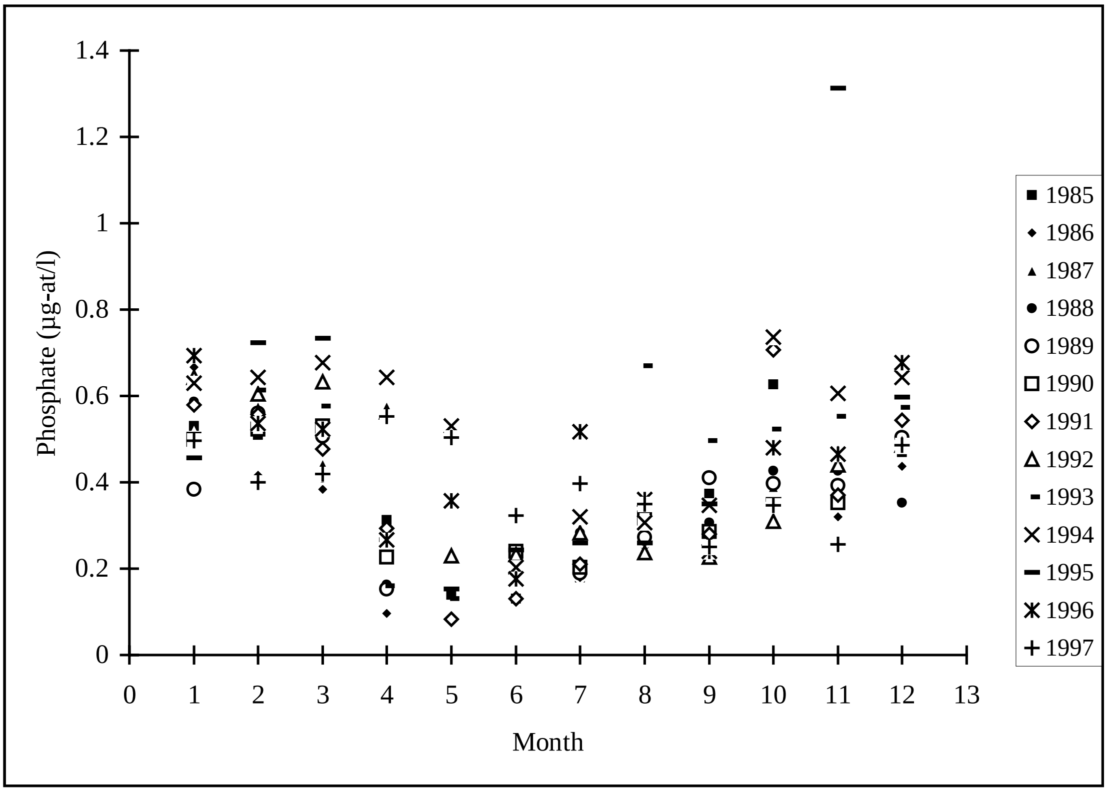



**Figure 7.** The seasonal cycle of phosphate in Ardmore Bay.

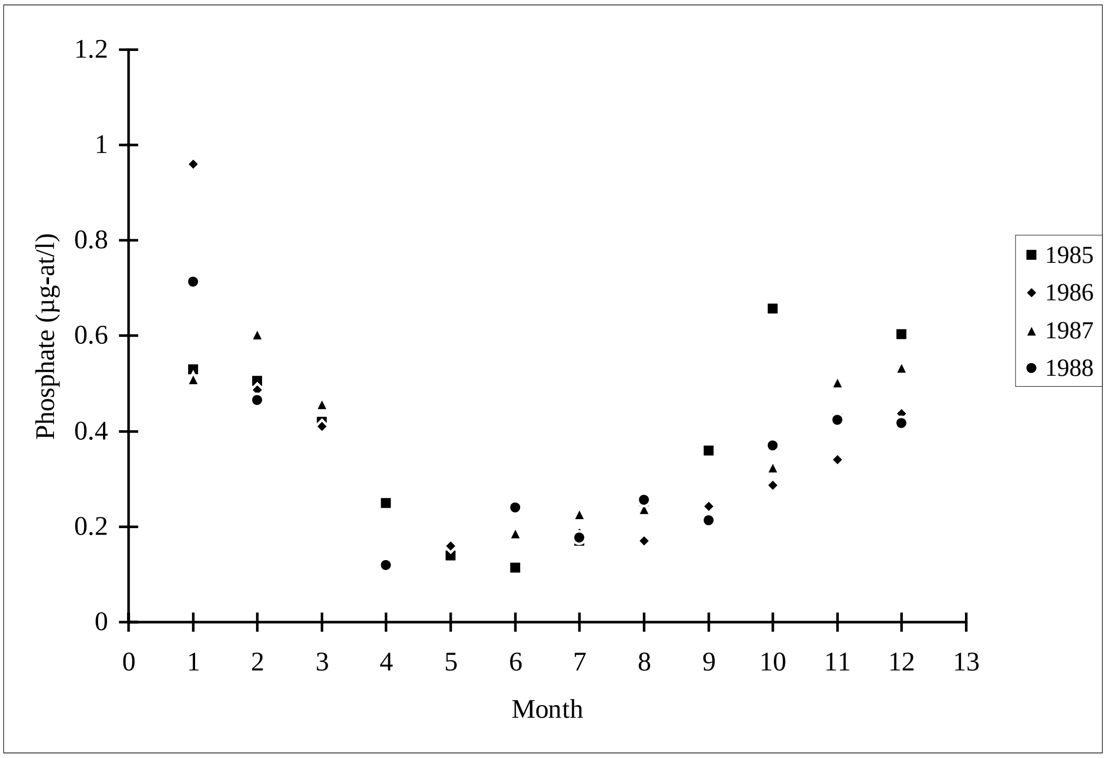



**Figure 8.** The seasonal cycle of phosphate at Illaunmaan.

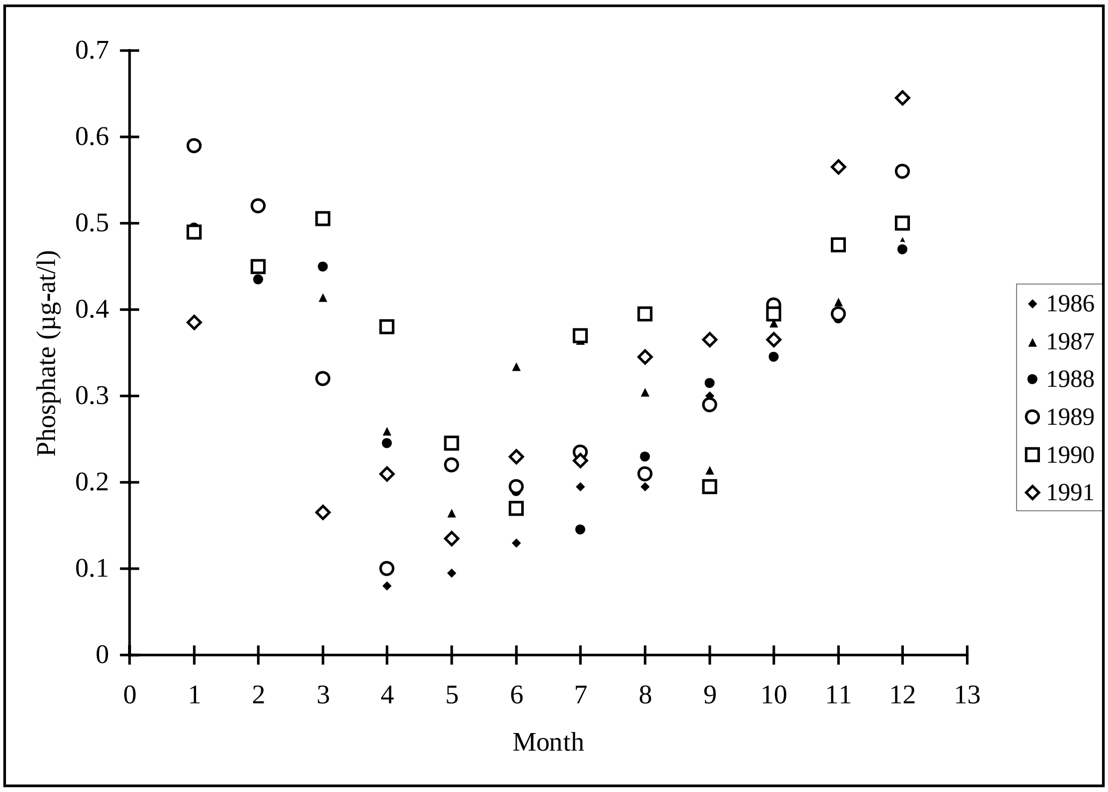



**Figure 9.** The seasonal cycle of phosphate in Lettercallow Bay.

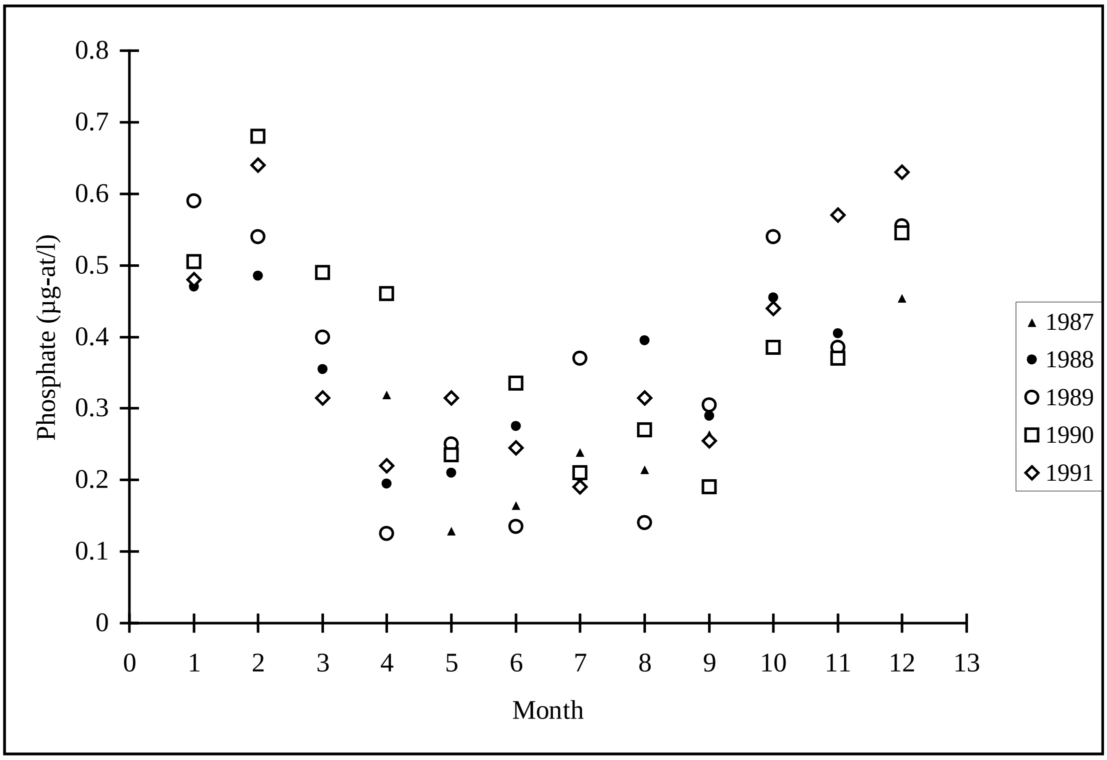



**Figure 10.** The seasonal cycle of phosphate in Knock Bay.

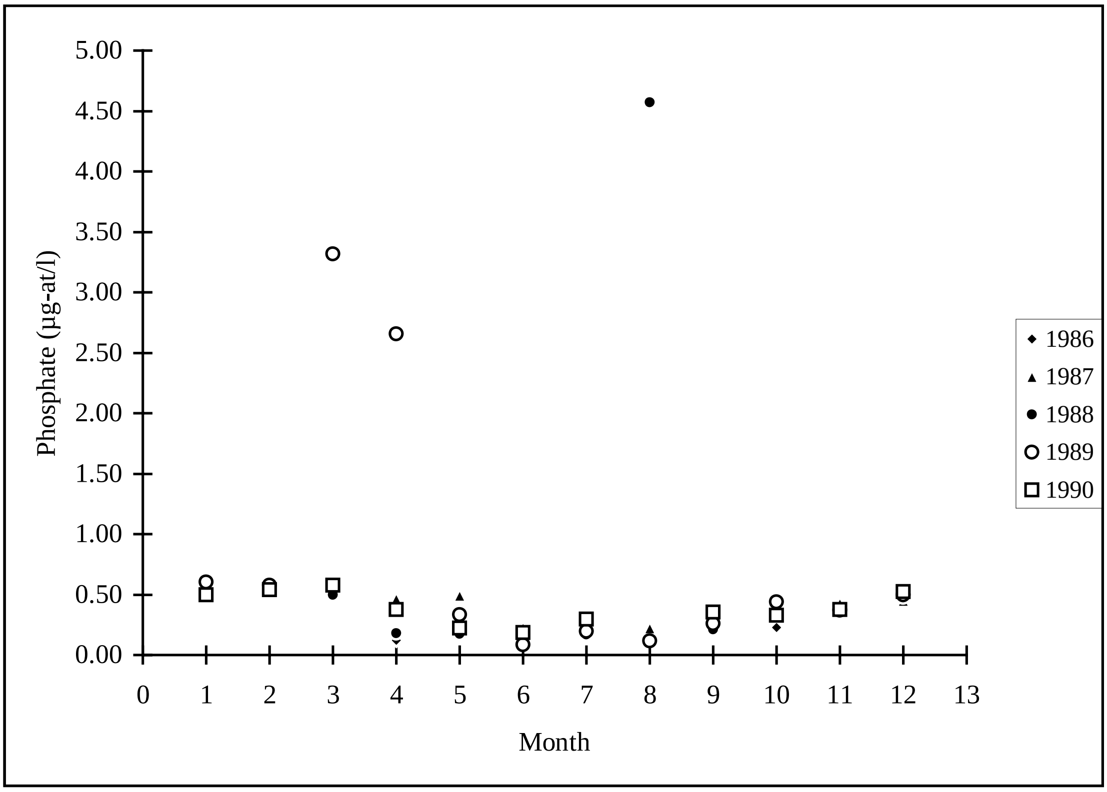


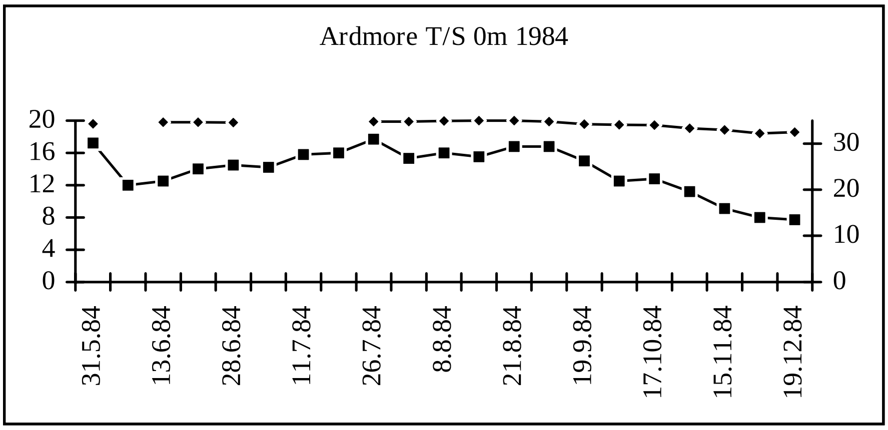

**Figure 11.** The seasonal cycle of phosphate in Casheen Bay.

## APPENDIX 2

Graphs illustrating Temperature & Salinity for five sites in Kilkieran Bay.

Temperature

Salinity


Ardmore T/S 0m 1984
20
16
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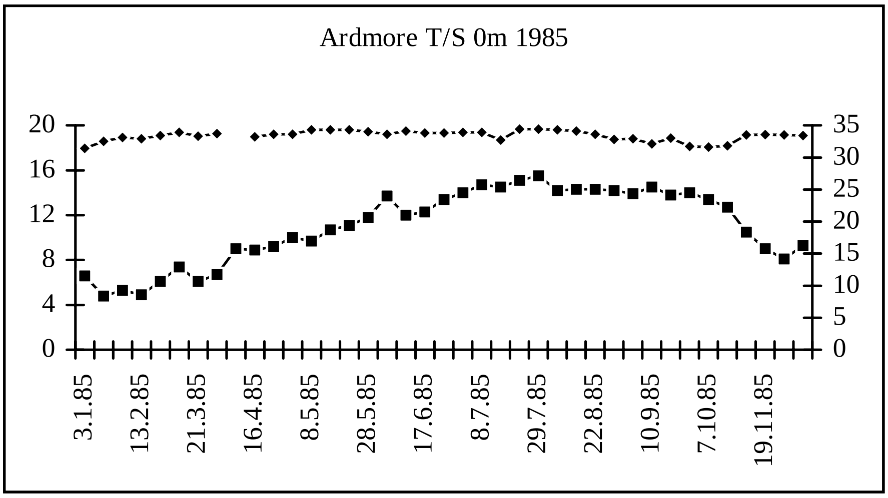
8
4
0
30
20
10
0
31.5.84
13.6.84
28.6.84
11.7.84
26.7.84
8.8.84
21.8.84
19.9.84
17.10.84
15.11.84
19.12.84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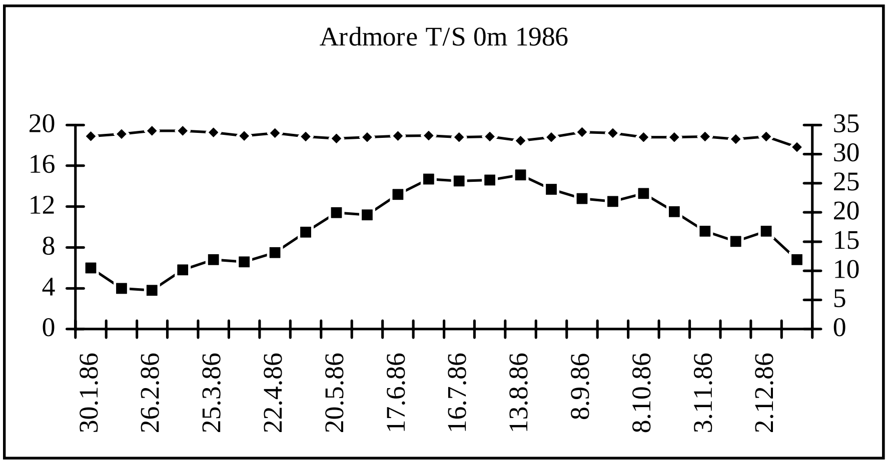
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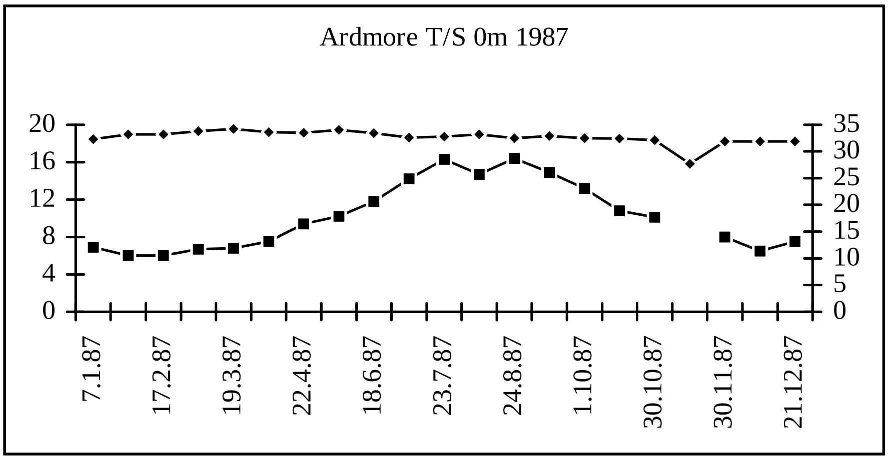
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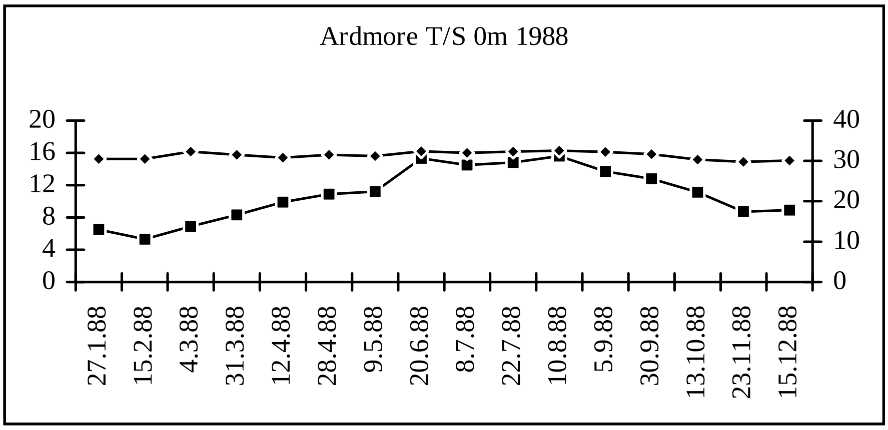
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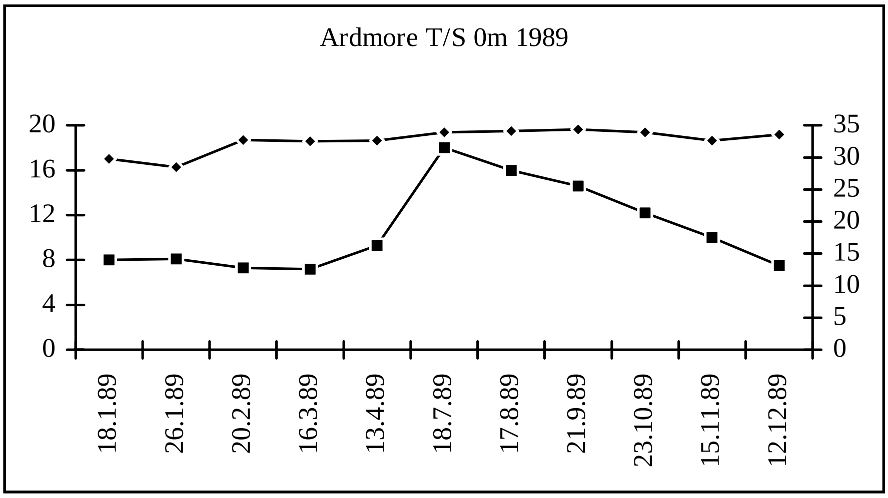
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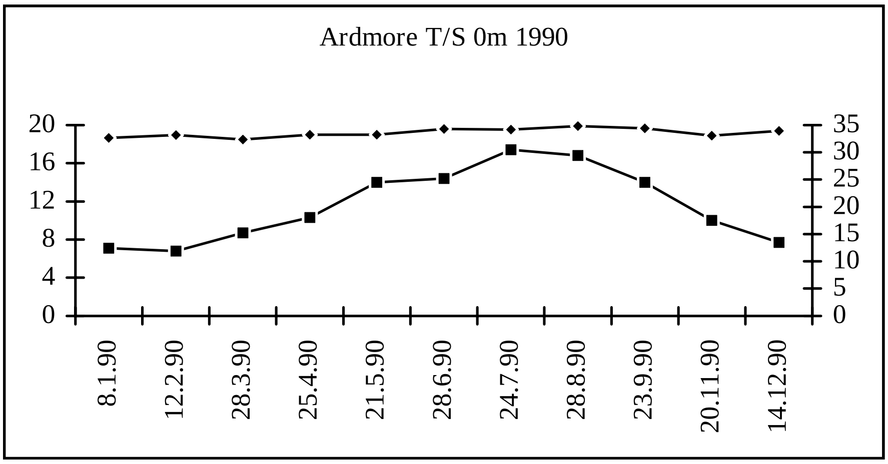
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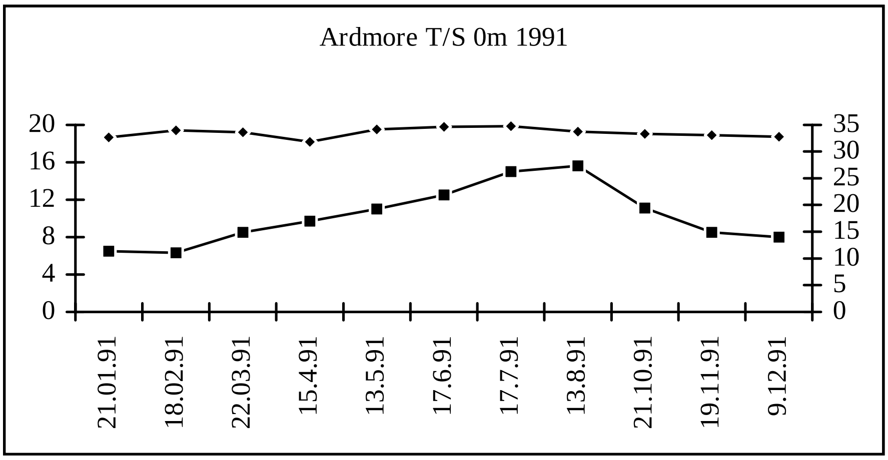
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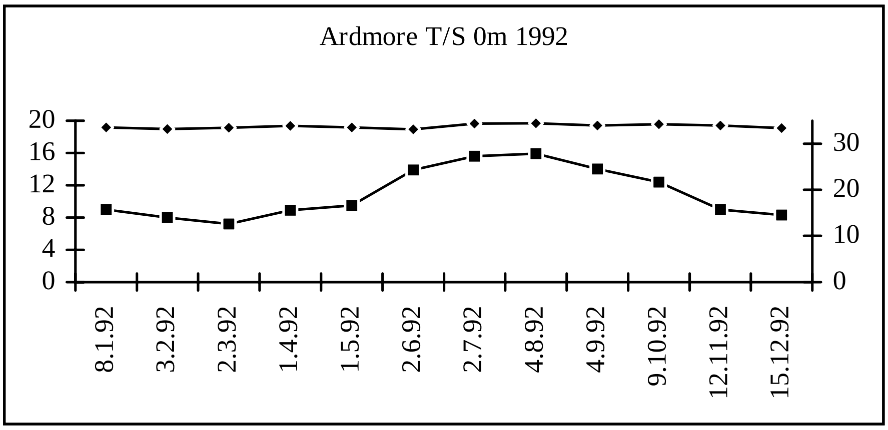
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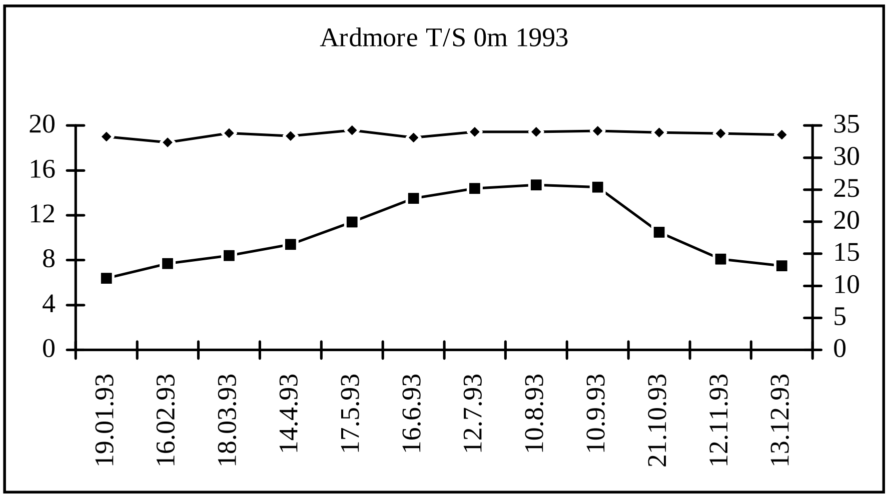
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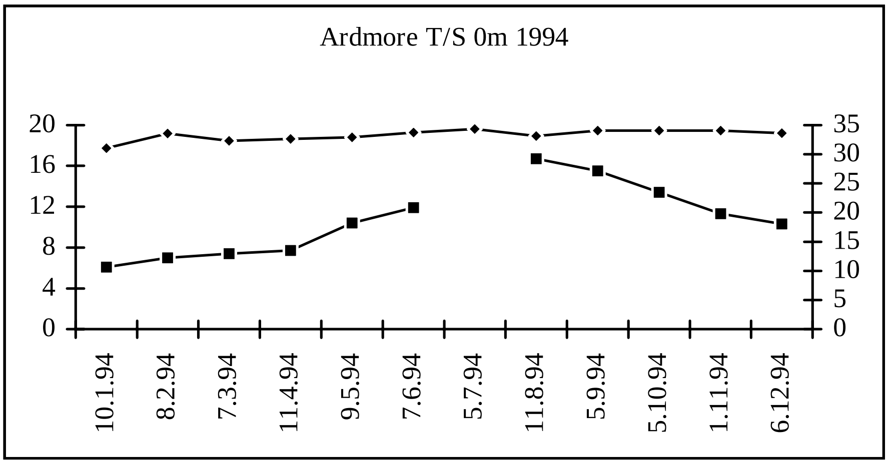
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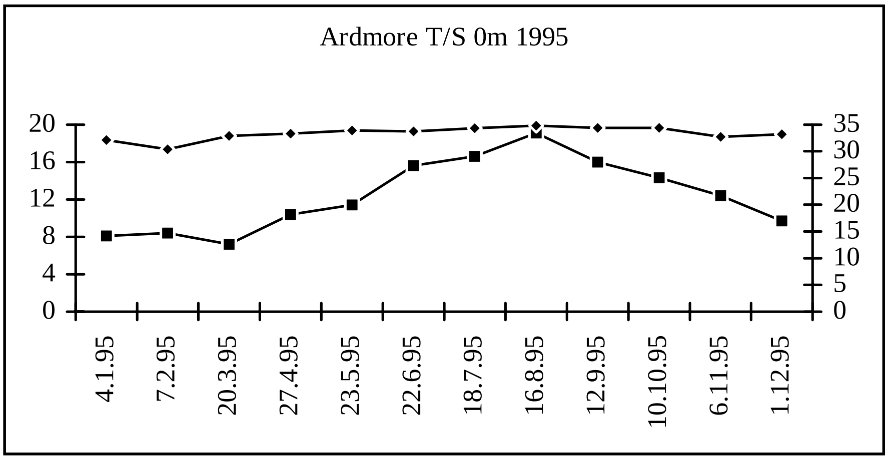
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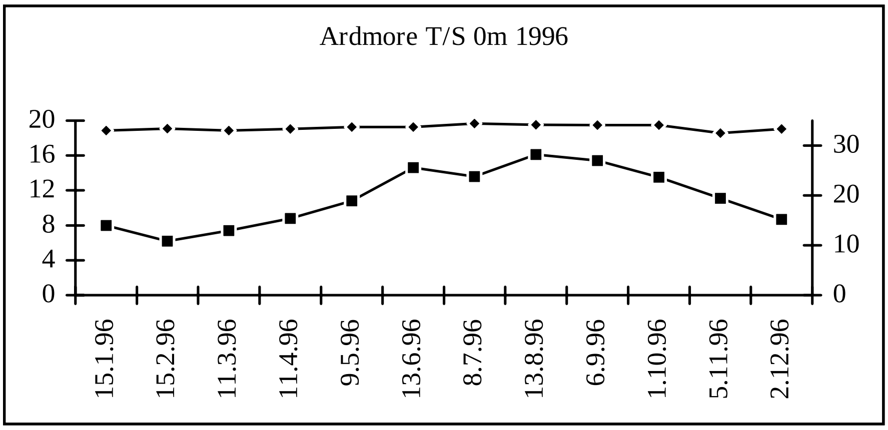
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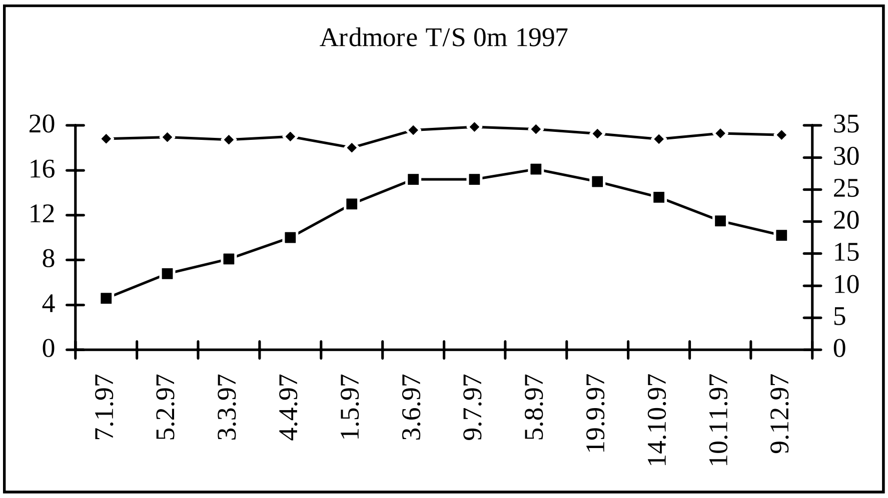
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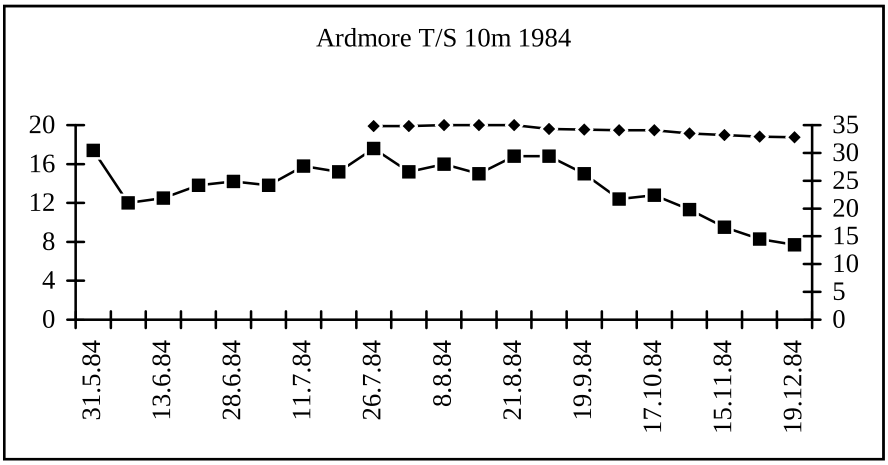
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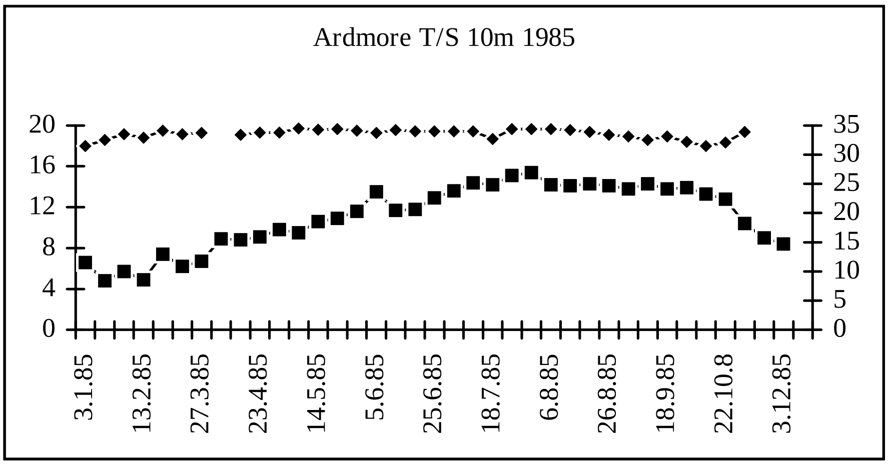
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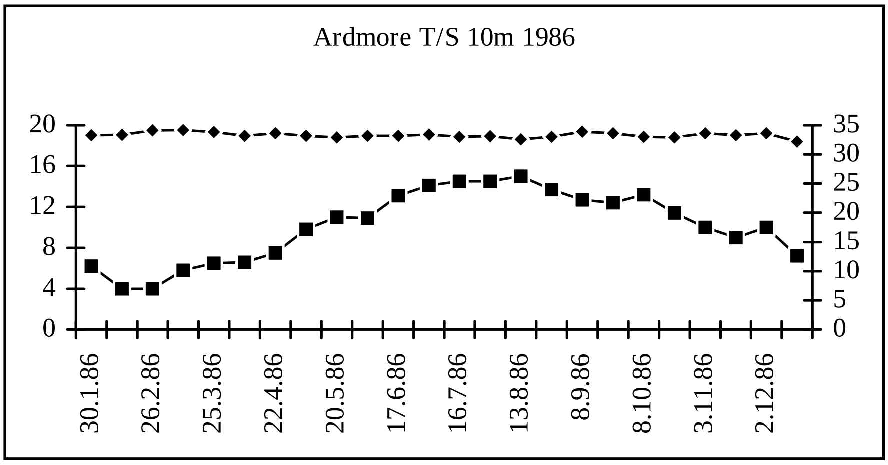
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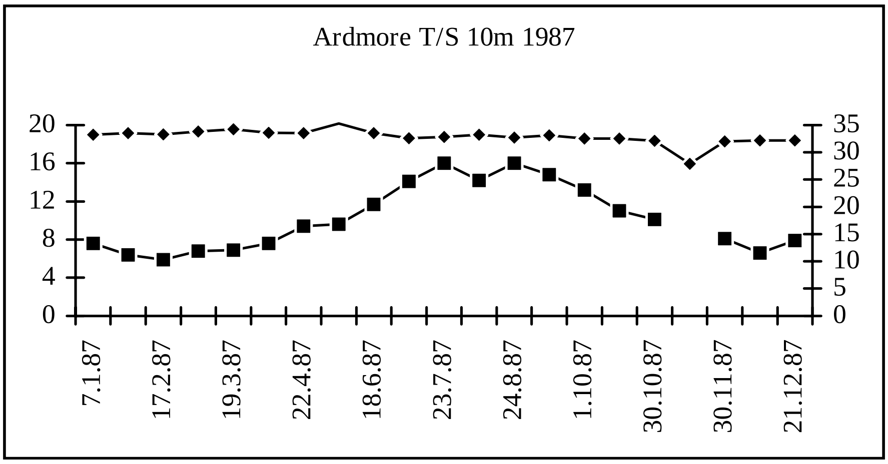
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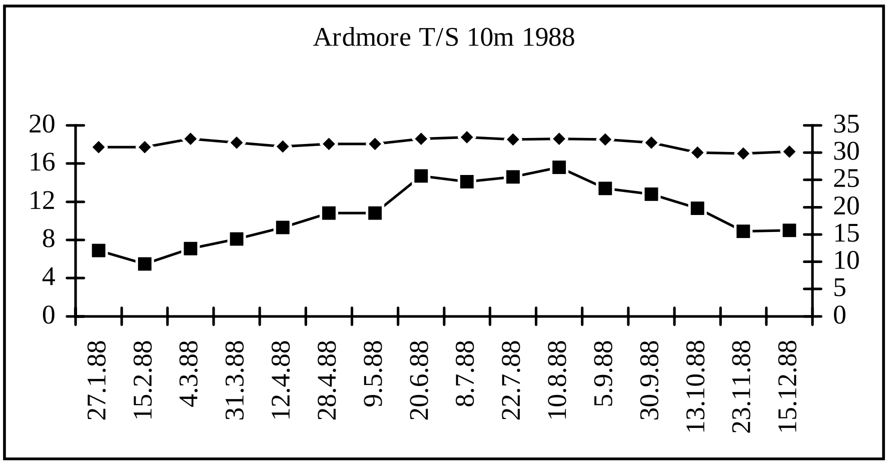
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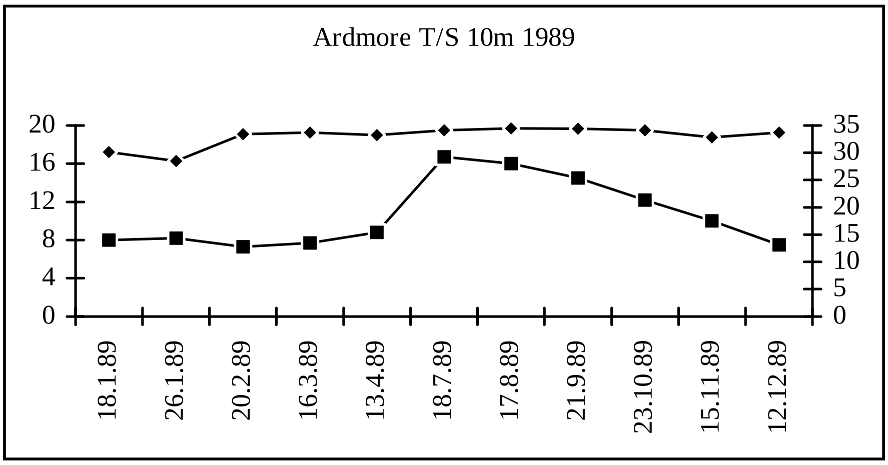
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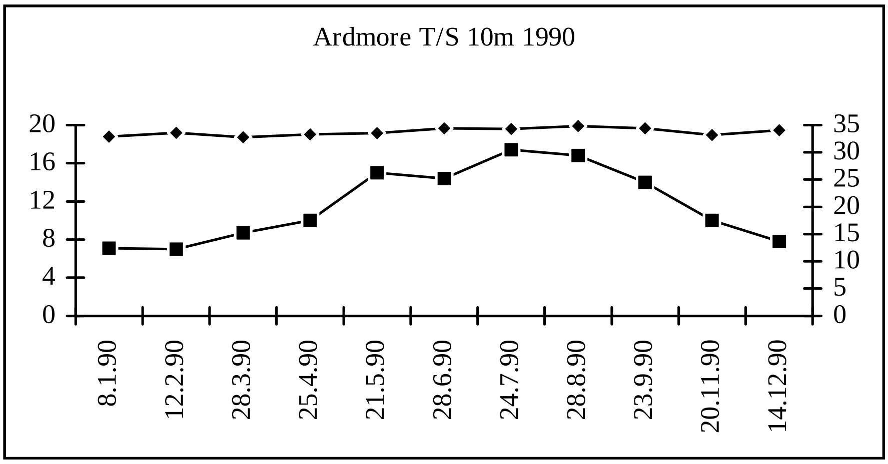
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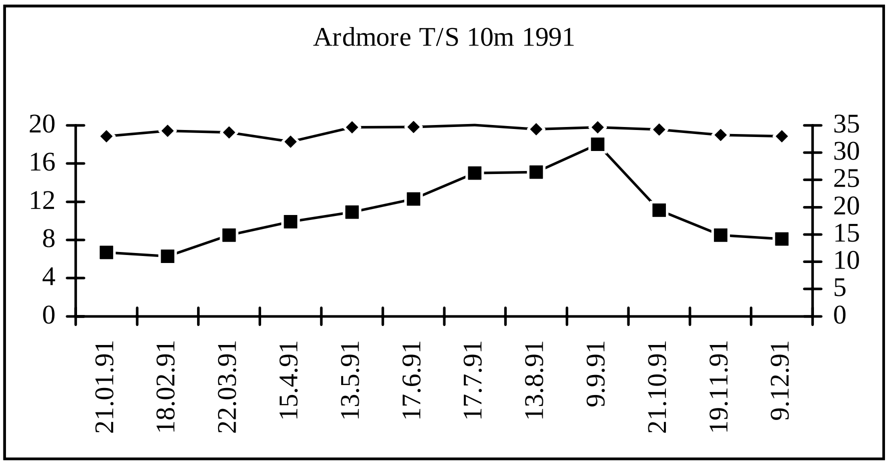
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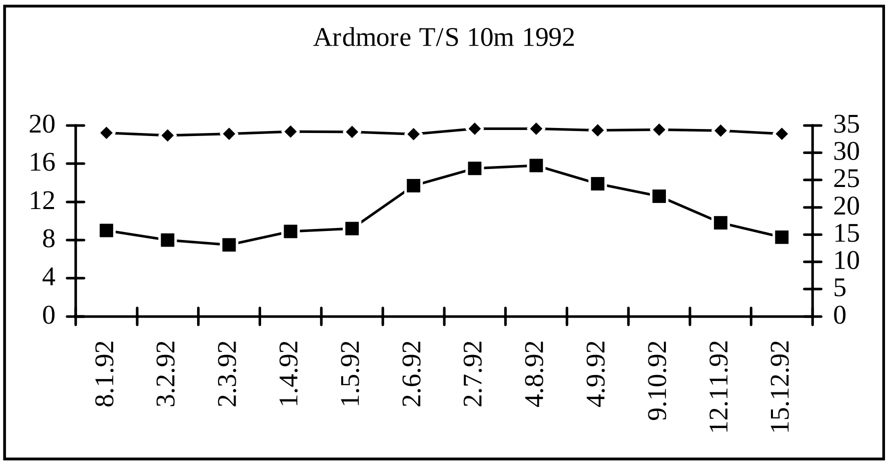
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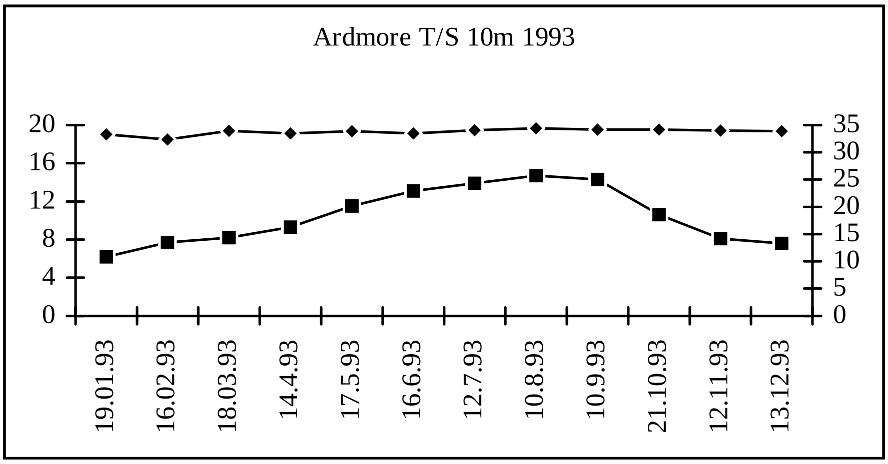
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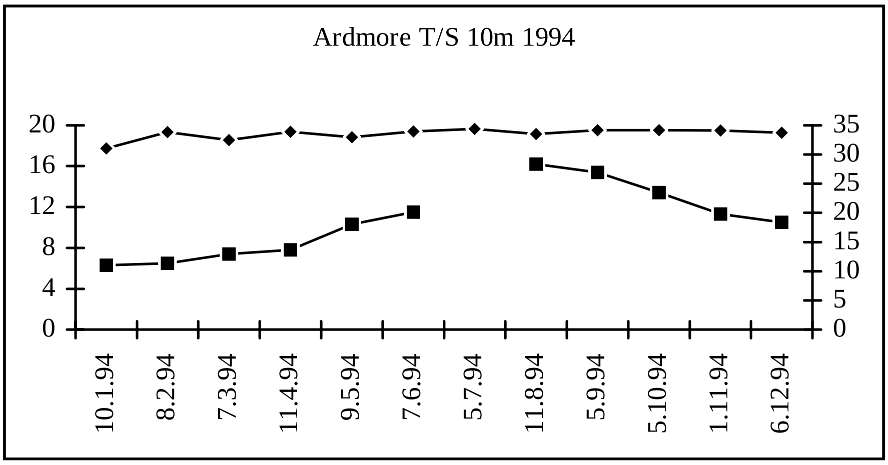
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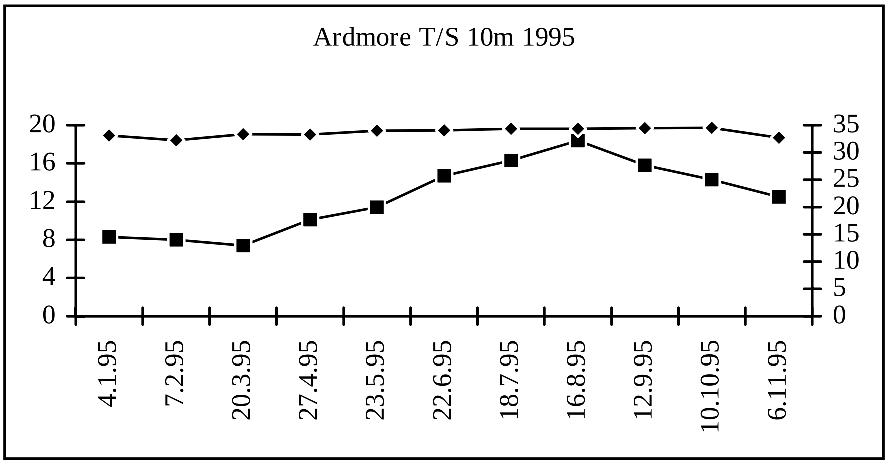
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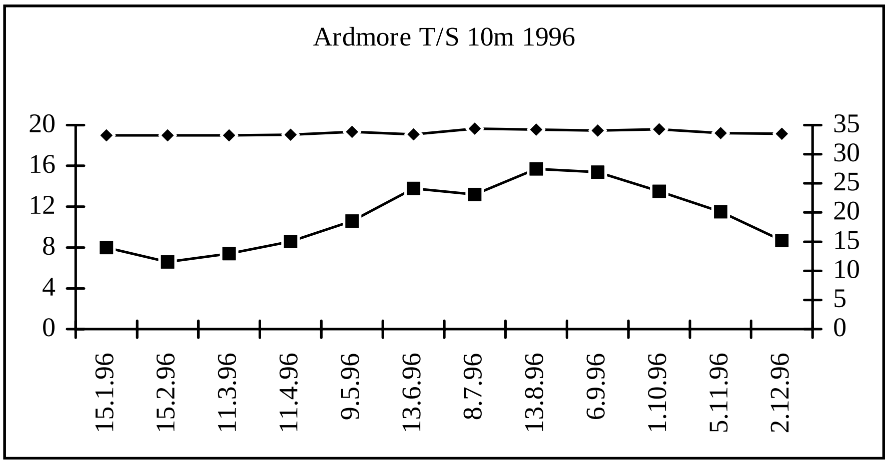
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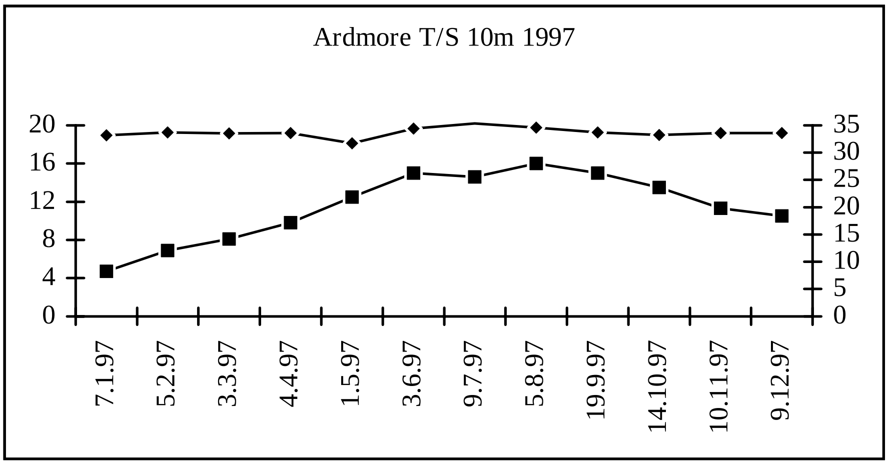
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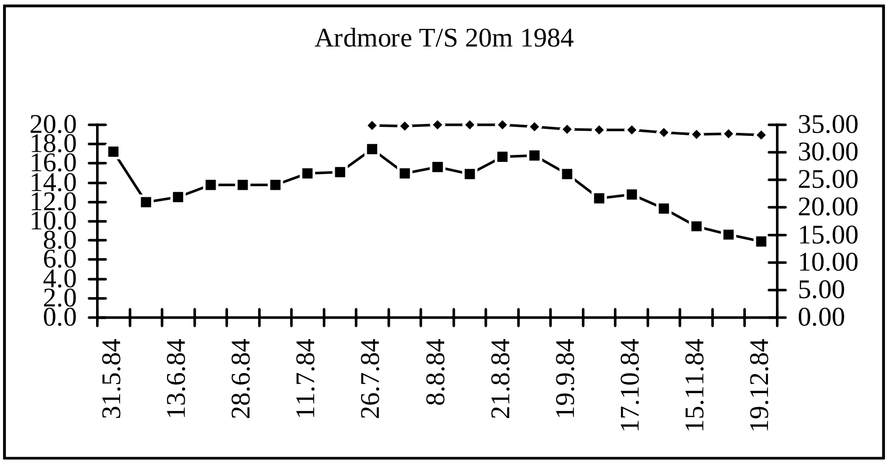
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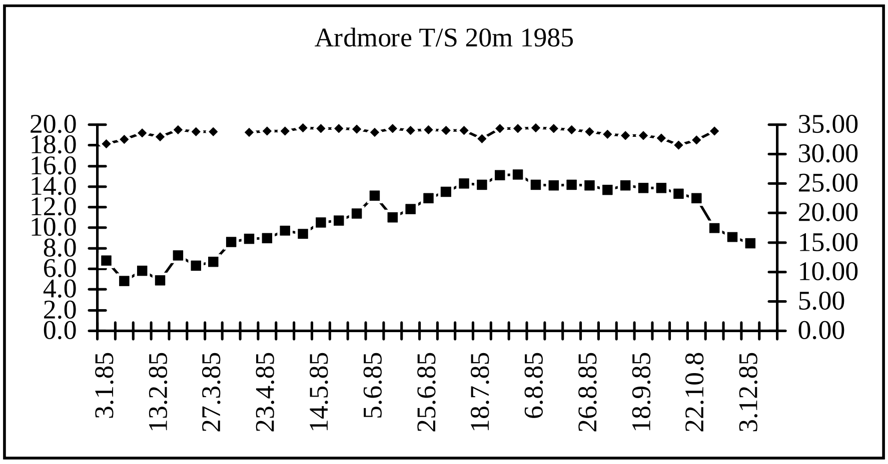
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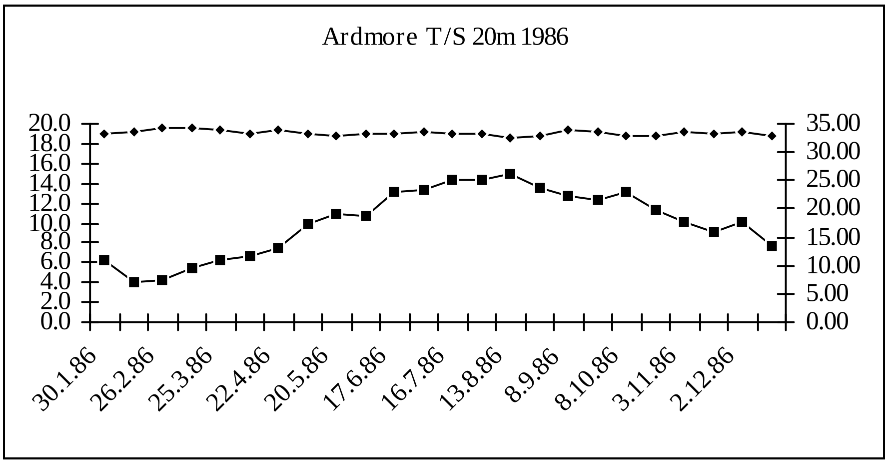
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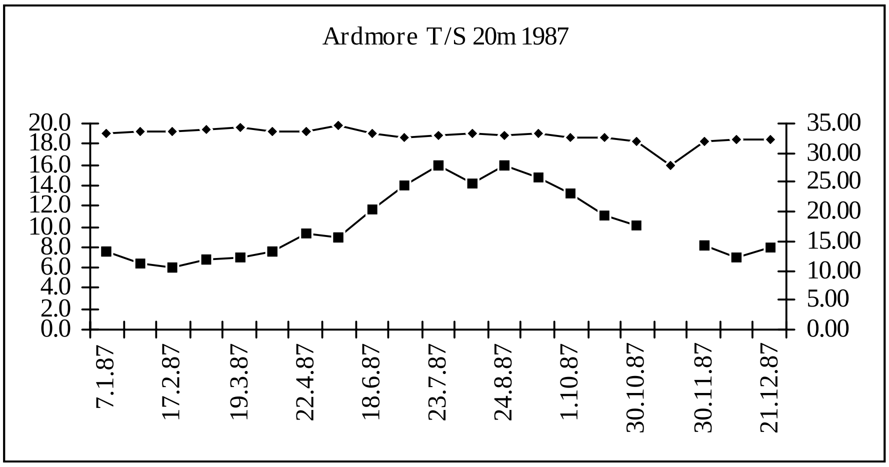
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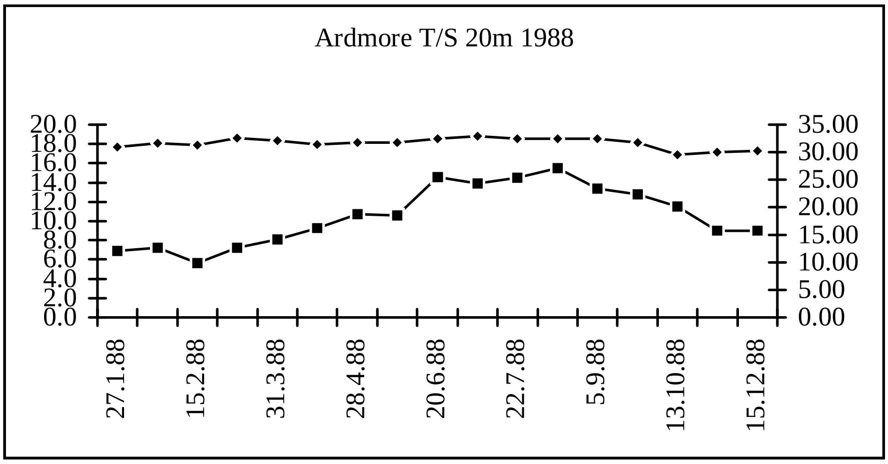
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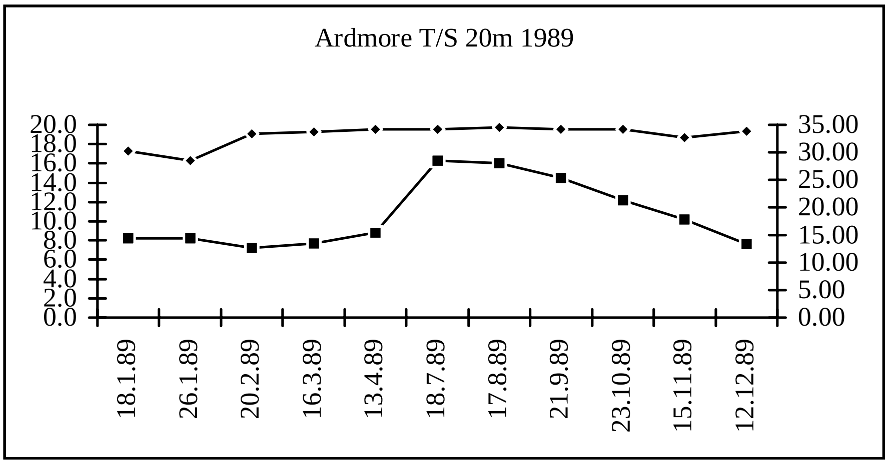
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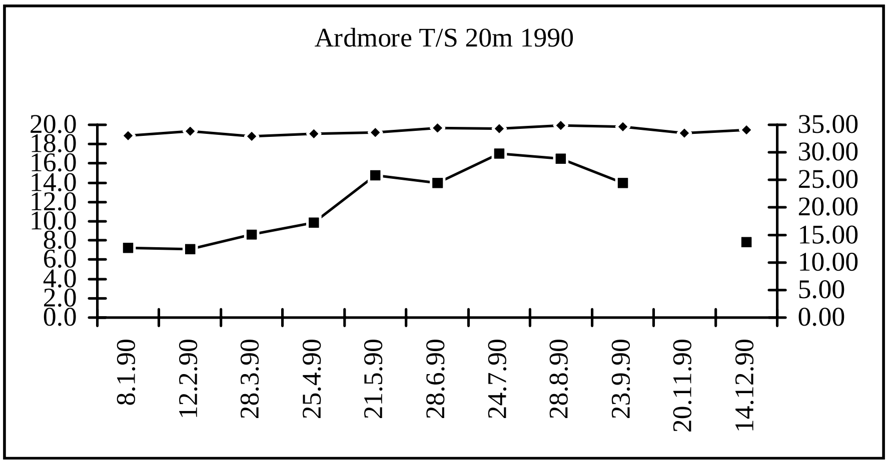
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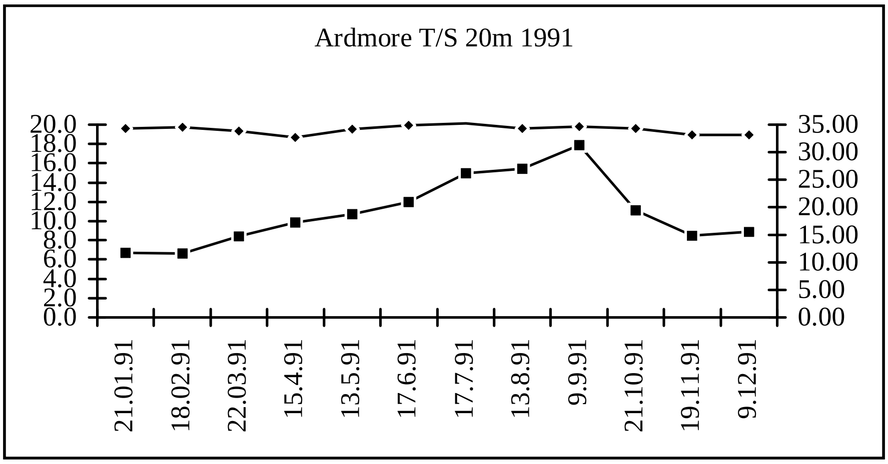
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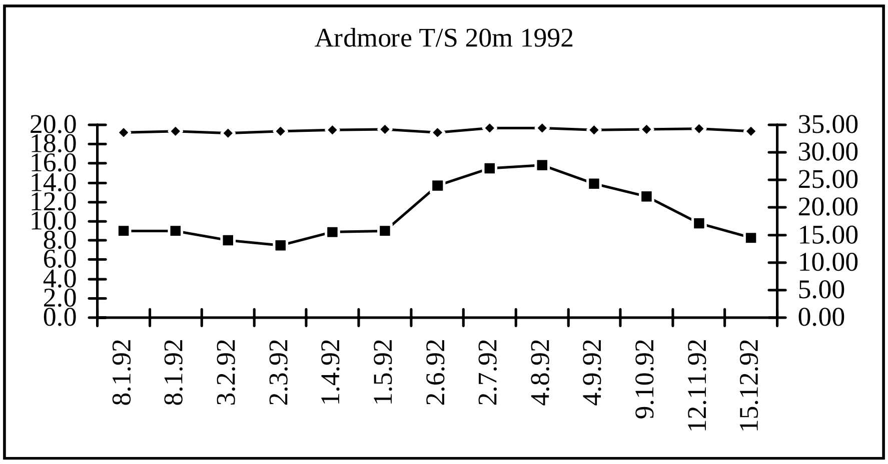
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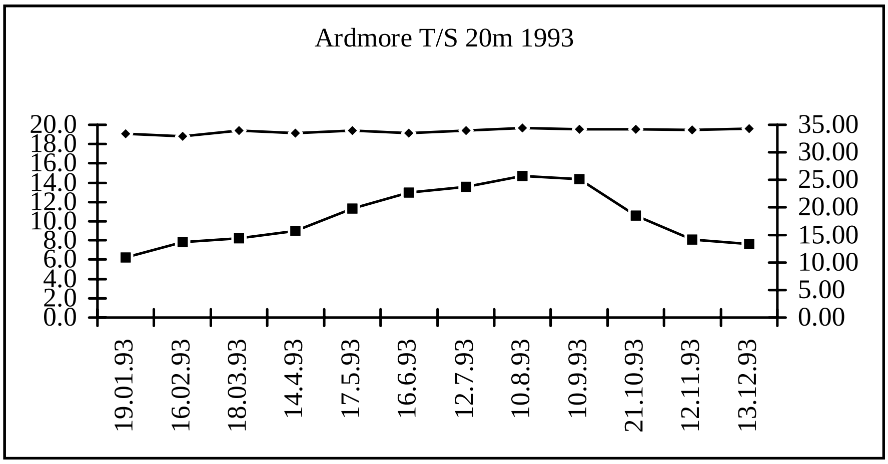
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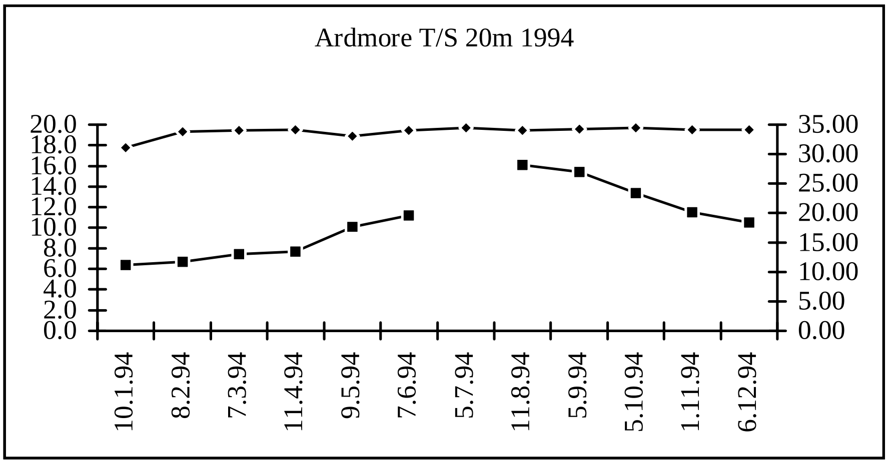
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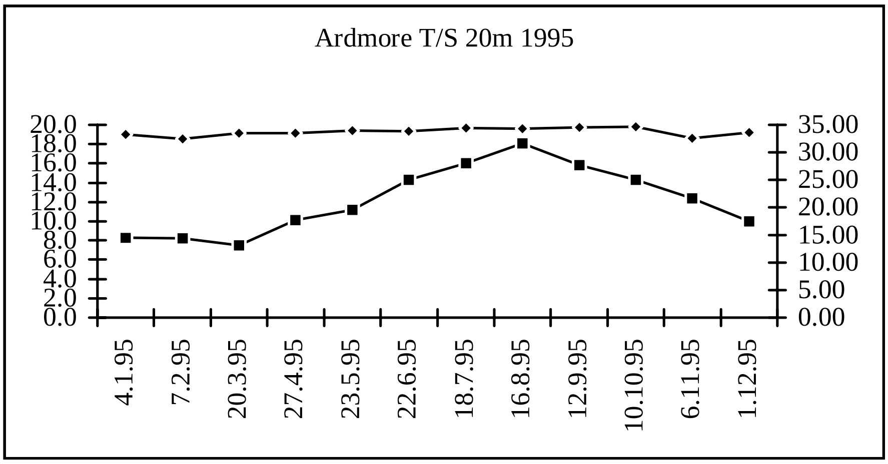
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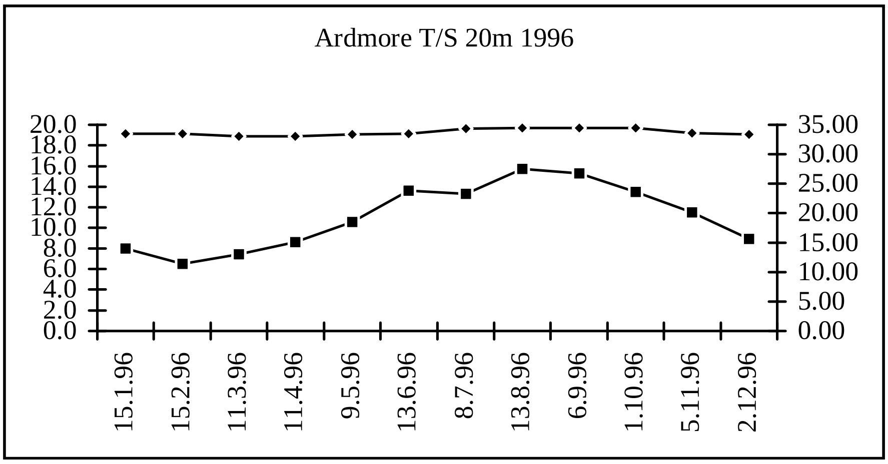
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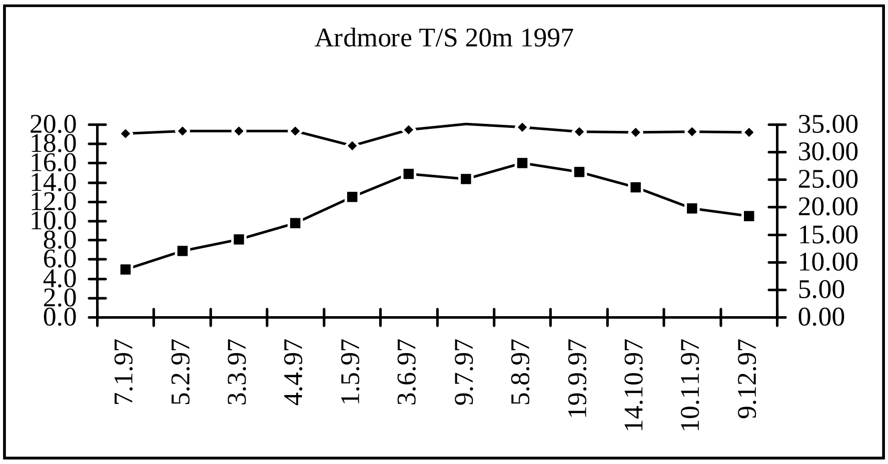
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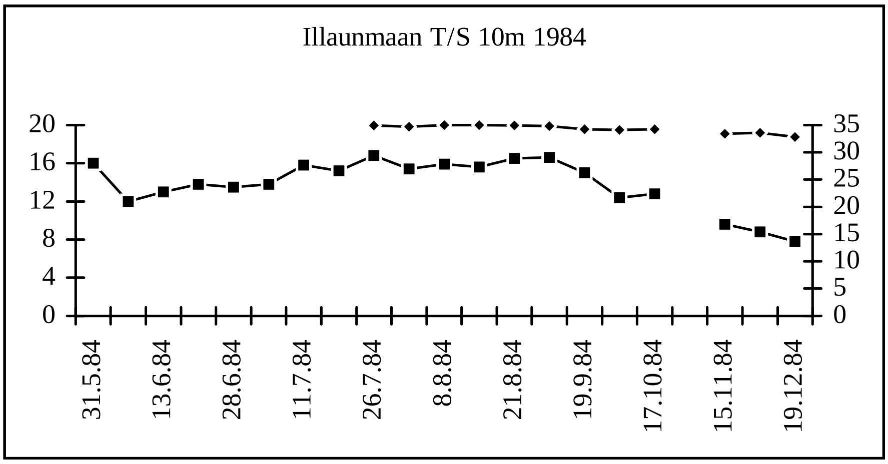
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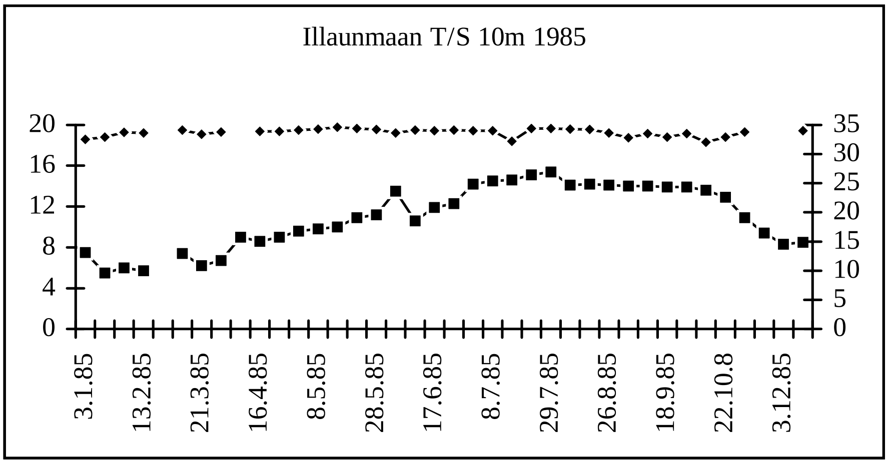
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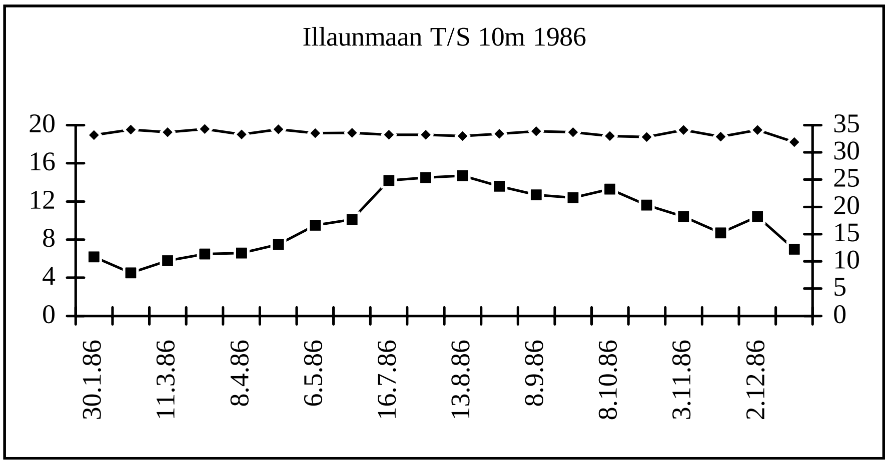
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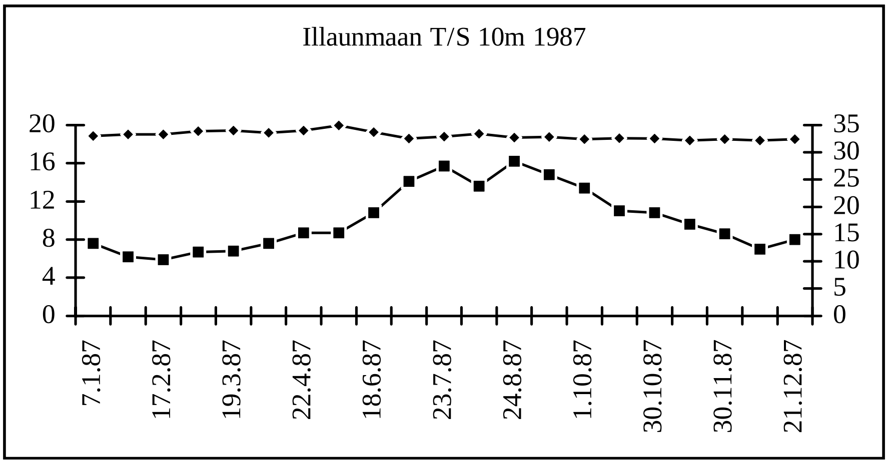
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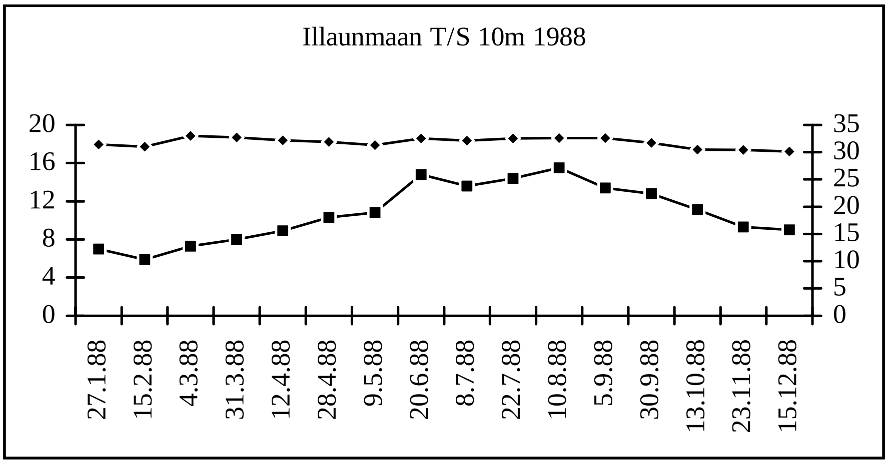
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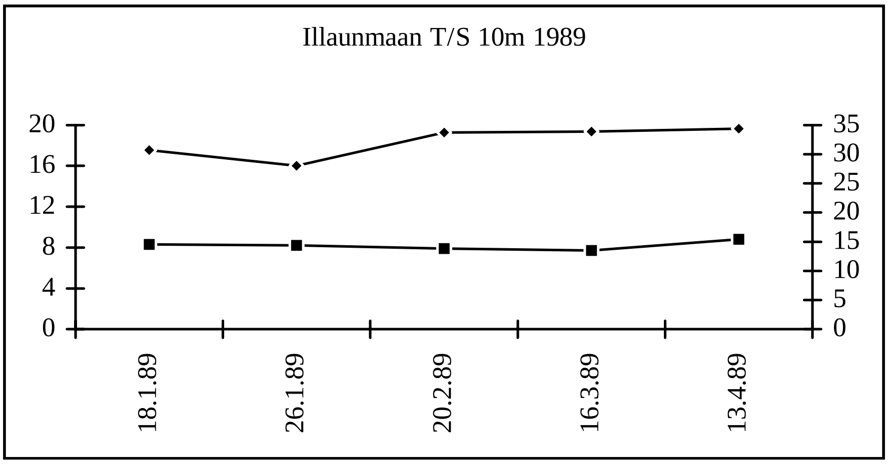
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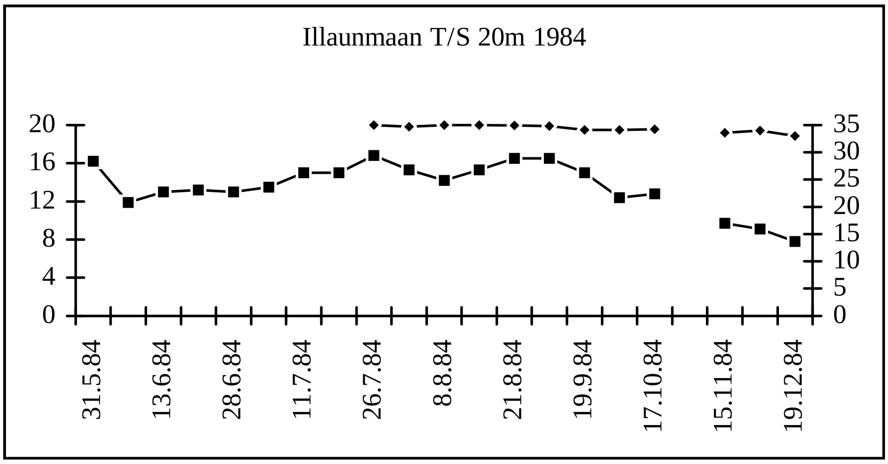
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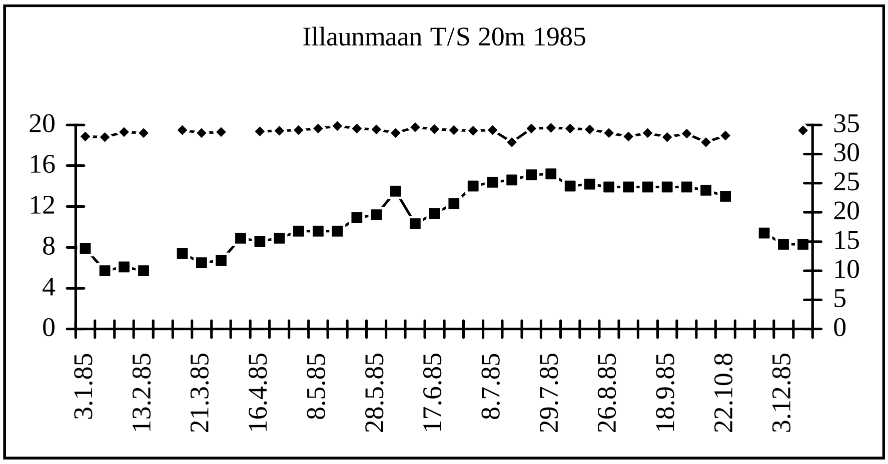
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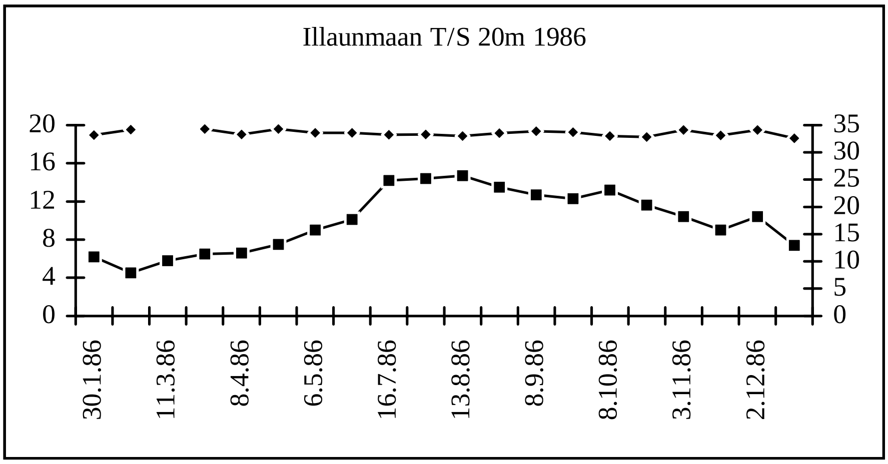
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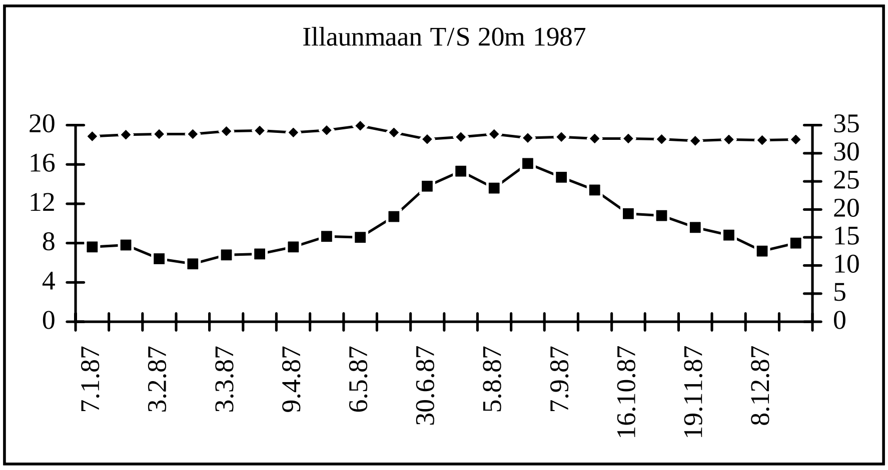
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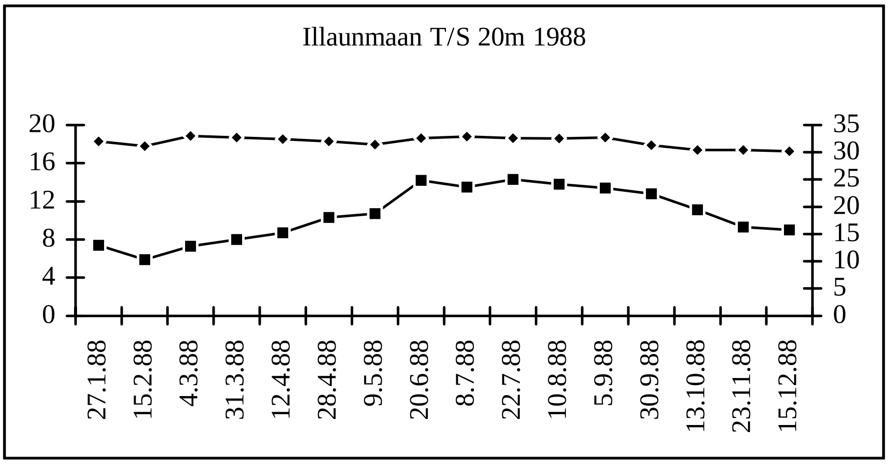
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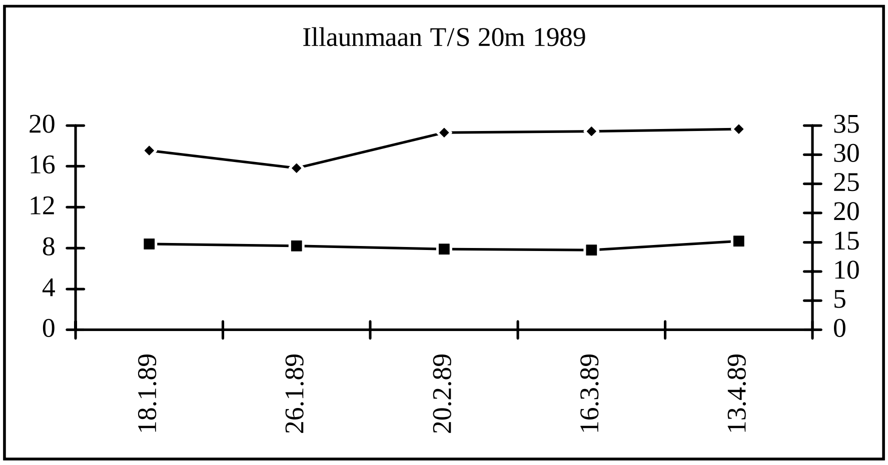
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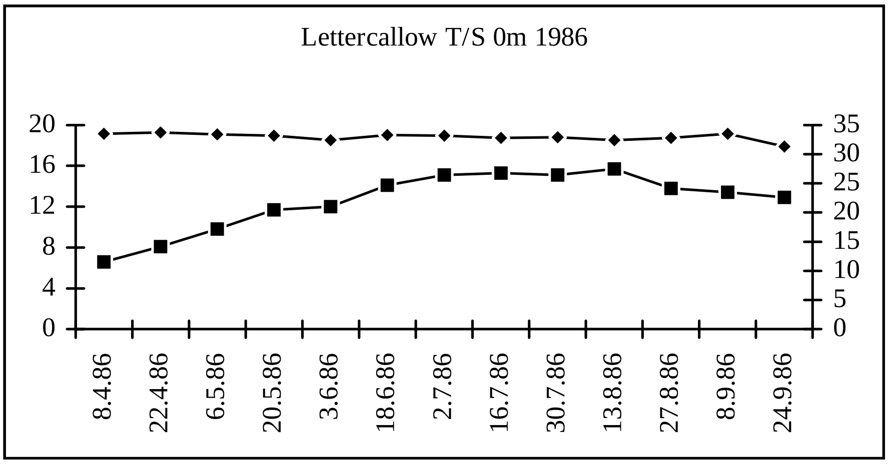
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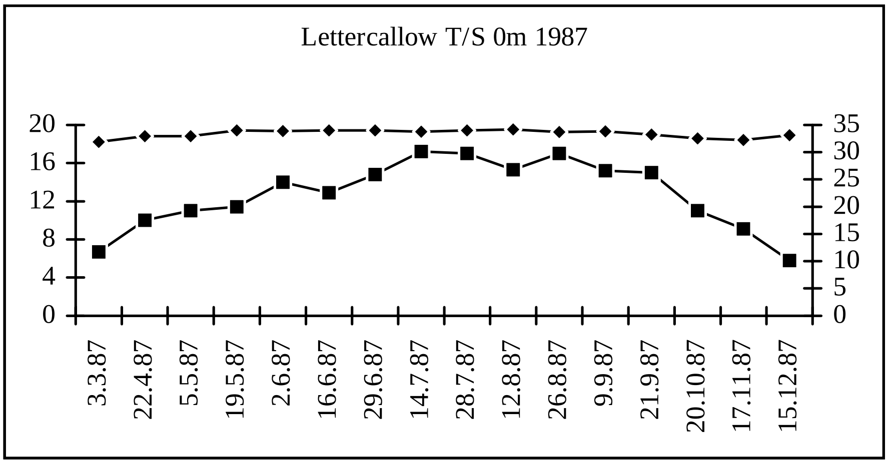
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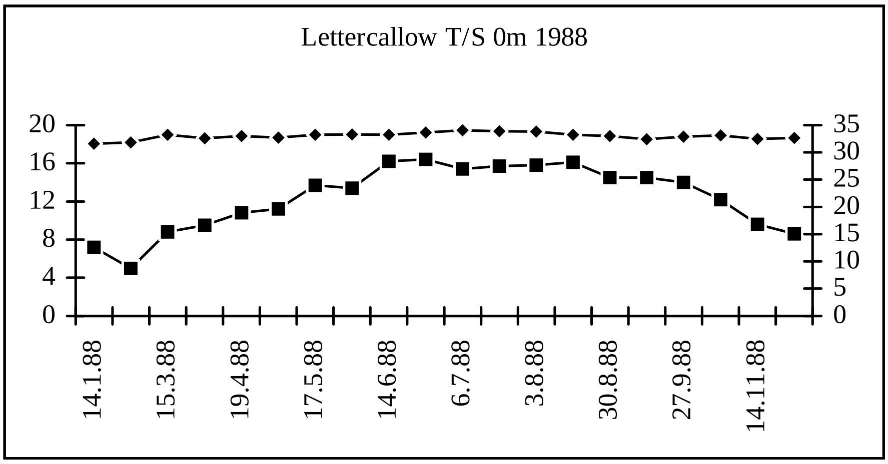
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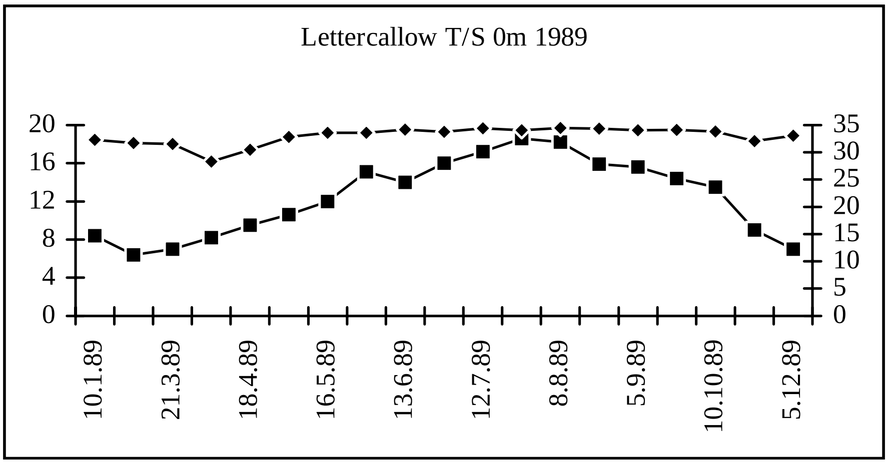
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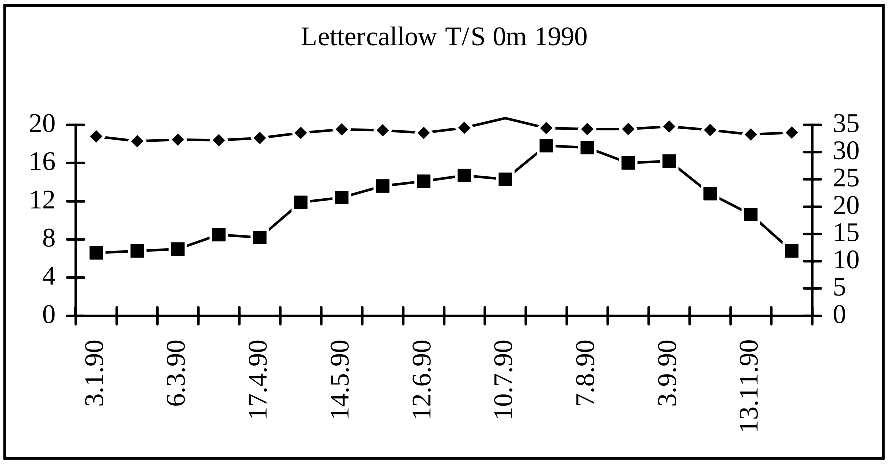
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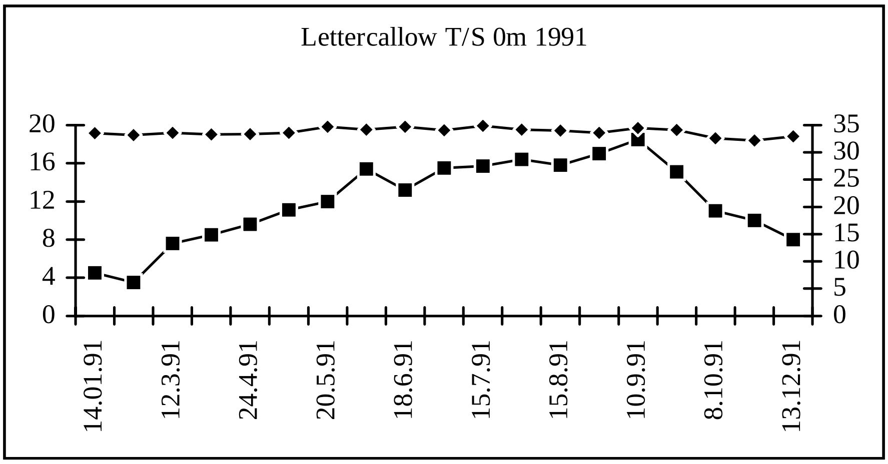
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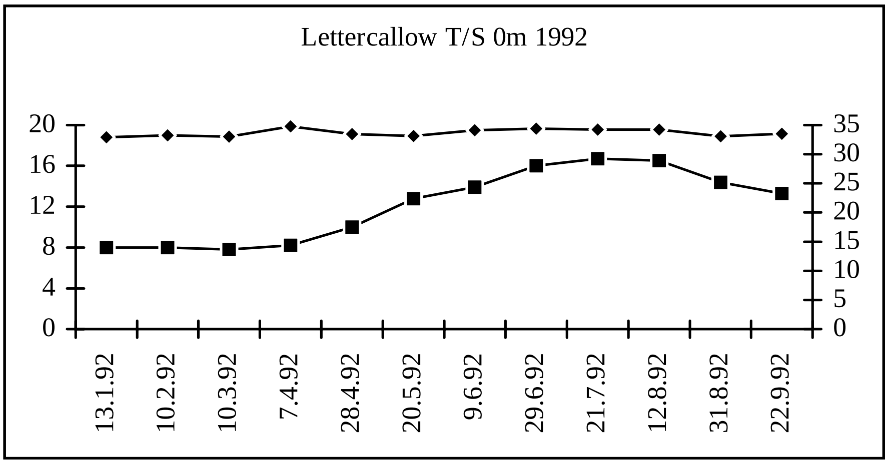
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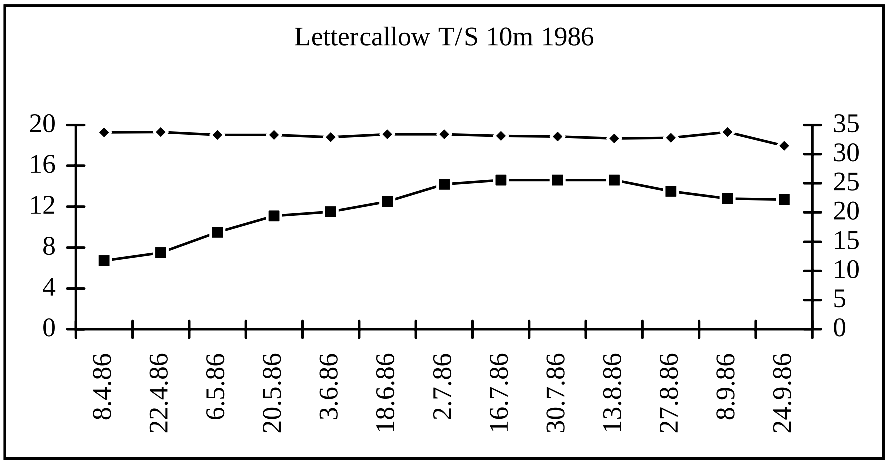
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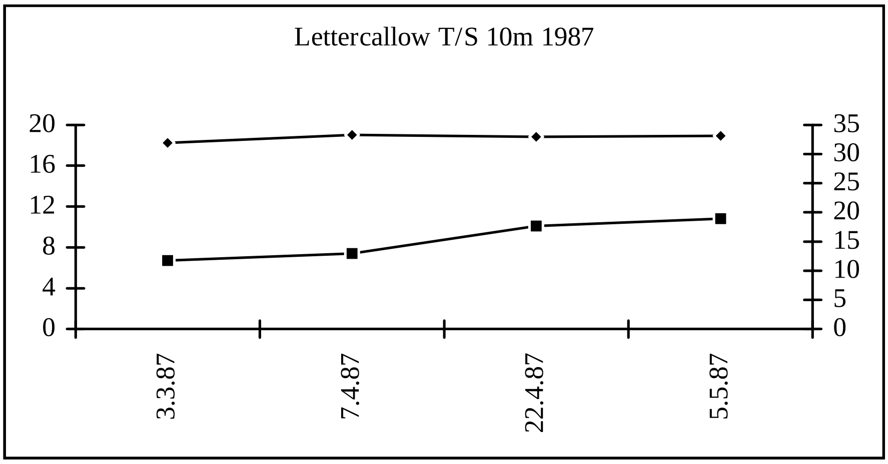
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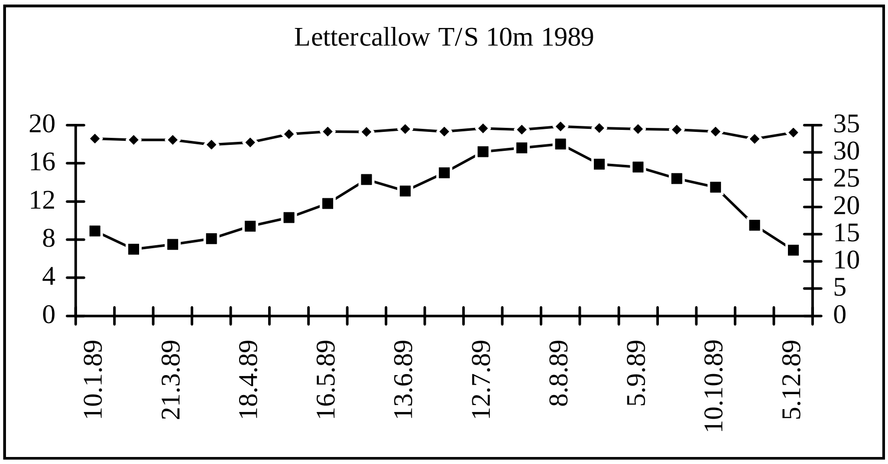
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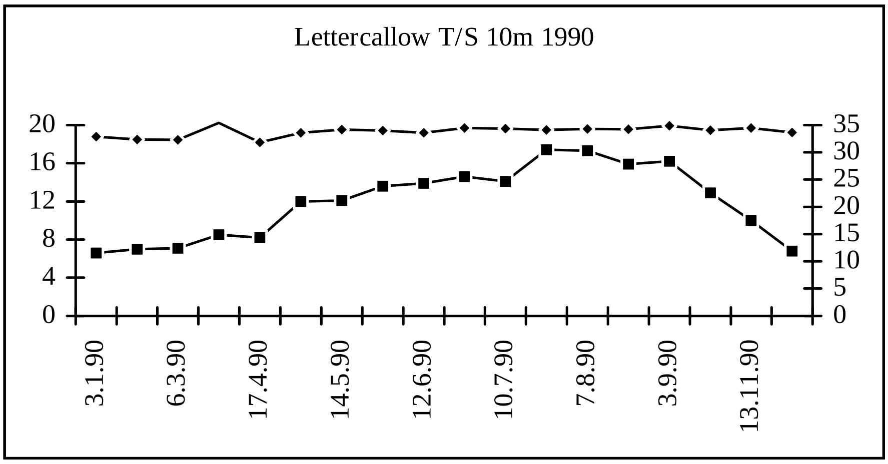
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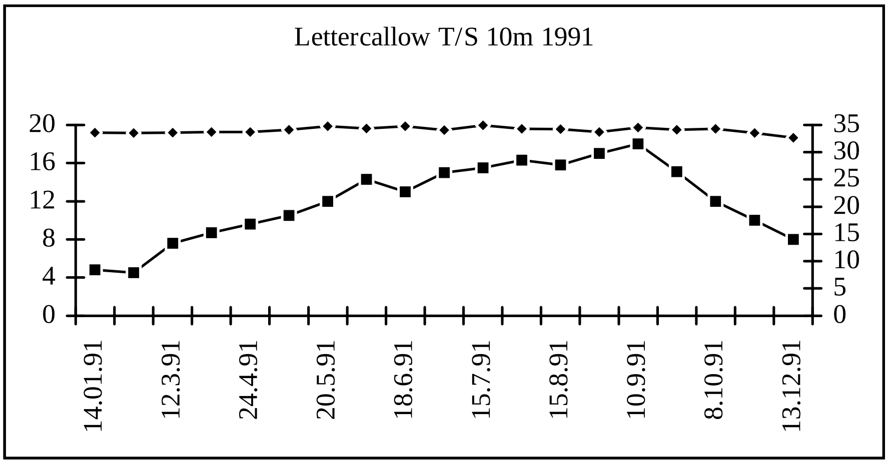
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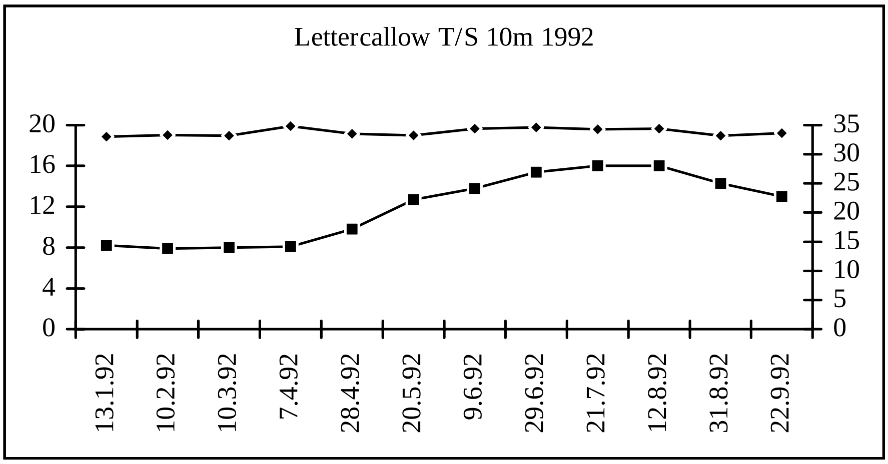
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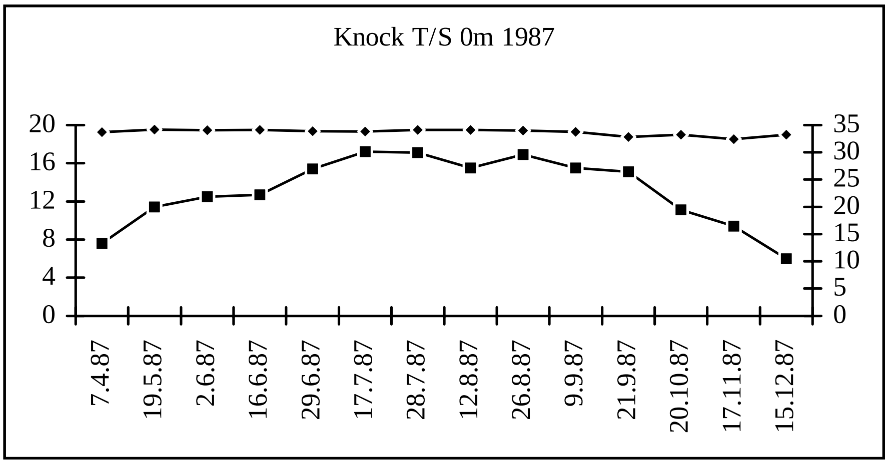
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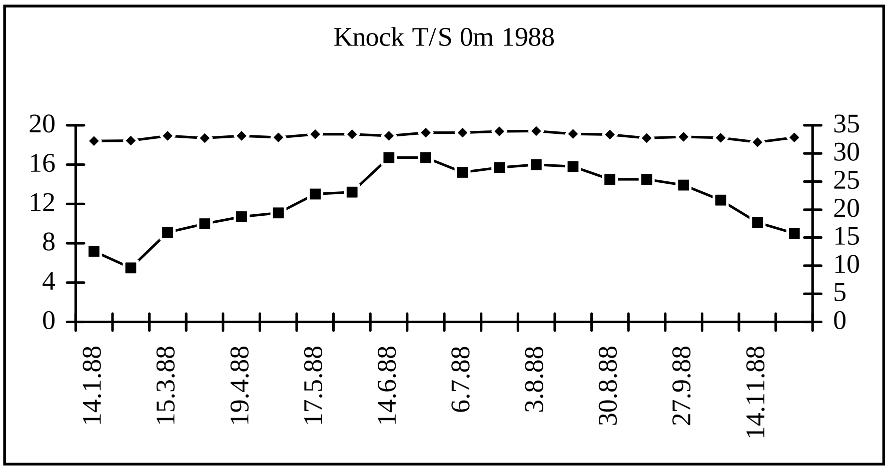
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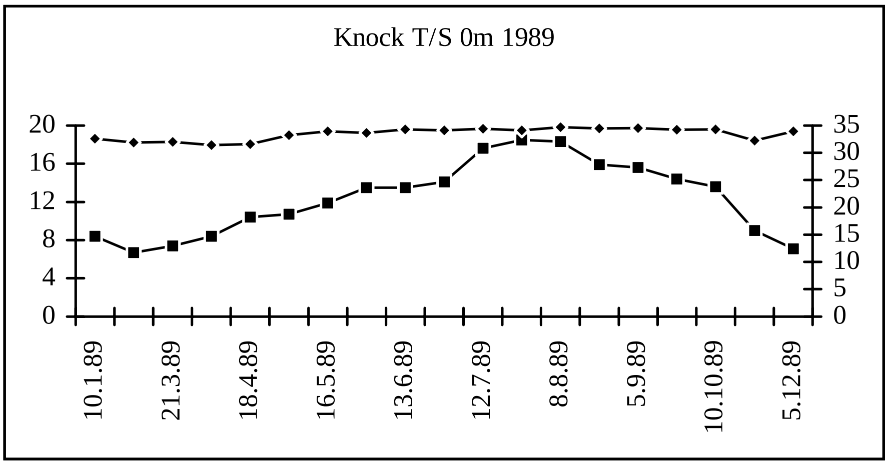
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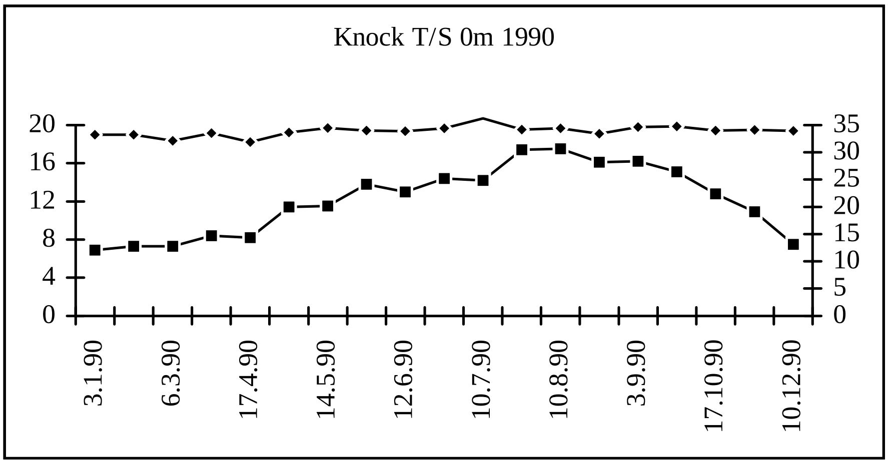
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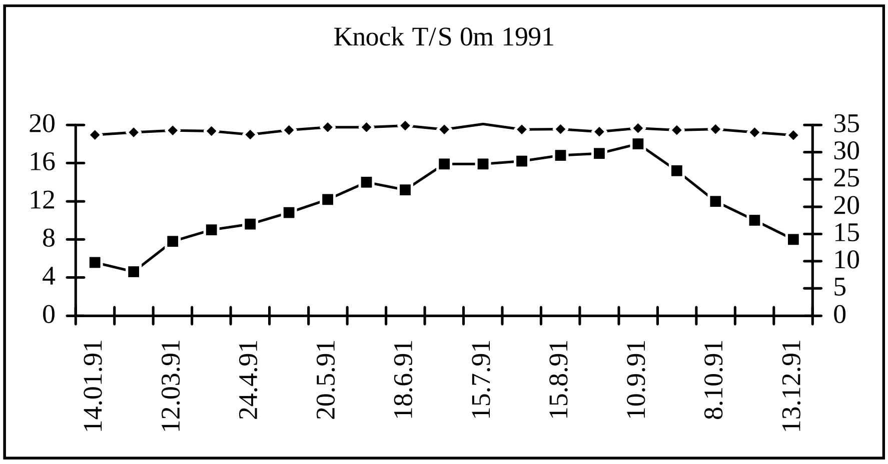
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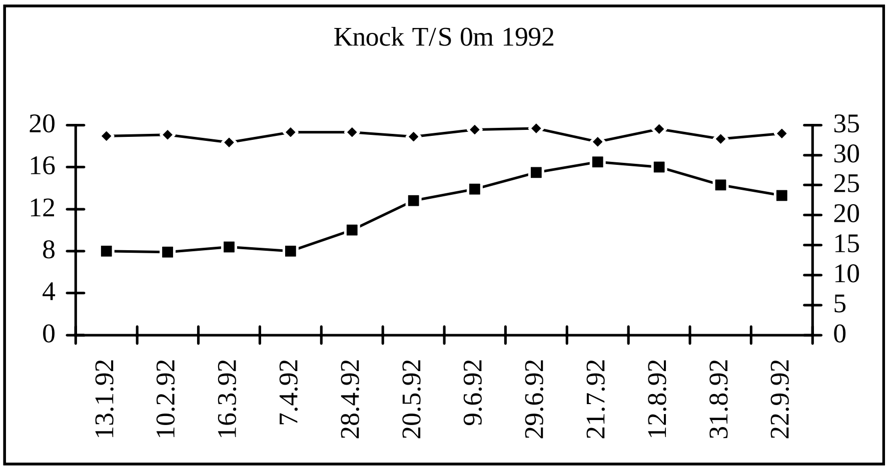
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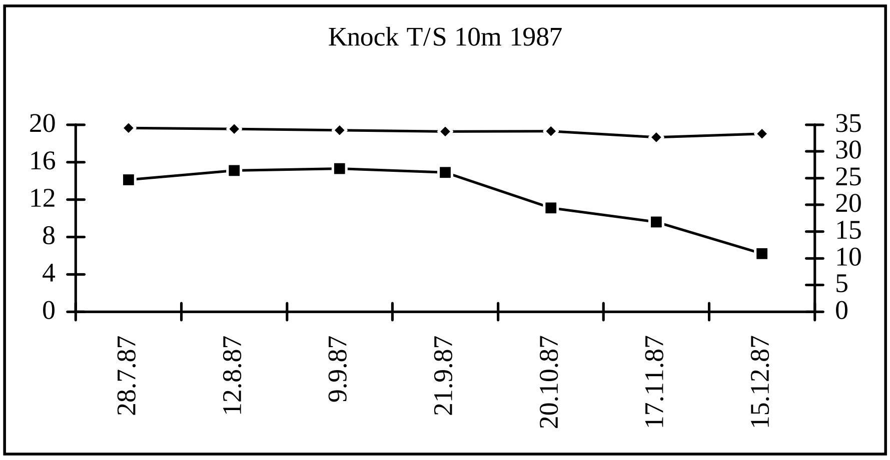
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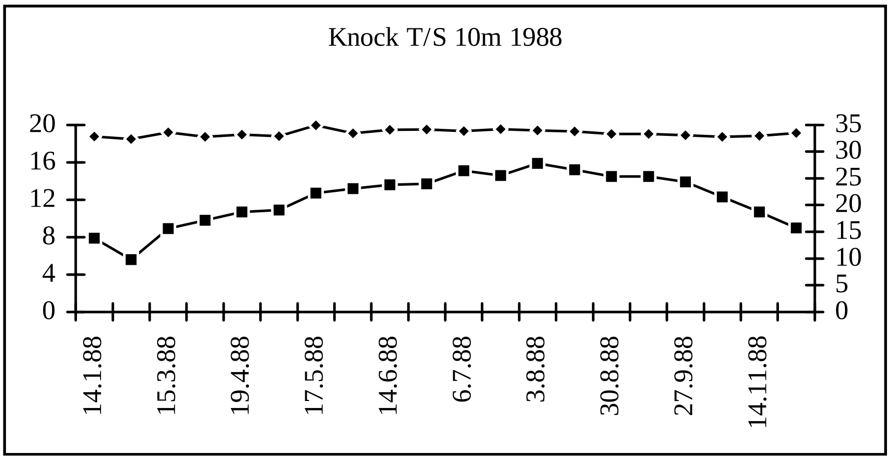
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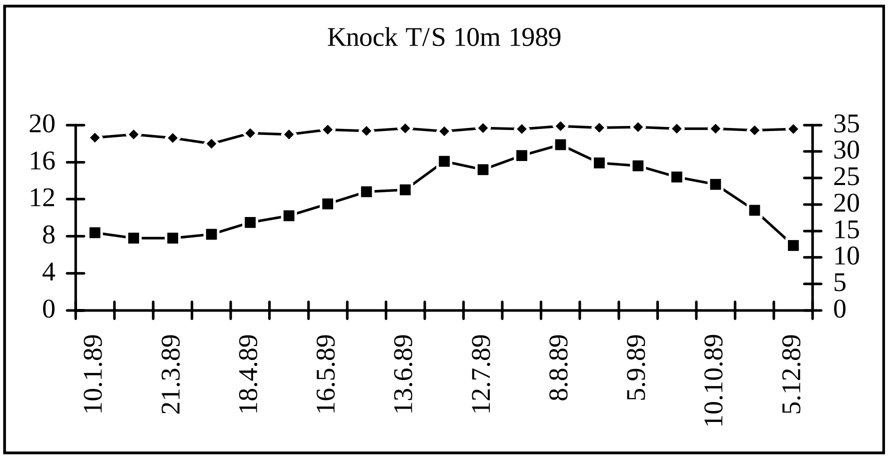
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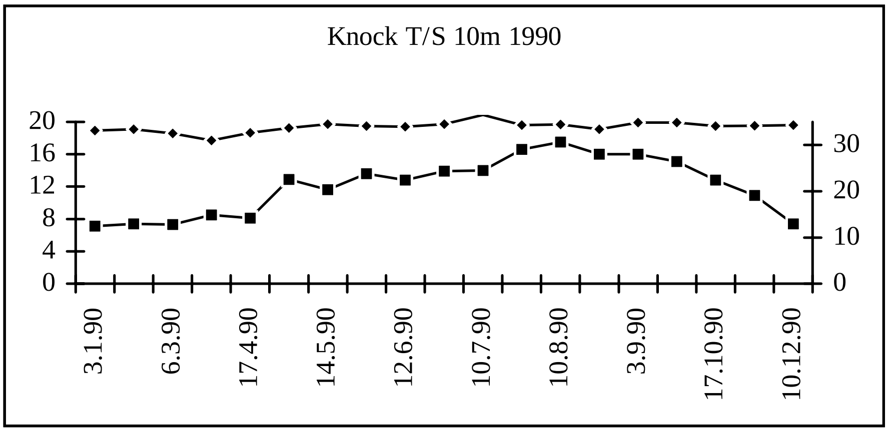
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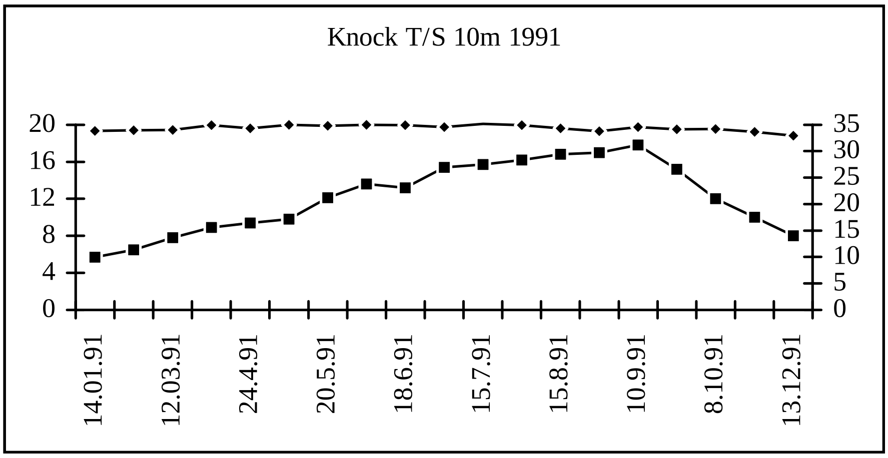
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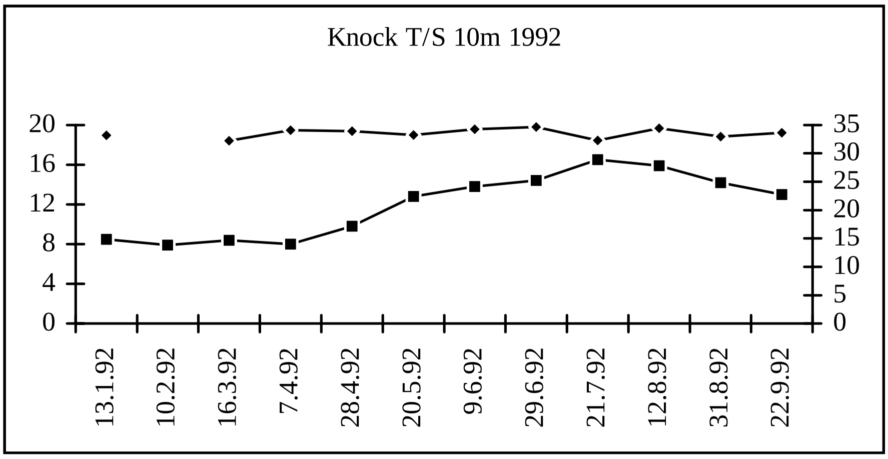
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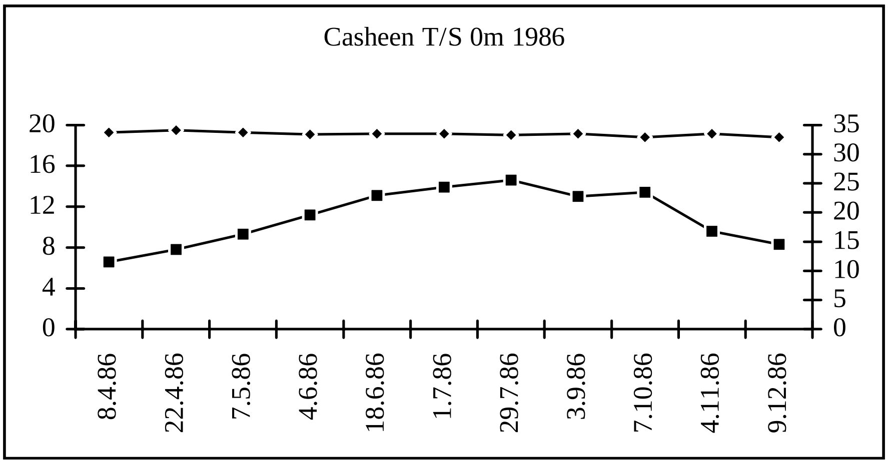
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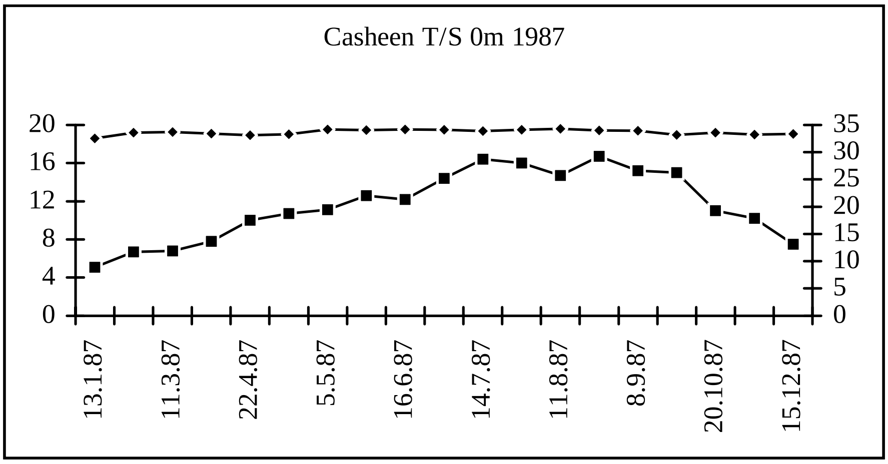
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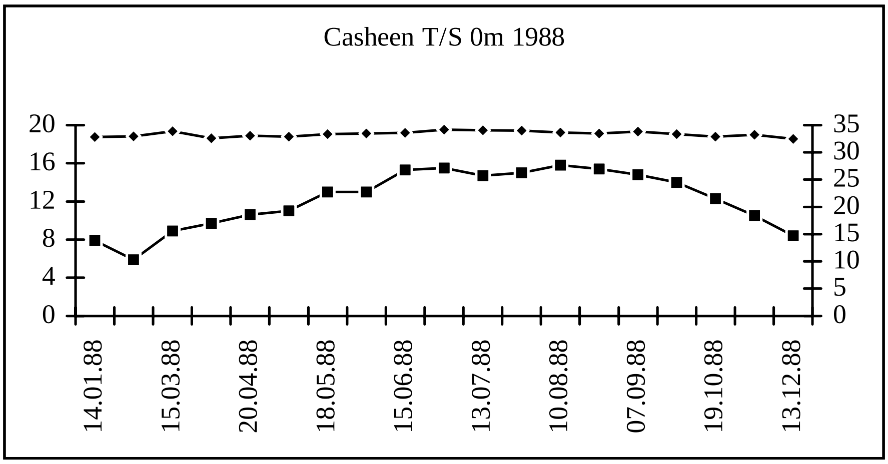
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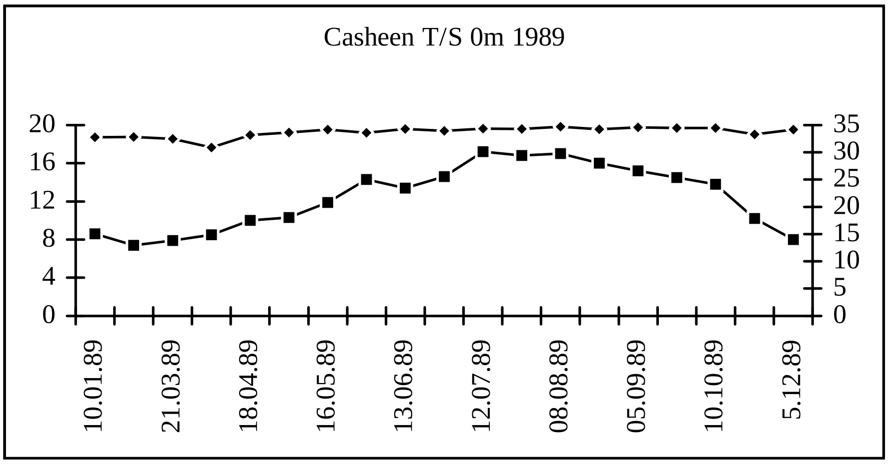
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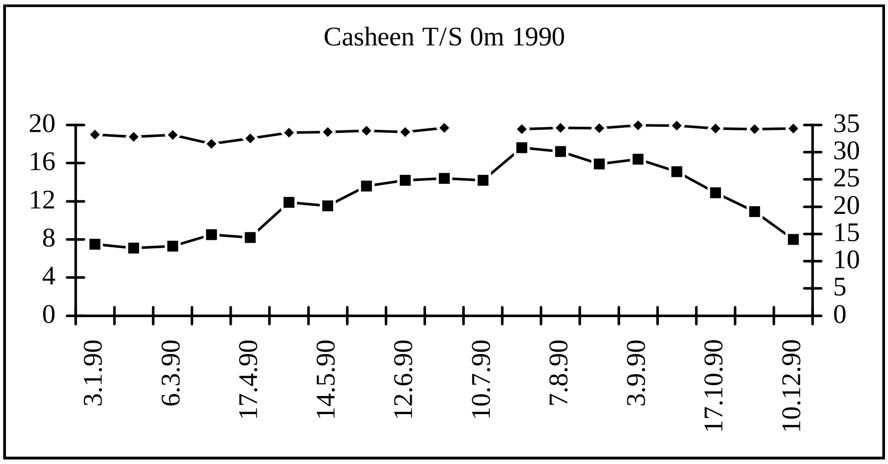
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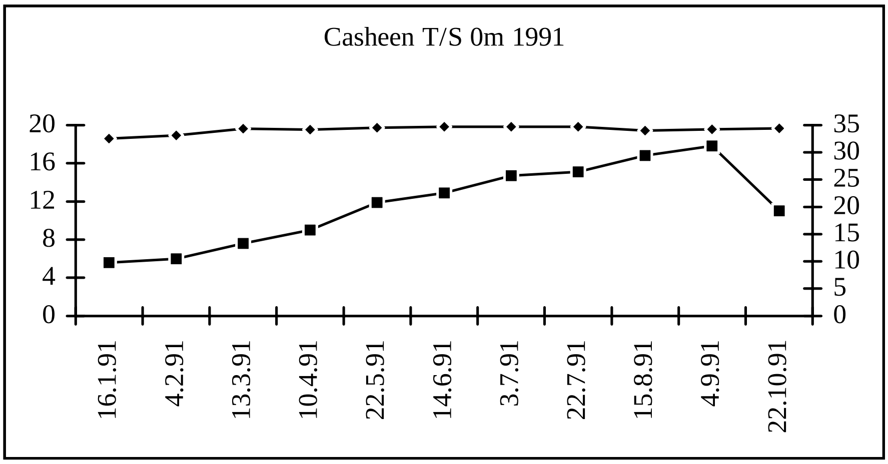
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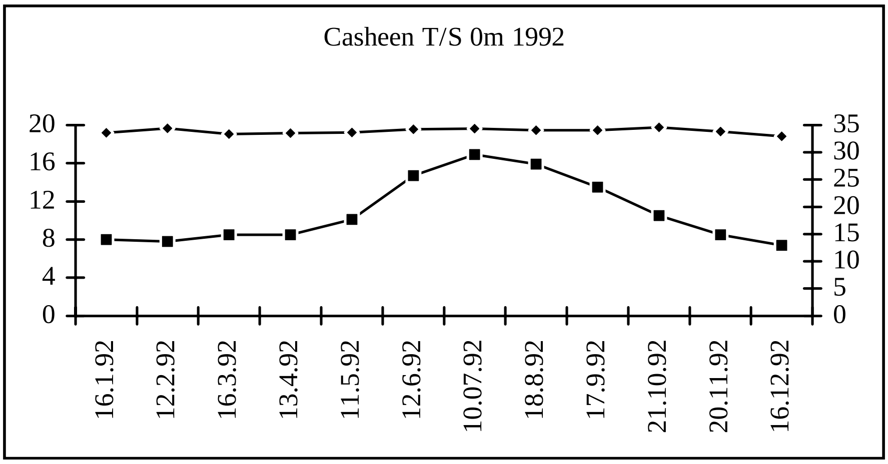
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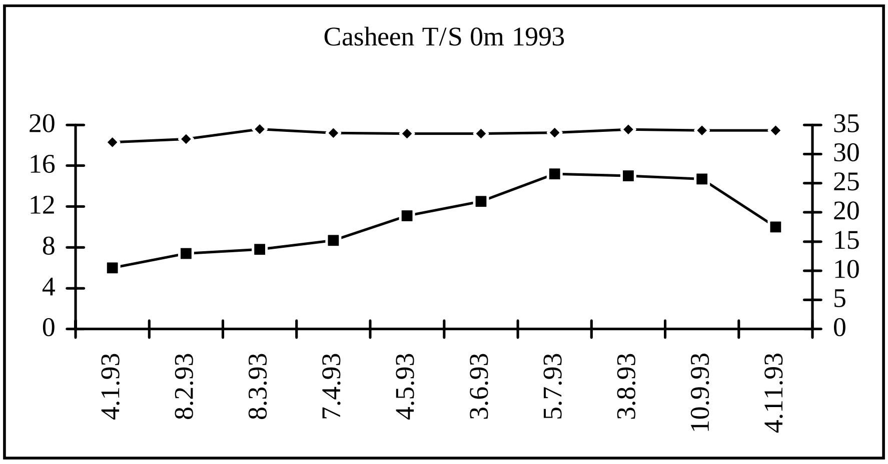
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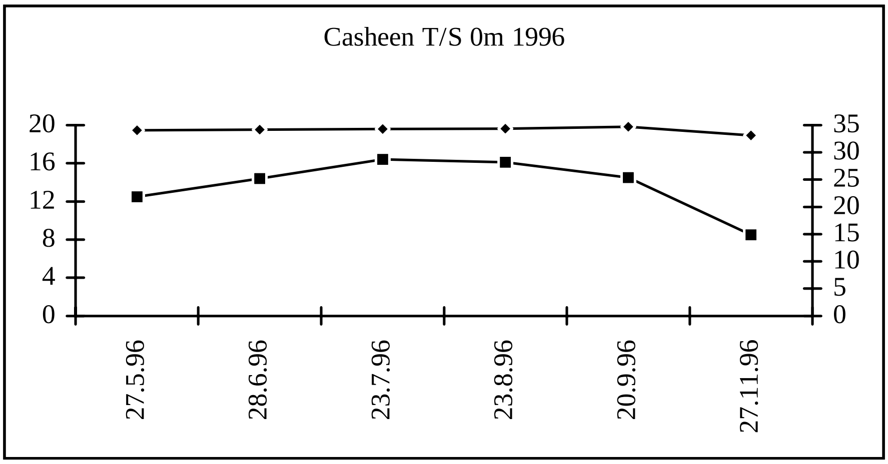
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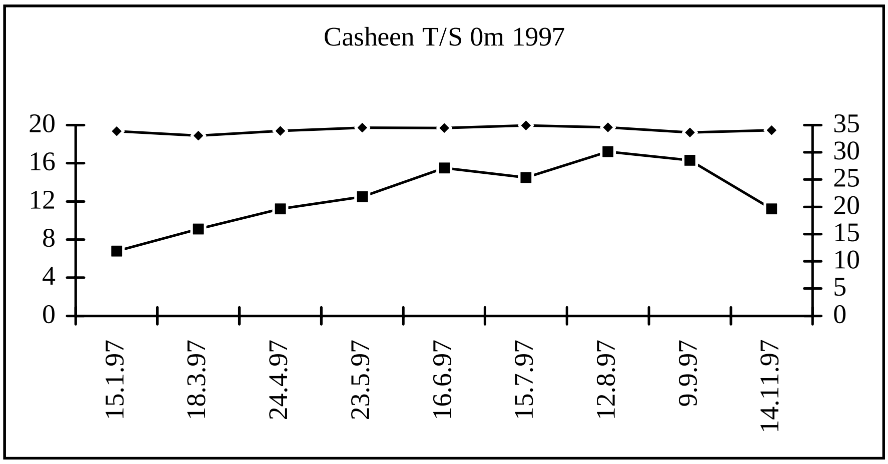
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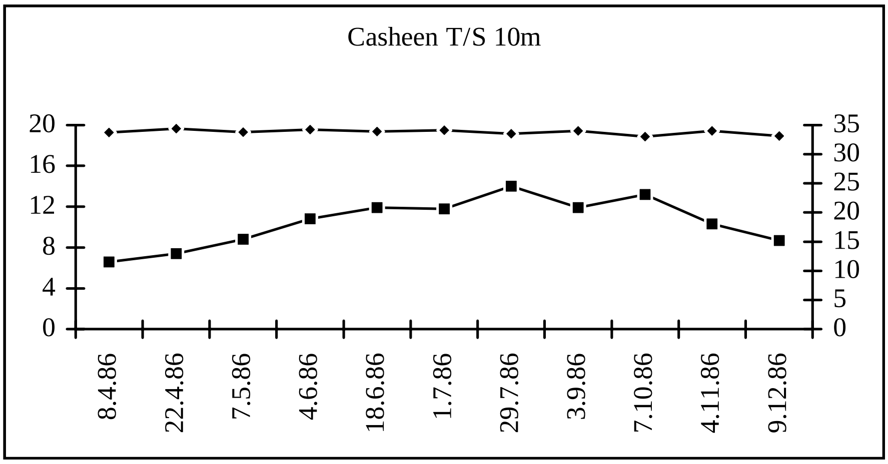
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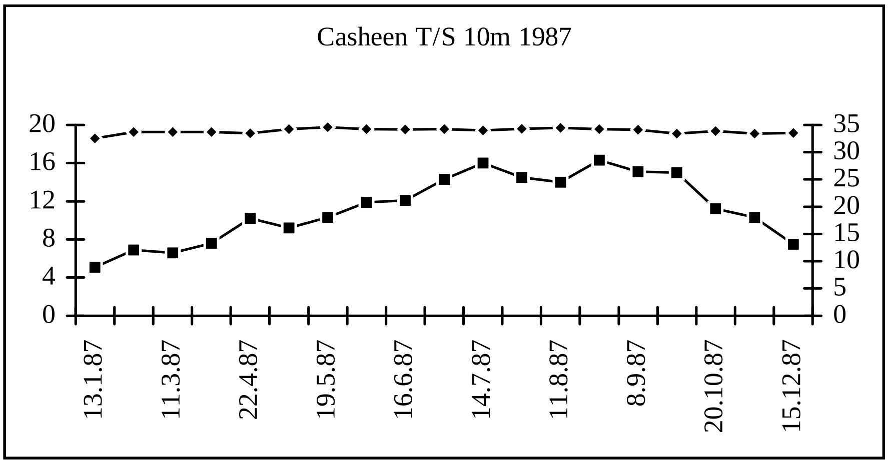
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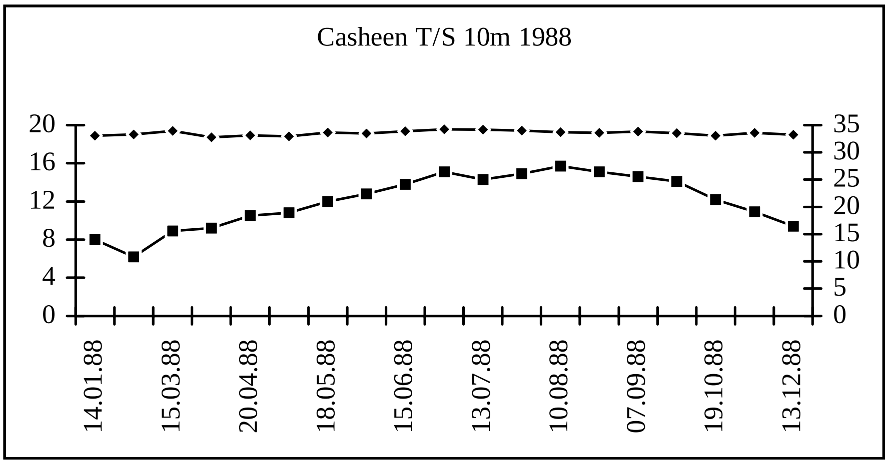
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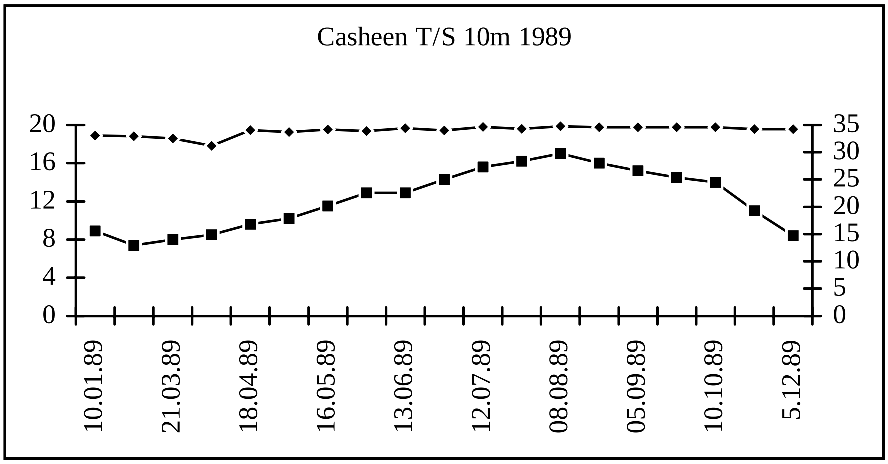
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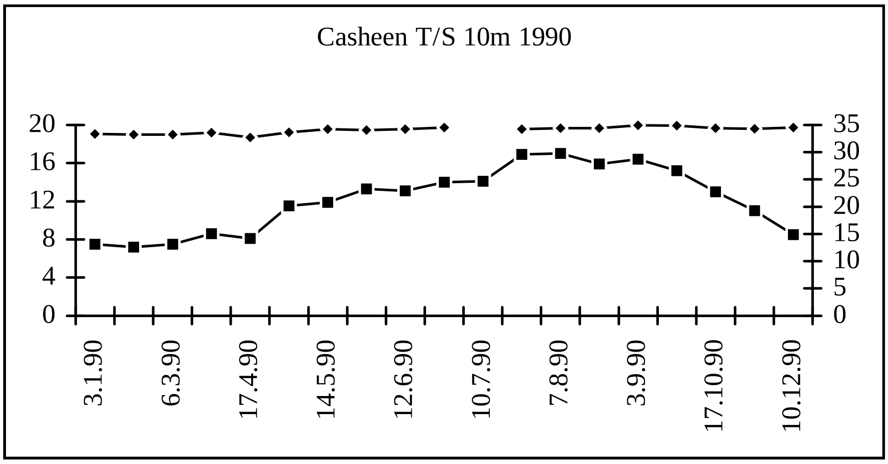
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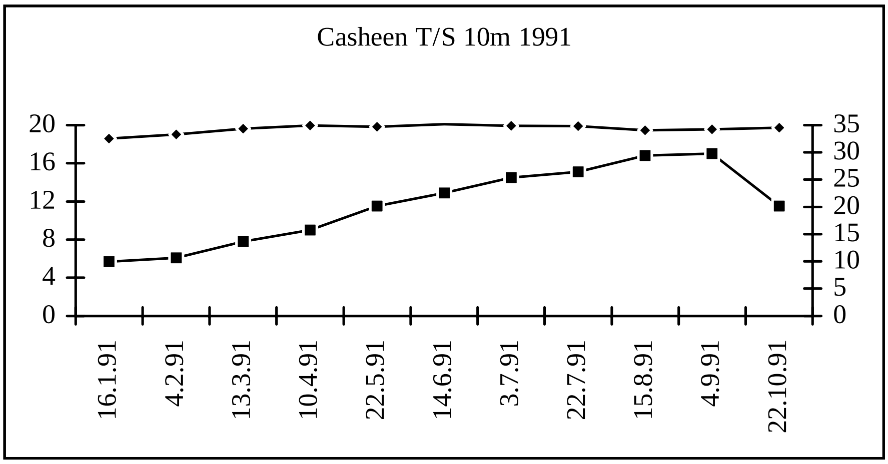
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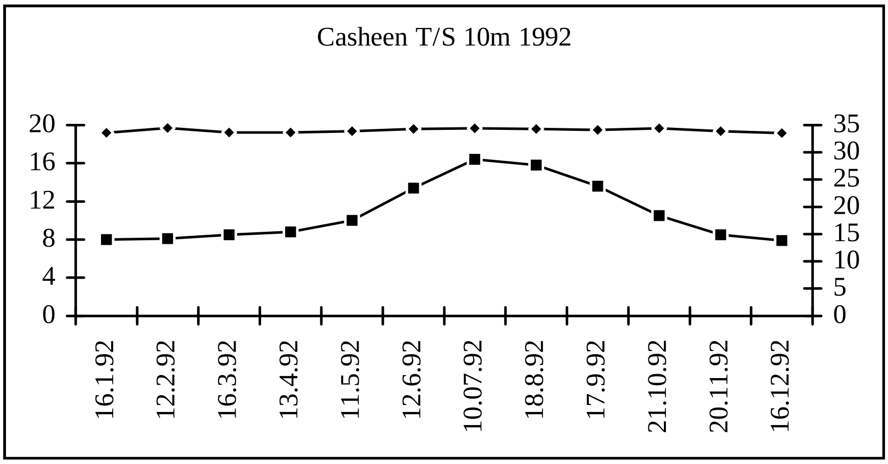
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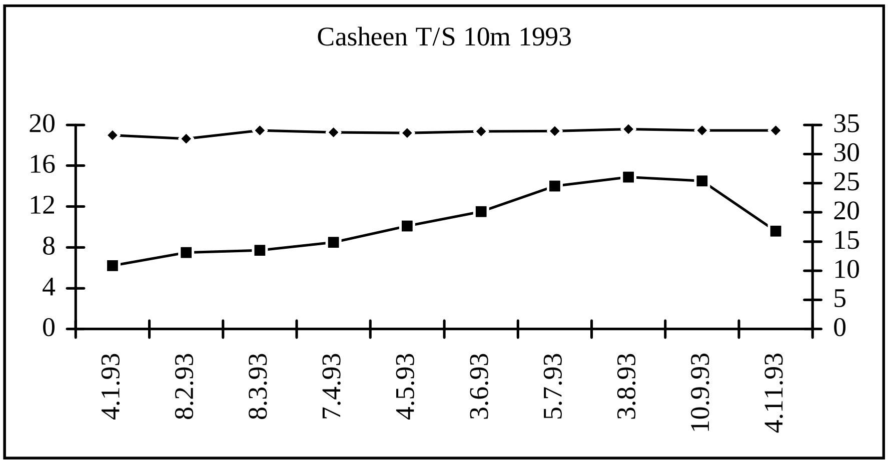
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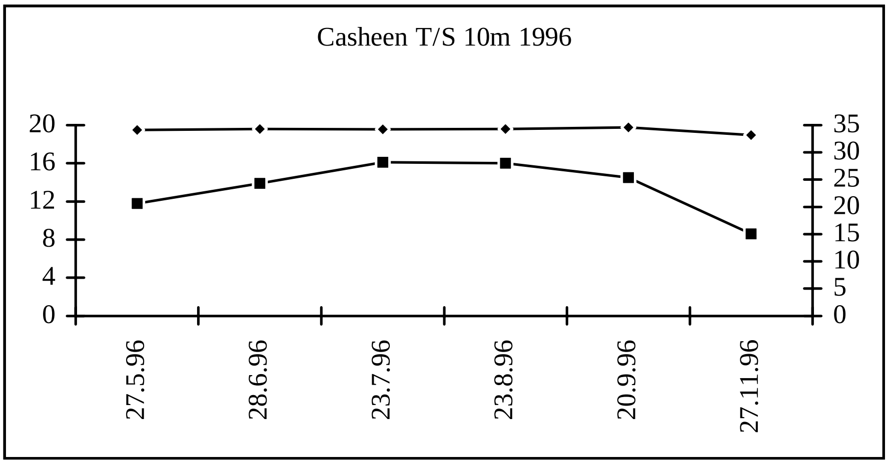
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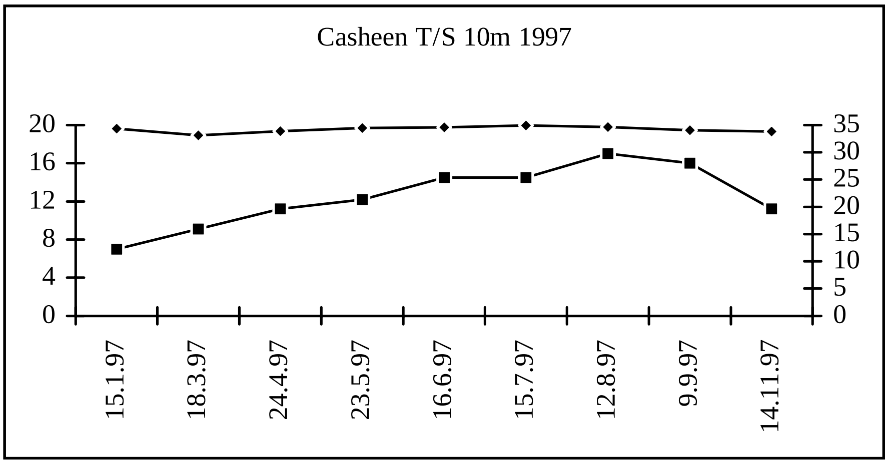
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