

## A SALMON INFORMATION SYSTEM AND ITS USE TO STUDY THE EPIDEMIOLOGY OF PANCREAS DISEASE

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*Malgré l'importance économique du saumon atlantique (Salmo salar) pour l'aquaculture, les méthodes relevant de l'épidémiologie sont encore relativement peu employées dans l'étude de ses maladies. Une base de données (Salmon Information System), établie en collaboration avec les salmoniculteurs irlandais pour étayer les travaux de recherche, a permis de suivre des variables portant sur les maladies, l'environnement, et différents aspects de production et de gestion des élevages de saumon. Collectées au long des saisons de production et traitées rétrospectivement, ces données ont permis de rechercher les liens pouvant exister entre pathologie et pratiques d'élevage. L'analyse suggère que certaines pratiques, comme la restriction à des cycles de production uniques suivis de jachère, peuvent moduler fortement les taux de mortalité. Des recommandations fondées sur ces constats ont pu être formulées à l'adresse des professionnels. En Irlande, au cours de la période 1988-1994, la cause de mortalité principale a été la maladie du pancréas (MP) qui rend compte de 50 % des pertes. Sept années de surveillance ont abouti à la saisie de données portant sur plus de 18 millions de poissons représentant un total de 52 cycles annuels de production et distribués sur 11 sites d'élevage marin. De 1989 à 1994 des flambées de MP ont été enregistrées sur 70 % des sites, entre le mois d'août et le mois d'octobre. La mortalité a beaucoup varié d'un site à l'autre ( $P < 0,05$ ), avec des taux d'autant plus élevés que la maladie survenait précocément ( $r = -0,62$ ;  $P < 0,01$ ). Il existe aussi une très forte corrélation entre la mortalité due à la MP et la durée des épisodes cliniques ( $r = 0,60$ ;  $P < 0,01$ ). Par contre aucune liaison n'a été établie avec le poids des smolts introduits, la charge initiale des cages et les pertes résultant du transfert en mer.*

A collaborative research project was established between the Irish Salmon Growers' Association and the Veterinary Sciences Division (DANI) to develop a computerised management and disease information retrieval system for production of farmed Atlantic salmon. Such a database was considered essential in facilitating the development of control strategies required to minimise the losses in production encountered by the Irish salmon industry following outbreaks of various disease conditions. The initial objective of the project was to identify production, environmental, disease and management factors which are significant in determining the profitability of Atlantic salmon farming in Ireland. At the time when development of the database was proposed, pancreas disease (PD) was a condition of unknown aetiology with a relatively high prevalence, which caused losses at the marine stage of production during 1987 estimated to be in the region of 5-6 million pounds during 1987 (Branson 1988).

PD was initially described in Scotland but is now known to occur in all of the major Atlantic salmon farming countries of Europe as well as in the USA (Munro et al 1984, Kent and Elston 1987, Poppe et al 1989, Murphy et al 1992). This disease normally affects salmon during their first year at sea and clinically it presents itself as a rapid decline in feed intake, a tendency to congregate in the corners of cages close to the surface of the water, and the appearance of white faecal casts (Munro et al 1984). Mortality rates of up to 45% have been reported in PD outbreaks but indirect production losses such as growth loss are probably more important (Menzies et al 1996). Earlier exploratory analysis using the database concentrated on investigating the temporal spread of PD during outbreaks on different sites; this indicated that the cause of PD was probably infectious (Menzies et al 1996). This has since been confirmed through the isolation of a toga-like virus from salmon affected by PD and the experimental reproduction of PD using this virus (Nelson et al 1995, McLoughlin et al 1996).

### MATERIALS AND METHODS

Prior to construction of the database in 1992, it was necessary to survey and visit the salmon producers to assess the information which is routinely recorded and to identify those sites with adequate accurate information which could be used for intensive monitoring. The sites selected for monitoring were visited annually so that data on management and disease could be updated by completion of a smolt performance questionnaire and by interviewing the site biologist and/or the farm manager. Retrospective data from 1988 onwards were available from some of the sites selected for intensive monitoring. Production information was obtained by downloading and standardising data from the various spreadsheet packages used by producers. Environmental data and pathology reports were obtained from the appropriate monitoring and diagnostic services. Disease outbreaks

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were identified by predefined criteria (Wheatley et al 1995). Clinical signs alone were not accepted as a diagnosis of PD and histological examination was required to confirm an outbreak.

Data were standardised in relation to each site and cage within a site. The variables were further categorised as annual site, annual cage, fortnightly site and fortnightly cage data. Within each of these data types, the variables were calculated for each fortnightly or annual interval. The database has been modified over the years and additional fields and tables have been incorporated to accommodate changes in management practices and enhancements to the system such as inclusion of feed input information.

More details relating to the establishment of the database and the findings reported from preliminary analyses can be found elsewhere (Wheatley et al 1995, Menzies et al 1996). Examples of the main types of production, disease, management and environmental data are shown in Table I.

**Table I**  
**Examples of the main variables for the variable types held within the database**

| VARIABLE TYPE         | VARIABLE                                |
|-----------------------|---|
| Annual site data      | Year farming started on site            |
|                       | Water depth at mean low spring tide     |
|                       | Maximum current speed                   |
|                       | Single or mixed generation site         |
|                       | Movement of operatives between sites    |
|                       | Length of fallowing before smolt input  |
|                       | Fish moved to a new site                |
| Annual cage data      | Bleeding of fish on-site                |
|                       | Cage type                               |
|                       | Depth and volume of cage                |
|                       | Single or block of cages                |
|                       | Number of cage blocks at the site       |
|                       | Source and strain of smolts             |
|                       | Vaccination                             |
|                       | Average weight and number at transfer   |
|                       | Transfer method                         |
| Fortnightly site data | Feeding method                          |
|                       | Water temperature                       |
|                       | Dissolved oxygen                        |
|                       | Salinity                                |
|                       | Chlorophyll                             |
|                       | Ammonia                                 |
|                       | Nitrite                                 |
| Fortnightly cage data | Nitrate                                 |
|                       | Number and percentage of mortalities    |
|                       | Occurrence of any of the major diseases |
|                       | Laboratory confirmation of diagnosis    |
|                       | Treatment and duration of treatment     |

The database was established using the relational database management software package ORACLE (Oracle Corporation, Redwood City, California). The software was mounted on a ALPHA 8200 server which has 512 megabytes of main memory. Routine statistical analyses were carried out using SPSS-X (SPSS Inc., Chicago, Illinois) and GENSTAT (Anon 1994).

The data presented relate to over 18.5 million Atlantic salmon smolts which were placed on 11 Irish marine Atlantic salmon farms located on the western coast of Ireland which cover 52 years of production at sea (from smolt input to the end of December inclusive, of the first year at sea) between 1988 and 1994.

Percentage mortality was used as the measure of production due to the inability to accurately assess biomass on the majority of the monitored sites. Mortality data were subjected to the arcsine root transformation for statistical analysis. Mortality rates were compared between sites using analysis of variance. When analysis of variance resulted in a significant *F*-test value, the Student's *t*-test was used to compare sites. When variances were significantly different between groups, the Student's *t*-value was calculated using the separate variance estimate. Standard linear regression and correlation techniques were used to determine whether significant associations occurred between mortality and PD outbreaks.

## RESULTS AND DISCUSSION

During recent years (1991-1994), the number of smolts being monitored using this system represented between 35%-50% of the total smolt input into Irish marine sites. The average mortality from input to the end of December over the years monitored (1989-1994) was 23.9%. The major factor affecting the profitability of salmon farms was PD, which contributed to half (49%) of the total mortality over the years 1988-1994. There was a significant downward trend in the mortalities due to PD ( $P < 0.05$ ) during this period. Annual PD outbreaks were recorded on over 70% of the monitored sites between 1989 and 1994, indicating the ubiquitous nature of the disease.

Between 1988 and 1994 there were 46 outbreaks of PD reported from the monitored sites with 61% of these outbreaks starting within the period August to October inclusive.

Analysis of annual mortality rates during outbreaks of PD over seven sites between 1990 and 1994 showed that mortalities were statistically significantly different between sites ( $P < 0.05$ ) but were not significantly different between years. Previous analyses, in relation to mortalities generally, indicated that the site management factors which were significantly correlated with reduced mortality were fallowing of sites, single generation rearing, slaughtering of fish away from the site and restriction of farm staff to one site (Wheatley et al 1995). Since 1992, the vast majority of marine sites now practice single generation rearing and fallowing of sites which may have contributed to the significant reduction in overall mortality during 1993/1994 (13.6%) compared to mortality rates in the previous five years (27.6%). However, PD continues to cause 50% of the overall mortality.

There was a very significant correlation obtained between the time of occurrence of PD and the percentage mortality during an outbreak, the earlier in the year a PD outbreak occurred then the higher mortality rate ( $r = -0.62$ ,  $P < 0.01$ ). A similar correlation was found between the time from smolt input and the percentage mortality for PD outbreaks ( $r = -0.59$ ,  $P < 0.01$ ). There was a highly statistically significant correlation between PD mortality rate and the duration of the outbreak of PD ( $r = 0.60$ ,  $P < 0.01$ ). The duration of PD outbreaks tended to be longer when they occurred earlier in the year. One possible explanation for these findings would be that younger fish populations are more susceptible to the effects of PD.

There was no correlation between PD mortality and smolt input weight, initial stocking density or transfer mortality. Additionally, there appeared to be no relationship between the interval from smolt input and the start of PD outbreaks.

## CONCLUSIONS

The establishment of the salmon information system has enabled disease, production and environmental variables to be compared and contrasted over spatial and temporal distributions. It has been utilised to identify site management factors which are detrimental to production as well as to help elucidate the epidemiology of PD. This on-going study will be of benefit to the Irish salmon industry as it will form a unique tool in facilitating their ability to maximise profitable production of Atlantic salmon. This is particularly relevant as the Fisheries Operational Programme 1994-1999 seeks to increase Irish salmon production by over 50% by 1999.

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