



Trinity House

TRINITY HOUSE CLIMATE CHANGE ADAPTATION REPORT 2016

Sea level rise | Cliff and shore erosion | Increased storm activity | Rising temperatures



Low level lighthouses at risk from sea

Hurst Point Lighthouse

© T.W. West



Lighthouses at risk from crumbling cliffs

Start Point Lighthouse

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Boat landings at risk from sea

Casquets Lighthouse

Main image:
Repairing the storm-damaged
boat landing at Les Hanois Lighthouse.

1. Statutory & Other Functions of a Public Nature

1.1 Aids to Navigation (AtoN) Provision

Trinity House is the General Lighthouse Authority (GLA) for England, Wales, Channel Islands and Gibraltar. Trinity House has responsibility, subject to certain provisions, for the superintendence and management of "all lighthouses, buoys and beacons" throughout its geographical area including "the adjacent seas and islands...." within and beyond territorial waters up to the outer limit of the UK Exclusive Economic Zone (EEZ). It provides a large number of traditional short-range AtoN complemented by a mix of radio navigation aids for the safety of all mariners engaged in general navigation irrespective of who pays for the service, the size or type of the vessel, her equipment fit, the competence of her crew, or flag.

The statutory authority for Trinity House in terms of AtoN is Part VIII of the Merchant Shipping Act (MSA) 1995 as amended by the Marine Navigation Act 2013.

There is a separate GLA for Scotland & the Isle of Man (the Northern Lighthouse Board) and another for the whole of Ireland (the Commissioners of Irish Lights).

Trinity House currently maintains 66 Lighthouses; 11 Light Vessels / Floats; 450 Buoys, and 8 Differential Global Positioning System (DGPS) Reference Stations.

1.2 Local AtoN

Other provisions of Part VIII of the MSA 1995 refer to Local Lighthouse Authorities which are required to obtain the consent of Trinity House to establish, alter or discontinue any aids to navigation within their local jurisdiction. As a part of its statutory responsibilities, Trinity House inspects local aids to navigation in ports and harbours and carries out seaward inspections of offshore installations in its area to ensure that the AtoN conform to approved standards and are working properly. Trinity House is also involved in the operation of the Port Marine Safety Code (PMSC) as far as ensuring the reliability and availability of aids to navigation are concerned.

1.3 Wreck Powers

Trinity House has a statutory responsibility for wrecks by virtue of Sections 252 and 253 of the MSA 1995. Trinity House has powers within its geographical area of responsibility to mark, raise, remove or destroy any vessel "sunk, stranded or abandoned in any fairway, or on the seashore or on or near any rock, shoal or bank, in the British Isles or any of the adjacent seas or islands" where there is no harbour or conservancy authority with powers to raise, remove, or destroy the vessel.

Internationally recognised geographical demarcation lines have been drawn between the UK and Ireland and with France, the Netherlands and Belgium for the purposes of wreck marking and dispersal.

Under the direction of the Secretary of State's Representative for Maritime Salvage and Intervention (SOSREP) as set out in the Wreck Removal Convention Act 2011 Trinity House may also be required to locate a wreck, ascertain if it is a danger to navigation, mark it if appropriate and possibly remove it. The Convention covers wrecks up to the outer limit of the UK EEZ.

1.4 SOLAS

The GLAs also discharge on behalf of the UK Government through the Department for Transport (DfT)/GLA Framework Agreement the UK's United Nations obligations under the International Convention for Safety of Life at Sea (SOLAS), in respect of the provision of AtoN, including those required to mark wrecks. The Convention requires such provision to take into account internationally recognised standards set by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA).

1.5 Commercial Activity

Trinity House also has powers to exploit commercially spare capacity in its assets by virtue of the powers contained in the Marine Navigation Act 2013. This consists primarily of supplying, laying and/or maintaining buoys on behalf of port and harbour authorities and other third parties such as wind farm operators on a commercial basis.

1.6 Funding

The costs of the GLAs' services are met from the General Lighthouse Fund (GLF). The income to the GLF comes mostly from light dues, which are charged on commercial shipping calling at ports in the United Kingdom and Republic of Ireland. There is no provision for Exchequer funding except in the Republic of Ireland and in respect of any guarantees given in relation to the GLAs' borrowing powers. As a 'quasi-trustee' of the GLF, the Secretary of State for Transport has a duty to ensure the effective management of the Fund and the adequate provision of AtoN at the minimum cost. DfT officials manage the GLF on a day to day basis.

1.7 Resources

In total Trinity House employs some 320 full and part-time staff and operates two ships along with a rapid intervention vessel and local boats. It has a small Headquarters in London; two operational bases at Harwich and Swansea; and another small inland base at St Just aerodrome near Land's End. It also has the services of a contract helicopter mainly for transferring technicians and supplies to offshore Lighthouses. Our annual budget is approximately £36M per annum.

1.8 Aims & Objectives

The overall aim of Trinity House is to deliver a reliable, efficient and cost-effective 'aids to navigation' service for the benefit and safety of all mariners.

Our objectives are set out in our Strategy. The current Strategy covers the period from 2015 to 2020 Key priorities during this period are

Priority One- Operational Delivery - Continuous Improvement

- To continue to assess appropriate need and type of Aid to Navigation based on an objective analysis of traffic, risk and user requirements.*
- To develop maintenance plans driven by achieving set, recognized engineering standards.*
- To implement the best quality and most efficient engineering solutions.*
- To manage our resources at a holistic level, ensuring the most effective and efficient use of our assets, technology and people.*
- To retain and maintain our Estate to the appropriate standard to ensure it is fit for purpose.*

Priority Two- Reputation Development

- To maximize our reputation and proactively develop a wider understanding of the value Trinity House brings to the maritime infrastructure.*
- To raise support amongst key stakeholders by facilitating an effective external relations strategy.*
- For Trinity House to be perceived as the best at what we do.*

Priority Three- New Business

- To further investigate opportunities for new business.*
- To develop consultancy opportunities as and where appropriate.*
- To develop opportunities for the exploitation of our Intellectual Property*

Priority Four- Internal Communications and Staff Engagement

- To ensure staff are trained and provided with development opportunities for the benefit of the individual and the organisation.*
- To establish good levels of two-way communication between Directors, Managers and staff and engage staff in decision making processes.*
- To encourage diversity amongst our workforce.*
- To fully support those with ambition to achieve their goals.*
- To effectively manage the performance of our staff by recognizing and rewarding achievement and tackling poor performance.*
- To ensure our staff have a safe environment in which to work.*

Priority Five- Cultural Change

- To develop a leadership style better suited to our organisational needs.*
- To change the way we work to become more people driven rather than process driven.*
- To empower our staff in decision making and problem solving.*
- To integrate our workforce and remove silos.*

Priority Six- Improving Working Practices

- To streamline working processes and make efficiencies*
- To establish consistency in design*
- To encourage good team-work*
- To achieve simplification in operating procedures*

None of these priorities are considered to be currently at material risk due to climate change. Looking to the future, some of the objectives that are likely to run from year to year potentially at material risk from climate change are:

- (i) Harm to our reputation and our wish to be perceived as the best at what we do, if we are unprepared for the consequences of climate change.
- (ii) Our opportunities for new business in the event of the above, but also in the event of having to deploy resources unexpectedly should climate change not be planned for.
- (iii) Applying the appropriate standards to AtoN provision (AtoN could fail if we do not act at the appropriate time to deal with sea level rise / erosion)

- (iii) Maintaining the drive for cost efficiency (preparing for / dealing with climate change may increase the call on resources)
- (v) Maintaining the highest standards of corporate governance (not identifying, controlling and monitoring the risks of climate change would be a failure of corporate governance);
- (vi) Reducing the service maintenance overhead in both AtoN and supporting infrastructure (preparing for / dealing with climate change may increase the call on resources at least in the short-term)
- (vii) Developing our estate management policies in line with good practice (failure to recognise and deal with the impacts of climate change could adversely affect our estate, although this may to some extent be beyond our control).

1.9 Stakeholders

Trinity House's primary stakeholders as a GLA are:

- (i) The Mariner for whom we provide our services;
- (ii) Ship owners, who pay for our services;
- (iii) The UK Government for whom we discharge its international obligations under SOLAS for the provision of AtoN including the marking of wrecks, and Parliament;
- (iv) Our staff;
- (v) Port & harbour authorities;
- (vi) Commercial customers;
- (vii) The International Association of Marine Aids to Navigation and Lighthouse Authorities.

To deliver our overall aim of a reliable, efficient and cost-effective aids to navigation service for the benefit and safety of all mariners we need to assess the impacts of climate change in terms of AtoN provision; adapt as necessary and ensure we continue to discharge the UK Government's international obligations and our statutory obligations in relation thereto. At the same time we need to continue to deliver value for money for the ship owner.

We also have a duty of care to our staff to ensure that they are not adversely affected by climate change whilst at work and to consult with them on matters affecting the workplace.

We regularly consult with all our other stakeholders including environmental organisations like Natural England and the Natural Resources Wales and heritage bodies like Historic England and Cadw. The impact of climate change on our activities will be raised with them as appropriate.

2. Assessment of Current & Predicted Impact of Climate Change on Statutory Functions

When determining the impact of climate change on its statutory functions as a GLA, Trinity House has taken account, the information available from:

- the Inter-Governmental Panel on Climate Change Fourth Assessment Report (IPCC AR5);
- the UK Government Stern report;
- the UK Climate Impacts Programme (UKCIP) including UKCP09 projections; and
- the Meteorological Office.

Having regard to the long-term nature of climate change, references in this report to the short term are up to 10 years (to 2025); the medium term between 10 and 40 years (to 2055) and the long-term more than 40 years.

The impact of climate change will be relatively slow and appropriate mitigation measures can be implemented within Trinity House's existing strategic and corporate planning arrangements. These are reviewed annually as part of the organisation's planning processes which look up to 10 years ahead.

There are various predicted changes to the climate as set out in the document published by Defra: *'Adapting to Climate Change: Helping Key Sectors to adapt to Climate Change - Statutory Guidance to Reporting Authorities 2009.'*

Having regard to Trinity House's key aims and objectives and having reviewed the activities carried out as described in the Trinity House management system, which is accredited to the ISO 9001 (quality), ISO 14001 (environmental) and OHSAS 18001 (health & safety) standards, the following are considered likely to have an impact on the statutory and other public functions of Trinity House:

1. Flooding (including sea level rise)
2. Erosion (cliff and beach)
3. Significant changes in weather paths (increased level of wind storms)
4. Increased demand for summer cooling / buildings becoming uncomfortably hot (in terms of employees & suppliers)

The impact of climate change has not to date had a material impact on Trinity House's statutory or other public functions nor is there an expectation of a material impact in the short term. Climate change was covered in the GLAs' 2015 Risk Management Review and is flagged in its organisational risk register as a factor with the potential to (i) impact on the provision of AtoN; ii) result in asset loss / damage or lead to an increased frequency of shipping casualties / wrecks and (iii) adversely affect the environment. The situation is reviewed by the Trinity House Board in the light of feedback from Executive Directors and Senior Managers and the views of its Audit & Risk Assurance Committee.

2.1 Flooding / Sea Level Rise

Having regard to UKCP09, Trinity House is making its current assessment of the impact of sea level rise on the basis that there is likely to be a rise of one metre by 2100. Whilst this is higher than the projected absolute sea level rise around the UK, it is lower than the High++ (extreme) scenario range for sea level rise and storm surges. As UKCP09 acknowledges, it is thought very unlikely that the upper end of the H++ ranges for sea level rise and surge will be realised during the 21st century.

Sea level rise is the most significant of the predicted changes in climate for Trinity House. A number of our fixed AtoN are sited at sea level and will be affected by a one metre rise in sea level. The impact will vary from the requirement to raise the level of a boat landing to the potential loss of a lighthouse.

Trinity House maintains some 67 Lighthouses (Including East Usk 'Lighthouse' that is owned by Newport Harbour Commissioners, but maintained by Trinity House on their behalf) and the assessment of the impact of a sea level rise (up to one metre) over the next 85 years to 2100 on these structures is as follows:

| | |
|----------------|---|
| 46 Lighthouses | No impact. |
| 12 Lighthouses | Boat landing will come under threat but not integrity of Lighthouse. Boat landing will need changing to accommodate higher water level or will be abandoned.* |
| 3 Lighthouses | Possible loss or significant defence works required.** |
| 8 Lighthouses | Cliff / beach erosion being monitored. Extent of cliff erosion due to climate change is uncertain.*** |
| 1 pier | Harwich is at sea level. |

*The twelve lighthouses with boat landings at risk are: Beachy Head, Casquets, Coquet, Godrevy, Hanois, Longships, Longstone, Nab Tower, Needles, Round Island, Skerries and St. Tudwal's.

**The three lighthouses at risk due to low level are Crow Point, Hurst Point and Hilbre Island

***The eight lighthouse monitored for geology are: Beachy Head, Bull Point, Flamborough Head, Mumbles, Nash Point, St. Catherine's, Start Point, Whitby and Hartland.

Most of the lighthouse estate is either built to withstand sea water and wave activity or is built on high land well above sea level, even allowing for a metre rise in sea levels. A few stations are built close to sea level and are not designed to withstand the effects of sustained sea water attack. It is these Lighthouses, which are under threat from the rise in sea levels. In the event that it were necessary to replace any of the structures, any new structure would be built with due regard to sustainability and would most likely be solar-powered. Indeed many of our Lighthouses and all our buoys are already solar-powered.

Boat landings are by their nature at sea level but can all be raised by modest reworking of their structure. In terms of timing for such work, the threshold would be when access to the station was constrained such that it was likely to affect the operation of the station in the following five year period. The position in this regard is risk assessed on a station by station basis annually.

As reliance on physical AtoN is decreasing in favour of new and emerging technologies it is expected that by 2100, the number of Lighthouses operated by Trinity House for safe navigation will have diminished. It is likely therefore that the impact on existing structures may only be minimal by this time as they may have been operationally decommissioned before remedial action is required. Changes projected over the next 20 years anticipate reducing range requirements of physical long-range aids to navigation. However, it is too early to make a detailed assessment at this stage.

As sea level rises, the increase of one metre may open up new shipping routes but, equally, affect the movement of sub-surface sandbanks. A generic overview of the tapestry of fixed and floating AtoN is carried out on a five yearly basis, together with an on-going assessment of individual aids as the bathymetry changes through regular hydrographic surveying. If and when change occurs, it may require the relocation of floating navigation buoys to a new position or the establishment of new buoy stations. Changing the pattern of deployment of floating AtoN in the light of shifting channels and shipping movements is already part of

Trinity House's business. Any changes required as a result of climate change will therefore not materially impact on our operations.

The greatest concern in terms of sea level is the impact on Trinity House's operational depot at Harwich and more particularly its pier and buoy yard. A sea level rise of one metre could render the pier unusable operationally and would impact on the operation of the buoy yard. A rise in sea levels will also affect Swansea but less so as it is in a locked basin. The worst case scenario is that Swansea Docks, which are the responsibility of Associated British Ports, will be flooded on a high spring tide surge but this will not be confined to Swansea. It will be a nationwide issue.

The pier at Harwich will require raising commensurately, which will not be possible given its age and design. Based on an even rise in sea levels from now to 2100, it is estimated that it will need to be replaced by a new structure in the medium term. Clearance on spring tides is currently about one metre, although it is wave-washed today in certain conditions. The threshold for undertaking the work will be when sea levels are likely adversely to affect the supplying and bunkering of Trinity House vessels from the pier in the following five to ten years. The position will be risk assessed on an annual basis.

The buoy yard can be protected by enhanced flood defences to ensure its operation up to 2100. Such action will be dependent on Environment Agency agreement, having regard to the flood risk to the town of Harwich generally. Again, the risk will be assessed on an annual basis. Maladaptation in this regard could adversely affect not only the town but also other locations along the river.

It is not expected that a sea level rise of one metre will have any material impact on the provision of floating AtoN (Light Vessels and Buoys). In extreme cases, where the rise is locally greater than one metre, the chain may have to be lengthened and / the moorings strengthened. Again, this would be carried out as part of line business. Chain is always considerably longer than the depth of water in which the buoy sits to allow for the rise and fall of the tide.

2.2 Erosion

Trinity House has eight Lighthouses (see table in section 2.1 above) which are near to cliffs, which are known to be unstable. Two of those are DGPS stations (Flamborough Head and St. Catherine's) but with overlapping coverage and therefore greater resilience, the temporary loss of one DGPS station whilst alternative arrangements were put in place would mean that there would be no interruption to the service as far as the mariner was concerned. Investigation of potential alternative sites is underway. Since the previous Climate Change Adaptation Report was published, Orfordness Lighthouse has been decommissioned as a result of beach erosion, although the extent to which this is due to climate change as opposed to naturally occurring factors is uncertain. Others are being closely monitored in terms of sea defence works. Again, the position is risk assessed on a station by station basis annually. It is not clear how climate change will impact on the current rate of cliff instability but it is likely that it will exacerbate the rate of erosion due to more severe weather and storm surges. That said, as the UK Climate Programme 09 (UKCP09) acknowledges, the projected long-term future trend in storm surge is physically small everywhere around the UK, and in many places can be accounted for by natural variability. The surge level expected to be exceeded on average once in 2, 10, 20 or 50 years is not projected to increase by more than 9 cm by 2100 anywhere around the UK coast (excluding the mean sea level change). Furthermore, all such lighthouses at risk are currently monitored by regular cliff or beach surveys (in line with an agreed survey matrix) which document any changes; their rate of change; and expected future stability. The position at all such stations is risk assessed annually. With this information, informed decisions can be taken about the

best solution which will range from 'do nothing', if appropriate, to abandon the station and site a new one further inland.

2.3 Increased Level of Storms

The intensity and frequency of storms is generally expected to increase, although there is some uncertainty in this regard with both the position and strength of the present day storm tracks. Severe windstorms have become more frequent in the past few decades, though not above a level seen in the 1920s. Increased storm activity is not expected to have a significant impact on our ability to deploy or maintain AtoN. Trinity House vessels are designed, and our crews are trained, to operate in stormy weather conditions. However, if these were prolonged, such conditions could potentially have an adverse impact on the delivery of our operations. This risk could be mitigated by changing our working patterns to make use of weather windows by, for example, longer working days during the summer months. Those lighthouses operated on mains power invariably have either a diesel or battery back-up system, which comes into play in the event of a loss of mains power.

Increased storm activity may however increase the likelihood of marine accidents. Ships tend to founder in storms so it is reasonable to anticipate that there may be a rise in shipping storm related incidents. Trinity House's role in such incidents is to locate the vessel, determine whether it is a danger to navigation and mark it with buoys if considered appropriate. It is impossible to predict when an incident or multiple incidents may occur and, as such, Trinity House must be resourced to be able to respond as necessary. The increasing reliance on technology, whilst in some ways enhancing bridge operations, may also lead the Mariner to navigate closer to other shipping and dangers, thereby increasing the risk of an incident.

2.4 Increased Demand for Summer Cooling / Buildings Becoming Uncomfortably Hot - Increased Level of Hotter days

With most of Trinity House's activities at or near the sea, the extremes of temperature are ameliorated by the effect of the ocean. However, any very hot day puts pressure on air conditioning systems for office staff. Climate projections suggest that summer temperatures could be expected to rise by up to 4°C to 5°C in southern England by 2080. This will inevitably increase the reliance on air conditioning but, having regard to the fact that our two operational bases (employing more than 50% of the workforce) are on the coast (Harwich & Swansea) where temperatures are ordinarily lower in summer, this is not considered to be a significant issue in terms of the work environment. A further third of the workforce is ordinarily at sea, where temperatures are also lower in summer.

In addition, our workforce is likely to decline over time, as new technology begins to supersede physical AtoN, although there will remain a requirement for a balanced mix of physical and radio aids.

The organisation has a number of strategic or critical suppliers as defined within our procurement system. In the medium term Trinity House will ascertain from those suppliers whether they envisage any difficulties in terms of adapting to climate change as far as it affects supplies to Trinity House. Strategic suppliers are those intrinsically linked to Trinity House's organisational strategy, by way of service and supplies, forming a functional part of the organisation's activities. Critical suppliers are those providing products and services for specific high-level/high expenditure projects and those non-sole-source suppliers providing products/services, where the cost and timescales for setting-up alternative sources would compromise projects or operations.

2.5 Benefits of Adaptation

Having regard to the scope of our statutory undertaking, no opportunities have been identified as a result of climate change adaptation within the organisation's current statutory framework.

Climate change may result in the organisation having to replace old historic buildings, which are expensive to maintain, with more modern, sustainable and cost-effective structures, where the older structures are lost due to cliff or sea erosion. This will however be the detriment of the country's built national heritage and landscape.

2.6 Summary

Using the approach to assessing, quantifying and reporting risk already in place in the organisation, a risk register has been established (see below) setting out the probability and impact of each of the four risks presented by climate change both before and after mitigation measures have been put in place. The format of the register follows that adopted for the organisational risk register and the Directorate / Departmental registers, which sit beneath it. The register sets out the position today and projections for the climate change risk profile of the organisation in 2020 and 2050.

**TRINITY HOUSE -
CLIMATE CHANGE - REGISTER OF RISKS (2015)**

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|---------------------------------------|--|---|-----------|---|--------------------------------------|--------|---|---|
| | | | Probability | Impact | | Probability | Impact | | |
| 1 | Sea Level Rise / Flooding | Loss of Trinity Pier Harwich Loss of buoy yard facility Loss of boat landings at some Lighthouses Flooding at some Lighthouses Loss of AtoN Significant call on General Lighthouse Fund | Low | Very High | Strategy Asset Management Plan Process inc regular risk assessment 10 Year Capital programme allowing for flexible adaptation Climate change projections Use of floating AtoN on temporary basis Insurance (Against claim arising from AtoN failure) Monitor Harwich flood defences with Environment Agency | Low | High | Monitor climate change predictions Monitor sea levels and impact on TH estate | Reported To: Board Executive *** Owned & Monitored by: Director of Operations |
| 2 | Erosion (Cliff & Beach) | Loss of AtoN Significant call on General Lighthouse Fund | Medium | Very High | Strategy Asset Management Plan Process 10 Year Capital programme allowing for flexible adaptation Cliff and beach monitoring inc regular risk assessment Use of utility structure Use of floating AtoN on temporary basis. Insurance (Against claim arising from AtoN failure) | Low | High | Ensure robust contingency arrangements in place in event of loss of a Lighthouse. | Reported To: Board Executive Directors *** Owned & Monitored by: Director of Operations |

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|---|--|---|--------|--|--------------------------------------|--------|---|--|
| | | | Probability | Impact | | Probability | Impact | | |
| 3 | Increased level of storms | Potential increase in AtoN failures Potential increase in maritime casualties | Medium | Medium | Back up power systems Helicopter access to many Lighthouses | Medium | Low | Monitor climate change predictions | Reported To: Board Executive Directors *** Owned & Monitored by: Director of Operations |
| 4 | Rising temperatures / Increased demand for summer cooling | Buildings becoming hotter Greater demand for air-conditioning Some strategic/critical suppliers have difficulty in meeting orders. | Medium | Medium | Circa 90% of work force located in coastal locations or on board ship where conditions are more temperate. | Low | Low | Monitor climate change predictions | Reported To: Board Executive Directors *** Owned & Monitored by: Director of Operations |
| | | | Low | | | | | | |

**TRINITY HOUSE -
CLIMATE CHANGE – PROJECTED REGISTER OF RISKS (2025)**

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|---------------------------------------|--|---|-----------|--|--------------------------------------|--------|---|---|
| | | | Probability | Impact | | Probability | Impact | | |
| 1 | Sea Level Rise / Flooding | Loss of Trinity Pier Harwich Loss of buoy yard facility Loss of boat landings at some Lighthouses Flooding at some Lighthouses Loss of AtoN Significant call on General Lighthouse Fund | Medium | Very High | Strategy Asset Management Plan Process inc regular risk assessment 10 Year Capital programme Climate change projections monitored Sea levels and impact on TH estate monitored Use of floating AtoN on temporary basis Insurance (Against claim arising from AtoN failure) | Medium | High | Prepare for Harwich Depot pier replacement Work with Environment Agency to enhance sea defences | Reported To: Board Executive *** Owned & Monitored by: Director of Operations |
| 2 | Erosion (Cliff & Beach) | Loss of AtoN Significant call on General Lighthouse Fund | High | Very High | Strategy Asset Management Plan Process 10 Year Capital programme allowing for flexible adaptation Cliff and beach monitoring inc regular risk assessment Climate change projections monitored Use of utility structure Use of floating AtoN on temporary basis. Insurance (Against claim arising from AtoN failure) | Low | High | | Reported To: Board Executive Directors *** Owned & Monitored by: Director of Operations |

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|--|--|--|--------|--|-----------------------------------|--------|---|---|
| | | | Probability | Impact | | Probability | Impact | | |
| 3 | Increased level of storms | <p>Potential increase in AtoN failures</p> <p>Potential increase in maritime casualties</p> <p>TH vessels unable to sail if prolonged</p> <p>Increase stress on rock towers.</p> | Medium | Medium | <p>Better understanding on relationship (if any) between severe weather & maritime casualties.</p> <p>Back up power systems</p> <p>Helicopter access to many Lighthouses.</p> <p>Revised working patterns in TH vessels</p> <p>Regular monitoring of building condition.</p> | Medium | Low | <p>Establish environmental effects of wave loading on Lighthouses. (The purpose is information gathering on the wave impact on structures in increased storm effects)</p> | <p>Reported To: Board Executive Directors ***</p> <p>Owned & Monitored by: Director of Operations</p> |
| 4 | Rising temperatures / Increased demand for summer cooling | <p>Buildings becoming hotter</p> <p>Greater demand for air-conditioning</p> <p>Some strategic/critical suppliers have difficulty in meeting orders.</p> | Medium | Medium | <p>Circa 90% of work force located in coastal locations or on board ship where conditions are more temperate.</p> | Low | Low | <p>Consider maintaining increased stocks of items of strategic/critical supply.</p> | <p>Reported To: Board Executive Directors ***</p> <p>Owned & Monitored by: Director of Operations</p> |

**TRINITY HOUSE -
CLIMATE CHANGE – PROJECTED REGISTER OF RISKS (2055)**

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|----------------------------------|---|---|--------|--|--------------------------------------|--------|---|---|
| | | | Probability | Impact | | Probability | Impact | | |
| 1 | Sea Level Rise / Flooding | Flooding at some Lighthouses Significant call on General Lighthouse Fund | High | High | New Pier at Harwich Harwich flood defences raised Boat landings raised where necessary e-Navigation in place with DGPS terrestrial backup Strategy Asset Management Plan Process 10 Year Capital programme Climate change projections allowing for flexible adaptation. Use of floating AtoN on temporary basis Insurance (Against claim arising from AtoN failure) | Low | Medium | Monitor sea levels and impact on TH estate | Reported To: Board Executive *** Owned & Monitored by: Director of Operations |

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|-----------------------------------|--|---|--------|--|--------------------------------------|--------|---|--|
| | | | Probability | Impact | | Probability | Impact | | |
| 2 | Erosion (Cliff & Beach) | Possible loss of AtoN Significant call on General Lighthouse Fund | High | High | Strategy Asset Management Plan Process 10 Year Capital programme allowing for flexible adaptation Cliff and beach monitoring (Stations previously at risk replaced by new utility structures further to landward or discontinued due to e-Navigation) Use of floating AtoN on temporary basis. Insurance (Against claim arising from AtoN failure) | Low | Medium | | Reported To: Board Executive Directors *** Owned & Monitored by: Director of Operations |

| No. | Risk Description | Consequence | ** Risk Estimation (Prior to Mitigation) | | Control & Treatment | Risk Estimation (Post Mitigation) | | Additional Actions (to reduce further the likelihood of adverse events and mitigate residual impact if they do occur) | Residual Risk: Reported to & Owned/ Monitored by: |
|-----|--|--|--|--------|--|-----------------------------------|--------|---|---|
| | | | Probability | Impact | | Probability | Impact | | |
| 3 | Increased level of storms | <p>Potential increase in maritime casualties</p> <p>TH vessels unable to sail if prolonged</p> <p>Increased cloud cover may reduce efficiency of solar panels and necessitate additional panels.</p> | High | High | <p>Enhanced long-term storm forecasting.</p> <p>Enhanced on on-board electronic navigation equipment.</p> <p>Revised working patterns in TH vessels.</p> | Medium | Low | Investigate potential for climate change-related cloud cover increase to affect solar efficiency. | <p>Reported To: Board Executive Directors ***</p> <p>Owned & Monitored by: Director of Operations</p> |
| 4 | Rising temperatures / Increased demand for summer cooling | <p>Buildings becoming hotter Greater demand for air-conditioning</p> <p>Some strategic/critical suppliers have difficulty in meeting orders.</p> | High | Medium | <p>Work force located in coastal locations or on board ship where conditions are more temperate.</p> <p>Increased stocks of items of strategic/critical supply maintained.</p> | Low | Low | | <p>Reported To: Board Executive Directors ***</p> <p>Owned & Monitored by: Director of Operations</p> |

Key:

Probability of Occurrence and Impact of Climate Change

| Estimation | Description | Indicators | Consequence of Impact |
|-------------------|---|---|---|
| Very High | Very likely to occur within 1 year or more than 80% chance of occurrence. | Has occurred within last 1 to 2 years. | Financial impact on TH/GLF likely to exceed £5M Major impact on TH strategic plans and delivery of operational services Major political and stakeholder concern Very low defensibility of realisation of risk Reinstatement to pre-risk condition extremely difficult requiring considerable resources and possible additional sanction from DfT. |
| High | Likely to occur every 1 to 2 years or 50% to 80% chance of occurrence. | Potential of it occurring within 5 years Has occurred. | Financial impact on TH/GLF likely to be in region of £1M to £5M Significant impact on TH strategic plans and delivery of operational services Significant political and stakeholder concern Low defensibility of realisation of risk Reinstatement to pre-risk condition requiring commitment of a high level of resources. |
| Medium | Possibility of occurrence in 10-year period or 20% to 50% chance of occurrence. | Has occurred, to varying degrees, within last 10 years History of some occurrence. | Financial impact on TH/GLF likely to be in region of £250K to £1M Moderate impact on TH strategic plans and delivery of operational services Moderate stakeholder impact/concern Some defensibility of realisation of risk probable Reinstatement to pre-risk condition possible with the commitment of a moderate level of resources. |
| Low | Unlikely to occur in a 10 year period or 10% to 20% chance of occurrence. | Has not occurred in last 10 years Low history of occurrence. | Financial impact of TH/GLF likely to be in the region of £50K to £250K Low impact on TH strategic plans and delivery of operational services Low stakeholder impact/concern Defensibility of realisation of risk likely Reinstatement to pre-risk condition likely to be achieved with the minimum commitment of resources. |
| Very Low | Highly unlikely to occur in a 20 year period or less than 10% chance of occurrence. | Has not occurred Occurrence more than 20 years ago. | Financial impact on TH/GLF likely to be below £50K Very low (if any) impact on TH strategic plans and delivery of operational services Little (if any) stakeholder concern/impact Excellent prospect of defensibility of realisation of risk Reinstatement to pre-risk condition very likely to be achieved. |

3. Proposals and Policies for Adapting to Climate Change

3.1 Sea Level Rise & Erosion

Each major fixed (as opposed to floating) AtoN or asset has a strategic plan which outlines what the intention is for that asset for the next 20 years. This plan identifies any risks specifically associated with that station. The risks related specifically to climate change are identified here. Each asset management plan is reviewed annually when the severity of the risks is re-evaluated.

Each major asset is modernised typically on a 20 year cycle when new technology is installed and the station is refurbished, although there is flexibility to effect works outside this cycle. It is at these modernisations that all aspects of the structure are assessed and redesigned to meet the navigational requirement, having regard inter alia to new equipment and its requirements. Any impact of climate change is considered and included in the design brief as part of normal process.

The planning process at Trinity House is initiated by the 10 year plan which identifies what works are anticipated over that period having regard to the asset plans. This is worked into a five year plan as the years pass and capital is sought to deliver this plan. The 5 year plan and the funding for it is worked up into a two year plan with firm designs; delivery dates; and resources allocated.

The planned works are delivered as the two year plan turns into the “in year” plan.

The above planning process allows for a flexible approach to adaptation and can take into account any predicted changes in climate and given the speed of the predicted changes it allows those areas of the operation at risk, whether from sea level rise or cliff or beach erosion, to be modified or replaced as required. This proactive approach also ensures that early action can be taken at lower cost, than might otherwise be the case with a more reactive approach.

One such recent example is the significant works that have been undertaken to strengthen and refurbish the landing at Hanois Lighthouse in 2015.

In terms of the costs of adaptation the work at Hanois came to approximately £365K. It is, however, not possible to use this figure as a benchmark for other stations. The approach will be different at each – including the possibility of, abandoning the landing and not effecting any work. Similarly, the costs of mitigating the effects of beach or cliff erosion are likely to vary from station to station. As a very broad indication, St Catherine’s Lighthouse on the Isle of Wight is built on an unstable cliff. In the event that the Lighthouse needs to be replaced due to erosion it is likely to cost between £2M and £3M to clear the existing site and establish a new AtoN. A contingency for such losses is held in the GLF.

Keeping up to date with prediction on climate change is managed by reviewing official publications such as the IPCC report. The next IPCC AR6 is due out in 2017.

3.2 Increased Level of Storms

There are no short-term implications of a rise in the number of storms. However, studies on climate change in this area will be kept under review and consideration will be given to putting in place a system of monitoring to determine what relationship exists (if any) between increased storm activity and the number of maritime casualties. Any action beyond that time will depend on the outcome.

If there were a trend to prolonged storm activity, consideration would be given to revising working patterns on board Trinity House vessels as described in Section 2.3.

3.3 Rising Temperatures

No action is considered necessary in the short to medium term (to 2055) based in the predicted rises in temperatures given in section 2.4 as far as Trinity House staff are concerned. However, consultation with strategic / critical suppliers will be needed in the medium term and stock levels (where necessary and possible) will be adjusted to ensure continuity of supply. Such an approach will allow for a flexible approach to climate change adaptation.

4. Uncertainties & Assumptions

4.1 Sea Levels

There are clearly a number of uncertainties in terms of the impact of climate change. The likely rise in sea level is the area where this most directly affects Trinity House. In preparing this report Trinity House has worked on the assumption that sea levels will rise by about one metre by 2100, which is considered to be a reasonable approach based on current data available. Indeed, some studies indicate that the increase may be lower. The assumption made therefore is not over-sensitive to some variation in terms of the actual level of rise.

Looking forward there is uncertainty in terms of the number of Lighthouses, which Trinity House will require in the medium to long term. It is essential that satellite navigation systems have appropriate backups - including the maintenance of core navigation skills amongst mariners and the availability of alternatives to electronic means of positioning. The extent of the requirement for physical aids will be determined accordingly.

There are also a number of other uncertainties in terms of the speed with which ships will become equipped with other electronic navigation positioning and communications equipment, which may well also impact on the future requirement for physical AtoN. Fewer lighthouses will reduce the impact of rising sea levels on Trinity House's operations and the draw on the GLF for such works.

4.2 Increased Level of Storms

There is uncertainty in terms of the relationship (if any) between increased storm activity (uncertain in itself) and the number of maritime casualties as discussed in Section 3.2 and further work will be carried out in this area.

Lightning has a severe impact on AtoN performance and is regularly monitored. However, there is no evidence to suggest that there has or will be an increase in lightning strikes as a result of climate change or through any other factors.

4.3 Rising Temperatures / Increased Need for Summer Cooling

There is clearly an element of uncertainty as to the extent to which temperatures will rise in the years ahead but based on the approach set out in Section 2.4, and having regard to the locations in which Trinity House staff operate, no problem is foreseen in terms of the delivery of our statutory functions. Again, the assumptions made are not over-sensitive to some variation in terms of the actual level of rise.

The implications in terms of our suppliers are discussed in Section 3.3.

5. Barriers and Interdependencies

5.1 Barriers to Adaptation

(i) Funding

A requirement prior to implementing adaptation activity requiring significant capital expenditure will be obtaining DfT approval. If it were needed, this would be sought as part of the agreed corporate planning process. The impact in terms of planning will be mitigated as far as reasonably possible through the arrangements described in Section 3.1 above.

The AtoN estate is in robust order and it is not considered that significant adaptation funding will be required in the short term. Longer term, it is not currently possible to provide a realistic estimate of the cost of implementing adaptation measures required as a result of climate change. This will however be kept under review and the DfT will be kept informed as part of the normal corporate planning process.

(ii) Consents / Approvals

As stated in Section 2.2, the Trinity House pier at Harwich will require reconstruction in the medium term to accommodate the predicted rise in sea levels. The land, on which the pier lies, is leased from the Crown Estate Commissioners and any demolition / reconstruction of the pier would be subject to the consent of the Commissioners and the Marine Management Organisation, who would consult with the various Government departments and agencies involved. The pier also lies within the jurisdiction of the Harwich Haven Authority, who would also wish to be content that any proposed works did not adversely affect the harbour and result in maladaptation.

The approach of public bodies such as the Environment Agency, Historic England / CADW, Natural Resources Wales, Natural England and Local Planning Authorities, have a significant potential to impact upon the ability of Trinity House to adapt to Climate Change.

Similarly, the environmental, planning, listed building and conservation law, directives and policy that these bodies interpret and implement and enforce also has a significant potential to impact upon the ability of Trinity House to adapt to Climate Change. Most of our Lighthouses are listed buildings in environmentally sensitive areas and the designations of further areas is currently under consideration. Any adaptation works would need to meet the requirements of the relevant regulatory bodies. In some cases this could mean that permission would not be granted for the works or the cost could become prohibitively expensive.

Early consultation with all such agencies and organisations on proposals, sustainable where possible, and underscoring our role as a safety critical service provider will be essential in terms of overcoming any such potential barriers. Consultation already takes place with these bodies.

5.2 Interdependencies

There are a number of interdependencies (regulatory / external and internal) in terms of the impact of climate change on Trinity House and the adaptation measures which will be required. Key are:

(i) *AtoN Provision*

Future AtoN provision will be affected by developments in technology including navigation systems with appropriate backups and the maintenance of core navigation skills, together with alternative electronic means of positioning and the success of backup systems.

(ii) *AtoN Support Infrastructure*

Harwich Haven Authority and Associated British Ports in ensuring that any adaptation measures necessary are taken so that there continues to be access to our berth facilities both at Harwich and Swansea.

Although the Harwich Buoy Yard could be enhanced by raising the existing flood defences, this would be part of a wider Environment Agency initiative in terms of the protection of the town of Harwich from flooding more generally.

(iii) *Strategic & Critical Suppliers*

The actions of strategic and critical suppliers to mitigate the effects of climate change. Due to Trinity House's specialist role, the number of strategic and critical suppliers is in some cases limited, and Trinity House's ability to continue to deliver its AtoN service may be dependent on the adaptation plans (where relevant) of those suppliers. However, the risk can to a large extent be mitigated by ensuring a stock of any items considered at risk in this regard.

In addition to these regulatory and external interdependencies, there would also be internal dependencies (engineering and marine operations) in terms of there being sufficient resources to effect any necessary works and/or deployment of AtoNs, especially if there were to be a number of capital projects, which were to become necessary within a short period. The probability of such an eventuality is however considered to be low due to the planning process described above.

6. Monitoring Review & Evaluation

Whilst the risks from Climate Change remain sufficiently mitigated at present, TH remains vigilant to the fact that the impact might be more significant in the longer term. The impact of climate change has already been recognised in previous risk assessment work. The GLAs' Triennial Risk Management Review of 2015 also commented on the possible increasing prospect of physical loss or damage to assets, or wreck incidents, arising from climate change (e.g. caused by extreme weather events etc.). Reference was included accordingly in the GLAs' overarching risk register.

The impact of climate change will be monitored by Trinity House's Environmental Working Group. This work will include monitoring the thresholds, above which climate change might pose a risk to the organisation's activities. Where it is considered that the impact of climate change is likely to be other than in previous risk assessments, due (say) to the availability of new climate change projections, the Working Group will recommend to the organisation's Executive a change to the risk register, which will be taken into account in the planning process. Where the recommendation includes the designation of a new risk, it will also include responsibility for the risk, including reporting on its management. The responsibility will be held at either Board or Senior Management level, thereby ensuring corporate commitment.

The individual risks will be monitored and owned as set out in the risk register in Section 2 above, which will be periodically reviewed by the Executive / SMT.

The risk register in common with other key organisational risk registers will be published on the Trinity House intranet and Managers will be encouraged to draw it to the attention of their staff so that it is taken into account in planning and other decision making and other stakeholders can be briefed accordingly.

These arrangements will ensure that the management of climate change adaptation and its associated risks are embedded within the organisation's existing risk management framework and processes.

Whilst climate change will not have a significant short-term impact on Trinity House's operations, the production of this updated report has ensured a continued focus on the possible areas of impact in the years ahead, together with those areas where a greater degree of monitoring will be required. In particular, the production of a climate change risk register engendered by this report will ensure that the risks of climate change are embedded within the organisation's strategic risk management processes.

GLOSSARY

| | |
|--------|---|
| AtoN | Aids to Navigation (Floating AtoNs: Light Vessels and Buoys) |
| AIS | Automatic Identification System |
| DfT | Department for Transport |
| DGPS | Differential Global Positioning System |
| eLoran | Enhanced Loran |
| GLA | General Lighthouse Authority |
| GLF | General Lighthouse Fund |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| IALA | International Association of Marine Aids to Navigation and Lighthouse Authority |
| IMO | International Maritime Organisation |
| IPCC | Inter-Governmental Panel on Climate Change |
| MSA | Merchant Shipping Act |
| SOLAS | International Convention for Safety of Life at Sea |
| SMT | Senior Management Team |
| TH | Trinity House |
| UKCIP | UK Climate Impacts Policy |
| UKCP | UK Climate Projections |