Anglesey Tern Diet Report

Report compiled in 2017 by Lizzy Green

Background

Observations of tern chick feeding have been carried out almost every year at the Skerries and Ynys Feurig, on Anglesey, since 1989 and 1992 respectively. This constitutes a huge data set of more than 20 years of diet data from each site, providing valuable insight into what terns feed their chicks on Anglesey and how this varies over time. The data was recorded electronically as raw field data (i.e. reporting the type and size of prey at every individual feeding event) and/or as summary data per nest per day (i.e. reporting the total number of prey and the % composition or total number of different prey types per nest per day). In some years the data had not been recorded electronically, but the original hard copy was available. In these cases, the data was kindly typed up by volunteers Pete and Jan Owens or scanned by Anglesey warden Ian Sims. Ian also provided clarity and helpful information regarding methodologies and data issues.

Preliminary checks of data

While examining the data it became apparent that at both sites in most years the data was collected during observations of Arctic tern nests. In some years data was also collected from roseate or common tern nests; for example, at Ynys Feurig in 2013 all data was from common tern nests. However, in the vast majority of years the proportion of non-Arctic tern nests was low; therefore the data was refined to include only Arctic tern nests. This was important because tern diet varies between species and years; thus, it would not appropriate to compare Arctic tern diets in some years with that of other tern species in other years. If it was not possible to distinguish which nests belonged to which species, that year of data was not assessed. Using the annual reports it was possible to identify tern species per nest for all but one year: in 2008 at Ynys Feurig, when the annual report refers to “commic” terns.

The annual percentage compositions of chick diet reported in the annual reports were compared to the percentage compositions calculated from the raw field data, and in many cases the values did not match. Therefore it was necessary to recalculate the annual percentage composition of Arctic tern chick diet using the raw field data or summary data where raw data was not available. However, further assessment revealed that in some years the summary data for the Skerries had been calculated incorrectly. For example, in 1997 only summary data per nest per day were available, but in 7 out of 16 nest-days the percentage composition of chick diet did not sum to 100%. This prevented the calculation of the total number of items per prey group and therefore the re-calculation of the annual percentage composition of Arctic tern chick diet at the Skerries in 1997. Data from 1997 was therefore omitted from further analysis. Data from 1999 was also omitted because of inconsistencies between the sum of the total number of items of each prey group and the overall total number of items recorded per nest. Thus, problems arose where field data was not available and inconsistencies were found in the summary data. In 2000 at the Skerries neither raw field data nor summary data per nest-day was available. As only the annual % composition was provided

and the calculation of this could not be checked, data from this year was also removed from further assessment.

The composition of Arctic tern chick diet at the Skerries and Ynys Feurig

I calculated the annual percentage of Arctic tern chick diet composed of different prey groups for the Skerries and Ynys Feurig separately. In some years some items were recorded as unknown type; these were omitted from the calculation of annual diet composition. I grouped the identified prey items as sandeels, clupeids or "other" (e.g. squid, gadoids, shrimp). For each prey group in each year I summed the total number of items that were observed being fed to chicks and divided this by the total number of identified prey items. I also calculated the mean prey length per year, averaged across all prey items with an estimated length (in bill lengths). Table 1 and Figure 1 show the annual diet composition of Arctic tern chicks at the Skerries from 1989-2016; Table 2 and Figure 2 show the annual diet composition of Arctic tern chicks at Ynys Feurig from 1992-2016. The figures show the compositions both including and excluding unknown items to demonstrate that this does not have a large impact on the overall pattern.

Between 1990 and the late 2000s Arctic tern chicks at both the Skerries and Ynys Feurig were fed predominantly on sandeels. In 2009 the proportion of clupeids in chick diet suddenly increased, particularly at Ynys Feurig where clupeids were the predominant prey from 2009-2012. By 2014 sandeels were again the most frequent prey fed to chicks on Ynys Feurig, although the proportion of clupeids remained relatively high until 2016. This suggests a recent shift towards a less sandeel-dominated diet. Whether this is the beginning of a long-term shift in diet or short-term variation is unknown.

In recent years the proportion of clupeids in Arctic tern chick diet at Ynys Feurig has been notably higher than that observed at the Skerries; between 2009 and 2016 clupeids made up, on average, 46.8% of chick diet on Ynys Feurig and 24.8% of chick diet on the Skerries (2017 data is only currently available for the Skerries and therefore not included in the calculation). A greater availability of clupeids around Ynys Feurig compared to the Skerries is in accordance with knowledge about clupeid distributions; both sprat and juvenile herring are found at higher abundances in shallow inshore areas (Heessen et al., 2005, 2015).

Table 1. The composition of Arctic tern chick diet (identified items only) at the Skerries 1989 – 2016 based on chick provisioning monitoring.

Year	% sandeel (of identified)	% clupeid (of identified)	% other (of identified)	Mean length of prey (bill lengths)	Comments if missing data
1989	32.143	67.857	0.000	1.56	
1990	94.444	1.852	3.704	1.1	
1991	92.997	2.526	4.478	0.97	
1992					No data
1993	71.781	27.790	0.429	1.34	
1994	83.296	16.036	0.668	1.47	
1995	96.344	3.656	0.000	1.19	
1996	74.459	25.405	5.541	1	
1997					7/16 nest-days do not sum to 100% prey
1998	97.188	2.250	0.063	1.2	
1999					On 4 dates, total items per prey group do not equal the total number of prey items
2000					Only annual % of prey given
2001	93.274	6.278	0.448	1.28	
2002	94.041	5.613	0.345	1.31	
2003	85.511	14.347	0.710	1.4	
2004	81.234	17.848	0.919	1.41	
2005	95.491	4.509	0.000	1.24	
2006	84.500	15.500	0.000	1.53	
2007					No monitoring carried out
2008	71.150	28.099	0.751	1.34	
2009	49.722	48.103	2.175	1.54	
2010	76.796	12.707	10.497	1.41	
2011	69.086	29.282	1.631	1.3	
2012	61.479	35.486	3.035	1.49	
2013	71.475	18.337	10.187	1.39	
2014	89.016	8.497	2.487	1.33	
2015	83.960	15.708	0.332	1.86	
2016	69.637	30.363	0.000	1.9	
2017	75.025	23.988	0.987	1.27	

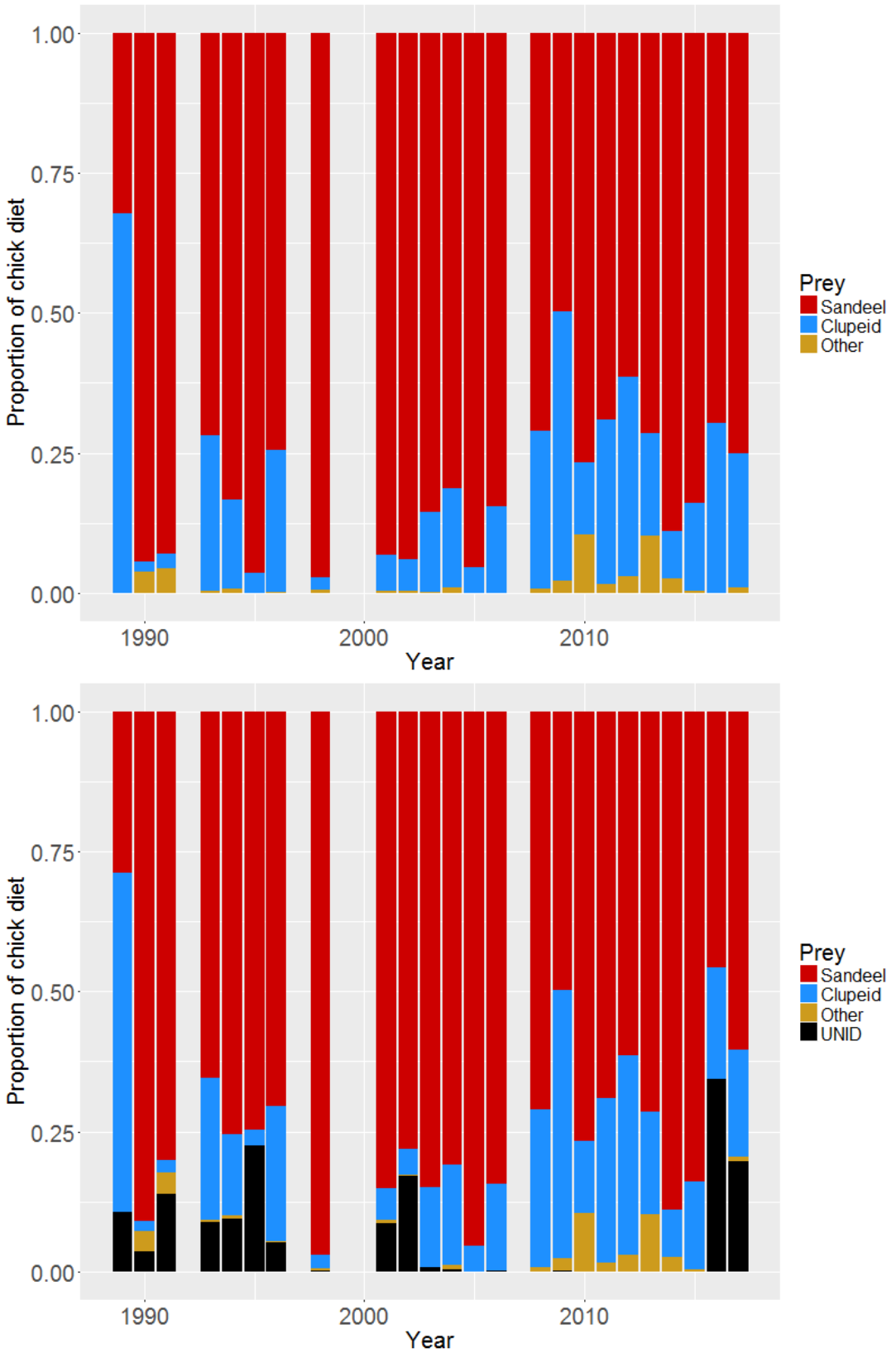

Figure 1. Proportional composition of Arctic tern chick diet at the Skerries, 1989-2016. Top: identified items only. Bottom: including unidentified items.

Table 2. The composition of Arctic tern chick diet at the Ynys Feurig 1992 – 2016 based on chick provisioning monitoring.

Year	% sandeel (of identified)	% clupeid (of identified)	% other (of identified)	Mean length of prey (bill lengths)	Comments if missing data
1992	65.421	26.168	8.411	1.06	
1993	84.615	0.000	15.385	1.35	
1994	90.789	3.947	5.263	0.87	
1995	82.390	4.088	13.522	0.99	
1996	84.420	11.957	3.623	1.35	
1997	71.406	23.962	4.633	1.59	
1998	95.545	2.772	1.683	1.27	
1999	81.847	11.911	6.242	0.87	
2000	85.404	13.043	1.553	1.93	
2001	97.809	0.598	1.594	1.3	
2002	93.635	1.082	5.283	1.44	
2003	96.347	1.142	2.511	1.39	
2004	86.562	7.507	5.931	1.05	
2005	68.909	20.183	10.907	1.33	
2006	84.167	10.833	5.000	1.51	
2007	80.539	13.680	5.780	1.23	
2008					Refer to “commic” terns when discussing study nests in the annual report. In table of objectives 2 they state arctic tern diet, but this is the same table used in the previous year and may not have been updated.
2009	14.610	82.955	2.435	1.5	
2010	35.484	55.376	9.140	1.49	
2011	26.027	43.322	30.651	1.42	
2012	22.436	62.821	14.744	1.15	
2013					Common tern data only
2014	52.193	39.693	8.114	1.24	
2015	55.376	28.495	16.129	1.43	
2016	72.500	15.000	12.500	1.06	

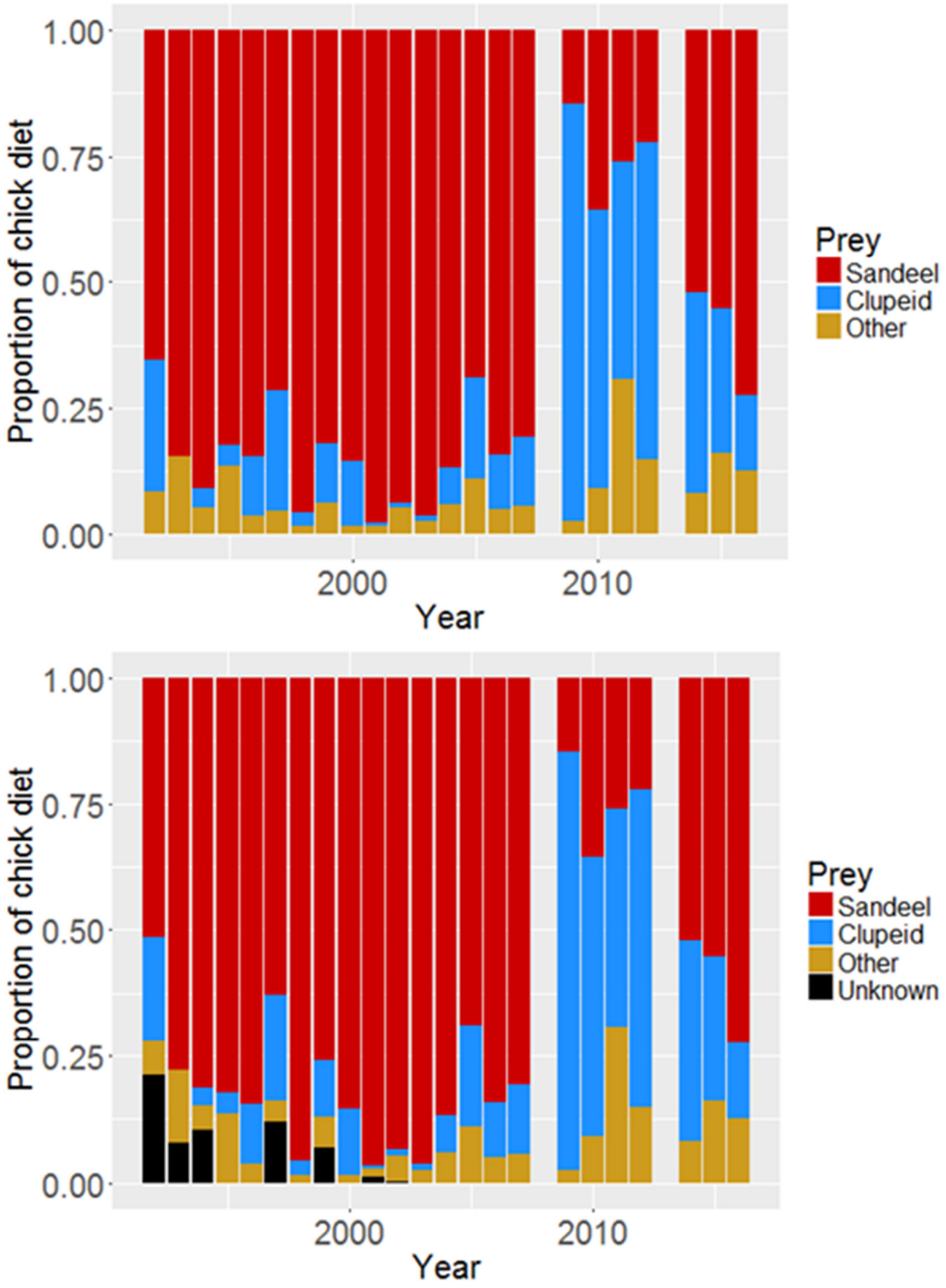

Figure 2. Proportional composition of Arctic tern chick diet at the Ynys Feurig, 1992-2016. Top: identified items only. Bottom: including unidentified items.

The relationship between chick diet composition and productivity

Previous studies have found that diet composition can affect seabird breeding success (Massias and Becker, 1990; Stienen and Brenninkmeijer, 1998; Wanless et al., 2005). However, there is no significant correlation between the proportion of sandeels, clupeids or "other" prey in Arctic tern chick diet and maximum or minimum annual estimates of productivity based on study nests observations at either the Skerries or Ynys Feurig. This is somewhat expected, as terns at these colonies have access to both clupeids and sandeels (high-energy prey) and can therefore switch between prey types if the availability of one declines. Additionally, any effect of diet is likely to be masked by other factors that can affect productivity such as predation of chicks, poor weather or disease. Although an attempt was made to filter out years where such factors had a large impact on chick survival, this was largely based on subjective assessments in the annual reports (e.g. "the level of predation was considered to be at an acceptably low level", "chick predation was moderate", "it is felt by the wardens that a large number of the missing chicks were predated but this was not actually seen") and therefore was deemed unreliable. Efforts should be made to develop a standardised method of quantitatively recording predation or losses of eggs/chicks to other factors. However, the difficulties associated with this suggestion are acknowledged, as it will not be possible to monitor every predation event (e.g. due to time limitations, physical obstructions and night-time predation events). A final complication is the uncertainty around the accuracy of the productivity estimates used in the correlations, with a wide range of productivity values encompassed by the minimum and maximum estimates in many years.

Does chick diet composition covary at the Skerries and Ynys Feurig?

Figure 3 shows a significant positive correlation between the proportion of sandeels in Arctic tern chick diets at the Skerries and Ynys Feurig for the 18 years between 1993 and 2016 where diet composition is known for both sites (Pearson correlation $r = 0.702$, $p = 0.001$). A similar but less strong correlation exists between the proportion of clupeids at both sites (Pearson correlation $r = 0.612$, $p = 0.007$). There is no significant correlation between the proportions of "other" prey between the two sites.

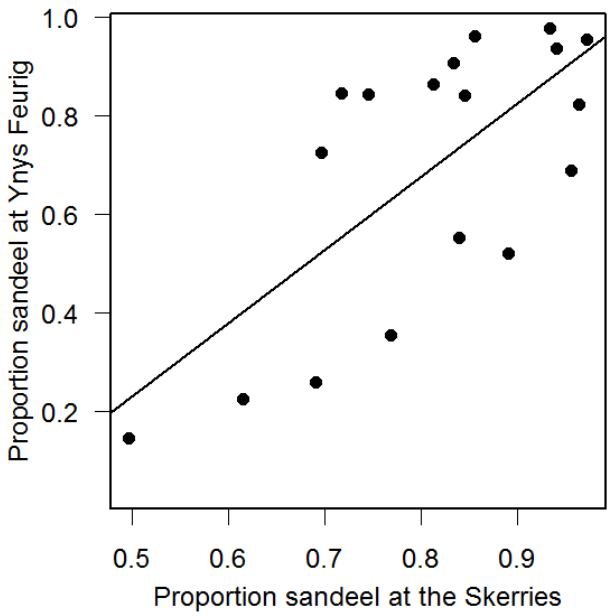

Figure 3. The correlation between the proportion of sandeels in Arctic tern chick diets at the Skerries and Ynys Feurig for the 18 years between 1993 and 2016 where diet composition is known for both sites.

Investigating the effect of SST on chick diet at Anglesey

The correlation between the annual proportion of sandeels (and clupeids) fed to Arctic tern chicks at the Skerries and Ynys Feurig suggests that the availability of this prey to foraging terns is driven by a common factor. It was hypothesised that this common factor may be water temperature in the surrounding area, as sandeel recruitment in the North Sea has been shown to be lower in warmer waters (Arnott and Ruxton, 2002; Frederiksen et al., 2004; Wright et al., 2017). To investigate whether temperature contributed to the observed inter-annual variation in the proportion of sandeels in Arctic tern chick diet at Anglesey, monthly sea surface temperature (SST) data from the HADISST model was accessed for the 1° x 1° grid cell that contains the Skerries and Ynys Feurig for 1991-2016. There was no significant effect of annual mean SST in the previous year or the mean SST of any month in the previous year on the proportion of sandeels in the diet of chicks at either site.

Data issues and recommendation for future diet monitoring

In addition to the problems already mentioned, there were other inconsistencies in the provisioning data and missing information. These are listed in the below table, with recommendations about how such issues should be avoided in the future to improve the value of the collected data.

Table 3. Problems encountered with electronic diet data and recommendations for future diet monitoring

Topic	Problem	Recommendation
Which tern species?	It wasn't always clear which tern species were being observed, so this had to be worked out from annual reports (when available). Recent years have only observed Arctic terns, so this may not be a problem anymore.	If nests of species other than Arctic terns are observed this MUST be clearly specified in the electronic data sheet
Number of chicks	Sometimes the number of chicks in a nest is not clear, particularly when the number changes. This is important for the calculation of chick hours and provisioning rates.	Always note the number of chicks in each nest. If the number of chicks changes make a note on the data sheet e.g. "chicks = 1 to 2" or "chicks = 2 to 1" and record in electronic data e.g. by highlighting the observation period when the number of chicks changes
Unknown items	Some years have reported no "unknown" prey, which may be true, but given that unknowns have accounted for up to 34% of items it seems unlikely. It may be that unknowns were recorded as "other" prey, which gives the impression that the item was observed and was identified as not being a sandeels or clupeids - although in reality it may have been one of these. This causes an inaccurate calculation of diet composition.	Items obscured from view or fed too quickly to be identified should be recorded as unknown ("?")
Recording 0 feeding events	Often unclear whether a nest was watched but no feeding took place or the nest was unwatched. Leads to an incorrect calculation of chick hours and feeding rate	If a nest is watched but no feeding takes place during observations, make this clear when recording the data electronically
Summary data	In some years the % composition of tern diet has been calculated incorrectly (not adding up to 100%) in the electronic summary data and the number of items has not been recorded so the errors cannot be rectified. Providing the raw data (i.e. number of items of each prey type) is more useful for analyses than just the % composition.	When recording the data electronically as summary tables, include the number of items of each prey type in addition to the percentage composition of diet
Nest IDs	Nest IDs have not always been used as unique identifiers – in some years (e.g. 2017 at the Skerries) nest IDs can refer to completely different nests on different days	Give each nest a unique nest number that remains the same throughout the season and is not used to refer to any other nests
Nest IDs	Complicated nest IDs make it unclear which nest is being referred	Avoid ambiguity and use a simple system to identify nests e.g. 1, 2, 3..

	to, e.g. N1 and NSN1 – is this one nest recorded differently by 2 different people? No information about what the letters mean.	If complexity needs to be added, keep it simple, e.g. 1A, 2A, 3A could refer to nests in area A; 1B, 2B, 3B could refer to nests in area B, etc. Clearly specify this in the electronic data sheet.

References

Heessen, H.J.L., Eastwood, P.D., Fletcher, N., Larsen, L.I., Ellis, J.R., Daan, N. and Ter Hofstede, R., 2005. ICES Atlas of North Sea Fishes (ICES-FishMap). Electronic publication. www.ices.dk/marineworld/ices-fishmap.asp, Version 01/2005.

Heessen, H.J.L., Daan, N. and Ellis, J.R., 2015. Fish atlas of the Celtic Sea, North Sea, and Baltic Sea. *Wageningen: Wageningen Academic Publishers*.

Massias, A. and Becker, P.H., 1990. Nutritive value of food and growth in Common Tern *Sterna hirundo* chicks. *Ornis Scandinavica*, pp.187-194.

Stienen, E.W.M. and Brenninkmeijer, A., 1998. Population trends in Common Terns *Sterna hirundo* along the Dutch coast. Vogelwelt, 119: 165–168.

Wanless, S., Harris, M.P., Redman, P. and Speakman, J.R., 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. *Marine Ecology Progress Series*, *294*, pp.1-8.