Sección 1: Análisis Exploratorio de los datos

In [1]:
```
import numpy as np
import os
from tensorflow import keras
from keras.models import load_model, clone_model
from keras.layers import Dense, Conv2D, Flatten, Activation, Dropout
from keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras.optimizers import Adam
import matplotlib.pyplot as plt
from matplotlib import image
from sklearn.metrics import confusion_matrix, classification_report, f1_score
import seaborn as sns
import tensorflow as tf
from tensorflow.keras import layers
from tensorflow.keras.applications import EfficientNetB0, Xception
from tensorflow_addons.metrics import F1Score
```

In [2]:
```
# Set workspace
%cd /content/Data/
```

```
/content/Data
```

In [3]:
```
def LoadImages (foldname):
  '''
  Returns array of images in the folder name provided in the format
  X_train, y_train, X_test, y_test, X_valid, y_valid
  '''
  X_train = []
  y_train = []
  X_test = []
  y_test = []
  X_valid = []
  y_valid = []

  # Train data
  for i in os.listdir(str(foldname+'/train/normal')):
    X_train.append(image.imread(str(foldname+'/train/normal/'+i)))
    y_train.append(0)
  for i in os.listdir(str(foldname+'/train/abnormal')):
    X_train.append(image.imread(str(foldname+'/train/abnormal/'+i)))
    y_train.append(1)

  # Test data
  for i in os.listdir(str(foldname+'/test/normal')):
    X_test.append(image.imread(str(foldname+'/test/normal/'+i)))
    y_test.append(0)
  for i in os.listdir(str(foldname+'/test/abnormal')):
    X_test.append(image.imread(str(foldname+'/test/abnormal/'+i)))
    y_test.append(1)

  # Validation data
  for i in os.listdir(str(foldname+'/valid/normal')):
    X_valid.append(image.imread(str(foldname+'/valid/normal/'+i)))
    y_valid.append(0)
  for i in os.listdir(str(foldname+'/valid/abnormal')):
    X_valid.append(image.imread(str(foldname+'/valid/abnormal/'+i)))
    y_valid.append(1)

  return np.array(X_train), np.array(y_train), np.array(X_test), np.array(y_test), np.array(X_valid), np.array
```

In [4]:
```
# Load images from Fold0
X_train_0, y_train_0, X_test_0, y_test_0, X_valid_0, y_valid_0 = LoadImages('Fold0')
```

In [5]:
```
def print_data_info(X_train, y_train, X_test, y_test, X_valid, y_valid):
  '''
  Prints shapes for train, test and valid arrays
  '''
  # Train data
  print("ENTRENAMIENTO\t", X_train.shape,
        "\nNº de imágenes:\t", X_train.shape[0],
        "\nTamaño:\t\t", X_train.shape[1], "x", X_train.shape[2], "píxeles",
        "\nColores:\t", X_train.shape[3],
        "\nNº de casos:\t", y_train.shape[0], '(\033[3mNormal\033[0m + \033[3mAbnormal\033[0m)',
        "\n- \033[3mNormal\033[0m:\t", sum(y_train==0),
        str('(\033[1m'+str(round((sum(y_train==0)/y_train.shape[0])*100, 1))+'%\033[0m)'),
        "\n- \033[3mAbnormal\033[0m:\t", sum(y_train==1),
        str('(\033[1m'+str(round((sum(y_train==1)/y_train.shape[0])*100, 1))+'%\033[0m)'))

  # Test data
  print("\n\nTEST\t\t", X_test.shape,
        "\nNº de imágenes:\t", X_test.shape[0],
        "\nTamaño:\t\t", X_test.shape[1], "x", X_test.shape[2], "píxeles",
        "\nColores:\t", X_test.shape[3],
        "\nNº de casos:\t", y_test.shape[0], '(\033[3mNormal\033[0m + \033[3mAbnormal\033[0m)',
        "\n- \033[3mNormal\033[0m:\t", sum(y_test==0),
        str('(\033[1m'+str(round((sum(y_test==0)/y_test.shape[0])*100, 1))+'%\033[0m)'),
        "\n- \033[3mAbnormal\033[0m:\t", sum(y_test==1),
        str('(\033[1m'+str(round((sum(y_test==1)/y_test.shape[0])*100, 1))+'%\033[0m)'))

  # Validation data
  print("\n\nVALIDACIÓN\t", X_valid.shape,
        "\nNº de imágenes:\t", X_valid.shape[0],
        "\nTamaño:\t\t", X_valid.shape[1], "x", X_valid.shape[2], "píxeles",
        "\nColores:\t", X_valid.shape[3],
        "\nNº de casos:\t", y_valid.shape[0], '(\033[3mNormal\033[0m + \033[3mAbnormal\033[0m)',
        "\n- \033[3mNormal\033[0m:\t", sum(y_valid==0),
        str('(\033[1m'+str(round((sum(y_valid==0)/y_valid.shape[0])*100, 1))+'%\033[0m)'),
        "\n- \033[3mAbnormal\033[0m:\t", sum(y_valid==1),
        str('(\033[1m'+str(round((sum(y_valid==1)/y_valid.shape[0])*100, 1))+'%\033[0m)'))
```

In [6]:
```
print_data_info(X_train_0, y_train_0, X_test_0, y_test_0, X_valid_0, y_valid_0)
```

```
ENTRENAMIENTO    (1379, 224, 224, 3)
Nº de imágenes:  1379
Tamaño:          224 x 224 píxeles
Colores:         3
Nº de casos:     1379 (Normal + Abnormal)
- Normal:        754 (54.7%)
- Abnormal:      625 (45.3%)


TEST             (174, 224, 224, 3)
Nº de imágenes:  174
Tamaño:          224 x 224 píxeles
Colores:         3
Nº de casos:     174 (Normal + Abnormal)
- Normal:        82 (47.1%)
- Abnormal:      92 (52.9%)


VALIDACIÓN       (154, 224, 224, 3)
Nº de imágenes:  154
Tamaño:          224 x 224 píxeles
Colores:         3
Nº de casos:     154 (Normal + Abnormal)
- Normal:        83 (53.9%)
- Abnormal:      71 (46.1%)
```

In [7]:
```
# Plot 10 random images in train array
fig, axis = plt.subplots(2, 5, figsize=(15, 6))
j = 0
r = np.random.choice(range(X_train_0.shape[0]), 10, replace=False)
for i, ax in enumerate(axis):
    for a in ax:
        a.imshow(X_train_0[r[j]])
        a.set_title('Normal' if y_train_0[r[j]] == 0 else 'Abnormal')
        a.axis('off')
        j=j+1
plt.tight_layout()
```

Sección 2. Entrenamiento de una red neuronal sobre una única partición

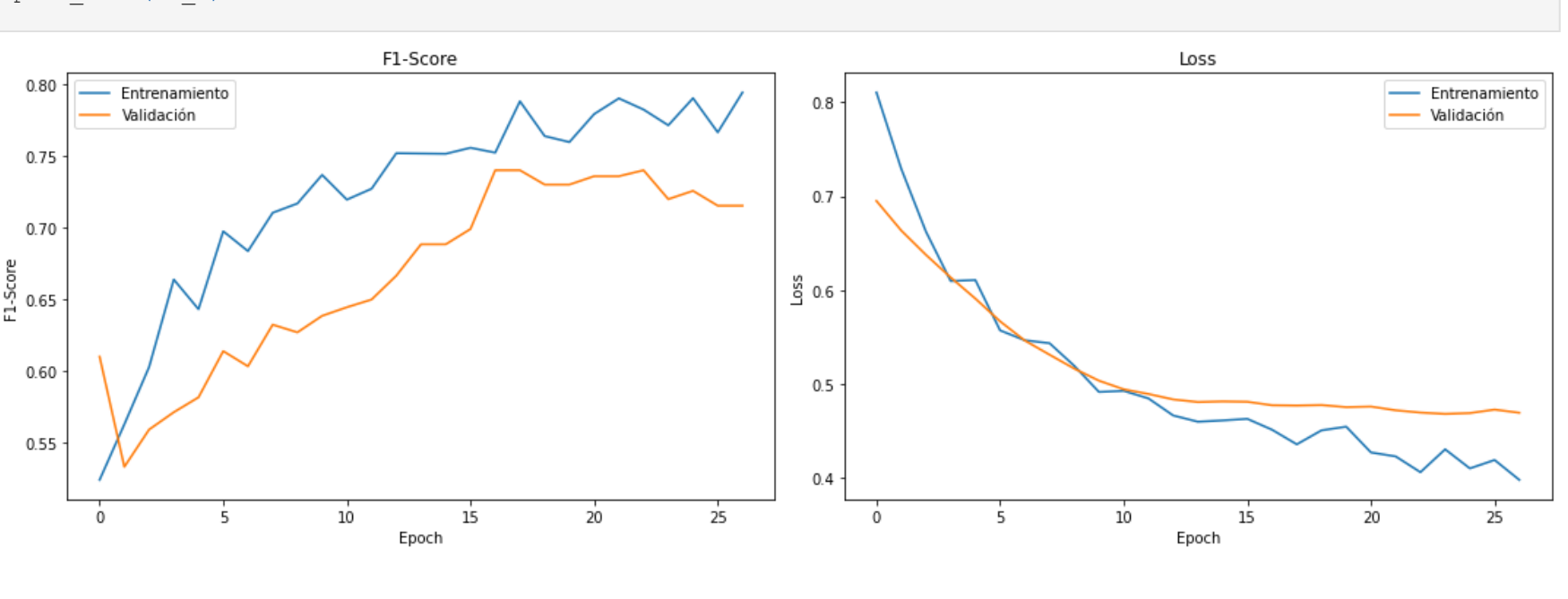
Modelo 1

In [8]:
```
# Set model input
input = layers.Input(shape=(X_train_0.shape[1], X_train_0.shape[2], X_train_0.shape[3]))

# Load EfficientNetB0 with ImageNet weights
m = EfficientNetB0(include_top=False, input_tensor=input, weights='imagenet')

# Freeze model
m.trainable = False

# Add layers
x = m(input, training=False)
x = layers.GlobalAveragePooling2D(name='NEW_GAP2D')(m.output)
x = layers.BatchNormalization(name='NEW_BN')(x)
x = layers.Dropout(.2, name='NEW_DO')(x)
output = layers.Dense(1, activation='sigmoid', name='NEW_D')(x)

# Assemble model
m1 = tf.keras.Model(input, output, name='EfficientNet_Model_1')

# Set optimizer
op = Adam(learning_rate=.0001)

# Set threshold to decide wheter a probability is considered as positive or negative result
threshold = .5

# Load F1Score
f1 = F1Score(num_classes=1, threshold=threshold)

# Compile
m1.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
m1.summary(show_trainable=True)
```

```
Model: "EfficientNet_Model_1"
_____________________________________________________________________________________________________________
 Layer (type)                      Output Shape            Param #   Connected to                      Trainable
=============================================================================================================
 input_1 (InputLayer)              [(None, 224, 224, 3)]   0         []                                N
 rescaling (Rescaling)             (None, 224, 224, 3)     0         ['input_1[0][0]']                 N
 normalization (Normalization)     (None, 224, 224, 3)     7         ['rescaling[0][0]']               N
 stem_conv_pad (ZeroPadding2D)     (None, 225, 225, 3)     0         ['normalization[0][0]']           N
 stem_conv (Conv2D)                (None, 112, 112, 32)    864       ['stem_conv_pad[0][0]']           N
 stem_bn (BatchNormalization)      (None, 112, 112, 32)    128       ['stem_conv[0][0]']               N
 stem_activation (Activation)      (None, 112, 112, 32)    0         ['stem_bn[0][0]']                 N
 block1a_dwconv (DepthwiseConv2D)  (None, 112, 112, 32)    288       ['stem_activation[0][0]']         N
 block1a_bn (BatchNormalization)   (None, 112, 112, 32)    128       ['block1a_dwconv[0][0]']          N
 block1a_activation (Activation)   (None, 112, 112, 32)    0         ['block1a_bn[0][0]']              N
 block1a_se_squeeze (GlobalAveragePooling2D)  (None, 32)   0         ['block1a_activation[0][0]']      N
 block1a_se_reshape (Reshape)      (None, 1, 1, 32)        0         ['block1a_se_squeeze[0][0]']      N
 block1a_se_reduce (Conv2D)        (None, 1, 1, 8)         264       ['block1a_se_reshape[0][0]']      N
 block1a_se_expand (Conv2D)        (None, 1, 1, 32)        288       ['block1a_se_reduce[0][0]']       N
 block1a_se_excite (Multiply)      (None, 112, 112, 32)    0         ['block1a_activation[0][0]',
                                                                      'block1a_se_expand[0][0]']       N
 block1a_project_conv (Conv2D)     (None, 112, 112, 16)    512       ['block1a_se_excite[0][0]']       N
 block1a_project_bn (BatchNormalization)  (None, 112, 112, 16)  64   ['block1a_project_conv[0][0]']    N
 block2a_expand_conv (Conv2D)      (None, 112, 112, 96)    1536      ['block1a_project_bn[0][0]']      N
 block2a_expand_bn (BatchNormalization)  (None, 112, 112, 96)  384   ['block2a_expand_conv[0][0]']     N
 block2a_expand_activation (Activation)  (None, 112, 112, 96)  0     ['block2a_expand_bn[0][0]']       N
 block2a_dwconv_pad (ZeroPadding2D)  (None, 113, 113, 96)  0         ['block2a_expand_activation[0][0]']  N
 block2a_dwconv (DepthwiseConv2D)  (None, 56, 56, 96)      864       ['block2a_dwconv_pad[0][0]']      N
 block2a_bn (BatchNormalization)   (None, 56, 56, 96)      384       ['block2a_dwconv[0][0]']          N
 block2a_activation (Activation)   (None, 56, 56, 96)      0         ['block2a_bn[0][0]']              N
 block2a_se_squeeze (GlobalAveragePooling2D)  (None, 96)   0         ['block2a_activation[0][0]']      N
 block2a_se_reshape (Reshape)      (None, 1, 1, 96)        0         ['block2a_se_squeeze[0][0]']      N
 block2a_se_reduce (Conv2D)        (None, 1, 1, 4)         388       ['block2a_se_reshape[0][0]']      N
 block2a_se_expand (Conv2D)        (None, 1, 1, 96)        480       ['block2a_se_reduce[0][0]']       N
 block2a_se_excite (Multiply)      (None, 56, 56, 96)      0         ['block2a_activation[0][0]',
                                                                      'block2a_se_expand[0][0]']       N
 block2a_project_conv (Conv2D)     (None, 56, 56, 24)      2304      ['block2a_se_excite[0][0]']       N
 block2a_project_bn (BatchNormalization)  (None, 56, 56, 24)  96     ['block2a_project_conv[0][0]']    N
 block2b_expand_conv (Conv2D)      (None, 56, 56, 144)     3456      ['block2a_project_bn[0][0]']      N
 block2b_expand_bn (BatchNormalization)  (None, 56, 56, 144)  576    ['block2b_expand_conv[0][0]']     N
 block2b_expand_activation (Activation)  (None, 56, 56, 144)  0      ['block2b_expand_bn[0][0]']       N
 block2b_dwconv (DepthwiseConv2D)  (None, 56, 56, 144)     1296      ['block2b_expand_activation[0][0]']  N
 block2b_bn (BatchNormalization)   (None, 56, 56, 144)     576       ['block2b_dwconv[0][0]']          N
 block2b_activation (Activation)   (None, 56, 56, 144)     0         ['block2b_bn[0][0]']              N
 block2b_se_squeeze (GlobalAveragePooling2D)  (None, 144)  0         ['block2b_activation[0][0]']      N
 block2b_se_reshape (Reshape)      (None, 1, 1, 144)       0         ['block2b_se_squeeze[0][0]']      N
 block2b_se_reduce (Conv2D)        (None, 1, 1, 6)         870       ['block2b_se_reshape[0][0]']      N
 block2b_se_expand (Conv2D)        (None, 1, 1, 144)       1008      ['block2b_se_reduce[0][0]']       N
 block2b_se_excite (Multiply)      (None, 56, 56, 144)     0         ['block2b_activation[0][0]',
                                                                      'block2b_se_expand[0][0]']       N
 block2b_project_conv (Conv2D)     (None, 56, 56, 24)      3456      ['block2b_se_excite[0][0]']       N
 block2b_project_bn (BatchNormalization)  (None, 56, 56, 24)  96     ['block2b_project_conv[0][0]']    N
 block2b_drop (Dropout)            (None, 56, 56, 24)      0         ['block2b_project_bn[0][0]']      N
 block2b_add (Add)                 (None, 56, 56, 24)      0         ['block2b_drop[0][0]',
                                                                      'block2a_project_bn[0][0]']      N
 block3a_expand_conv (Conv2D)      (None, 56, 56, 144)     3456      ['block2b_add[0][0]']             N
 block3a_expand_bn (BatchNormalization)  (None, 56, 56, 144)  576    ['block3a_expand_conv[0][0]']     N
 block3a_expand_activation (Activation)  (None, 56, 56, 144)  0      ['block3a_expand_bn[0][0]']       N
 block3a_dwconv_pad (ZeroPadding2D)  (None, 59, 59, 144)   0         ['block3a_expand_activation[0][0]']  N
 block3a_dwconv (DepthwiseConv2D)  (None, 28, 28, 144)     3600      ['block3a_dwconv_pad[0][0]']      N
 block3a_bn (BatchNormalization)   (None, 28, 28, 144)     576       ['block3a_dwconv[0][0]']          N
 block3a_activation (Activation)   (None, 28, 28, 144)     0         ['block3a_bn[0][0]']              N
 block3a_se_squeeze (GlobalAveragePooling2D)  (None, 144)  0         ['block3a_activation[0][0]']      N
 block3a_se_reshape (Reshape)      (None, 1, 1, 144)       0         ['block3a_se_squeeze[0][0]']      N
 block3a_se_reduce (Conv2D)        (None, 1, 1, 6)         870       ['block3a_se_reshape[0][0]']      N
 block3a_se_expand (Conv2D)        (None, 1, 1, 144)       1008      ['block3a_se_reduce[0][0]']       N
 block3a_se_excite (Multiply)      (None, 28, 28, 144)     0         ['block3a_activation[0][0]',
                                                                      'block3a_se_expand[0][0]']       N
 block3a_project_conv (Conv2D)     (None, 28, 28, 40)      5760      ['block3a_se_excite[0][0]']       N
 block3a_project_bn (BatchNormalization)  (None, 28, 28, 40)  160    ['block3a_project_conv[0][0]']    N
 block3b_expand_conv (Conv2D)      (None, 28, 28, 240)     9600      ['block3a_project_bn[0][0]']      N
 block3b_expand_bn (BatchNormalization)  (None, 28, 28, 240)  960    ['block3b_expand_conv[0][0]']     N
 block3b_expand_activation (Activation)  (None, 28, 28, 240)  0      ['block3b_expand_bn[0][0]']       N
 block3b_dwconv (DepthwiseConv2D)  (None, 28, 28, 240)     6000      ['block3b_expand_activation[0][0]']  N
 block3b_bn (BatchNormalization)   (None, 28, 28, 240)     960       ['block3b_dwconv[0][0]']          N
 block3b_activation (Activation)   (None, 28, 28, 240)     0         ['block3b_bn[0][0]']              N
 block3b_se_squeeze (GlobalAveragePooling2D)  (None, 240)  0         ['block3b_activation[0][0]']      N
 block3b_se_reshape (Reshape)      (None, 1, 1, 240)       0         ['block3b_se_squeeze[0][0]']      N
 block3b_se_reduce (Conv2D)        (None, 1, 1, 10)        2410      ['block3b_se_reshape[0][0]']      N
 block3b_se_expand (Conv2D)        (None, 1, 1, 240)       2640      ['block3b_se_reduce[0][0]']       N
 block3b_se_excite (Multiply)      (None, 28, 28, 240)     0         ['block3b_activation[0][0]',
                                                                      'block3b_se_expand[0][0]']       N
 block3b_project_conv (Conv2D)     (None, 28, 28, 40)      9600      ['block3b_se_excite[0][0]']       N
 block3b_project_bn (BatchNormalization)  (None, 28, 28, 40)  160    ['block3b_project_conv[0][0]']    N
 block3b_drop (Dropout)            (None, 28, 28, 40)      0         ['block3b_project_bn[0][0]']      N
 block3b_add (Add)                 (None, 28, 28, 40)      0         ['block3b_drop[0][0]',
                                                                      'block3a_project_bn[0][0]']      N
 block4a_expand_conv (Conv2D)      (None, 28, 28, 240)     9600      ['block3b_add[0][0]']             N
 block4a_expand_bn (BatchNormalization)  (None, 28, 28, 240)  960    ['block4a_expand_conv[0][0]']     N
 block4a_expand_activation (Activation)  (None, 28, 28, 240)  0      ['block4a_expand_bn[0][0]']       N
 block4a_dwconv_pad (ZeroPadding2D)  (None, 29, 29, 240)   0         ['block4a_expand_activation[0][0]']  N
 block4a_dwconv (DepthwiseConv2D)  (None, 14, 14, 240)     2160      ['block4a_dwconv_pad[0][0]']      N
 block4a_bn (BatchNormalization)   (None, 14, 14, 240)     960       ['block4a_dwconv[0][0]']          N
 block4a_activation (Activation)   (None, 14, 14, 240)     0         ['block4a_bn[0][0]']              N
 block4a_se_squeeze (GlobalAveragePooling2D)  (None, 240)  0         ['block4a_activation[0][0]']      N
 block4a_se_reshape (Reshape)      (None, 1, 1, 240)       0         ['block4a_se_squeeze[0][0]']      N
 block4a_se_reduce (Conv2D)        (None, 1, 1, 10)        2410      ['block4a_se_reshape[0][0]']      N
 block4a_se_expand (Conv2D)        (None, 1, 1, 240)       2640      ['block4a_se_reduce[0][0]']       N
 block4a_se_excite (Multiply)      (None, 14, 14, 240)     0         ['block4a_activation[0][0]',
                                                                      'block4a_se_expand[0][0]']       N
 block4a_project_conv (Conv2D)     (None, 14, 14, 80)      19200     ['block4a_se_excite[0][0]']       N
 block4a_project_bn (BatchNormalization)  (None, 14, 14, 80)  320    ['block4a_project_conv[0][0]']    N
 block4b_expand_conv (Conv2D)      (None, 14, 14, 480)     38400     ['block4a_project_bn[0][0]']      N
 block4b_expand_bn (BatchNormalization)  (None, 14, 14, 480)  1920   ['block4b_expand_conv[0][0]']     N
 block4b_expand_activation (Activation)  (None, 14, 14, 480)  0      ['block4b_expand_bn[0][0]']       N
 block4b_dwconv (DepthwiseConv2D)  (None, 14, 14, 480)     4320      ['block4b_expand_activation[0][0]']  N
 block4b_bn (BatchNormalization)   (None, 14, 14, 480)     1920      ['block4b_dwconv[0][0]']          N
 block4b_activation (Activation)   (None, 14, 14, 480)     0         ['block4b_bn[0][0]']              N
 block4b_se_squeeze (GlobalAveragePooling2D)  (None, 480)  0         ['block4b_activation[0][0]']      N
 block4b_se_reshape (Reshape)      (None, 1, 1, 480)       0         ['block4b_se_squeeze[0][0]']      N
 block4b_se_reduce (Conv2D)        (None, 1, 1, 20)        9620      ['block4b_se_reshape[0][0]']      N
 block4b_se_expand (Conv2D)        (None, 1, 1, 480)       10080     ['block4b_se_reduce[0][0]']       N
 block4b_se_excite (Multiply)      (None, 14, 14, 480)     0         ['block4b_activation[0][0]',
                                                                      'block4b_se_expand[0][0]']       N
 block4b_project_conv (Conv2D)     (None, 14, 14, 80)      38400     ['block4b_se_excite[0][0]']       N
 block4b_project_bn (BatchNormalization)  (None, 14, 14, 80)  320    ['block4b_project_conv[0][0]']    N
 block4b_drop (Dropout)            (None, 14, 14, 80)      0         ['block4b_project_bn[0][0]']      N
 block4b_add (Add)                 (None, 14, 14, 80)      0         ['block4b_drop[0][0]',
                                                                      'block4a_project_bn[0][0]']      N
 block4c_expand_conv (Conv2D)      (None, 14, 14, 480)     38400     ['block4b_add[0][0]']             N
 block4c_expand_bn (BatchNormalization)  (None, 14, 14, 480)  1920   ['block4c_expand_conv[0][0]']     N
 block4c_expand_activation (Activation)  (None, 14, 14, 480)  0      ['block4c_expand_bn[0][0]']       N
 block4c_dwconv (DepthwiseConv2D)  (None, 14, 14, 480)     4320      ['block4c_expand_activation[0][0]']  N
 block4c_bn (BatchNormalization)   (None, 14, 14, 480)     1920      ['block4c_dwconv[0][0]']          N
 block4c_activation (Activation)   (None, 14, 14, 480)     0         ['block4c_bn[0][0]']              N
 block4c_se_squeeze (GlobalAveragePooling2D)  (None, 480)  0         ['block4c_activation[0][0]']      N
 block4c_se_reshape (Reshape)      (None, 1, 1, 480)       0         ['block4c_se_squeeze[0][0]']      N
 block4c_se_reduce (Conv2D)        (None, 1, 1, 20)        9620      ['block4c_se_reshape[0][0]']      N
 block4c_se_expand (Conv2D)        (None, 1, 1, 480)       10080     ['block4c_se_reduce[0][0]']       N
 block4c_se_excite (Multiply)      (None, 14, 14, 480)     0         ['block4c_activation[0][0]',
                                                                      'block4c_se_expand[0][0]']       N
 block4c_project_conv (Conv2D)     (None, 14, 14, 80)      38400     ['block4c_se_excite[0][0]']       N
 block4c_project_bn (BatchNormalization)  (None, 14, 14, 80)  320    ['block4c_project_conv[0][0]']    N
 block4c_drop (Dropout)            (None, 14, 14, 80)      0         ['block4c_project_bn[0][0]']      N
 block4c_add (Add)                 (None, 14, 14, 80)      0         ['block4c_drop[0][0]',
                                                                      'block4b_add[0][0]']             N
 block5a_expand_conv (Conv2D)      (None, 14, 14, 480)     38400     ['block4c_add[0][0]']             N
 block5a_expand_bn (BatchNormalization)  (None, 14, 14, 480)  1920   ['block5a_expand_conv[0][0]']     N
 block5a_expand_activation (Activation)  (None, 14, 14, 480)  0      ['block5a_expand_bn[0][0]']       N
 block5a_dwconv (DepthwiseConv2D)  (None, 14, 14, 480)     12000     ['block5a_expand_activation[0][0]']  N
 block5a_bn (BatchNormalization)   (None, 14, 14, 480)     1920      ['block5a_dwconv[0][0]']          N
 block5a_activation (Activation)   (None, 14, 14, 480)     0         ['block5a_bn[0][0]']              N
 block5a_se_squeeze (GlobalAveragePooling2D)  (None, 480)  0         ['block5a_activation[0][0]']      N
 block5a_se_reshape (Reshape)      (None, 1, 1, 480)       0         ['block5a_se_squeeze[0][0]']      N
 block5a_se_reduce (Conv2D)        (None, 1, 1, 20)        9620      ['block5a_se_reshape[0][0]']      N
 block5a_se_expand (Conv2D)        (None, 1, 1, 480)       10080     ['block5a_se_reduce[0][0]']       N
 block5a_se_excite (Multiply)      (None, 14, 14, 480)     0         ['block5a_activation[0][0]',
                                                                      'block5a_se_expand[0][0]']       N
 block5a_project_conv (Conv2D)     (None, 14, 14, 112)     53760     ['block5a_se_excite[0][0]']       N
 block5a_project_bn (BatchNormalization)  (None, 14, 14, 112)  448   ['block5a_project_conv[0][0]']    N
 block5b_expand_conv (Conv2D)      (None, 14, 14, 672)     75264     ['block5a_project_bn[0][0]']      N
 block5b_expand_bn (BatchNormalization)  (None, 14, 14, 672)  2688   ['block5b_expand_conv[0][0]']     N
 block5b_expand_activation (Activation)  (None, 14, 14, 672)  0      ['block5b_expand_bn[0][0]']       N
 block5b_dwconv (DepthwiseConv2D)  (None, 14, 14, 672)     16800     ['block5b_expand_activation[0][0]']  N
 block5b_bn (BatchNormalization)   (None, 14, 14, 672)     2688      ['block5b_dwconv[0][0]']          N
 block5b_activation (Activation)   (None, 14, 14, 672)     0         ['block5b_bn[0][0]']              N
 block5b_se_squeeze (GlobalAveragePooling2D)  (None, 672)  0         ['block5b_activation[0][0]']      N
 block5b_se_reshape (Reshape)      (None, 1, 1, 672)       0         ['block5b_se_squeeze[0][0]']      N
 block5b_se_reduce (Conv2D)        (None, 1, 1, 28)        18844     ['block5b_se_reshape[0][0]']      N
 block5b_se_expand (Conv2D)        (None, 1, 1, 672)       19488     ['block5b_se_reduce[0][0]']       N
 block5b_se_excite (Multiply)      (None, 14, 14, 672)     0         ['block5b_activation[0][0]',
                                                                      'block5b_se_expand[0][0]']       N
 block5b_project_conv (Conv2D)     (None, 14, 14, 112)     75264     ['block5b_se_excite[0][0]']       N
 block5b_project_bn (BatchNormalization)  (None, 14, 14, 112)  448   ['block5b_project_conv[0][0]']    N
 block5b_drop (Dropout)            (None, 14, 14, 112)     0         ['block5b_project_bn[0][0]']      N
 block5b_add (Add)                 (None, 14, 14, 112)     0         ['block5b_drop[0][0]',
                                                                      'block5a_project_bn[0][0]']      N
 block5c_expand_conv (Conv2D)      (None, 14, 14, 672)     75264     ['block5b_add[0][0]']             N
 block5c_expand_bn (BatchNormalization)  (None, 14, 14, 672)  2688   ['block5c_expand_conv[0][0]']     N
 block5c_expand_activation (Activation)  (None, 14, 14, 672)  0      ['block5c_expand_bn[0][0]']       N
 block5c_dwconv (DepthwiseConv2D)  (None, 14, 14, 672)     16800     ['block5c_expand_activation[0][0]']  N
 block5c_bn (BatchNormalization)   (None, 14, 14, 672)     2688      ['block5c_dwconv[0][0]']          N
 block5c_activation (Activation)   (None, 14, 14, 672)     0         ['block5c_bn[0][0]']              N
 block5c_se_squeeze (GlobalAveragePooling2D)  (None, 672)  0         ['block5c_activation[0][0]']      N
 block5c_se_reshape (Reshape)      (None, 1, 1, 672)       0         ['block5c_se_squeeze[0][0]']      N
 block5c_se_reduce (Conv2D)        (None, 1, 1, 28)        18844     ['block5c_se_reshape[0][0]']      N
 block5c_se_expand (Conv2D)        (None, 1, 1, 672)       19488     ['block5c_se_reduce[0][0]']       N
 block5c_se_excite (Multiply)      (None, 14, 14, 672)     0         ['block5c_activation[0][0]',
                                                                      'block5c_se_expand[0][0]']       N
 block5c_project_conv (Conv2D)     (None, 14, 14, 112)     75264     ['block5c_se_excite[0][0]']       N
 block5c_project_bn (BatchNormalization)  (None, 14, 14, 112)  448   ['block5c_project_conv[0][0]']    N
 block5c_drop (Dropout)            (None, 14, 14, 112)     0         ['block5c_project_bn[0][0]']      N
 block5c_add (Add)                 (None, 14, 14, 112)     0         ['block5c_drop[0][0]',
                                                                      'block5b_add[0][0]']             N
 block6a_expand_conv (Conv2D)      (None, 14, 14, 672)     75264     ['block5c_add[0][0]']             N
 block6a_expand_bn (BatchNormalization)  (None, 14, 14, 672)  2688   ['block6a_expand_conv[0][0]']     N
 block6a_expand_activation (Activation)  (None, 14, 14, 672)  0      ['block6a_expand_bn[0][0]']       N
 block6a_dwconv_pad (ZeroPadding2D)  (None, 17, 17, 672)   0         ['block6a_expand_activation[0][0]']  N
 block6a_dwconv (DepthwiseConv2D)  (None, 7, 7, 672)       16800     ['block6a_dwconv_pad[0][0]']      N
 block6a_bn (BatchNormalization)   (None, 7, 7, 672)       2688      ['block6a_dwconv[0][0]']          N
 block6a_activation (Activation)   (None, 7, 7, 672)       0         ['block6a_bn[0][0]']              N
 block6a_se_squeeze (GlobalAveragePooling2D)  (None, 672)  0         ['block6a_activation[0][0]']      N
 block6a_se_reshape (Reshape)      (None, 1, 1, 672)       0         ['block6a_se_squeeze[0][0]']      N
 block6a_se_reduce (Conv2D)        (None, 1, 1, 28)        18844     ['block6a_se_reshape[0][0]']      N
 block6a_se_expand (Conv2D)        (None, 1, 1, 672)       19488     ['block6a_se_reduce[0][0]']       N
 block6a_se_excite (Multiply)      (None, 7, 7, 672)       0         ['block6a_activation[0][0]',
                                                                      'block6a_se_expand[0][0]']       N
 block6a_project_conv (Conv2D)     (None, 7, 7, 192)       129024    ['block6a_se_excite[0][0]']       N
 block6a_project_bn (BatchNormalization)  (None, 7, 7, 192)  768     ['block6a_project_conv[0][0]']    N
 block6b_expand_conv (Conv2D)      (None, 7, 7, 1152)      221184    ['block6a_project_bn[0][0]']      N
 block6b_expand_bn (BatchNormalization)  (None, 7, 7, 1152)  4608    ['block6b_expand_conv[0][0]']     N
 block6b_expand_activation (Activation)  (None, 7, 7, 1152)  0       ['block6b_expand_bn[0][0]']       N
 block6b_dwconv (DepthwiseConv2D)  (None, 7, 7, 1152)      28800     ['block6b_expand_activation[0][0]']  N
 block6b_bn (BatchNormalization)   (None, 7, 7, 1152)      4608      ['block6b_dwconv[0][0]']          N
 block6b_activation (Activation)   (None, 7, 7, 1152)      0         ['block6b_bn[0][0]']              N
 block6b_se_squeeze (GlobalAveragePooling2D)  (None, 1152)  0        ['block6b_activation[0][0]']      N
 block6b_se_reshape (Reshape)      (None, 1, 1, 1152)      0         ['block6b_se_squeeze[0][0]']      N
 block6b_se_reduce (Conv2D)        (None, 1, 1, 48)        55344     ['block6b_se_reshape[0][0]']      N
 block6b_se_expand (Conv2D)        (None, 1, 1, 1152)      56448     ['block6b_se_reduce[0][0]']       N
 block6b_se_excite (Multiply)      (None, 7, 7, 1152)      0         ['block6b_activation[0][0]',
                                                                      'block6b_se_expand[0][0]']       N
 block6b_project_conv (Conv2D)     (None, 7, 7, 192)       221184    ['block6b_se_excite[0][0]']       N
 block6b_project_bn (BatchNormalization)  (None, 7, 7, 192)  768     ['block6b_project_conv[0][0]']    N
 block6b_drop (Dropout)            (None, 7, 7, 192)       0         ['block6b_project_bn[0][0]']      N
 block6b_add (Add)                 (None, 7, 7, 192)       0         ['block6b_drop[0][0]',
                                                                      'block6a_project_bn[0][0]']      N
 block6c_expand_conv (Conv2D)      (None, 7, 7, 1152)      221184    ['block6b_add[0][0]']             N
 block6c_expand_bn (BatchNormalization)  (None, 7, 7, 1152)  4608    ['block6c_expand_conv[0][0]']     N
 block6c_expand_activation (Activation)  (None, 7, 7, 1152)  0       ['block6c_expand_bn[0][0]']       N
 block6c_dwconv (DepthwiseConv2D)  (None, 7, 7, 1152)      28800     ['block6c_expand_activation[0][0]']  N
 block6c_bn (BatchNormalization)   (None, 7, 7, 1152)      4608      ['block6c_dwconv[0][0]']          N
 block6c_activation (Activation)   (None, 7, 7, 1152)      0         ['block6c_bn[0][0]']              N
 block6c_se_squeeze (GlobalAveragePooling2D)  (None, 1152)  0        ['block6c_activation[0][0]']      N
 block6c_se_reshape (Reshape)      (None, 1, 1, 1152)      0         ['block6c_se_squeeze[0][0]']      N
 block6c_se_reduce (Conv2D)        (None, 1, 1, 48)        55344     ['block6c_se_reshape[0][0]']      N
 block6c_se_expand (Conv2D)        (None, 1, 1, 1152)      56448     ['block6c_se_reduce[0][0]']       N
 block6c_se_excite (Multiply)      (None, 7, 7, 1152)      0         ['block6c_activation[0][0]',
                                                                      'block6c_se_expand[0][0]']       N
 block6c_project_conv (Conv2D)     (None, 7, 7, 192)       221184    ['block6c_se_excite[0][0]']       N
 block6c_project_bn (BatchNormalization)  (None, 7, 7, 192)  768     ['block6c_project_conv[0][0]']    N
 block6c_drop (Dropout)            (None, 7, 7, 192)       0         ['block6c_project_bn[0][0]']      N
 block6c_add (Add)                 (None, 7, 7, 192)       0         ['block6c_drop[0][0]',
                                                                      'block6b_add[0][0]']             N
 block6d_expand_conv (Conv2D)      (None, 7, 7, 1152)      221184    ['block6c_add[0][0]']             N
 block6d_expand_bn (BatchNormalization)  (None, 7, 7, 1152)  4608    ['block6d_expand_conv[0][0]']     N
 block6d_expand_activation (Activation)  (None, 7, 7, 1152)  0       ['block6d_expand_bn[0][0]']       N
 block6d_dwconv (DepthwiseConv2D)  (None, 7, 7, 1152)      28800     ['block6d_expand_activation[0][0]']  N
 block6d_bn (BatchNormalization)   (None, 7, 7, 1152)      4608      ['block6d_dwconv[0][0]']          N
 block6d_activation (Activation)   (None, 7, 7, 1152)      0         ['block6d_bn[0][0]']              N
 block6d_se_squeeze (GlobalAveragePooling2D)  (None, 1152)  0        ['block6d_activation[0][0]']      N
 block6d_se_reshape (Reshape)      (None, 1, 1, 1152)      0         ['block6d_se_squeeze[0][0]']      N
 block6d_se_reduce (Conv2D)        (None, 1, 1, 48)        55344     ['block6d_se_reshape[0][0]']      N
 block6d_se_expand (Conv2D)        (None, 1, 1, 1152)      56448     ['block6d_se_reduce[0][0]']       N
 block6d_se_excite (Multiply)      (None, 7, 7, 1152)      0         ['block6d_activation[0][0]',
                                                                      'block6d_se_expand[0][0]']       N
 block6d_project_conv (Conv2D)     (None, 7, 7, 192)       221184    ['block6d_se_excite[0][0]']       N
 block6d_project_bn (BatchNormalization)  (None, 7, 7, 192)  768     ['block6d_project_conv[0][0]']    N
 block6d_drop (Dropout)            (None, 7, 7, 192)       0         ['block6d_project_bn[0][0]']      N
 block6d_add (Add)                 (None, 7, 7, 192)       0         ['block6d_drop[0][0]',
                                                                      'block6c_add[0][0]']             N
 block7a_expand_conv (Conv2D)      (None, 7, 7, 1152)      221184    ['block6d_add[0][0]']             N
 block7a_expand_bn (BatchNormalization)  (None, 7, 7, 1152)  4608    ['block7a_expand_conv[0][0]']     N
 block7a_expand_activation (Activation)  (None, 7, 7, 1152)  0       ['block7a_expand_bn[0][0]']       N
 block7a_dwconv (DepthwiseConv2D)  (None, 7, 7, 1152)      10368     ['block7a_expand_activation[0][0]']  N
 block7a_bn (BatchNormalization)   (None, 7, 7, 1152)      4608      ['block7a_dwconv[0][0]']          N
 block7a_activation (Activation)   (None, 7, 7, 1152)      0         ['block7a_bn[0][0]']              N
 block7a_se_squeeze (GlobalAveragePooling2D)  (None, 1152)  0        ['block7a_activation[0][0]']      N
 block7a_se_reshape (Reshape)      (None, 1, 1, 1152)      0         ['block7a_se_squeeze[0][0]']      N
 block7a_se_reduce (Conv2D)        (None, 1, 1, 48)        55344     ['block7a_se_reshape[0][0]']      N
 block7a_se_expand (Conv2D)        (None, 1, 1, 1152)      56448     ['block7a_se_reduce[0][0]']       N
 block7a_se_excite (Multiply)      (None, 7, 7, 1152)      0         ['block7a_activation[0][0]',
                                                                      'block7a_se_expand[0][0]']       N
 block7a_project_conv (Conv2D)     (None, 7, 7, 320)       368640    ['block7a_se_excite[0][0]']       N
 block7a_project_bn (BatchNormalization)  (None, 7, 7, 320)  1280    ['block7a_project_conv[0][0]']    N
 top_conv (Conv2D)                 (None, 7, 7, 1280)      409600    ['block7a_project_bn[0][0]']      N
 top_bn (BatchNormalization)       (None, 7, 7, 1280)      5120      ['top_conv[0][0]']                N
 top_activation (Activation)       (None, 7, 7, 1280)      0         ['top_bn[0][0]']                  N
 NEW_GAP2D (GlobalAveragePooling2D)  (None, 1280)          0         ['top_activation[0][0]']          Y
 NEW_BN (BatchNormalization)       (None, 1280)            5120      ['NEW_GAP2D[0][0]']               Y
 NEW_DO (Dropout)                  (None, 1280)            0         ['NEW_BN[0][0]']                  Y
 NEW_D (Dense)                     (None, 1)               1281      ['NEW_DO[0][0]']                  Y

=============================================================================================================
Total params: 4,055,972
Trainable params: 3,841
Non-trainable params: 4,052,131
_____________________________________________________________________________________________________________
```

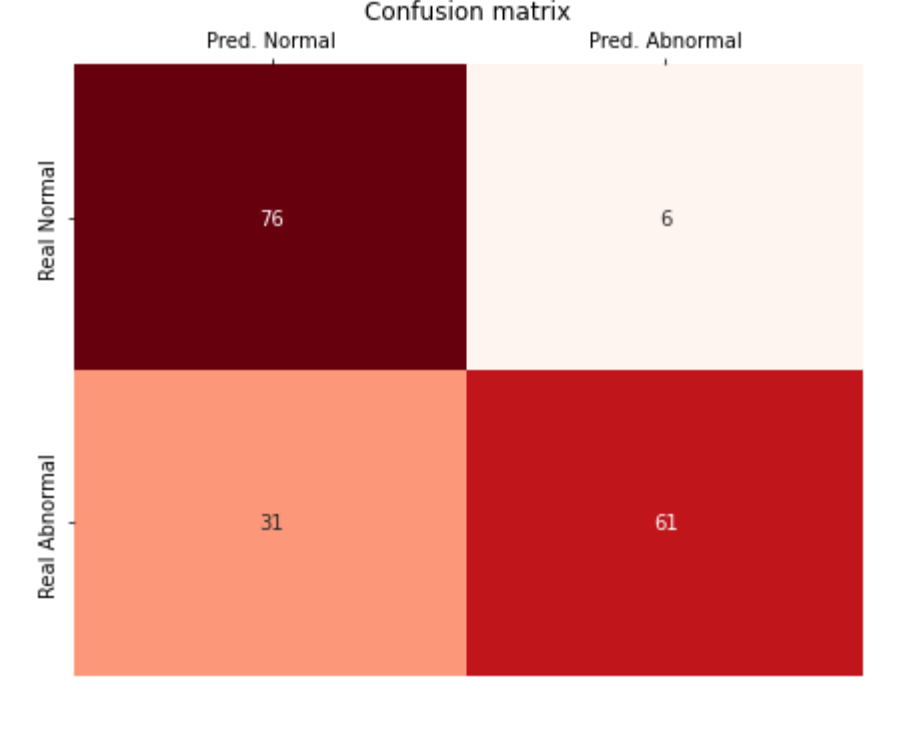
In [9]:
```
# Set parameters
epochs = 60
bs = 32

# Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
callbacks = [EarlyStopping(monitor='val_f1_score',
                           mode='max',
                           patience=10),
             ModelCheckpoint(filepath='model1.h5',
                             monitor='val_f1_score',
                             mode='max',
                             save_best_only=True,
                             save_weights_only=True)]

# Train model
m1_h = m1.fit(X_train_0, y_train_0,
              epochs=epochs,
              batch_size=bs,
              callbacks=callbacks,
              validation_data=(X_valid_0, y_valid_0),
              verbose=0)
```

In [10]:
```
# Plot F1-Score and Loss
def plot_hist(mfit):
  '''
  Receives a fitted model and plots F1-Score and Loss functions
  '''
  fig, ax = plt.subplots(nrows=1, ncols=2, figsize=(15,5))

  ax[0].plot(mfit.history['f1_score'])
  ax[0].plot(mfit.history['val_f1_score'])
  ax[0].set_title('F1-Score')
  ax[0].set_ylabel('F1-Score')
  ax[0].set_xlabel('Epoch')
  ax[0].legend(['Entrenamiento', 'Validación'], loc='upper left')

  ax[1].plot(mfit.history['loss'])
  ax[1].plot(mfit.history['val_loss'])
  ax[1].set_title('Loss')
  ax[1].set_ylabel('Loss')
  ax[1].set_xlabel('Epoch')
  ax[1].legend(['Entrenamiento', 'Validación'], loc='upper right')

  plt.tight_layout()

plot_hist(m1_h)
```



```
In [11]:
# Load best weights
m1.load_weights('model1.h5')

# Predict test data
y_pred_0 = m1.predict(X_test_0)

# Create binary prediction array
y_pred_0 = np.asarray([0 if i < threshold else 1 for i in y_pred_0])

# Define function to get F1-Score and plot confusion matrix
def get_f1_plot_cm(y_test, y_pred, get_f1=True, plot_title='Confusion matrix'):
  '''
  Returns F1-Score and plots confusion matrix given real and prediction data
  '''
  # Create and plot Confusion Matrix
  cm = confusion_matrix(y_test, y_pred)
  plt.figure(figsize = (6,5))
  ax = plt.subplot()
  sns.heatmap(cm, annot=True, fmt='g', cbar=False, cmap='Reds')
  ax.set_yticklabels(['Real Normal', 'Real Abnormal'])
  ax.set_xticklabels(['Pred. Normal', 'Pred. Abnormal'], )
  ax.set_title(plot_title)
  ax.tick_params(labeltop=True, top=True, labelbottom=False, bottom=False)

  plt.tight_layout()

  # Get and print F1-Score
  if get_f1:
    m_f1 = f1_score(y_test, y_pred)
    print('Con threshold =', threshold, ', el F1-Score es', round(m_f1, 3), '\n')

    return m_f1
  else: return None

# Get and print F1-Score and confusion matrix
m1_f1 = get_f1_plot_cm(y_test_0, y_pred_0)
```

```
Con threshold = 0.5 , el F1-Score es 0.767
```



Modelo 2

```
In [12]:
# Clone previous model
m2 = clone_model(m1)

# Load weights
m2.load_weights('model1.h5')

# Set name
m2._name = 'EfficientNet_Model_2'

# Unfreeze last 20 layers except BatchNormalization ones
ls = m2.layers
for l in ls[-21:-1]:
  if l.__class__.__name__ != 'BatchNormalization':
    l.trainable=True

# Set optimizer with a lower learning rate due to the need for precision in fine tuning
op = Adam(learning_rate=.00001)

# Compile model
m2.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
m2.summary(show_trainable=True)
```

Model: "EfficientNet_Model_2"

Layer (type)	Output Shape	Param #	Connected to	Trainable
input_1 (InputLayer)	[(None, 224, 224, 3)]	0	[]	Y
rescaling (Rescaling)	(None, 224, 224, 3)	0	['input_1[0][0]']	N
normalization (Normalization)	(None, 224, 224, 3)	7	['rescaling[0][0]']	N
stem_conv_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	['normalization[0][0]']	N
stem_conv (Conv2D)	(None, 112, 112, 32)	864	['stem_conv_pad[0][0]']	N
stem_bn (BatchNormalization)	(None, 112, 112, 32)	128	['stem_conv[0][0]']	N
stem_activation (Activation)	(None, 112, 112, 32)	0	['stem_bn[0][0]']	N
block1a_dwconv (DepthwiseConv2D)	(None, 112, 112, 32)	288	['stem_activation[0][0]']	N
block1a_bn (BatchNormalization)	(None, 112, 112, 32)	128	['block1a_dwconv[0][0]']	N
block1a_activation (Activation)	(None, 112, 112, 32)	0	['block1a_bn[0][0]']	N
block1a_se_squeeze (GlobalAveragePooling2D)	(None, 32)	0	['block1a_activation[0][0]']	N
block1a_se_reshape (Reshape)	(None, 1, 1, 32)	0	['block1a_se_squeeze[0][0]']	N
block1a_se_reduce (Conv2D)	(None, 1, 1, 8)	264	['block1a_se_reshape[0][0]']	N
block1a_se_expand (Conv2D)	(None, 1, 1, 32)	288	['block1a_se_reduce[0][0]']	N
block1a_se_excite (Multiply)	(None, 112, 112, 32)	0	['block1a_activation[0][0]', 'block1a_se_expand[0][0]']	N
block1a_project_conv (Conv2D)	(None, 112, 112, 16)	512	['block1a_se_excite[0][0]']	N
block1a_project_bn (BatchNormalization)	(None, 112, 112, 16)	64	['block1a_project_conv[0][0]']	N
block2a_expand_conv (Conv2D)	(None, 112, 112, 96)	1536	['block1a_project_bn[0][0]']	N
block2a_expand_bn (BatchNormalization)	(None, 112, 112, 96)	384	['block2a_expand_conv[0][0]']	N
block2a_expand_activation (Activation)	(None, 112, 112, 96)	0	['block2a_expand_bn[0][0]']	N
block2a_dwconv_pad (ZeroPadding2D)	(None, 113, 113, 96)	0	['block2a_expand_activation[0][0]']	N
block2a_dwconv (DepthwiseConv2D)	(None, 56, 56, 96)	864	['block2a_dwconv_pad[0][0]']	N
block2a_bn (BatchNormalization)	(None, 56, 56, 96)	384	['block2a_dwconv[0][0]']	N
block2a_activation (Activation)	(None, 56, 56, 96)	0	['block2a_bn[0][0]']	N
block2a_se_squeeze (GlobalAveragePooling2D)	(None, 96)	0	['block2a_activation[0][0]']	N
block2a_se_reshape (Reshape)	(None, 1, 1, 96)	0	['block2a_se_squeeze[0][0]']	N
block2a_se_reduce (Conv2D)	(None, 1, 1, 4)	388	['block2a_se_reshape[0][0]']	N
block2a_se_expand (Conv2D)	(None, 1, 1, 96)	480	['block2a_se_reduce[0][0]']	N
block2a_se_excite (Multiply)	(None, 56, 56, 96)	0	['block2a_activation[0][0]', 'block2a_se_expand[0][0]']	N
block2a_project_conv (Conv2D)	(None, 56, 56, 24)	2304	['block2a_se_excite[0][0]']	N
block2a_project_bn (BatchNormalization)	(None, 56, 56, 24)	96	['block2a_project_conv[0][0]']	N
block2b_expand_conv (Conv2D)	(None, 56, 56, 144)	3456	['block2a_project_bn[0][0]']	N
block2b_expand_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block2b_expand_conv[0][0]']	N
block2b_expand_activation (Activation)	(None, 56, 56, 144)	0	['block2b_expand_bn[0][0]']	N
block2b_dwconv (DepthwiseConv2D)	(None, 56, 56, 144)	1296	['block2b_expand_activation[0][0]']	N
block2b_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block2b_dwconv[0][0]']	N
block2b_activation (Activation)	(None, 56, 56, 144)	0	['block2b_bn[0][0]']	N
block2b_se_squeeze (GlobalAveragePooling2D)	(None, 144)	0	['block2b_activation[0][0]']	N
block2b_se_reshape (Reshape)	(None, 1, 1, 144)	0	['block2b_se_squeeze[0][0]']	N
block2b_se_reduce (Conv2D)	(None, 1, 1, 6)	870	['block2b_se_reshape[0][0]']	N
block2b_se_expand (Conv2D)	(None, 1, 1, 144)	1008	['block2b_se_reduce[0][0]']	N
block2b_se_excite (Multiply)	(None, 56, 56, 144)	0	['block2b_activation[0][0]', 'block2b_se_expand[0][0]']	N
block2b_project_conv (Conv2D)	(None, 56, 56, 24)	3456	['block2b_se_excite[0][0]']	N
block2b_project_bn (BatchNormalization)	(None, 56, 56, 24)	96	['block2b_project_conv[0][0]']	N
block2b_drop (Dropout)	(None, 56, 56, 24)	0	['block2b_project_bn[0][0]']	N
block2b_add (Add)	(None, 56, 56, 24)	0	['block2b_drop[0][0]', 'block2a_project_bn[0][0]']	N
block3a_expand_conv (Conv2D)	(None, 56, 56, 144)	3456	['block2b_add[0][0]']	N
block3a_expand_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block3a_expand_conv[0][0]']	N
block3a_expand_activation (Activation)	(None, 56, 56, 144)	0	['block3a_expand_bn[0][0]']	N
block3a_dwconv_pad (ZeroPadding2D)	(None, 59, 59, 144)	0	['block3a_expand_activation[0][0]']	N
block3a_dwconv (DepthwiseConv2D)	(None, 28, 28, 144)	3600	['block3a_dwconv_pad[0][0]']	N
block3a_bn (BatchNormalization)	(None, 28, 28, 144)	576	['block3a_dwconv[0][0]']	N
block3a_activation (Activation)	(None, 28, 28, 144)	0	['block3a_bn[0][0]']	N
block3a_se_squeeze (GlobalAveragePooling2D)	(None, 144)	0	['block3a_activation[0][0]']	N
block3a_se_reshape (Reshape)	(None, 1, 1, 144)	0	['block3a_se_squeeze[0][0]']	N
block3a_se_reduce (Conv2D)	(None, 1, 1, 6)	870	['block3a_se_reshape[0][0]']	N
block3a_se_expand (Conv2D)	(None, 1, 1, 144)	1008	['block3a_se_reduce[0][0]']	N
block3a_se_excite (Multiply)	(None, 28, 28, 144)	0	['block3a_activation[0][0]', 'block3a_se_expand[0][0]']	N
block3a_project_conv (Conv2D)	(None, 28, 28, 40)	5760	['block3a_se_excite[0][0]']	N
block3a_project_bn (BatchNormalization)	(None, 28, 28, 40)	160	['block3a_project_conv[0][0]']	N
block3b_expand_conv (Conv2D)	(None, 28, 28, 240)	9600	['block3a_project_bn[0][0]']	N
block3b_expand_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block3b_expand_conv[0][0]']	N
block3b_expand_activation (Activation)	(None, 28, 28, 240)	0	['block3b_expand_bn[0][0]']	N
block3b_dwconv (DepthwiseConv2D)	(None, 28, 28, 240)	6000	['block3b_expand_activation[0][0]']	N
block3b_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block3b_dwconv[0][0]']	N
block3b_activation (Activation)	(None, 28, 28, 240)	0	['block3b_bn[0][0]']	N
block3b_se_squeeze (GlobalAveragePooling2D)	(None, 240)	0	['block3b_activation[0][0]']	N
block3b_se_reshape (Reshape)	(None, 1, 1, 240)	0	['block3b_se_squeeze[0][0]']	N
block3b_se_reduce (Conv2D)	(None, 1, 1, 10)	2410	['block3b_se_reshape[0][0]']	N
block3b_se_expand (Conv2D)	(None, 1, 1, 240)	2640	['block3b_se_reduce[0][0]']	N
block3b_se_excite (Multiply)	(None, 28, 28, 240)	0	['block3b_activation[0][0]', 'block3b_se_expand[0][0]']	N
block3b_project_conv (Conv2D)	(None, 28, 28, 40)	9600	['block3b_se_excite[0][0]']	N
block3b_project_bn (BatchNormalization)	(None, 28, 28, 40)	160	['block3b_project_conv[0][0]']	N
block3b_drop (Dropout)	(None, 28, 28, 40)	0	['block3b_project_bn[0][0]']	N
block3b_add (Add)	(None, 28, 28, 40)	0	['block3b_drop[0][0]', 'block3a_project_bn[0][0]']	N
block4a_expand_conv (Conv2D)	(None, 28, 28, 240)	9600	['block3b_add[0][0]']	N
block4a_expand_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block4a_expand_conv[0][0]']	N
block4a_expand_activation (Activation)	(None, 28, 28, 240)	0	['block4a_expand_bn[0][0]']	N
block4a_dwconv_pad (ZeroPadding2D)	(None, 29, 29, 240)	0	['block4a_expand_activation[0][0]']	N
block4a_dwconv (DepthwiseConv2D)	(None, 14, 14, 240)	2160	['block4a_dwconv_pad[0][0]']	N
block4a_bn (BatchNormalization)	(None, 14, 14, 240)	960	['block4a_dwconv[0][0]']	N
block4a_activation (Activation)	(None, 14, 14, 240)	0	['block4a_bn[0][0]']	N
block4a_se_squeeze (GlobalAveragePooling2D)	(None, 240)	0	['block4a_activation[0][0]']	N
block4a_se_reshape (Reshape)	(None, 1, 1, 240)	0	['block4a_se_squeeze[0][0]']	N
block4a_se_reduce (Conv2D)	(None, 1, 1, 10)	2410	['block4a_se_reshape[0][0]']	N
block4a_se_expand (Conv2D)	(None, 1, 1, 240)	2640	['block4a_se_reduce[0][0]']	N
block4a_se_excite (Multiply)	(None, 14, 14, 240)	0	['block4a_activation[0][0]', 'block4a_se_expand[0][0]']	N
block4a_project_conv (Conv2D)	(None, 14, 14, 80)	19200	['block4a_se_excite[0][0]']	N
block4a_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4a_project_conv[0][0]']	N
block4b_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4a_project_bn[0][0]']	N
block4b_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4b_expand_conv[0][0]']	N
block4b_expand_activation (Activation)	(None, 14, 14, 480)	0	['block4b_expand_bn[0][0]']	N
block4b_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4320	['block4b_expand_activation[0][0]']	N
block4b_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4b_dwconv[0][0]']	N
block4b_activation (Activation)	(None, 14, 14, 480)	0	['block4b_bn[0][0]']	N
block4b_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block4b_activation[0][0]']	N
block4b_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block4b_se_squeeze[0][0]']	N
block4b_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block4b_se_reshape[0][0]']	N
block4b_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block4b_se_reduce[0][0]']	N
block4b_se_excite (Multiply)	(None, 14, 14, 480)	0	['block4b_activation[0][0]', 'block4b_se_expand[0][0]']	N
block4b_project_conv (Conv2D)	(None, 14, 14, 80)	38400	['block4b_se_excite[0][0]']	N
block4b_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4b_project_conv[0][0]']	N
block4b_drop (Dropout)	(None, 14, 14, 80)	0	['block4b_project_bn[0][0]']	N
block4b_add (Add)	(None, 14, 14, 80)	0	['block4b_drop[0][0]', 'block4a_project_bn[0][0]']	N
block4c_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4b_add[0][0]']	N
block4c_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4c_expand_conv[0][0]']	N
block4c_expand_activation (Activation)	(None, 14, 14, 480)	0	['block4c_expand_bn[0][0]']	N
block4c_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4320	['block4c_expand_activation[0][0]']	N
block4c_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4c_dwconv[0][0]']	N
block4c_activation (Activation)	(None, 14, 14, 480)	0	['block4c_bn[0][0]']	N
block4c_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block4c_activation[0][0]']	N
block4c_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block4c_se_squeeze[0][0]']	N
block4c_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block4c_se_reshape[0][0]']	N
block4c_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block4c_se_reduce[0][0]']	N
block4c_se_excite (Multiply)	(None, 14, 14, 480)	0	['block4c_activation[0][0]', 'block4c_se_expand[0][0]']	N
block4c_project_conv (Conv2D)	(None, 14, 14, 80)	38400	['block4c_se_excite[0][0]']	N
block4c_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4c_project_conv[0][0]']	N
block4c_drop (Dropout)	(None, 14, 14, 80)	0	['block4c_project_bn[0][0]']	N
block4c_add (Add)	(None, 14, 14, 80)	0	['block4c_drop[0][0]', 'block4b_add[0][0]']	N
block5a_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4c_add[0][0]']	N
block5a_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block5a_expand_conv[0][0]']	N
block5a_expand_activation (Activation)	(None, 14, 14, 480)	0	['block5a_expand_bn[0][0]']	N
block5a_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	12000	['block5a_expand_activation[0][0]']	N
block5a_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block5a_dwconv[0][0]']	N
block5a_activation (Activation)	(None, 14, 14, 480)	0	['block5a_bn[0][0]']	N
block5a_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block5a_activation[0][0]']	N
block5a_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block5a_se_squeeze[0][0]']	N
block5a_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block5a_se_reshape[0][0]']	N
block5a_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block5a_se_reduce[0][0]']	N
block5a_se_excite (Multiply)	(None, 14, 14, 480)	0	['block5a_activation[0][0]', 'block5a_se_expand[0][0]']	N
block5a_project_conv (Conv2D)	(None, 14, 14, 112)	53760	['block5a_se_excite[0][0]']	N
block5a_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5a_project_conv[0][0]']	N
block5b_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5a_project_bn[0][0]']	N
block5b_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5b_expand_conv[0][0]']	N
block5b_expand_activation (Activation)	(None, 14, 14, 672)	0	['block5b_expand_bn[0][0]']	N
block5b_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16800	['block5b_expand_activation[0][0]']	N
block5b_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5b_dwconv[0][0]']	N
block5b_activation (Activation)	(None, 14, 14, 672)	0	['block5b_bn[0][0]']	N
block5b_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block5b_activation[0][0]']	N
block5b_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block5b_se_squeeze[0][0]']	N
block5b_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block5b_se_reshape[0][0]']	N
block5b_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block5b_se_reduce[0][0]']	N
block5b_se_excite (Multiply)	(None, 14, 14, 672)	0	['block5b_activation[0][0]', 'block5b_se_expand[0][0]']	N
block5b_project_conv (Conv2D)	(None, 14, 14, 112)	75264	['block5b_se_excite[0][0]']	N
block5b_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5b_project_conv[0][0]']	N
block5b_drop (Dropout)	(None, 14, 14, 112)	0	['block5b_project_bn[0][0]']	N
block5b_add (Add)	(None, 14, 14, 112)	0	['block5b_drop[0][0]', 'block5a_project_bn[0][0]']	N
block5c_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5b_add[0][0]']	N
block5c_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5c_expand_conv[0][0]']	N
block5c_expand_activation (Activation)	(None, 14, 14, 672)	0	['block5c_expand_bn[0][0]']	N
block5c_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16800	['block5c_expand_activation[0][0]']	N
block5c_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5c_dwconv[0][0]']	N
block5c_activation (Activation)	(None, 14, 14, 672)	0	['block5c_bn[0][0]']	N
block5c_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block5c_activation[0][0]']	N
block5c_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block5c_se_squeeze[0][0]']	N
block5c_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block5c_se_reshape[0][0]']	N
block5c_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block5c_se_reduce[0][0]']	N
block5c_se_excite (Multiply)	(None, 14, 14, 672)	0	['block5c_activation[0][0]', 'block5c_se_expand[0][0]']	N
block5c_project_conv (Conv2D)	(None, 14, 14, 112)	75264	['block5c_se_excite[0][0]']	N
block5c_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5c_project_conv[0][0]']	N
block5c_drop (Dropout)	(None, 14, 14, 112)	0	['block5c_project_bn[0][0]']	N
block5c_add (Add)	(None, 14, 14, 112)	0	['block5c_drop[0][0]', 'block5b_add[0][0]']	N
block6a_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5c_add[0][0]']	N
block6a_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block6a_expand_conv[0][0]']	N
block6a_expand_activation (Activation)	(None, 14, 14, 672)	0	['block6a_expand_bn[0][0]']	N
block6a_dwconv_pad (ZeroPadding2D)	(None, 17, 17, 672)	0	['block6a_expand_activation[0][0]']	N
block6a_dwconv (DepthwiseConv2D)	(None, 7, 7, 672)	16800	['block6a_dwconv_pad[0][0]']	N
block6a_bn (BatchNormalization)	(None, 7, 7, 672)	2688	['block6a_dwconv[0][0]']	N
block6a_activation (Activation)	(None, 7, 7, 672)	0	['block6a_bn[0][0]']	N
block6a_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block6a_activation[0][0]']	N
block6a_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block6a_se_squeeze[0][0]']	N
block6a_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block6a_se_reshape[0][0]']	N
block6a_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block6a_se_reduce[0][0]']	N
block6a_se_excite (Multiply)	(None, 7, 7, 672)	0	['block6a_activation[0][0]', 'block6a_se_expand[0][0]']	N
block6a_project_conv (Conv2D)	(None, 7, 7, 192)	129024	['block6a_se_excite[0][0]']	N
block6a_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6a_project_conv[0][0]']	N
block6b_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6a_project_bn[0][0]']	N
block6b_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6b_expand_conv[0][0]']	N
block6b_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6b_expand_bn[0][0]']	N
block6b_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6b_expand_activation[0][0]']	N
block6b_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6b_dwconv[0][0]']	N
block6b_activation (Activation)	(None, 7, 7, 1152)	0	['block6b_bn[0][0]']	N
block6b_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6b_activation[0][0]']	N
block6b_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6b_se_squeeze[0][0]']	N
block6b_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6b_se_reshape[0][0]']	N
block6b_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6b_se_reduce[0][0]']	N
block6b_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6b_activation[0][0]', 'block6b_se_expand[0][0]']	N
block6b_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6b_se_excite[0][0]']	N
block6b_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6b_project_conv[0][0]']	N
block6b_drop (Dropout)	(None, 7, 7, 192)	0	['block6b_project_bn[0][0]']	N
block6b_add (Add)	(None, 7, 7, 192)	0	['block6b_drop[0][0]', 'block6a_project_bn[0][0]']	N
block6c_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6b_add[0][0]']	N
block6c_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6c_expand_conv[0][0]']	N
block6c_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6c_expand_bn[0][0]']	N
block6c_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6c_expand_activation[0][0]']	N
block6c_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6c_dwconv[0][0]']	N
block6c_activation (Activation)	(None, 7, 7, 1152)	0	['block6c_bn[0][0]']	N
block6c_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6c_activation[0][0]']	N
block6c_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6c_se_squeeze[0][0]']	N
block6c_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6c_se_reshape[0][0]']	N
block6c_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6c_se_reduce[0][0]']	N
block6c_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6c_activation[0][0]', 'block6c_se_expand[0][0]']	N
block6c_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6c_se_excite[0][0]']	N
block6c_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6c_project_conv[0][0]']	N
block6c_drop (Dropout)	(None, 7, 7, 192)	0	['block6c_project_bn[0][0]']	N
block6c_add (Add)	(None, 7, 7, 192)	0	['block6c_drop[0][0]', 'block6b_add[0][0]']	N
block6d_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6c_add[0][0]']	N
block6d_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6d_expand_conv[0][0]']	N
block6d_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6d_expand_bn[0][0]']	N
block6d_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6d_expand_activation[0][0]']	N
block6d_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6d_dwconv[0][0]']	N
block6d_activation (Activation)	(None, 7, 7, 1152)	0	['block6d_bn[0][0]']	N
block6d_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6d_activation[0][0]']	N
block6d_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6d_se_squeeze[0][0]']	N
block6d_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6d_se_reshape[0][0]']	N
block6d_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6d_se_reduce[0][0]']	N
block6d_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6d_activation[0][0]', 'block6d_se_expand[0][0]']	N
block6d_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6d_se_excite[0][0]']	N
block6d_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6d_project_conv[0][0]']	N
block6d_drop (Dropout)	(None, 7, 7, 192)	0	['block6d_project_bn[0][0]']	N
block6d_add (Add)	(None, 7, 7, 192)	0	['block6d_drop[0][0]', 'block6c_add[0][0]']	Y
block7a_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6d_add[0][0]']	Y
block7a_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block7a_expand_conv[0][0]']	N
block7a_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block7a_expand_bn[0][0]']	Y
block7a_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	10368	['block7a_expand_activation[0][0]']	Y
block7a_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block7a_dwconv[0][0]']	N
block7a_activation (Activation)	(None, 7, 7, 1152)	0	['block7a_bn[0][0]']	Y
block7a_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block7a_activation[0][0]']	Y
block7a_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block7a_se_squeeze[0][0]']	Y
block7a_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block7a_se_reshape[0][0]']	Y
block7a_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block7a_se_reduce[0][0]']	Y
block7a_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block7a_activation[0][0]', 'block7a_se_expand[0][0]']	Y
block7a_project_conv (Conv2D)	(None, 7, 7, 320)	368640	['block7a_se_excite[0][0]']	Y
block7a_project_bn (BatchNormalization)	(None, 7, 7, 320)	1280	['block7a_project_conv[0][0]']	N
top_conv (Conv2D)	(None, 7, 7, 1280)	409600	['block7a_project_bn[0][0]']	Y
top_bn (BatchNormalization)	(None, 7, 7, 1280)	5120	['top_conv[0][0]']	N
top_activation (Activation)	(None, 7, 7, 1280)	0	['top_bn[0][0]']	Y
NEW_GAP2D (GlobalAveragePooling2D)	(None, 1280)	0	['top_activation[0][0]']	Y
NEW_BN (BatchNormalization)	(None, 1280)	5120	['NEW_GAP2D[0][0]']	Y
NEW_DO (Dropout)	(None, 1280)	0	['NEW_BN[0][0]']	Y
NEW_D (Dense)	(None, 1)	1281	['NEW_DO[0][0]']	Y

```
Total params: 4,055,972
Trainable params: 1,125,425
Non-trainable params: 2,930,547
```

```
In [13]:
# Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
callbacks = [EarlyStopping(monitor='val_f1_score',
                           mode='max',
                           patience=10),
             ModelCheckpoint(filepath='model2.h5',
                             monitor='val_f1_score',
                             mode='max',
                             save_best_only=True,
                             save_weights_only=True)]

# Train model
m2_h = m2.fit(X_train_0, y_train_0,
              epochs=epochs,
              batch_size=bs,
              callbacks=callbacks,
              validation_data=(X_valid_0, y_valid_0),
              verbose=0)
```

```
In [14]:
# Plot F1-Score and Loss
plot_hist(m2_h)
```



```
In [15]:
# Load best weights
m2.load_weights('model2.h5')

# Predict test data
y_pred_0 = m2.predict(X_test_0)

# Create binary prediction array with same threshold used earlier (.5)
y_pred_0 = np.asarray([0 if i < threshold else 1 for i in y_pred_0])

# Get and print F1-Score and confusion matrix
m2_f1 = get_f1_plot_cm(y_test_0, y_pred_0)
```

```
Con threshold = 0.5 , el F1-Score es 0.882
```


Modelo 3

```
In [16]:
# Clone previous model
m3 = clone_model(m2)

# Load weights
m3.load_weights('model2.h5')

# Set name
m3._name = 'EfficientNet_Model_3'

# Unfreeze
for i, l in enumerate(m3.layers):
  if l.__class__.__name__ != 'BatchNormalization':
    l.trainable = True

# Compile model with a lower learning_rate due to the need for precision in fine-tuning
m3.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
m3.summary(show_trainable=True)
```

Model: "EfficientNet_Model_3"

Layer (type)	Output Shape	Param #	Connected to	Trainable
input_1 (InputLayer)	[(None, 224, 224, 3)]	0	[]	Y
rescaling (Rescaling)	(None, 224, 224, 3)	0	['input_1[0][0]']	Y
normalization (Normalization)	(None, 224, 224, 3)	7	['rescaling[0][0]']	Y
stem_conv_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	['normalization[0][0]']	Y
stem_conv (Conv2D)	(None, 112, 112, 32)	864	['stem_conv_pad[0][0]']	Y
stem_bn (BatchNormalization)	(None, 112, 112, 32)	128	['stem_conv[0][0]']	N
stem_activation (Activation)	(None, 112, 112, 32)	0	['stem_bn[0][0]']	Y
block1a_dwconv (DepthwiseConv2D)	(None, 112, 112, 32)	288	['stem_activation[0][0]']	Y
block1a_bn (BatchNormalization)	(None, 112, 112, 32)	128	['block1a_dwconv[0][0]']	N
block1a_activation (Activation)	(None, 112, 112, 32)	0	['block1a_bn[0][0]']	Y
block1a_se_squeeze (GlobalAveragePooling2D)	(None, 32)	0	['block1a_activation[0][0]']	Y
block1a_se_reshape (Reshape)	(None, 1, 1, 32)	0	['block1a_se_squeeze[0][0]']	Y
block1a_se_reduce (Conv2D)	(None, 1, 1, 8)	264	['block1a_se_reshape[0][0]']	Y
block1a_se_expand (Conv2D)	(None, 1, 1, 32)	288	['block1a_se_reduce[0][0]']	Y
block1a_se_excite (Multiply)	(None, 112, 112, 32)	0	['block1a_activation[0][0]', 'block1a_se_expand[0][0]']	Y
block1a_project_conv (Conv2D)	(None, 112, 112, 16)	512	['block1a_se_excite[0][0]']	Y
block1a_project_bn (BatchNormalization)	(None, 112, 112, 16)	64	['block1a_project_conv[0][0]']	N
block2a_expand_conv (Conv2D)	(None, 112, 112, 96)	1536	['block1a_project_bn[0][0]']	Y
block2a_expand_bn (BatchNormalization)	(None, 112, 112, 96)	384	['block2a_expand_conv[0][0]']	N
block2a_expand_activation (Activation)	(None, 112, 112, 96)	0	['block2a_expand_bn[0][0]']	Y
block2a_dwconv_pad (ZeroPadding2D)	(None, 113, 113, 96)	0	['block2a_expand_activation[0][0]']	Y
block2a_dwconv (DepthwiseConv2D)	(None, 56, 56, 96)	864	['block2a_dwconv_pad[0][0]']	Y
block2a_bn (BatchNormalization)	(None, 56, 56, 96)	384	['block2a_dwconv[0][0]']	N
block2a_activation (Activation)	(None, 56, 56, 96)	0	['block2a_bn[0][0]']	Y
block2a_se_squeeze (GlobalAveragePooling2D)	(None, 96)	0	['block2a_activation[0][0]']	Y
block2a_se_reshape (Reshape)	(None, 1, 1, 96)	0	['block2a_se_squeeze[0][0]']	Y
block2a_se_reduce (Conv2D)	(None, 1, 1, 4)	388	['block2a_se_reshape[0][0]']	Y
block2a_se_expand (Conv2D)	(None, 1, 1, 96)	480	['block2a_se_reduce[0][0]']	Y
block2a_se_excite (Multiply)	(None, 56, 56, 96)	0	['block2a_activation[0][0]', 'block2a_se_expand[0][0]']	Y
block2a_project_conv (Conv2D)	(None, 56, 56, 24)	2304	['block2a_se_excite[0][0]']	Y
block2a_project_bn (BatchNormalization)	(None, 56, 56, 24)	96	['block2a_project_conv[0][0]']	N
block2b_expand_conv (Conv2D)	(None, 56, 56, 144)	3456	['block2a_project_bn[0][0]']	Y
block2b_expand_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block2b_expand_conv[0][0]']	N
block2b_expand_activation (Activation)	(None, 56, 56, 144)	0	['block2b_expand_bn[0][0]']	Y
block2b_dwconv (DepthwiseConv2D)	(None, 56, 56, 144)	1296	['block2b_expand_activation[0][0]']	Y
block2b_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block2b_dwconv[0][0]']	N
block2b_activation (Activation)	(None, 56, 56, 144)	0	['block2b_bn[0][0]']	Y
block2b_se_squeeze (GlobalAveragePooling2D)	(None, 144)	0	['block2b_activation[0][0]']	Y
block2b_se_reshape (Reshape)	(None, 1, 1, 144)	0	['block2b_se_squeeze[0][0]']	Y
block2b_se_reduce (Conv2D)	(None, 1, 1, 6)	870	['block2b_se_reshape[0][0]']	Y
block2b_se_expand (Conv2D)	(None, 1, 1, 144)	1008	['block2b_se_reduce[0][0]']	Y
block2b_se_excite (Multiply)	(None, 56, 56, 144)	0	['block2b_activation[0][0]', 'block2b_se_expand[0][0]']	Y
block2b_project_conv (Conv2D)	(None, 56, 56, 24)	3456	['block2b_se_excite[0][0]']	Y
block2b_project_bn (BatchNormalization)	(None, 56, 56, 24)	96	['block2b_project_conv[0][0]']	N
block2b_drop (Dropout)	(None, 56, 56, 24)	0	['block2b_project_bn[0][0]']	Y
block2b_add (Add)	(None, 56, 56, 24)	0	['block2b_drop[0][0]', 'block2a_project_bn[0][0]']	Y
block3a_expand_conv (Conv2D)	(None, 56, 56, 144)	3456	['block2b_add[0][0]']	Y
block3a_expand_bn (BatchNormalization)	(None, 56, 56, 144)	576	['block3a_expand_conv[0][0]']	N
block3a_expand_activation (Activation)	(None, 56, 56, 144)	0	['block3a_expand_bn[0][0]']	Y
block3a_dwconv_pad (ZeroPadding2D)	(None, 59, 59, 144)	0	['block3a_expand_activation[0][0]']	Y
block3a_dwconv (DepthwiseConv2D)	(None, 28, 28, 144)	3600	['block3a_dwconv_pad[0][0]']	Y
block3a_bn (BatchNormalization)	(None, 28, 28, 144)	576	['block3a_dwconv[0][0]']	N
block3a_activation (Activation)	(None, 28, 28, 144)	0	['block3a_bn[0][0]']	Y
block3a_se_squeeze (GlobalAveragePooling2D)	(None, 144)	0	['block3a_activation[0][0]']	Y
block3a_se_reshape (Reshape)	(None, 1, 1, 144)	0	['block3a_se_squeeze[0][0]']	Y
block3a_se_reduce (Conv2D)	(None, 1, 1, 6)	870	['block3a_se_reshape[0][0]']	Y
block3a_se_expand (Conv2D)	(None, 1, 1, 144)	1008	['block3a_se_reduce[0][0]']	Y
block3a_se_excite (Multiply)	(None, 28, 28, 144)	0	['block3a_activation[0][0]', 'block3a_se_expand[0][0]']	Y
block3a_project_conv (Conv2D)	(None, 28, 28, 40)	5760	['block3a_se_excite[0][0]']	Y
block3a_project_bn (BatchNormalization)	(None, 28, 28, 40)	160	['block3a_project_conv[0][0]']	N
block3b_expand_conv (Conv2D)	(None, 28, 28, 240)	9600	['block3a_project_bn[0][0]']	Y
block3b_expand_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block3b_expand_conv[0][0]']	N
block3b_expand_activation (Activation)	(None, 28, 28, 240)	0	['block3b_expand_bn[0][0]']	Y
block3b_dwconv (DepthwiseConv2D)	(None, 28, 28, 240)	6000	['block3b_expand_activation[0][0]']	Y
block3b_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block3b_dwconv[0][0]']	N
block3b_activation (Activation)	(None, 28, 28, 240)	0	['block3b_bn[0][0]']	Y
block3b_se_squeeze (GlobalAveragePooling2D)	(None, 240)	0	['block3b_activation[0][0]']	Y
block3b_se_reshape (Reshape)	(None, 1, 1, 240)	0	['block3b_se_squeeze[0][0]']	Y
block3b_se_reduce (Conv2D)	(None, 1, 1, 10)	2410	['block3b_se_reshape[0][0]']	Y
block3b_se_expand (Conv2D)	(None, 1, 1, 240)	2640	['block3b_se_reduce[0][0]']	Y
block3b_se_excite (Multiply)	(None, 28, 28, 240)	0	['block3b_activation[0][0]', 'block3b_se_expand[0][0]']	Y
block3b_project_conv (Conv2D)	(None, 28, 28, 40)	9600	['block3b_se_excite[0][0]']	Y
block3b_project_bn (BatchNormalization)	(None, 28, 28, 40)	160	['block3b_project_conv[0][0]']	N
block3b_drop (Dropout)	(None, 28, 28, 40)	0	['block3b_project_bn[0][0]']	Y
block3b_add (Add)	(None, 28, 28, 40)	0	['block3b_drop[0][0]', 'block3a_project_bn[0][0]']	Y
block4a_expand_conv (Conv2D)	(None, 28, 28, 240)	9600	['block3b_add[0][0]']	Y
block4a_expand_bn (BatchNormalization)	(None, 28, 28, 240)	960	['block4a_expand_conv[0][0]']	N
block4a_expand_activation (Activation)	(None, 28, 28, 240)	0	['block4a_expand_bn[0][0]']	Y
block4a_dwconv_pad (ZeroPadding2D)	(None, 29, 29, 240)	0	['block4a_expand_activation[0][0]']	Y
block4a_dwconv (DepthwiseConv2D)	(None, 14, 14, 240)	2160	['block4a_dwconv_pad[0][0]']	Y
block4a_bn (BatchNormalization)	(None, 14, 14, 240)	960	['block4a_dwconv[0][0]']	N
block4a_activation (Activation)	(None, 14, 14, 240)	0	['block4a_bn[0][0]']	Y
block4a_se_squeeze (GlobalAveragePooling2D)	(None, 240)	0	['block4a_activation[0][0]']	Y
block4a_se_reshape (Reshape)	(None, 1, 1, 240)	0	['block4a_se_squeeze[0][0]']	Y
block4a_se_reduce (Conv2D)	(None, 1, 1, 10)	2410	['block4a_se_reshape[0][0]']	Y
block4a_se_expand (Conv2D)	(None, 1, 1, 240)	2640	['block4a_se_reduce[0][0]']	Y
block4a_se_excite (Multiply)	(None, 14, 14, 240)	0	['block4a_activation[0][0]', 'block4a_se_expand[0][0]']	Y
block4a_project_conv (Conv2D)	(None, 14, 14, 80)	19200	['block4a_se_excite[0][0]']	Y
block4a_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4a_project_conv[0][0]']	N
block4b_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4a_project_bn[0][0]']	Y
block4b_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4b_expand_conv[0][0]']	N
block4b_expand_activation (Activation)	(None, 14, 14, 480)	0	['block4b_expand_bn[0][0]']	Y
block4b_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4320	['block4b_expand_activation[0][0]']	Y
block4b_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4b_dwconv[0][0]']	N
block4b_activation (Activation)	(None, 14, 14, 480)	0	['block4b_bn[0][0]']	Y
block4b_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block4b_activation[0][0]']	Y
block4b_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block4b_se_squeeze[0][0]']	Y
block4b_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block4b_se_reshape[0][0]']	Y
block4b_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block4b_se_reduce[0][0]']	Y
block4b_se_excite (Multiply)	(None, 14, 14, 480)	0	['block4b_activation[0][0]', 'block4b_se_expand[0][0]']	Y
block4b_project_conv (Conv2D)	(None, 14, 14, 80)	38400	['block4b_se_excite[0][0]']	Y
block4b_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4b_project_conv[0][0]']	N
block4b_drop (Dropout)	(None, 14, 14, 80)	0	['block4b_project_bn[0][0]']	Y
block4b_add (Add)	(None, 14, 14, 80)	0	['block4b_drop[0][0]', 'block4a_project_bn[0][0]']	Y
block4c_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4b_add[0][0]']	Y
block4c_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4c_expand_conv[0][0]']	N
block4c_expand_activation (Activation)	(None, 14, 14, 480)	0	['block4c_expand_bn[0][0]']	Y
block4c_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4320	['block4c_expand_activation[0][0]']	Y
block4c_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block4c_dwconv[0][0]']	N
block4c_activation (Activation)	(None, 14, 14, 480)	0	['block4c_bn[0][0]']	Y
block4c_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block4c_activation[0][0]']	Y
block4c_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block4c_se_squeeze[0][0]']	Y
block4c_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block4c_se_reshape[0][0]']	Y
block4c_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block4c_se_reduce[0][0]']	Y
block4c_se_excite (Multiply)	(None, 14, 14, 480)	0	['block4c_activation[0][0]', 'block4c_se_expand[0][0]']	Y
block4c_project_conv (Conv2D)	(None, 14, 14, 80)	38400	['block4c_se_excite[0][0]']	Y
block4c_project_bn (BatchNormalization)	(None, 14, 14, 80)	320	['block4c_project_conv[0][0]']	N
block4c_drop (Dropout)	(None, 14, 14, 80)	0	['block4c_project_bn[0][0]']	Y
block4c_add (Add)	(None, 14, 14, 80)	0	['block4c_drop[0][0]', 'block4b_add[0][0]']	Y
block5a_expand_conv (Conv2D)	(None, 14, 14, 480)	38400	['block4c_add[0][0]']	Y
block5a_expand_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block5a_expand_conv[0][0]']	N
block5a_expand_activation (Activation)	(None, 14, 14, 480)	0	['block5a_expand_bn[0][0]']	Y
block5a_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	12000	['block5a_expand_activation[0][0]']	Y
block5a_bn (BatchNormalization)	(None, 14, 14, 480)	1920	['block5a_dwconv[0][0]']	N
block5a_activation (Activation)	(None, 14, 14, 480)	0	['block5a_bn[0][0]']	Y
block5a_se_squeeze (GlobalAveragePooling2D)	(None, 480)	0	['block5a_activation[0][0]']	Y
block5a_se_reshape (Reshape)	(None, 1, 1, 480)	0	['block5a_se_squeeze[0][0]']	Y
block5a_se_reduce (Conv2D)	(None, 1, 1, 20)	9620	['block5a_se_reshape[0][0]']	Y
block5a_se_expand (Conv2D)	(None, 1, 1, 480)	10080	['block5a_se_reduce[0][0]']	Y
block5a_se_excite (Multiply)	(None, 14, 14, 480)	0	['block5a_activation[0][0]', 'block5a_se_expand[0][0]']	Y
block5a_project_conv (Conv2D)	(None, 14, 14, 112)	53760	['block5a_se_excite[0][0]']	Y
block5a_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5a_project_conv[0][0]']	N
block5b_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5a_project_bn[0][0]']	Y
block5b_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5b_expand_conv[0][0]']	N
block5b_expand_activation (Activation)	(None, 14, 14, 672)	0	['block5b_expand_bn[0][0]']	Y
block5b_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16800	['block5b_expand_activation[0][0]']	Y
block5b_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5b_dwconv[0][0]']	N
block5b_activation (Activation)	(None, 14, 14, 672)	0	['block5b_bn[0][0]']	Y
block5b_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block5b_activation[0][0]']	Y
block5b_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block5b_se_squeeze[0][0]']	Y
block5b_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block5b_se_reshape[0][0]']	Y
block5b_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block5b_se_reduce[0][0]']	Y
block5b_se_excite (Multiply)	(None, 14, 14, 672)	0	['block5b_activation[0][0]', 'block5b_se_expand[0][0]']	Y
block5b_project_conv (Conv2D)	(None, 14, 14, 112)	75264	['block5b_se_excite[0][0]']	Y
block5b_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5b_project_conv[0][0]']	N
block5b_drop (Dropout)	(None, 14, 14, 112)	0	['block5b_project_bn[0][0]']	Y
block5b_add (Add)	(None, 14, 14, 112)	0	['block5b_drop[0][0]', 'block5a_project_bn[0][0]']	Y
block5c_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5b_add[0][0]']	Y
block5c_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5c_expand_conv[0][0]']	N
block5c_expand_activation (Activation)	(None, 14, 14, 672)	0	['block5c_expand_bn[0][0]']	Y
block5c_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16800	['block5c_expand_activation[0][0]']	Y
block5c_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block5c_dwconv[0][0]']	N
block5c_activation (Activation)	(None, 14, 14, 672)	0	['block5c_bn[0][0]']	Y
block5c_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block5c_activation[0][0]']	Y
block5c_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block5c_se_squeeze[0][0]']	Y
block5c_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block5c_se_reshape[0][0]']	Y
block5c_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block5c_se_reduce[0][0]']	Y
block5c_se_excite (Multiply)	(None, 14, 14, 672)	0	['block5c_activation[0][0]', 'block5c_se_expand[0][0]']	Y
block5c_project_conv (Conv2D)	(None, 14, 14, 112)	75264	['block5c_se_excite[0][0]']	Y
block5c_project_bn (BatchNormalization)	(None, 14, 14, 112)	448	['block5c_project_conv[0][0]']	N
block5c_drop (Dropout)	(None, 14, 14, 112)	0	['block5c_project_bn[0][0]']	Y
block5c_add (Add)	(None, 14, 14, 112)	0	['block5c_drop[0][0]', 'block5b_add[0][0]']	Y
block6a_expand_conv (Conv2D)	(None, 14, 14, 672)	75264	['block5c_add[0][0]']	Y
block6a_expand_bn (BatchNormalization)	(None, 14, 14, 672)	2688	['block6a_expand_conv[0][0]']	N
block6a_expand_activation (Activation)	(None, 14, 14, 672)	0	['block6a_expand_bn[0][0]']	Y
block6a_dwconv_pad (ZeroPadding2D)	(None, 17, 17, 672)	0	['block6a_expand_activation[0][0]']	Y
block6a_dwconv (DepthwiseConv2D)	(None, 7, 7, 672)	16800	['block6a_dwconv_pad[0][0]']	Y
block6a_bn (BatchNormalization)	(None, 7, 7, 672)	2688	['block6a_dwconv[0][0]']	N
block6a_activation (Activation)	(None, 7, 7, 672)	0	['block6a_bn[0][0]']	Y
block6a_se_squeeze (GlobalAveragePooling2D)	(None, 672)	0	['block6a_activation[0][0]']	Y
block6a_se_reshape (Reshape)	(None, 1, 1, 672)	0	['block6a_se_squeeze[0][0]']	Y
block6a_se_reduce (Conv2D)	(None, 1, 1, 28)	18844	['block6a_se_reshape[0][0]']	Y
block6a_se_expand (Conv2D)	(None, 1, 1, 672)	19488	['block6a_se_reduce[0][0]']	Y
block6a_se_excite (Multiply)	(None, 7, 7, 672)	0	['block6a_activation[0][0]', 'block6a_se_expand[0][0]']	Y
block6a_project_conv (Conv2D)	(None, 7, 7, 192)	129024	['block6a_se_excite[0][0]']	Y
block6a_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6a_project_conv[0][0]']	N
block6b_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6a_project_bn[0][0]']	Y
block6b_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6b_expand_conv[0][0]']	N
block6b_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6b_expand_bn[0][0]']	Y
block6b_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6b_expand_activation[0][0]']	Y
block6b_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6b_dwconv[0][0]']	N
block6b_activation (Activation)	(None, 7, 7, 1152)	0	['block6b_bn[0][0]']	Y
block6b_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6b_activation[0][0]']	Y
block6b_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6b_se_squeeze[0][0]']	Y
block6b_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6b_se_reshape[0][0]']	Y
block6b_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6b_se_reduce[0][0]']	Y
block6b_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6b_activation[0][0]', 'block6b_se_expand[0][0]']	Y
block6b_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6b_se_excite[0][0]']	Y
block6b_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6b_project_conv[0][0]']	N
block6b_drop (Dropout)	(None, 7, 7, 192)	0	['block6b_project_bn[0][0]']	Y
block6b_add (Add)	(None, 7, 7, 192)	0	['block6b_drop[0][0]', 'block6a_project_bn[0][0]']	Y
block6c_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6b_add[0][0]']	Y
block6c_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6c_expand_conv[0][0]']	N
block6c_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6c_expand_bn[0][0]']	Y
block6c_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6c_expand_activation[0][0]']	Y
block6c_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6c_dwconv[0][0]']	N
block6c_activation (Activation)	(None, 7, 7, 1152)	0	['block6c_bn[0][0]']	Y
block6c_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6c_activation[0][0]']	Y
block6c_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6c_se_squeeze[0][0]']	Y
block6c_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6c_se_reshape[0][0]']	Y
block6c_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6c_se_reduce[0][0]']	Y
block6c_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6c_activation[0][0]', 'block6c_se_expand[0][0]']	Y
block6c_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6c_se_excite[0][0]']	Y
block6c_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6c_project_conv[0][0]']	N
block6c_drop (Dropout)	(None, 7, 7, 192)	0	['block6c_project_bn[0][0]']	Y
block6c_add (Add)	(None, 7, 7, 192)	0	['block6c_drop[0][0]', 'block6b_add[0][0]']	Y
block6d_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6c_add[0][0]']	Y
block6d_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6d_expand_conv[0][0]']	N
block6d_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block6d_expand_bn[0][0]']	Y
block6d_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28800	['block6d_expand_activation[0][0]']	Y
block6d_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block6d_dwconv[0][0]']	N
block6d_activation (Activation)	(None, 7, 7, 1152)	0	['block6d_bn[0][0]']	Y
block6d_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block6d_activation[0][0]']	Y
block6d_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block6d_se_squeeze[0][0]']	Y
block6d_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block6d_se_reshape[0][0]']	Y
block6d_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block6d_se_reduce[0][0]']	Y
block6d_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block6d_activation[0][0]', 'block6d_se_expand[0][0]']	Y
block6d_project_conv (Conv2D)	(None, 7, 7, 192)	221184	['block6d_se_excite[0][0]']	Y
block6d_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	['block6d_project_conv[0][0]']	N
block6d_drop (Dropout)	(None, 7, 7, 192)	0	['block6d_project_bn[0][0]']	Y
block6d_add (Add)	(None, 7, 7, 192)	0	['block6d_drop[0][0]', 'block6c_add[0][0]']	Y
block7a_expand_conv (Conv2D)	(None, 7, 7, 1152)	221184	['block6d_add[0][0]']	Y
block7a_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block7a_expand_conv[0][0]']	N
block7a_expand_activation (Activation)	(None, 7, 7, 1152)	0	['block7a_expand_bn[0][0]']	Y
block7a_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	10368	['block7a_expand_activation[0][0]']	Y
block7a_bn (BatchNormalization)	(None, 7, 7, 1152)	4608	['block7a_dwconv[0][0]']	N
block7a_activation (Activation)	(None, 7, 7, 1152)	0	['block7a_bn[0][0]']	Y
block7a_se_squeeze (GlobalAveragePooling2D)	(None, 1152)	0	['block7a_activation[0][0]']	Y
block7a_se_reshape (Reshape)	(None, 1, 1, 1152)	0	['block7a_se_squeeze[0][0]']	Y
block7a_se_reduce (Conv2D)	(None, 1, 1, 48)	55344	['block7a_se_reshape[0][0]']	Y
block7a_se_expand (Conv2D)	(None, 1, 1, 1152)	56448	['block7a_se_reduce[0][0]']	Y
block7a_se_excite (Multiply)	(None, 7, 7, 1152)	0	['block7a_activation[0][0]', 'block7a_se_expand[0][0]']	Y
block7a_project_conv (Conv2D)	(None, 7, 7, 320)	368640	['block7a_se_excite[0][0]']	Y
block7a_project_bn (BatchNormalization)	(None, 7, 7, 320)	1280	['block7a_project_conv[0][0]']	N
top_conv (Conv2D)	(None, 7, 7, 1280)	409600	['block7a_project_bn[0][0]']	Y
top_bn (BatchNormalization)	(None, 7, 7, 1280)	5120	['top_conv[0][0]']	Y
top_activation (Activation)	(None, 7, 7, 1280)	0	['top_bn[0][0]']	Y
NEW_GAP2D (GlobalAveragePooling2D)	(None, 1280)	0	['top_activation[0][0]']	Y
NEW_BN (BatchNormalization)	(None, 1280)	5120	['NEW_GAP2D[0][0]']	Y
NEW_DO (Dropout)	(None, 1280)	0	['NEW_BN[0][0]']	Y
NEW_D (Dense)	(None, 1)	1281	['NEW_DO[0][0]']	Y

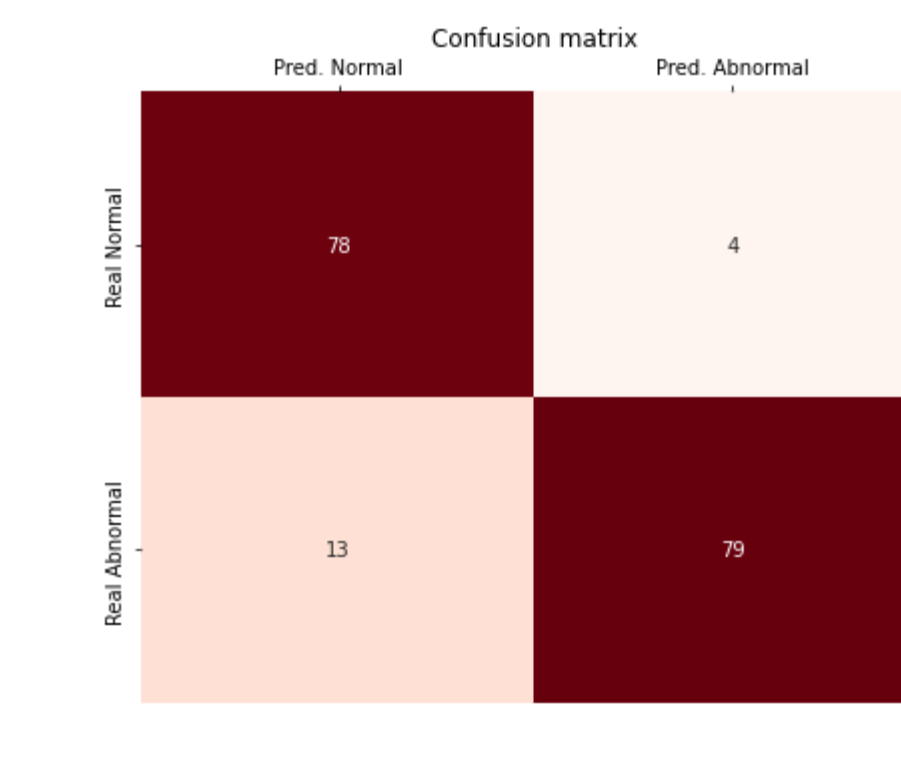
Total params: 4,055,972
Trainable params: 3,969,373
Non-trainable params: 86,599

In [17]:

```
# Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
callbacks = [EarlyStopping(monitor='val_f1_score',
                           mode='max',
                           patience=10),
             ModelCheckpoint(filepath='model3.h5',
                             monitor='val_f1_score',
                             mode='max',
                             save_best_only=True,
                             save_weights_only=True)]

# Train model
m3_h = m3.fit(X_train_0, y_train_0,
              epochs=epochs,
              batch_size=bs,
              callbacks=callbacks,
              validation_data=(X_valid_0, y_valid_0),
              verbose=0)
```

In [18]:

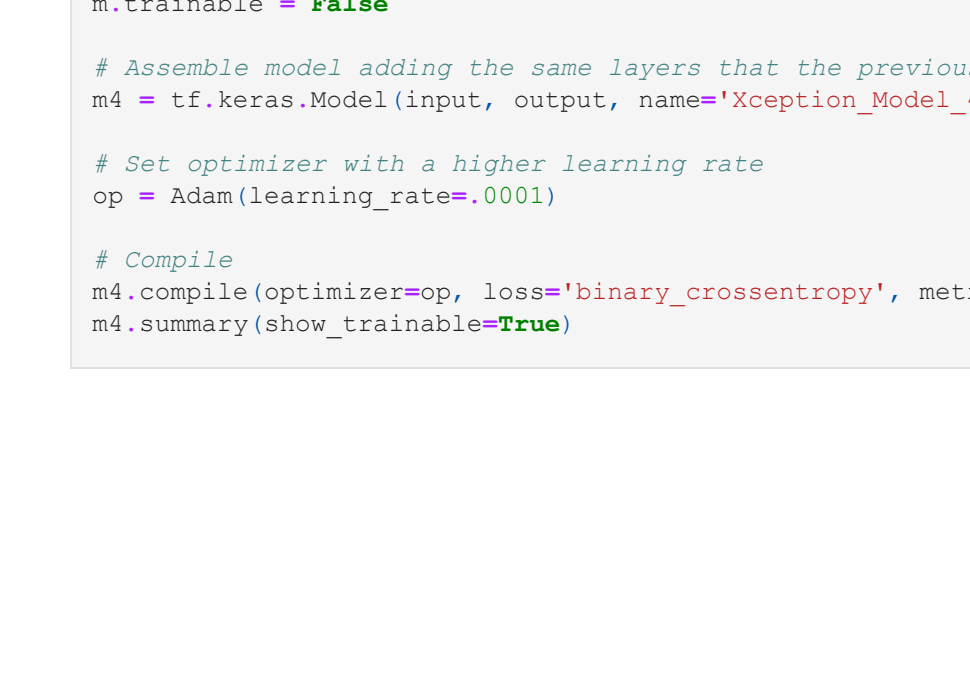
```
# Plot F1-Score and Loss
plot_hist(m3_h)
```



In [19]:

```
# Load best weights
m3.load_weights('model3.h5')

# Predict test data
y_pred_0 = m3.predict(X_test_0)

# Create binary prediction array with same threshold used earlier (.5)
y_pred_0 = np.asarray([0 if i < threshold else 1 for i in y_pred_0])

# Get and print F1-Score and confusion matrix
m3_f1 = get_f1_plot_cm(y_test_0, y_pred_0)
```

Con threshold = 0.5 , el F1-Score es 0.903



Modelo 4

In [20]:

```
# Load Xception with ImageNet weights
m = Xception(include_top=False, input_tensor=input, weights='imagenet', input_shape=X_train_0.shape[1:4])

# Freeze model
m.trainable = False

# Assemble model adding the same layers that the previous ones
m4 = tf.keras.Model(input, output, name='Xception_Model_4')

# Set optimizer with a higher learning rate
op = Adam(learning_rate=.0001)

# Compile
m4.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
m4.summary(show_trainable=True)
```

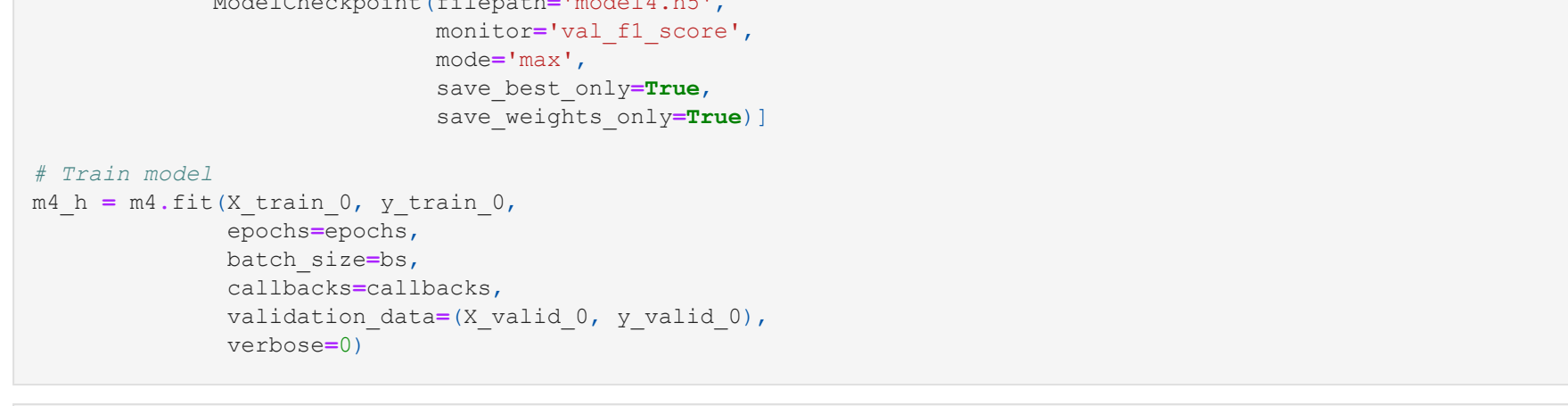
```
Model: "Xception_Model_4"
________________________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to                     Trainable
================================================================================================================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []                               N
                                )]
 rescaling (Rescaling)          (None, 224, 224, 3)  0           ['input_1[0][0]']                N
 normalization (Normalization)  (None, 224, 224, 3)  7           ['rescaling[0][0]']              N
 stem_conv_pad (ZeroPadding2D)  (None, 225, 225, 3)  0           ['normalization[0][0]']          N
 stem_conv (Conv2D)             (None, 112, 112, 32  864         ['stem_conv_pad[0][0]']          N
                                )
 stem_bn (BatchNormalization)   (None, 112, 112, 32  128         ['stem_conv[0][0]']              N
                                )
 stem_activation (Activation)   (None, 112, 112, 32  0           ['stem_bn[0][0]']                N
                                )
 block1a_dwconv (DepthwiseConv2  (None, 112, 112, 32  288        ['stem_activation[0][0]']        N
 D)                             )
 block1a_bn (BatchNormalization  (None, 112, 112, 32  128        ['block1a_dwconv[0][0]']         N
 )                              )
 block1a_activation (Activation  (None, 112, 112, 32  0          ['block1a_bn[0][0]']             N
 )                              )
 block1a_se_squeeze (GlobalAver  (None, 32)          0           ['block1a_activation[0][0]']     N
 agePooling2D)
 block1a_se_reshape (Reshape)   (None, 1, 1, 32)     0           ['block1a_se_squeeze[0][0]']     N
 block1a_se_reduce (Conv2D)     (None, 1, 1, 8)      264         ['block1a_se_reshape[0][0]']     N
 block1a_se_expand (Conv2D)     (None, 1, 1, 32)     288         ['block1a_se_reduce[0][0]']      N
 block1a_se_excite (Multiply)   (None, 112, 112, 32  0           ['block1a_activation[0][0]',     N
                                )                                 'block1a_se_expand[0][0]']
 block1a_project_conv (Conv2D)  (None, 112, 112, 16  512         ['block1a_se_excite[0][0]']      N
                                )
 block1a_project_bn (BatchNorma  (None, 112, 112, 16  64         ['block1a_project_conv[0][0]']   N
 lization)                      )
 block2a_expand_conv (Conv2D)   (None, 112, 112, 96  1536        ['block1a_project_bn[0][0]']     N
                                )
 block2a_expand_bn (BatchNormal  (None, 112, 112, 96  384        ['block2a_expand_conv[0][0]']    N
 ization)                       )
 block2a_expand_activation (Act  (None, 112, 112, 96  0          ['block2a_expand_bn[0][0]']      N
 ivation)                       )
 block2a_dwconv_pad (ZeroPaddin  (None, 113, 113, 96  0          ['block2a_expand_activation[0][  N
 g2D)                           )                                0]']
 block2a_dwconv (DepthwiseConv2  (None, 56, 56, 96)  864         ['block2a_dwconv_pad[0][0]']     N
 D)
 block2a_bn (BatchNormalization  (None, 56, 56, 96)  384         ['block2a_dwconv[0][0]']         N
 )
 block2a_activation (Activation  (None, 56, 56, 96)  0           ['block2a_bn[0][0]']             N
 )
 block2a_se_squeeze (GlobalAver  (None, 96)          0           ['block2a_activation[0][0]']     N
 agePooling2D)
 block2a_se_reshape (Reshape)   (None, 1, 1, 96)     0           ['block2a_se_squeeze[0][0]']     N
 block2a_se_reduce (Conv2D)     (None, 1, 1, 4)      388         ['block2a_se_reshape[0][0]']     N
 block2a_se_expand (Conv2D)     (None, 1, 1, 96)     480         ['block2a_se_reduce[0][0]']      N
 block2a_se_excite (Multiply)   (None, 56, 56, 96)   0           ['block2a_activation[0][0]',     N
                                                                  'block2a_se_expand[0][0]']
 block2a_project_conv (Conv2D)  (None, 56, 56, 24)   2304        ['block2a_se_excite[0][0]']      N
 block2a_project_bn (BatchNorma  (None, 56, 56, 24)  96          ['block2a_project_conv[0][0]']   N
 lization)
 block2b_expand_conv (Conv2D)   (None, 56, 56, 144)  3456        ['block2a_project_bn[0][0]']     N
 block2b_expand_bn (BatchNormal  (None, 56, 56, 144)  576        ['block2b_expand_conv[0][0]']    N
 ization)
 block2b_expand_activation (Act  (None, 56, 56, 144)  0          ['block2b_expand_bn[0][0]']      N
 ivation)
 block2b_dwconv (DepthwiseConv2  (None, 56, 56, 144)  1296       ['block2b_expand_activation[0][  N
 D)                                                              0]']
 block2b_bn (BatchNormalization  (None, 56, 56, 144)  576        ['block2b_dwconv[0][0]']         N
 )
 block2b_activation (Activation  (None, 56, 56, 144)  0          ['block2b_bn[0][0]']             N
 )
 block2b_se_squeeze (GlobalAver  (None, 144)         0           ['block2b_activation[0][0]']     N
 agePooling2D)
 block2b_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block2b_se_squeeze[0][0]']     N
 block2b_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block2b_se_reshape[0][0]']     N
 block2b_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block2b_se_reduce[0][0]']      N
 block2b_se_excite (Multiply)   (None, 56, 56, 144)  0           ['block2b_activation[0][0]',     N
                                                                  'block2b_se_expand[0][0]']
 block2b_project_conv (Conv2D)  (None, 56, 56, 24)   3456        ['block2b_se_excite[0][0]']      N
 block2b_project_bn (BatchNorma  (None, 56, 56, 24)  96          ['block2b_project_conv[0][0]']   N
 lization)
 block2b_drop (Dropout)         (None, 56, 56, 24)   0           ['block2b_project_bn[0][0]']     N
 block2b_add (Add)              (None, 56, 56, 24)   0           ['block2b_drop[0][0]',           N
                                                                  'block2a_project_bn[0][0]']
 block3a_expand_conv (Conv2D)   (None, 56, 56, 144)  3456        ['block2b_add[0][0]']            N
 block3a_expand_bn (BatchNormal  (None, 56, 56, 144)  576        ['block3a_expand_conv[0][0]']    N
 ization)
 block3a_expand_activation (Act  (None, 56, 56, 144)  0          ['block3a_expand_bn[0][0]']      N
 ivation)
 block3a_dwconv_pad (ZeroPaddin  (None, 59, 59, 144)  0          ['block3a_expand_activation[0][  N
 g2D)                                                            0]']
 block3a_dwconv (DepthwiseConv2  (None, 28, 28, 144)  3600       ['block3a_dwconv_pad[0][0]']     N
 D)
 block3a_bn (BatchNormalization  (None, 28, 28, 144)  576        ['block3a_dwconv[0][0]']         N
 )
 block3a_activation (Activation  (None, 28, 28, 144)  0          ['block3a_bn[0][0]']             N
 )
 block3a_se_squeeze (GlobalAver  (None, 144)         0           ['block3a_activation[0][0]']     N
 agePooling2D)
 block3a_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block3a_se_squeeze[0][0]']     N
 block3a_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block3a_se_reshape[0][0]']     N
 block3a_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block3a_se_reduce[0][0]']      N
 block3a_se_excite (Multiply)   (None, 28, 28, 144)  0           ['block3a_activation[0][0]',     N
                                                                  'block3a_se_expand[0][0]']
 block3a_project_conv (Conv2D)  (None, 28, 28, 40)   5760        ['block3a_se_excite[0][0]']      N
 block3a_project_bn (BatchNorma  (None, 28, 28, 40)  160         ['block3a_project_conv[0][0]']   N
 lization)
 block3b_expand_conv (Conv2D)   (None, 28, 28, 240)  9600        ['block3a_project_bn[0][0]']     N
 block3b_expand_bn (BatchNormal  (None, 28, 28, 240)  960        ['block3b_expand_conv[0][0]']    N
 ization)
 block3b_expand_activation (Act  (None, 28, 28, 240)  0          ['block3b_expand_bn[0][0]']      N
 ivation)
 block3b_dwconv (DepthwiseConv2  (None, 28, 28, 240)  6000       ['block3b_expand_activation[0][  N
 D)                                                              0]']
 block3b_bn (BatchNormalization  (None, 28, 28, 240)  960        ['block3b_dwconv[0][0]']         N
 )
 block3b_activation (Activation  (None, 28, 28, 240)  0          ['block3b_bn[0][0]']             N
 )
 block3b_se_squeeze (GlobalAver  (None, 240)         0           ['block3b_activation[0][0]']     N
 agePooling2D)
 block3b_se_reshape (Reshape)   (None, 1, 1, 240)    0           ['block3b_se_squeeze[0][0]']     N
 block3b_se_reduce (Conv2D)     (None, 1, 1, 10)     2410        ['block3b_se_reshape[0][0]']     N
 block3b_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block3b_se_reduce[0][0]']      N
 block3b_se_excite (Multiply)   (None, 28, 28, 240)  0           ['block3b_activation[0][0]',     N
                                                                  'block3b_se_expand[0][0]']
 block3b_project_conv (Conv2D)  (None, 28, 28, 40)   9600        ['block3b_se_excite[0][0]']      N
 block3b_project_bn (BatchNorma  (None, 28, 28, 40)  160         ['block3b_project_conv[0][0]']   N
 lization)
 block3b_drop (Dropout)         (None, 28, 28, 40)   0           ['block3b_project_bn[0][0]']     N
 block3b_add (Add)              (None, 28, 28, 40)   0           ['block3b_drop[0][0]',           N
                                                                  'block3a_project_bn[0][0]']
 block4a_expand_conv (Conv2D)   (None, 28, 28, 240)  9600        ['block3b_add[0][0]']            N
 block4a_expand_bn (BatchNormal  (None, 28, 28, 240)  960        ['block4a_expand_conv[0][0]']    N
 ization)
 block4a_expand_activation (Act  (None, 28, 28, 240)  0          ['block4a_expand_bn[0][0]']      N
 ivation)
 block4a_dwconv_pad (ZeroPaddin  (None, 29, 29, 240)  0          ['block4a_expand_activation[0][  N
 g2D)                                                            0]']
 block4a_dwconv (DepthwiseConv2  (None, 14, 14, 240)  2160       ['block4a_dwconv_pad[0][0]']     N
 D)
 block4a_bn (BatchNormalization  (None, 14, 14, 240)  960        ['block4a_dwconv[0][0]']         N
 )
 block4a_activation (Activation  (None, 14, 14, 240)  0          ['block4a_bn[0][0]']             N
 )
 block4a_se_squeeze (GlobalAver  (None, 240)         0           ['block4a_activation[0][0]']     N
 agePooling2D)
 block4a_se_reshape (Reshape)   (None, 1, 1, 240)    0           ['block4a_se_squeeze[0][0]']     N
 block4a_se_reduce (Conv2D)     (None, 1, 1, 10)     2410        ['block4a_se_reshape[0][0]']     N
 block4a_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block4a_se_reduce[0][0]']      N
 block4a_se_excite (Multiply)   (None, 14, 14, 240)  0           ['block4a_activation[0][0]',     N
                                                                  'block4a_se_expand[0][0]']
 block4a_project_conv (Conv2D)  (None, 14, 14, 80)   19200       ['block4a_se_excite[0][0]']      N
 block4a_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4a_project_conv[0][0]']   N
 lization)
 block4b_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4a_project_bn[0][0]']     N
 block4b_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block4b_expand_conv[0][0]']    N
 ization)
 block4b_expand_activation (Act  (None, 14, 14, 480)  0          ['block4b_expand_bn[0][0]']      N
 ivation)
 block4b_dwconv (DepthwiseConv2  (None, 14, 14, 480)  4320       ['block4b_expand_activation[0][  N
 D)                                                              0]']
 block4b_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block4b_dwconv[0][0]']         N
 )
 block4b_activation (Activation  (None, 14, 14, 480)  0          ['block4b_bn[0][0]']             N
 )
 block4b_se_squeeze (GlobalAver  (None, 480)         0           ['block4b_activation[0][0]']     N
 agePooling2D)
 block4b_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4b_se_squeeze[0][0]']     N
 block4b_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4b_se_reshape[0][0]']     N
 block4b_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4b_se_reduce[0][0]']      N
 block4b_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block4b_activation[0][0]',     N
                                                                  'block4b_se_expand[0][0]']
 block4b_project_conv (Conv2D)  (None, 14, 14, 80)   38400       ['block4b_se_excite[0][0]']      N
 block4b_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4b_project_conv[0][0]']   N
 lization)
 block4b_drop (Dropout)         (None, 14, 14, 80)   0           ['block4b_project_bn[0][0]']     N
 block4b_add (Add)              (None, 14, 14, 80)   0           ['block4b_drop[0][0]',           N
                                                                  'block4a_project_bn[0][0]']
 block4c_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4b_add[0][0]']            N
 block4c_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block4c_expand_conv[0][0]']    N
 ization)
 block4c_expand_activation (Act  (None, 14, 14, 480)  0          ['block4c_expand_bn[0][0]']      N
 ivation)
 block4c_dwconv (DepthwiseConv2  (None, 14, 14, 480)  4320       ['block4c_expand_activation[0][  N
 D)                                                              0]']
 block4c_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block4c_dwconv[0][0]']         N
 )
 block4c_activation (Activation  (None, 14, 14, 480)  0          ['block4c_bn[0][0]']             N
 )
 block4c_se_squeeze (GlobalAver  (None, 480)         0           ['block4c_activation[0][0]']     N
 agePooling2D)
 block4c_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4c_se_squeeze[0][0]']     N
 block4c_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4c_se_reshape[0][0]']     N
 block4c_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4c_se_reduce[0][0]']      N
 block4c_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block4c_activation[0][0]',     N
                                                                  'block4c_se_expand[0][0]']
 block4c_project_conv (Conv2D)  (None, 14, 14, 80)   38400       ['block4c_se_excite[0][0]']      N
 block4c_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4c_project_conv[0][0]']   N
 lization)
 block4c_drop (Dropout)         (None, 14, 14, 80)   0           ['block4c_project_bn[0][0]']     N
 block4c_add (Add)              (None, 14, 14, 80)   0           ['block4c_drop[0][0]',           N
                                                                  'block4b_add[0][0]']
 block5a_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4c_add[0][0]']            N
 block5a_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block5a_expand_conv[0][0]']    N
 ization)
 block5a_expand_activation (Act  (None, 14, 14, 480)  0          ['block5a_expand_bn[0][0]']      N
 ivation)
 block5a_dwconv (DepthwiseConv2  (None, 14, 14, 480)  12000      ['block5a_expand_activation[0][  N
 D)                                                              0]']
 block5a_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block5a_dwconv[0][0]']         N
 )
 block5a_activation (Activation  (None, 14, 14, 480)  0          ['block5a_bn[0][0]']             N
 )
 block5a_se_squeeze (GlobalAver  (None, 480)         0           ['block5a_activation[0][0]']     N
 agePooling2D)
 block5a_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block5a_se_squeeze[0][0]']     N
 block5a_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block5a_se_reshape[0][0]']     N
 block5a_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block5a_se_reduce[0][0]']      N
 block5a_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block5a_activation[0][0]',     N
                                                                  'block5a_se_expand[0][0]']
 block5a_project_conv (Conv2D)  (None, 14, 14, 112)  53760       ['block5a_se_excite[0][0]']      N
 block5a_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5a_project_conv[0][0]']   N
 lization)
 block5b_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5a_project_bn[0][0]']     N
 block5b_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block5b_expand_conv[0][0]']    N
 ization)
 block5b_expand_activation (Act  (None, 14, 14, 672)  0          ['block5b_expand_bn[0][0]']      N
 ivation)
 block5b_dwconv (DepthwiseConv2  (None, 14, 14, 672)  16800      ['block5b_expand_activation[0][  N
 D)                                                              0]']
 block5b_bn (BatchNormalization  (None, 14, 14, 672)  2688       ['block5b_dwconv[0][0]']         N
 )
 block5b_activation (Activation  (None, 14, 14, 672)  0          ['block5b_bn[0][0]']             N
 )
 block5b_se_squeeze (GlobalAver  (None, 672)         0           ['block5b_activation[0][0]']     N
 agePooling2D)
 block5b_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5b_se_squeeze[0][0]']     N
 block5b_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5b_se_reshape[0][0]']     N
 block5b_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5b_se_reduce[0][0]']      N
 block5b_se_excite (Multiply)   (None, 14, 14, 672)  0           ['block5b_activation[0][0]',     N
                                                                  'block5b_se_expand[0][0]']
 block5b_project_conv (Conv2D)  (None, 14, 14, 112)  75264       ['block5b_se_excite[0][0]']      N
 block5b_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5b_project_conv[0][0]']   N
 lization)
 block5b_drop (Dropout)         (None, 14, 14, 112)  0           ['block5b_project_bn[0][0]']     N
 block5b_add (Add)              (None, 14, 14, 112)  0           ['block5b_drop[0][0]',           N
                                                                  'block5a_project_bn[0][0]']
 block5c_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5b_add[0][0]']            N
 block5c_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block5c_expand_conv[0][0]']    N
 ization)
 block5c_expand_activation (Act  (None, 14, 14, 672)  0          ['block5c_expand_bn[0][0]']      N
 ivation)
 block5c_dwconv (DepthwiseConv2  (None, 14, 14, 672)  16800      ['block5c_expand_activation[0][  N
 D)                                                              0]']
 block5c_bn (BatchNormalization  (None, 14, 14, 672)  2688       ['block5c_dwconv[0][0]']         N
 )
 block5c_activation (Activation  (None, 14, 14, 672)  0          ['block5c_bn[0][0]']             N
 )
 block5c_se_squeeze (GlobalAver  (None, 672)         0           ['block5c_activation[0][0]']     N
 agePooling2D)
 block5c_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5c_se_squeeze[0][0]']     N
 block5c_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5c_se_reshape[0][0]']     N
 block5c_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5c_se_reduce[0][0]']      N
 block5c_se_excite (Multiply)   (None, 14, 14, 672)  0           ['block5c_activation[0][0]',     N
                                                                  'block5c_se_expand[0][0]']
 block5c_project_conv (Conv2D)  (None, 14, 14, 112)  75264       ['block5c_se_excite[0][0]']      N
 block5c_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5c_project_conv[0][0]']   N
 lization)
 block5c_drop (Dropout)         (None, 14, 14, 112)  0           ['block5c_project_bn[0][0]']     N
 block5c_add (Add)              (None, 14, 14, 112)  0           ['block5c_drop[0][0]',           N
                                                                  'block5b_add[0][0]']
 block6a_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5c_add[0][0]']            N
 block6a_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block6a_expand_conv[0][0]']    N
 ization)
 block6a_expand_activation (Act  (None, 14, 14, 672)  0          ['block6a_expand_bn[0][0]']      N
 ivation)
 block6a_dwconv_pad (ZeroPaddin  (None, 17, 17, 672)  0          ['block6a_expand_activation[0][  N
 g2D)                                                            0]']
 block6a_dwconv (DepthwiseConv2  (None, 7, 7, 672)   16800       ['block6a_dwconv_pad[0][0]']     N
 D)
 block6a_bn (BatchNormalization  (None, 7, 7, 672)   2688        ['block6a_dwconv[0][0]']         N
 )
 block6a_activation (Activation  (None, 7, 7, 672)   0           ['block6a_bn[0][0]']             N
 )
 block6a_se_squeeze (GlobalAver  (None, 672)         0           ['block6a_activation[0][0]']     N
 agePooling2D)
 block6a_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block6a_se_squeeze[0][0]']     N
 block6a_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block6a_se_reshape[0][0]']     N
 block6a_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block6a_se_reduce[0][0]']      N
 block6a_se_excite (Multiply)   (None, 7, 7, 672)    0           ['block6a_activation[0][0]',     N
                                                                  'block6a_se_expand[0][0]']
 block6a_project_conv (Conv2D)  (None, 7, 7, 192)    129024      ['block6a_se_excite[0][0]']      N
 block6a_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6a_project_conv[0][0]']   N
 lization)
 block6b_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6a_project_bn[0][0]']     N
 block6b_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6b_expand_conv[0][0]']    N
 ization)
 block6b_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6b_expand_bn[0][0]']      N
 ivation)
 block6b_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6b_expand_activation[0][  N
 D)                                                              0]']
 block6b_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6b_dwconv[0][0]']         N
 )
 block6b_activation (Activation  (None, 7, 7, 1152)  0           ['block6b_bn[0][0]']             N
 )
 block6b_se_squeeze (GlobalAver  (None, 1152)        0           ['block6b_activation[0][0]']     N
 agePooling2D)
 block6b_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6b_se_squeeze[0][0]']     N
 block6b_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6b_se_reshape[0][0]']     N
 block6b_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6b_se_reduce[0][0]']      N
 block6b_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6b_activation[0][0]',     N
                                                                  'block6b_se_expand[0][0]']
 block6b_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6b_se_excite[0][0]']      N
 block6b_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6b_project_conv[0][0]']   N
 lization)
 block6b_drop (Dropout)         (None, 7, 7, 192)    0           ['block6b_project_bn[0][0]']     N
 block6b_add (Add)              (None, 7, 7, 192)    0           ['block6b_drop[0][0]',           N
                                                                  'block6a_project_bn[0][0]']
 block6c_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6b_add[0][0]']            N
 block6c_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6c_expand_conv[0][0]']    N
 ization)
 block6c_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6c_expand_bn[0][0]']      N
 ivation)
 block6c_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6c_expand_activation[0][  N
 D)                                                              0]']
 block6c_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6c_dwconv[0][0]']         N
 )
 block6c_activation (Activation  (None, 7, 7, 1152)  0           ['block6c_bn[0][0]']             N
 )
 block6c_se_squeeze (GlobalAver  (None, 1152)        0           ['block6c_activation[0][0]']     N
 agePooling2D)
 block6c_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6c_se_squeeze[0][0]']     N
 block6c_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6c_se_reshape[0][0]']     N
 block6c_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6c_se_reduce[0][0]']      N
 block6c_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6c_activation[0][0]',     N
                                                                  'block6c_se_expand[0][0]']
 block6c_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6c_se_excite[0][0]']      N
 block6c_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6c_project_conv[0][0]']   N
 lization)
 block6c_drop (Dropout)         (None, 7, 7, 192)    0           ['block6c_project_bn[0][0]']     N
 block6c_add (Add)              (None, 7, 7, 192)    0           ['block6c_drop[0][0]',           N
                                                                  'block6b_add[0][0]']
 block6d_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6c_add[0][0]']            N
 block6d_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6d_expand_conv[0][0]']    N
 ization)
 block6d_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6d_expand_bn[0][0]']      N
 ivation)
 block6d_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6d_expand_activation[0][  N
 D)                                                              0]']
 block6d_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6d_dwconv[0][0]']         N
 )
 block6d_activation (Activation  (None, 7, 7, 1152)  0           ['block6d_bn[0][0]']             N
 )
 block6d_se_squeeze (GlobalAver  (None, 1152)        0           ['block6d_activation[0][0]']     N
 agePooling2D)
 block6d_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6d_se_squeeze[0][0]']     N
 block6d_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6d_se_reshape[0][0]']     N
 block6d_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6d_se_reduce[0][0]']      N
 block6d_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6d_activation[0][0]',     N
                                                                  'block6d_se_expand[0][0]']
 block6d_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6d_se_excite[0][0]']      N
 block6d_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6d_project_conv[0][0]']   N
 lization)
 block6d_drop (Dropout)         (None, 7, 7, 192)    0           ['block6d_project_bn[0][0]']     N
 block6d_add (Add)              (None, 7, 7, 192)    0           ['block6d_drop[0][0]',           N
                                                                  'block6c_add[0][0]']
 block7a_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6d_add[0][0]']            N
 block7a_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block7a_expand_conv[0][0]']    N
 ization)
 block7a_expand_activation (Act  (None, 7, 7, 1152)  0           ['block7a_expand_bn[0][0]']      N
 ivation)
 block7a_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  10368       ['block7a_expand_activation[0][  N
 D)                                                              0]']
 block7a_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block7a_dwconv[0][0]']         N
 )
 block7a_activation (Activation  (None, 7, 7, 1152)  0           ['block7a_bn[0][0]']             N
 )
 block7a_se_squeeze (GlobalAver  (None, 1152)        0           ['block7a_activation[0][0]']     N
 agePooling2D)
 block7a_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block7a_se_squeeze[0][0]']     N
 block7a_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block7a_se_reshape[0][0]']     N
 block7a_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block7a_se_reduce[0][0]']      N
 block7a_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block7a_activation[0][0]',     N
                                                                  'block7a_se_expand[0][0]']
 block7a_project_conv (Conv2D)  (None, 7, 7, 320)    368640      ['block7a_se_excite[0][0]']      N
 block7a_project_bn (BatchNorma  (None, 7, 7, 320)   1280        ['block7a_project_conv[0][0]']   N
 lization)
 top_conv (Conv2D)              (None, 7, 7, 1280)   409600      ['block7a_project_bn[0][0]']     N
 top_bn (BatchNormalization)    (None, 7, 7, 1280)   5120        ['top_conv[0][0]']               N
 top_activation (Activation)    (None, 7, 7, 1280)   0           ['top_bn[0][0]']                 N
 NEW_GAP2D (GlobalAveragePoolin  (None, 1280)        0           ['top_activation[0][0]']         Y
 g2D)
 NEW_BN (BatchNormalization)    (None, 1280)         5120        ['NEW_GAP2D[0][0]']              Y
 NEW_DO (Dropout)               (None, 1280)         0           ['NEW_BN[0][0]']                 Y
 NEW_D (Dense)                  (None, 1)            1281        ['NEW_DO[0][0]']                 Y
================================================================================================================
Total params: 4,055,972
Trainable params: 3,841
Non-trainable params: 4,052,131
________________________________________________________________________________________________________________
```

In [21]:

```python
# Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
callbacks = [EarlyStopping(monitor='val_f1_score',
                           mode='max',
                           patience=10),
             ModelCheckpoint(filepath='model4.h5',
                             monitor='val_f1_score',
                             mode='max',
                             save_best_only=True,
                             save_weights_only=True)]

# Train model
m4_h = m4.fit(X_train_0, y_train_0,
              epochs=epochs,
              batch_size=bs,
              callbacks=callbacks,
              validation_data=(X_valid_0, y_valid_0),
              verbose=0)
```

In [22]:

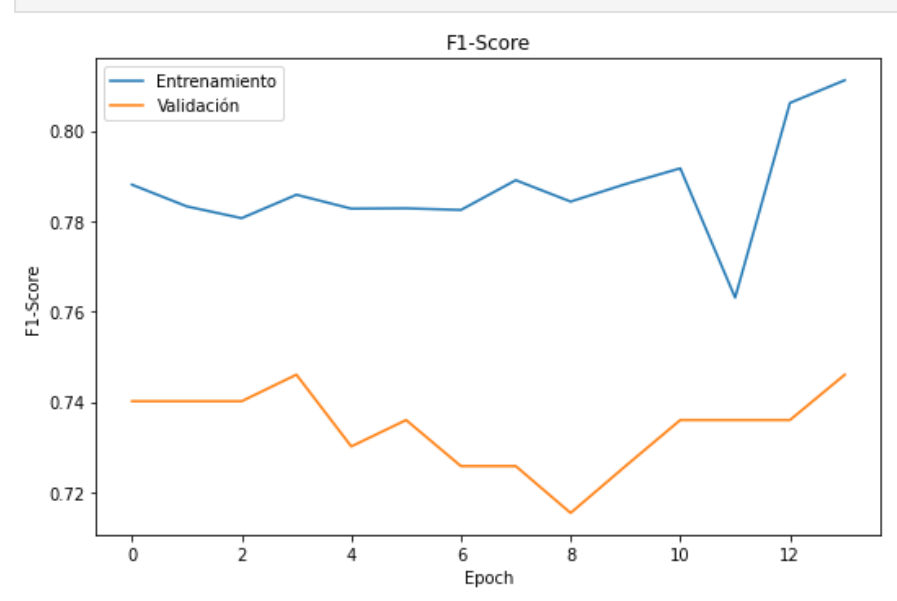
```python
# Plot F1-Score and Loss
plot_hist(m4_h)
```



In [23]:

```python
# Load best weights
m4.load_weights('model4.h5')

# Predict test data
y_pred_0 = m4.predict(X_test_0)

# Create binary prediction array with same threshold used earlier (.5)
y_pred_0 = np.asarray([0 if i < threshold else 1 for i in y_pred_0])

# Get and print F1-Score and confusion matrix
m4_f1 = get_f1_plot_cm(y_test_0, y_pred_0)
```

```
Con threshold = 0.5 , el F1-Score es 0.772
```



Modelo 5

In [24]:

```python
# Clone previous model
m5 = clone_model(m4)

# Load weights
m5.load_weights('model4.h5')

# Set name
m5._name = 'Xception_Model_5'

# Unfreeze
ls = m5.layers
for l in ls:
  if l.__class__.__name__ != 'BatchNormalization':
    l.trainable=True

# Set optimizer with a lower learning rate due to the need for precision in fine tuning
op = Adam(learning_rate=.00001)

# Compile model
m5.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
m5.summary(show_trainable=True)
```

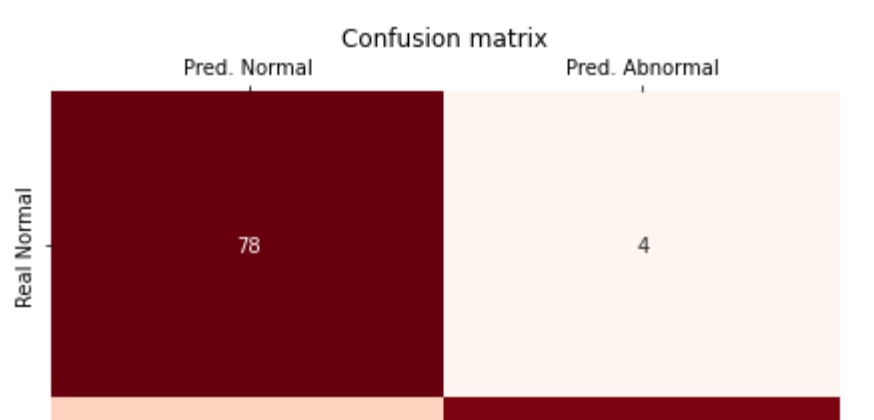
```
Model: "Xception_Model_5"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to                     Trainable
==================================================================================================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []                               Y
                                )]
 rescaling (Rescaling)          (None, 224, 224, 3)  0           ['input_1[0][0]']                Y
 normalization (Normalization)  (None, 224, 224, 3)  7           ['rescaling[0][0]']              Y
 stem_conv_pad (ZeroPadding2D)  (None, 225, 225, 3)  0           ['normalization[0][0]']          Y
 stem_conv (Conv2D)             (None, 112, 112, 32  864         ['stem_conv_pad[0][0]']          Y
                                )
 stem_bn (BatchNormalization)   (None, 112, 112, 32  128         ['stem_conv[0][0]']              N
                                )
 stem_activation (Activation)   (None, 112, 112, 32  0           ['stem_bn[0][0]']                Y
                                )
 block1a_dwconv (DepthwiseConv2  (None, 112, 112, 32  288        ['stem_activation[0][0]']        Y
 D)                             )
 block1a_bn (BatchNormalization  (None, 112, 112, 32  128        ['block1a_dwconv[0][0]']         N
 )                              )
 block1a_activation (Activation  (None, 112, 112, 32  0          ['block1a_bn[0][0]']             Y
 )                              )
 block1a_se_squeeze (GlobalAver  (None, 32)          0           ['block1a_activation[0][0]']     Y
 agePooling2D)
 block1a_se_reshape (Reshape)   (None, 1, 1, 32)     0           ['block1a_se_squeeze[0][0]']     Y
 block1a_se_reduce (Conv2D)     (None, 1, 1, 8)      264         ['block1a_se_reshape[0][0]']     Y
 block1a_se_expand (Conv2D)     (None, 1, 1, 32)     288         ['block1a_se_reduce[0][0]']      Y
 block1a_se_excite (Multiply)   (None, 112, 112, 32  0           ['block1a_activation[0][0]',     Y
                                )                                 'block1a_se_expand[0][0]']
 block1a_project_conv (Conv2D)  (None, 112, 112, 16  512         ['block1a_se_excite[0][0]']      Y
                                )
 block1a_project_bn (BatchNorma  (None, 112, 112, 16  64         ['block1a_project_conv[0][0]']   N
 lization)                      )
 block2a_expand_conv (Conv2D)   (None, 112, 112, 96  1536        ['block1a_project_bn[0][0]']     Y
                                )
 block2a_expand_bn (BatchNormal  (None, 112, 112, 96  384        ['block2a_expand_conv[0][0]']    N
 ization)                       )
 block2a_expand_activation (Act  (None, 112, 112, 96  0          ['block2a_expand_bn[0][0]']      Y
 ivation)                       )
 block2a_dwconv_pad (ZeroPaddin  (None, 113, 113, 96  0          ['block2a_expand_activation[0][  Y
 g2D)                           )                                0]']
 block2a_dwconv (DepthwiseConv2  (None, 56, 56, 96)  864         ['block2a_dwconv_pad[0][0]']     Y
 D)
 block2a_bn (BatchNormalization  (None, 56, 56, 96)  384         ['block2a_dwconv[0][0]']         N
 )
 block2a_activation (Activation  (None, 56, 56, 96)  0           ['block2a_bn[0][0]']             Y
 )
 block2a_se_squeeze (GlobalAver  (None, 96)          0           ['block2a_activation[0][0]']     Y
 agePooling2D)
 block2a_se_reshape (Reshape)   (None, 1, 1, 96)     0           ['block2a_se_squeeze[0][0]']     Y
 block2a_se_reduce (Conv2D)     (None, 1, 1, 4)      388         ['block2a_se_reshape[0][0]']     Y
 block2a_se_expand (Conv2D)     (None, 1, 1, 96)     480         ['block2a_se_reduce[0][0]']      Y
 block2a_se_excite (Multiply)   (None, 56, 56, 96)   0           ['block2a_activation[0][0]',     Y
                                                                  'block2a_se_expand[0][0]']
 block2a_project_conv (Conv2D)  (None, 56, 56, 24)   2304        ['block2a_se_excite[0][0]']      Y
 block2a_project_bn (BatchNorma  (None, 56, 56, 24)  96          ['block2a_project_conv[0][0]']   N
 lization)
 block2b_expand_conv (Conv2D)   (None, 56, 56, 144)  3456        ['block2a_project_bn[0][0]']     Y
 block2b_expand_bn (BatchNormal  (None, 56, 56, 144)  576        ['block2b_expand_conv[0][0]']    N
 ization)
 block2b_expand_activation (Act  (None, 56, 56, 144)  0          ['block2b_expand_bn[0][0]']      Y
 ivation)
 block2b_dwconv (DepthwiseConv2  (None, 56, 56, 144)  1296       ['block2b_expand_activation[0][  Y
 D)                                                              0]']
 block2b_bn (BatchNormalization  (None, 56, 56, 144)  576        ['block2b_dwconv[0][0]']         N
 )
 block2b_activation (Activation  (None, 56, 56, 144)  0          ['block2b_bn[0][0]']             Y
 )
 block2b_se_squeeze (GlobalAver  (None, 144)         0           ['block2b_activation[0][0]']     Y
 agePooling2D)
 block2b_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block2b_se_squeeze[0][0]']     Y
 block2b_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block2b_se_reshape[0][0]']     Y
 block2b_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block2b_se_reduce[0][0]']      Y
 block2b_se_excite (Multiply)   (None, 56, 56, 144)  0           ['block2b_activation[0][0]',     Y
                                                                  'block2b_se_expand[0][0]']
 block2b_project_conv (Conv2D)  (None, 56, 56, 24)   3456        ['block2b_se_excite[0][0]']      Y
 block2b_project_bn (BatchNorma  (None, 56, 56, 24)  96          ['block2b_project_conv[0][0]']   N
 lization)
 block2b_drop (Dropout)         (None, 56, 56, 24)   0           ['block2b_project_bn[0][0]']     Y
 block2b_add (Add)              (None, 56, 56, 24)   0           ['block2b_drop[0][0]',           Y
                                                                  'block2a_project_bn[0][0]']
 block3a_expand_conv (Conv2D)   (None, 56, 56, 144)  3456        ['block2b_add[0][0]']            Y
 block3a_expand_bn (BatchNormal  (None, 56, 56, 144)  576        ['block3a_expand_conv[0][0]']    N
 ization)
 block3a_expand_activation (Act  (None, 56, 56, 144)  0          ['block3a_expand_bn[0][0]']      Y
 ivation)
 block3a_dwconv_pad (ZeroPaddin  (None, 59, 59, 144)  0          ['block3a_expand_activation[0][  Y
 g2D)                                                            0]']
 block3a_dwconv (DepthwiseConv2  (None, 28, 28, 144)  3600       ['block3a_dwconv_pad[0][0]']     Y
 D)
 block3a_bn (BatchNormalization  (None, 28, 28, 144)  576        ['block3a_dwconv[0][0]']         N
 )
 block3a_activation (Activation  (None, 28, 28, 144)  0          ['block3a_bn[0][0]']             Y
 )
 block3a_se_squeeze (GlobalAver  (None, 144)         0           ['block3a_activation[0][0]']     Y
 agePooling2D)
 block3a_se_reshape (Reshape)   (None, 1, 1, 144)    0           ['block3a_se_squeeze[0][0]']     Y
 block3a_se_reduce (Conv2D)     (None, 1, 1, 6)      870         ['block3a_se_reshape[0][0]']     Y
 block3a_se_expand (Conv2D)     (None, 1, 1, 144)    1008        ['block3a_se_reduce[0][0]']      Y
 block3a_se_excite (Multiply)   (None, 28, 28, 144)  0           ['block3a_activation[0][0]',     Y
                                                                  'block3a_se_expand[0][0]']
 block3a_project_conv (Conv2D)  (None, 28, 28, 40)   5760        ['block3a_se_excite[0][0]']      Y
 block3a_project_bn (BatchNorma  (None, 28, 28, 40)  160         ['block3a_project_conv[0][0]']   N
 lization)
 block3b_expand_conv (Conv2D)   (None, 28, 28, 240)  9600        ['block3a_project_bn[0][0]']     Y
 block3b_expand_bn (BatchNormal  (None, 28, 28, 240)  960        ['block3b_expand_conv[0][0]']    N
 ization)
 block3b_expand_activation (Act  (None, 28, 28, 240)  0          ['block3b_expand_bn[0][0]']      Y
 ivation)
 block3b_dwconv (DepthwiseConv2  (None, 28, 28, 240)  6000       ['block3b_expand_activation[0][  Y
 D)                                                              0]']
 block3b_bn (BatchNormalization  (None, 28, 28, 240)  960        ['block3b_dwconv[0][0]']         N
 )
 block3b_activation (Activation  (None, 28, 28, 240)  0          ['block3b_bn[0][0]']             Y
 )
 block3b_se_squeeze (GlobalAver  (None, 240)         0           ['block3b_activation[0][0]']     Y
 agePooling2D)
 block3b_se_reshape (Reshape)   (None, 1, 1, 240)    0           ['block3b_se_squeeze[0][0]']     Y
 block3b_se_reduce (Conv2D)     (None, 1, 1, 10)     2410        ['block3b_se_reshape[0][0]']     Y
 block3b_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block3b_se_reduce[0][0]']      Y
 block3b_se_excite (Multiply)   (None, 28, 28, 240)  0           ['block3b_activation[0][0]',     Y
                                                                  'block3b_se_expand[0][0]']
 block3b_project_conv (Conv2D)  (None, 28, 28, 40)   9600        ['block3b_se_excite[0][0]']      Y
 block3b_project_bn (BatchNorma  (None, 28, 28, 40)  160         ['block3b_project_conv[0][0]']   N
 lization)
 block3b_drop (Dropout)         (None, 28, 28, 40)   0           ['block3b_project_bn[0][0]']     Y
 block3b_add (Add)              (None, 28, 28, 40)   0           ['block3b_drop[0][0]',           Y
                                                                  'block3a_project_bn[0][0]']
 block4a_expand_conv (Conv2D)   (None, 28, 28, 240)  9600        ['block3b_add[0][0]']            Y
 block4a_expand_bn (BatchNormal  (None, 28, 28, 240)  960        ['block4a_expand_conv[0][0]']    N
 ization)
 block4a_expand_activation (Act  (None, 28, 28, 240)  0          ['block4a_expand_bn[0][0]']      Y
 ivation)
 block4a_dwconv_pad (ZeroPaddin  (None, 29, 29, 240)  0          ['block4a_expand_activation[0][  Y
 g2D)                                                            0]']
 block4a_dwconv (DepthwiseConv2  (None, 14, 14, 240)  2160       ['block4a_dwconv_pad[0][0]']     Y
 D)
 block4a_bn (BatchNormalization  (None, 14, 14, 240)  960        ['block4a_dwconv[0][0]']         N
 )
 block4a_activation (Activation  (None, 14, 14, 240)  0          ['block4a_bn[0][0]']             Y
 )
 block4a_se_squeeze (GlobalAver  (None, 240)         0           ['block4a_activation[0][0]']     Y
 agePooling2D)
 block4a_se_reshape (Reshape)   (None, 1, 1, 240)    0           ['block4a_se_squeeze[0][0]']     Y
 block4a_se_reduce (Conv2D)     (None, 1, 1, 10)     2410        ['block4a_se_reshape[0][0]']     Y
 block4a_se_expand (Conv2D)     (None, 1, 1, 240)    2640        ['block4a_se_reduce[0][0]']      Y
 block4a_se_excite (Multiply)   (None, 14, 14, 240)  0           ['block4a_activation[0][0]',     Y
                                                                  'block4a_se_expand[0][0]']
 block4a_project_conv (Conv2D)  (None, 14, 14, 80)   19200       ['block4a_se_excite[0][0]']      Y
 block4a_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4a_project_conv[0][0]']   N
 lization)
 block4b_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4a_project_bn[0][0]']     Y
 block4b_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block4b_expand_conv[0][0]']    N
 ization)
 block4b_expand_activation (Act  (None, 14, 14, 480)  0          ['block4b_expand_bn[0][0]']      Y
 ivation)
 block4b_dwconv (DepthwiseConv2  (None, 14, 14, 480)  4320       ['block4b_expand_activation[0][  Y
 D)                                                              0]']
 block4b_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block4b_dwconv[0][0]']         N
 )
 block4b_activation (Activation  (None, 14, 14, 480)  0          ['block4b_bn[0][0]']             Y
 )
 block4b_se_squeeze (GlobalAver  (None, 480)         0           ['block4b_activation[0][0]']     Y
 agePooling2D)
 block4b_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4b_se_squeeze[0][0]']     Y
 block4b_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4b_se_reshape[0][0]']     Y
 block4b_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4b_se_reduce[0][0]']      Y
 block4b_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block4b_activation[0][0]',     Y
                                                                  'block4b_se_expand[0][0]']
 block4b_project_conv (Conv2D)  (None, 14, 14, 80)   38400       ['block4b_se_excite[0][0]']      Y
 block4b_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4b_project_conv[0][0]']   N
 lization)
 block4b_drop (Dropout)         (None, 14, 14, 80)   0           ['block4b_project_bn[0][0]']     Y
 block4b_add (Add)              (None, 14, 14, 80)   0           ['block4b_drop[0][0]',           Y
                                                                  'block4a_project_bn[0][0]']
 block4c_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4b_add[0][0]']            Y
 block4c_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block4c_expand_conv[0][0]']    N
 ization)
 block4c_expand_activation (Act  (None, 14, 14, 480)  0          ['block4c_expand_bn[0][0]']      Y
 ivation)
 block4c_dwconv (DepthwiseConv2  (None, 14, 14, 480)  4320       ['block4c_expand_activation[0][  Y
 D)                                                              0]']
 block4c_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block4c_dwconv[0][0]']         N
 )
 block4c_activation (Activation  (None, 14, 14, 480)  0          ['block4c_bn[0][0]']             Y
 )
 block4c_se_squeeze (GlobalAver  (None, 480)         0           ['block4c_activation[0][0]']     Y
 agePooling2D)
 block4c_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block4c_se_squeeze[0][0]']     Y
 block4c_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block4c_se_reshape[0][0]']     Y
 block4c_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block4c_se_reduce[0][0]']      Y
 block4c_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block4c_activation[0][0]',     Y
                                                                  'block4c_se_expand[0][0]']
 block4c_project_conv (Conv2D)  (None, 14, 14, 80)   38400       ['block4c_se_excite[0][0]']      Y
 block4c_project_bn (BatchNorma  (None, 14, 14, 80)  320         ['block4c_project_conv[0][0]']   N
 lization)
 block4c_drop (Dropout)         (None, 14, 14, 80)   0           ['block4c_project_bn[0][0]']     Y
 block4c_add (Add)              (None, 14, 14, 80)   0           ['block4c_drop[0][0]',           Y
                                                                  'block4b_add[0][0]']
 block5a_expand_conv (Conv2D)   (None, 14, 14, 480)  38400       ['block4c_add[0][0]']            Y
 block5a_expand_bn (BatchNormal  (None, 14, 14, 480)  1920       ['block5a_expand_conv[0][0]']    N
 ization)
 block5a_expand_activation (Act  (None, 14, 14, 480)  0          ['block5a_expand_bn[0][0]']      Y
 ivation)
 block5a_dwconv (DepthwiseConv2  (None, 14, 14, 480)  12000      ['block5a_expand_activation[0][  Y
 D)                                                              0]']
 block5a_bn (BatchNormalization  (None, 14, 14, 480)  1920       ['block5a_dwconv[0][0]']         N
 )
 block5a_activation (Activation  (None, 14, 14, 480)  0          ['block5a_bn[0][0]']             Y
 )
 block5a_se_squeeze (GlobalAver  (None, 480)         0           ['block5a_activation[0][0]']     Y
 agePooling2D)
 block5a_se_reshape (Reshape)   (None, 1, 1, 480)    0           ['block5a_se_squeeze[0][0]']     Y
 block5a_se_reduce (Conv2D)     (None, 1, 1, 20)     9620        ['block5a_se_reshape[0][0]']     Y
 block5a_se_expand (Conv2D)     (None, 1, 1, 480)    10080       ['block5a_se_reduce[0][0]']      Y
 block5a_se_excite (Multiply)   (None, 14, 14, 480)  0           ['block5a_activation[0][0]',     Y
                                                                  'block5a_se_expand[0][0]']
 block5a_project_conv (Conv2D)  (None, 14, 14, 112)  53760       ['block5a_se_excite[0][0]']      Y
 block5a_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5a_project_conv[0][0]']   N
 lization)
 block5b_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5a_project_bn[0][0]']     Y
 block5b_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block5b_expand_conv[0][0]']    N
 ization)
 block5b_expand_activation (Act  (None, 14, 14, 672)  0          ['block5b_expand_bn[0][0]']      Y
 ivation)
 block5b_dwconv (DepthwiseConv2  (None, 14, 14, 672)  16800      ['block5b_expand_activation[0][  Y
 D)                                                              0]']
 block5b_bn (BatchNormalization  (None, 14, 14, 672)  2688       ['block5b_dwconv[0][0]']         N
 )
 block5b_activation (Activation  (None, 14, 14, 672)  0          ['block5b_bn[0][0]']             Y
 )
 block5b_se_squeeze (GlobalAver  (None, 672)         0           ['block5b_activation[0][0]']     Y
 agePooling2D)
 block5b_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5b_se_squeeze[0][0]']     Y
 block5b_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5b_se_reshape[0][0]']     Y
 block5b_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5b_se_reduce[0][0]']      Y
 block5b_se_excite (Multiply)   (None, 14, 14, 672)  0           ['block5b_activation[0][0]',     Y
                                                                  'block5b_se_expand[0][0]']
 block5b_project_conv (Conv2D)  (None, 14, 14, 112)  75264       ['block5b_se_excite[0][0]']      Y
 block5b_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5b_project_conv[0][0]']   N
 lization)
 block5b_drop (Dropout)         (None, 14, 14, 112)  0           ['block5b_project_bn[0][0]']     Y
 block5b_add (Add)              (None, 14, 14, 112)  0           ['block5b_drop[0][0]',           Y
                                                                  'block5a_project_bn[0][0]']
 block5c_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5b_add[0][0]']            Y
 block5c_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block5c_expand_conv[0][0]']    N
 ization)
 block5c_expand_activation (Act  (None, 14, 14, 672)  0          ['block5c_expand_bn[0][0]']      Y
 ivation)
 block5c_dwconv (DepthwiseConv2  (None, 14, 14, 672)  16800      ['block5c_expand_activation[0][  Y
 D)                                                              0]']
 block5c_bn (BatchNormalization  (None, 14, 14, 672)  2688       ['block5c_dwconv[0][0]']         N
 )
 block5c_activation (Activation  (None, 14, 14, 672)  0          ['block5c_bn[0][0]']             Y
 )
 block5c_se_squeeze (GlobalAver  (None, 672)         0           ['block5c_activation[0][0]']     Y
 agePooling2D)
 block5c_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block5c_se_squeeze[0][0]']     Y
 block5c_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block5c_se_reshape[0][0]']     Y
 block5c_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block5c_se_reduce[0][0]']      Y
 block5c_se_excite (Multiply)   (None, 14, 14, 672)  0           ['block5c_activation[0][0]',     Y
                                                                  'block5c_se_expand[0][0]']
 block5c_project_conv (Conv2D)  (None, 14, 14, 112)  75264       ['block5c_se_excite[0][0]']      Y
 block5c_project_bn (BatchNorma  (None, 14, 14, 112)  448        ['block5c_project_conv[0][0]']   N
 lization)
 block5c_drop (Dropout)         (None, 14, 14, 112)  0           ['block5c_project_bn[0][0]']     Y
 block5c_add (Add)              (None, 14, 14, 112)  0           ['block5c_drop[0][0]',           Y
                                                                  'block5b_add[0][0]']
 block6a_expand_conv (Conv2D)   (None, 14, 14, 672)  75264       ['block5c_add[0][0]']            Y
 block6a_expand_bn (BatchNormal  (None, 14, 14, 672)  2688       ['block6a_expand_conv[0][0]']    N
 ization)
 block6a_expand_activation (Act  (None, 14, 14, 672)  0          ['block6a_expand_bn[0][0]']      Y
 ivation)
 block6a_dwconv_pad (ZeroPaddin  (None, 17, 17, 672)  0          ['block6a_expand_activation[0][  Y
 g2D)                                                            0]']
 block6a_dwconv (DepthwiseConv2  (None, 7, 7, 672)   16800       ['block6a_dwconv_pad[0][0]']     Y
 D)
 block6a_bn (BatchNormalization  (None, 7, 7, 672)   2688        ['block6a_dwconv[0][0]']         N
 )
 block6a_activation (Activation  (None, 7, 7, 672)   0           ['block6a_bn[0][0]']             Y
 )
 block6a_se_squeeze (GlobalAver  (None, 672)         0           ['block6a_activation[0][0]']     Y
 agePooling2D)
 block6a_se_reshape (Reshape)   (None, 1, 1, 672)    0           ['block6a_se_squeeze[0][0]']     Y
 block6a_se_reduce (Conv2D)     (None, 1, 1, 28)     18844       ['block6a_se_reshape[0][0]']     Y
 block6a_se_expand (Conv2D)     (None, 1, 1, 672)    19488       ['block6a_se_reduce[0][0]']      Y
 block6a_se_excite (Multiply)   (None, 7, 7, 672)    0           ['block6a_activation[0][0]',     Y
                                                                  'block6a_se_expand[0][0]']
 block6a_project_conv (Conv2D)  (None, 7, 7, 192)    129024      ['block6a_se_excite[0][0]']      Y
 block6a_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6a_project_conv[0][0]']   N
 lization)
 block6b_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6a_project_bn[0][0]']     Y
 block6b_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6b_expand_conv[0][0]']    N
 ization)
 block6b_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6b_expand_bn[0][0]']      Y
 ivation)
 block6b_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6b_expand_activation[0][  Y
 D)                                                              0]']
 block6b_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6b_dwconv[0][0]']         N
 )
 block6b_activation (Activation  (None, 7, 7, 1152)  0           ['block6b_bn[0][0]']             Y
 )
 block6b_se_squeeze (GlobalAver  (None, 1152)        0           ['block6b_activation[0][0]']     Y
 agePooling2D)
 block6b_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6b_se_squeeze[0][0]']     Y
 block6b_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6b_se_reshape[0][0]']     Y
 block6b_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6b_se_reduce[0][0]']      Y
 block6b_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6b_activation[0][0]',     Y
                                                                  'block6b_se_expand[0][0]']
 block6b_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6b_se_excite[0][0]']      Y
 block6b_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6b_project_conv[0][0]']   N
 lization)
 block6b_drop (Dropout)         (None, 7, 7, 192)    0           ['block6b_project_bn[0][0]']     Y
 block6b_add (Add)              (None, 7, 7, 192)    0           ['block6b_drop[0][0]',           Y
                                                                  'block6a_project_bn[0][0]']
 block6c_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6b_add[0][0]']            Y
 block6c_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6c_expand_conv[0][0]']    N
 ization)
 block6c_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6c_expand_bn[0][0]']      Y
 ivation)
 block6c_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6c_expand_activation[0][  Y
 D)                                                              0]']
 block6c_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6c_dwconv[0][0]']         N
 )
 block6c_activation (Activation  (None, 7, 7, 1152)  0           ['block6c_bn[0][0]']             Y
 )
 block6c_se_squeeze (GlobalAver  (None, 1152)        0           ['block6c_activation[0][0]']     Y
 agePooling2D)
 block6c_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6c_se_squeeze[0][0]']     Y
 block6c_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6c_se_reshape[0][0]']     Y
 block6c_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6c_se_reduce[0][0]']      Y
 block6c_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6c_activation[0][0]',     Y
                                                                  'block6c_se_expand[0][0]']
 block6c_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6c_se_excite[0][0]']      Y
 block6c_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6c_project_conv[0][0]']   N
 lization)
 block6c_drop (Dropout)         (None, 7, 7, 192)    0           ['block6c_project_bn[0][0]']     Y
 block6c_add (Add)              (None, 7, 7, 192)    0           ['block6c_drop[0][0]',           Y
                                                                  'block6b_add[0][0]']
 block6d_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6c_add[0][0]']            Y
 block6d_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block6d_expand_conv[0][0]']    N
 ization)
 block6d_expand_activation (Act  (None, 7, 7, 1152)  0           ['block6d_expand_bn[0][0]']      Y
 ivation)
 block6d_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  28800       ['block6d_expand_activation[0][  Y
 D)                                                              0]']
 block6d_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block6d_dwconv[0][0]']         N
 )
 block6d_activation (Activation  (None, 7, 7, 1152)  0           ['block6d_bn[0][0]']             Y
 )
 block6d_se_squeeze (GlobalAver  (None, 1152)        0           ['block6d_activation[0][0]']     Y
 agePooling2D)
 block6d_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block6d_se_squeeze[0][0]']     Y
 block6d_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block6d_se_reshape[0][0]']     Y
 block6d_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block6d_se_reduce[0][0]']      Y
 block6d_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block6d_activation[0][0]',     Y
                                                                  'block6d_se_expand[0][0]']
 block6d_project_conv (Conv2D)  (None, 7, 7, 192)    221184      ['block6d_se_excite[0][0]']      Y
 block6d_project_bn (BatchNorma  (None, 7, 7, 192)   768         ['block6d_project_conv[0][0]']   N
 lization)
 block6d_drop (Dropout)         (None, 7, 7, 192)    0           ['block6d_project_bn[0][0]']     Y
 block6d_add (Add)              (None, 7, 7, 192)    0           ['block6d_drop[0][0]',           Y
                                                                  'block6c_add[0][0]']
 block7a_expand_conv (Conv2D)   (None, 7, 7, 1152)   221184      ['block6d_add[0][0]']            Y
 block7a_expand_bn (BatchNormal  (None, 7, 7, 1152)  4608        ['block7a_expand_conv[0][0]']    N
 ization)
 block7a_expand_activation (Act  (None, 7, 7, 1152)  0           ['block7a_expand_bn[0][0]']      Y
 ivation)
 block7a_dwconv (DepthwiseConv2  (None, 7, 7, 1152)  10368       ['block7a_expand_activation[0][  Y
 D)                                                              0]']
 block7a_bn (BatchNormalization  (None, 7, 7, 1152)  4608        ['block7a_dwconv[0][0]']         N
 )
 block7a_activation (Activation  (None, 7, 7, 1152)  0           ['block7a_bn[0][0]']             Y
 )
 block7a_se_squeeze (GlobalAver  (None, 1152)        0           ['block7a_activation[0][0]']     Y
 agePooling2D)
 block7a_se_reshape (Reshape)   (None, 1, 1, 1152)   0           ['block7a_se_squeeze[0][0]']     Y
 block7a_se_reduce (Conv2D)     (None, 1, 1, 48)     55344       ['block7a_se_reshape[0][0]']     Y
 block7a_se_expand (Conv2D)     (None, 1, 1, 1152)   56448       ['block7a_se_reduce[0][0]']      Y
 block7a_se_excite (Multiply)   (None, 7, 7, 1152)   0           ['block7a_activation[0][0]',     Y
                                                                  'block7a_se_expand[0][0]']
 block7a_project_conv (Conv2D)  (None, 7, 7, 320)    368640      ['block7a_se_excite[0][0]']      Y
 block7a_project_bn (BatchNorma  (None, 7, 7, 320)   1280        ['block7a_project_conv[0][0]']   N
 lization)
 top_conv (Conv2D)              (None, 7, 7, 1280)   409600      ['block7a_project_bn[0][0]']     Y
 top_bn (BatchNormalization)    (None, 7, 7, 1280)   5120        ['top_conv[0][0]']               N
 top_activation (Activation)    (None, 7, 7, 1280)   0           ['top_bn[0][0]']                 Y
 NEW_GAP2D (GlobalAveragePoolin  (None, 1280)        0           ['top_activation[0][0]']         Y
 g2D)
 NEW_BN (BatchNormalization)    (None, 1280)         5120        ['NEW_GAP2D[0][0]']              Y
 NEW_DO (Dropout)               (None, 1280)         0           ['NEW_BN[0][0]']                 Y
 NEW_D (Dense)                  (None, 1)            1281        ['NEW_DO[0][0]']                 Y
==================================================================================================
Total params: 4,055,972
Trainable params: 3,969,373
Non-trainable params: 86,599
__________________________________________________________________________________________________
```

In [25]:

```python
# Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
callbacks = [EarlyStopping(monitor='val_f1_score',
                           mode='max',
                           patience=10),
             ModelCheckpoint(filepath='model5.h5',
                             monitor='val_f1_score',
                             mode='max',
                             save_best_only=True,
                             save_weights_only=True)]

# Train model
m5_h = m5.fit(X_train_0, y_train_0,
              epochs=epochs,
              batch_size=bs,
              callbacks=callbacks,
              validation_data=(X_valid_0, y_valid_0),
              verbose=0)
```

In [26]:

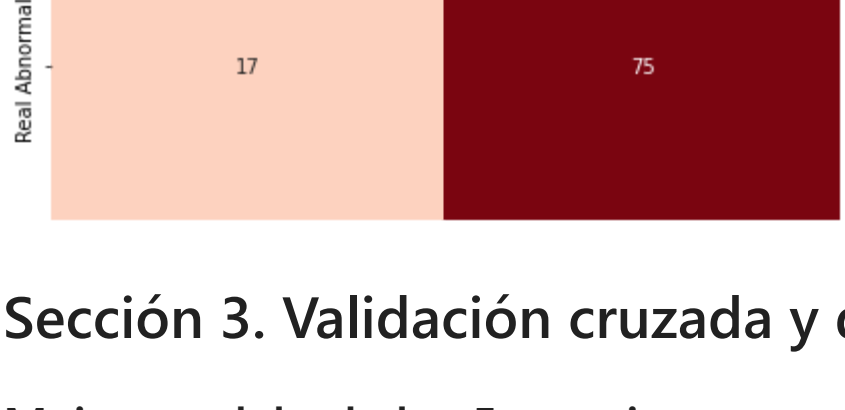
```python
# Plot F1-Score and Loss
plot_hist(m5_h)
```



In [27]:

```python
# Load best weights
m5.load_weights('model5.h5')

# Predict test data
y_pred_0 = m5.predict(X_test_0)

# Create binary prediction array with same threshold used earlier (.5)
y_pred_0 = np.asarray([0 if i < threshold else 1 for i in y_pred_0])

# Get and print F1-Score and confusion matrix
m5_f1 = get_f1_plot_cm(y_test_0, y_pred_0)
```

```
Con threshold = 0.5 , el F1-Score es 0.877
```



Sección 3. Validación cruzada y discusión

Mejor modelo de los 5 anteriores

In [28]:

```python
# Print F1-Scores
print('F1-SCORES')
m_f1 = [m1_f1, m2_f1, m3_f1, m4_f1, m5_f1]
for i,j in enumerate(m_f1):
  print('Modelo', i+1, '->', round(j,3))

# Get best model
best = m_f1.index([max(m_f1)])+1
print('\nEl mejor modelo es el Modelo', best)
models = [m1, m2, m3, m4, m5]
bm = clone_model(models[best-1])

# Load weights and compile
bm.load_weights('model'+str(best)+'.h5')
bm.compile(optimizer=op, loss='binary_crossentropy', metrics=[f1])
```

```
F1-SCORES
Modelo 1 -> 0.767
Modelo 2 -> 0.882
Modelo 3 -> 0.903
Modelo 4 -> 0.772
Modelo 5 -> 0.877

El mejor modelo es el Modelo 3
```

Cross-Validation

In [29]:

```python
n_folds = 10
X_train = []
y_train = []
X_test = []
y_test = []
X_valid = []
y_valid = []

# Load data
for i in range(n_folds):
  print('Fold' + str(i) + '...', end=' ')
  X_train_tmp, y_train_tmp, X_test_tmp, y_test_tmp, X_valid_tmp, y_valid_tmp = LoadImages('Fold'+str(i))
  X_train.append(X_train_tmp)
  y_train.append(y_train_tmp)
  X_test.append(X_test_tmp)
  y_test.append(y_test_tmp)
  X_valid.append(X_valid_tmp)
  y_valid.append(y_valid_tmp)
  print('loaded.')
```

```
Fold0... loaded.
Fold1... loaded.
Fold2... loaded.
Fold3... loaded.
Fold4... loaded.
Fold5... loaded.
Fold6... loaded.
Fold7... loaded.
Fold8... loaded.
Fold9... loaded.
```

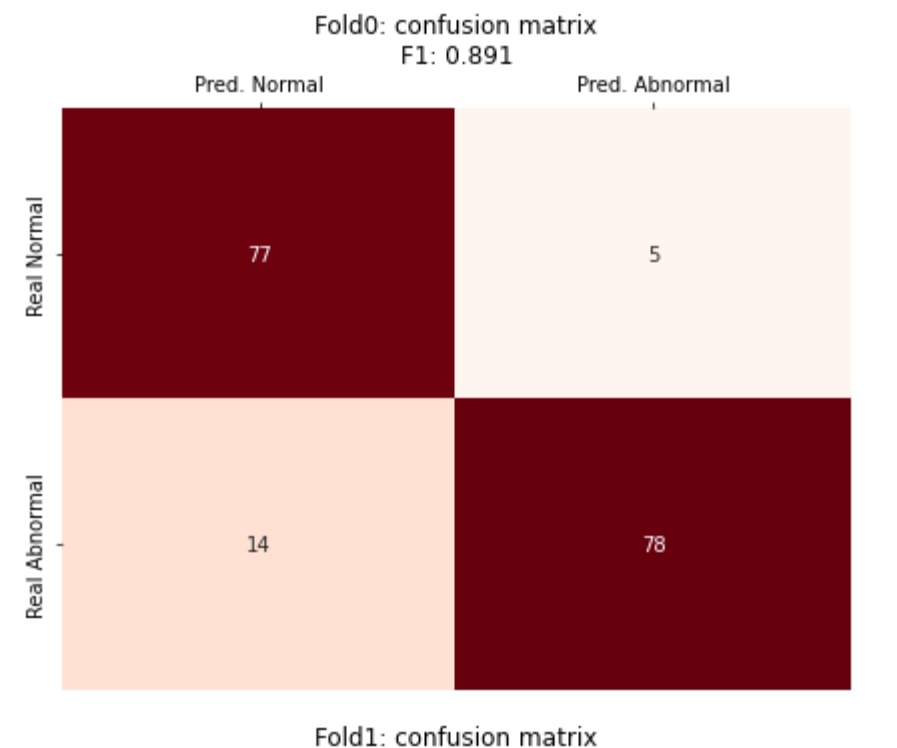
In [30]:

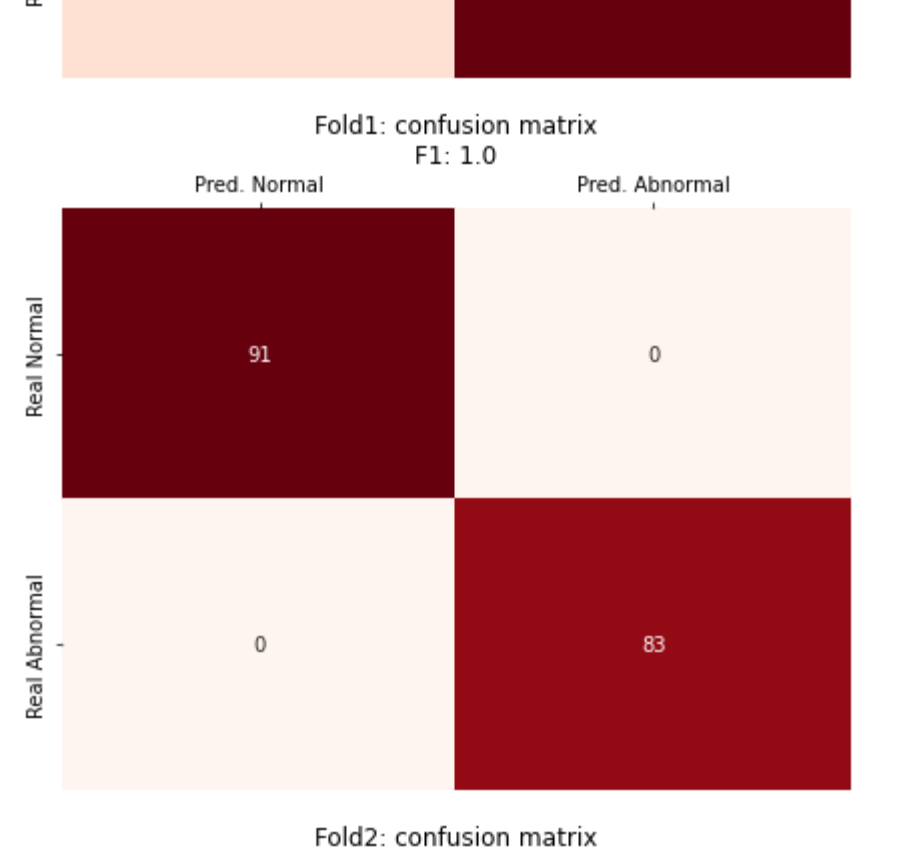
```python
bm_h = []     # List for models' history
y_pred = []   # List for models' predictions
bm_f1 = []    # List for models' F1-Score

for i in range(n_folds):
  print('FOLD'+str(i)+':\tTraining...', end=' ')
  # Set callbacks to save only the best model (based on F1-Score on validation data) whithin the training
  callbacks = [EarlyStopping(monitor='val_f1_score',
                             mode='max',
                             patience=10),
               ModelCheckpoint(filepath='bestmodel'+str(i)+'.h5',
                               monitor='val_f1_score',
                               mode='max',
                               save_best_only=True,
                               save_weights_only=True)]

  # Train model
  bm_h = bm.fit(X_train[i], y_train[i],
                epochs=epochs,
                batch_size=bs,
                callbacks=callbacks,
                validation_data=(X_valid[i], y_valid[i]),
                verbose=0)
  print('done.\n\tPredicting...', end=' ')

  # Predict
  y_pred.append(bm.predict(X_test[i]))
  # Create binary prediction array with same threshold used earlier (.5)
  y_pred[i] = np.asarray([0 if j < threshold else 1 for j in y_pred[i]])
  print('done.\n\tCalculating F1...', end=' ')

  # Get F1-Score
  bm_f1.append(f1_score(y_test[i], y_pred[i]))
  print('done.\n')

  # Return to initial weights
  bm.load_weights('model'+str(best)+'.h5')
```

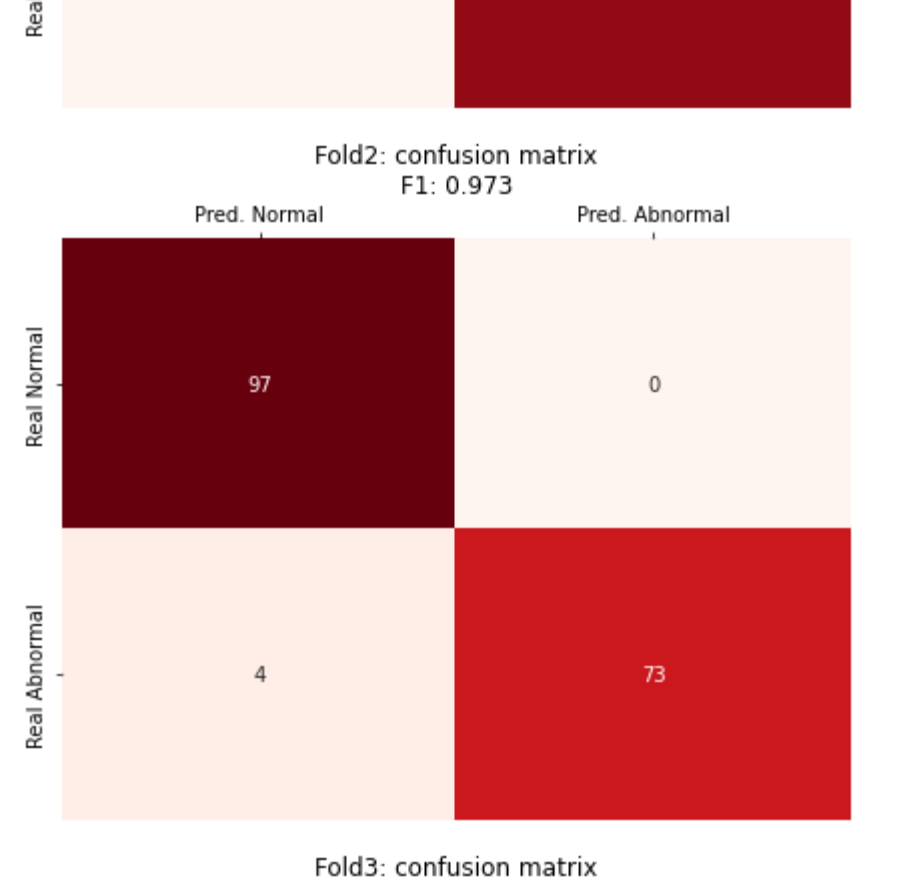
```
FOLD0:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD1:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD2:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD3:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD4:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD5:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD6:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD7:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD8:	Training... done.
	Predicting... done.
	Calculating F1... done.

FOLD9:	Training... done.
	Predicting... done.
	Calculating F1... done.
```

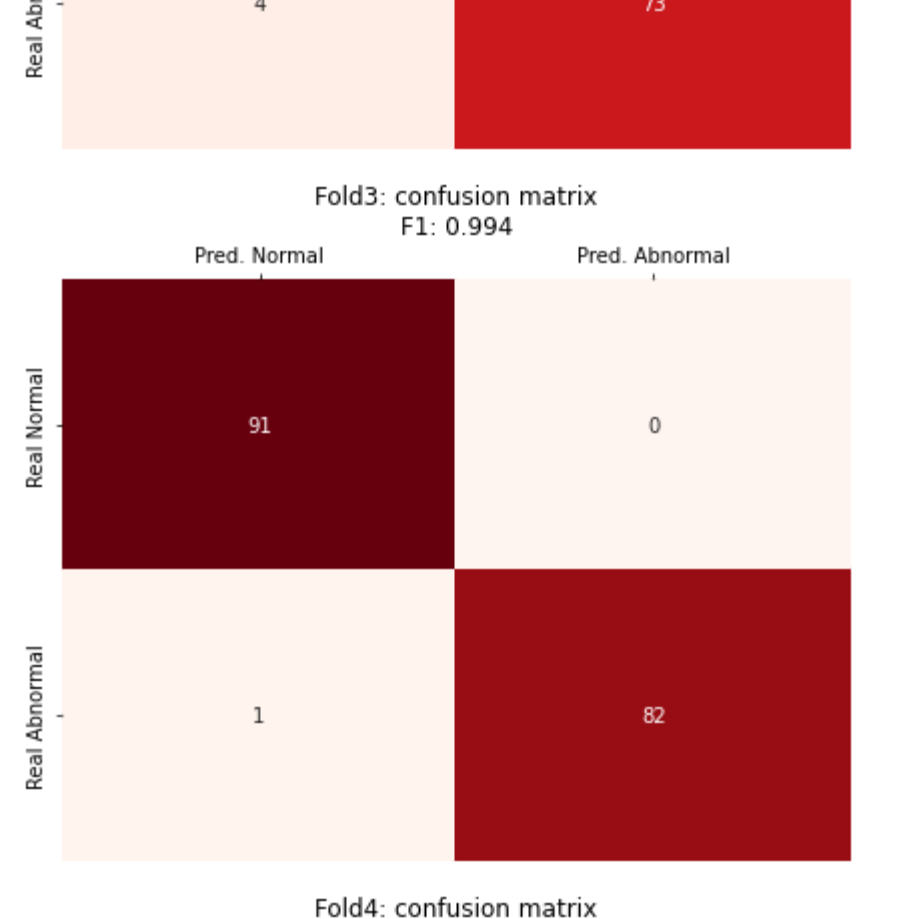
In [31]:

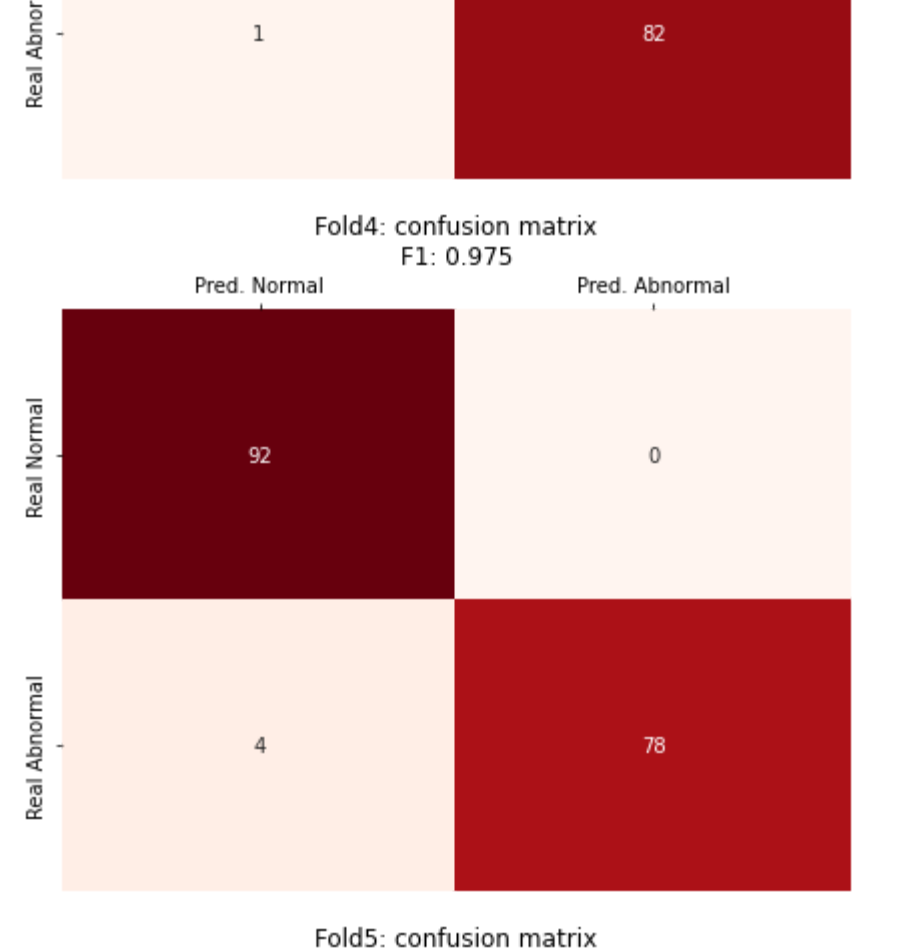
```python
for i in range(len(y_pred)):
  get_f1_plot_cm(y_test[i], y_pred[i], get_f1=False, plot_title='Fold'+str(i)+': confusion matrix\nF1: '+str(r
```

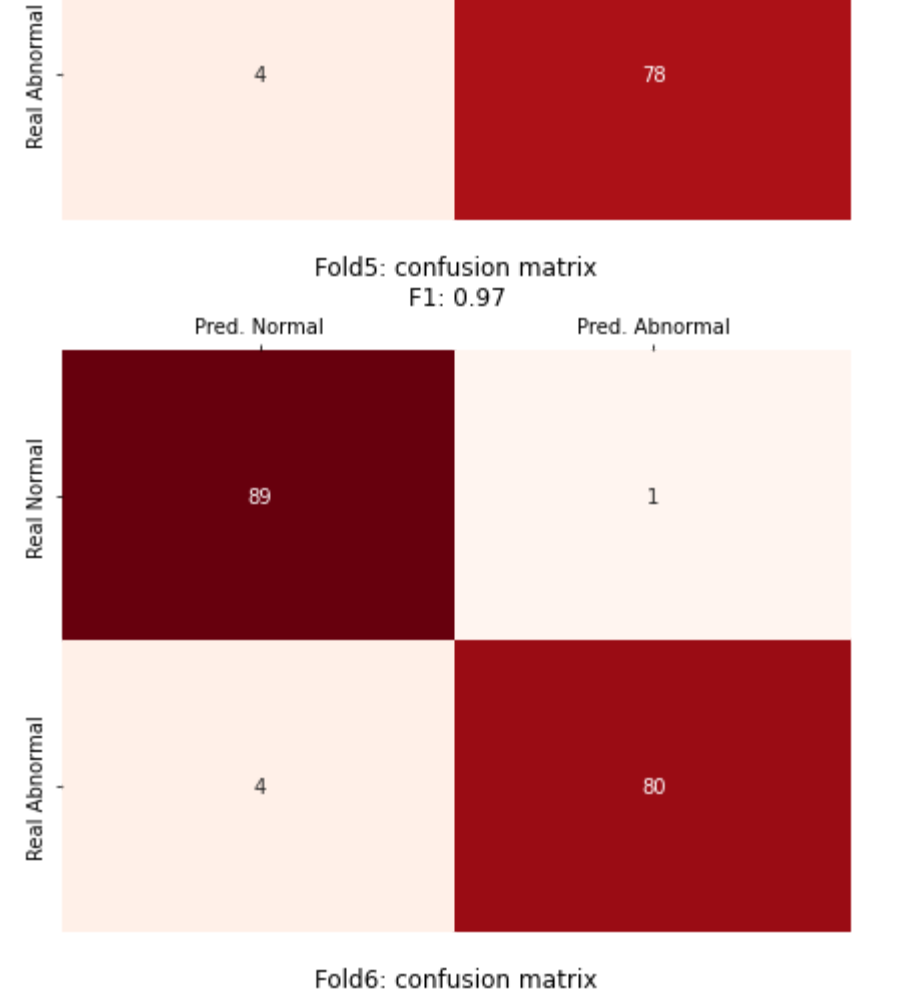


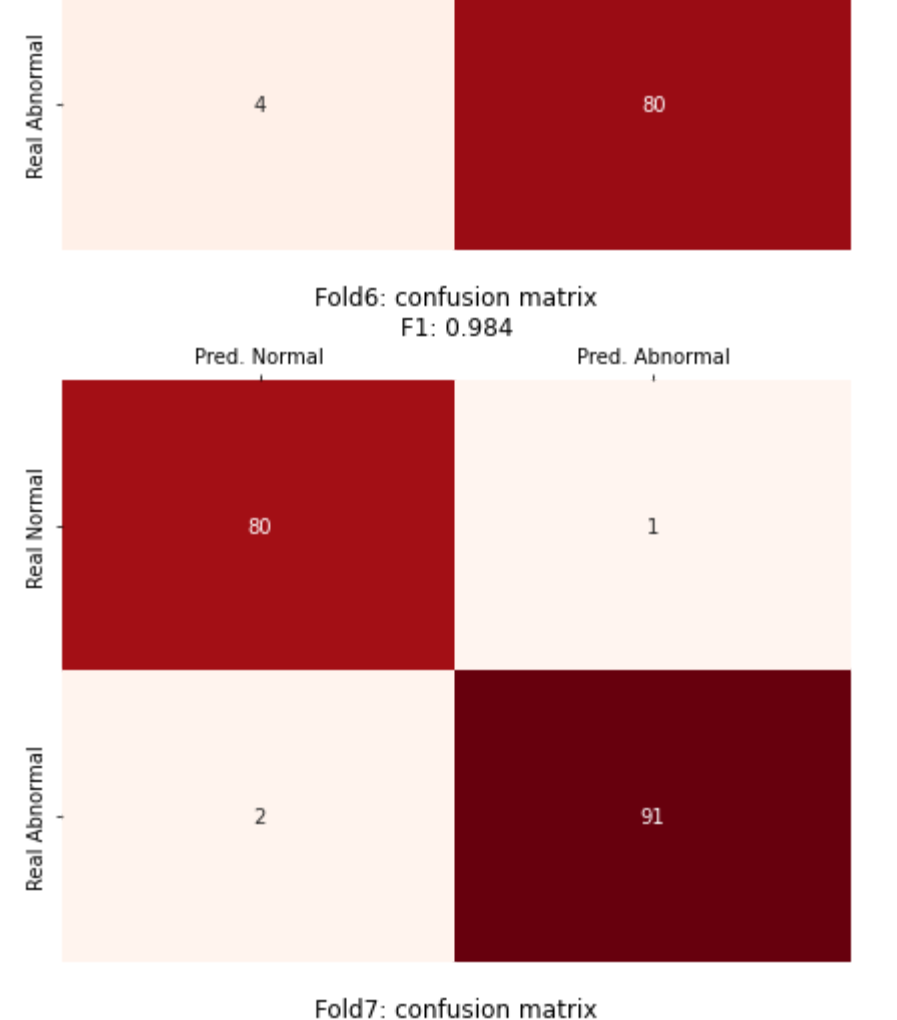


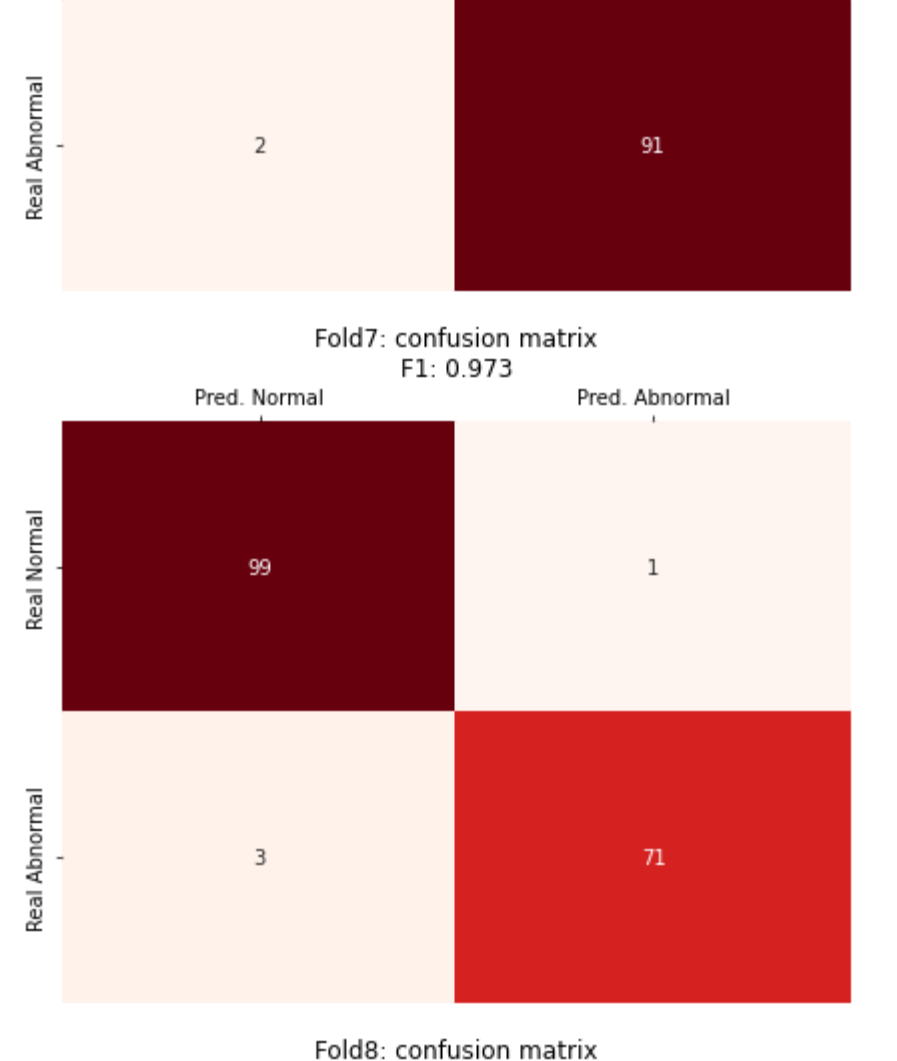


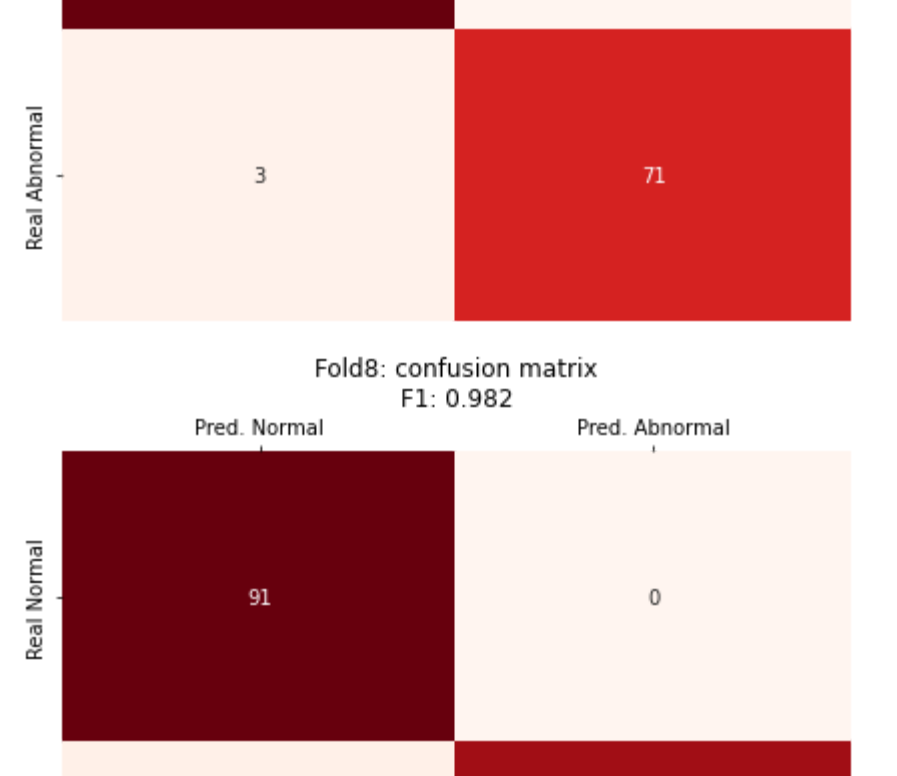


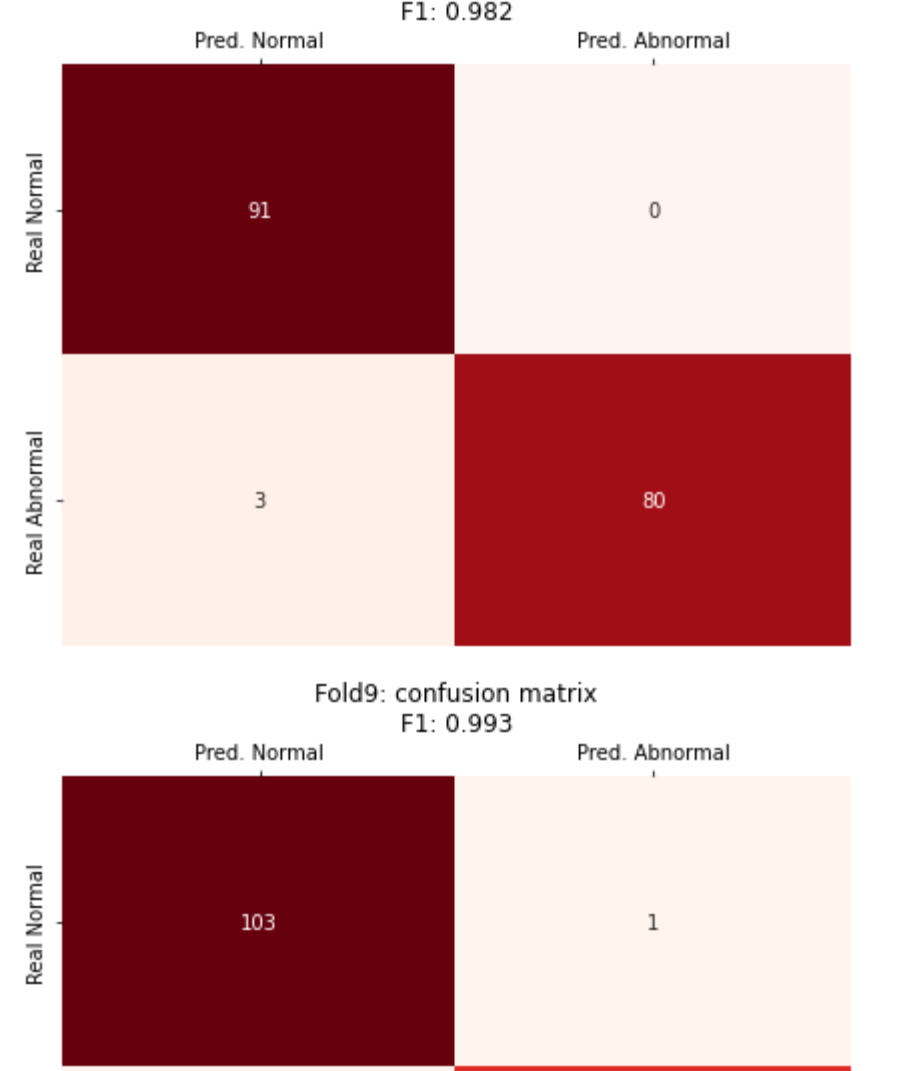












In [32]:

```
print('F1-SCORES')
for i in range(len(bm_f1)):
  print('Fold'+str(i)+' -> '+str(round(bm_f1[i],4)))

print('\nValor medio ->', round(np.average(bm_f1),4))
print('Desviación estándar ->', round(np.std(bm_f1),4))
```

```
F1-SCORES
Fold0 -> 0.8914
Fold1 -> 1.0
Fold2 -> 0.9733
Fold3 -> 0.9939
Fold4 -> 0.975
Fold5 -> 0.9697
Fold6 -> 0.9838
Fold7 -> 0.9726
Fold8 -> 0.9816
Fold9 -> 0.9929

Valor medio -> 0.9734
Desviación estándar -> 0.029
```

Minimizar falsos negativos

In [33]:

```
# Get False Negatives given actual values and predictions
def get_fn(y_t, y_p):
  '''
  Returns False Negatives given two arrays: real values and predicted values
  '''
  cm = confusion_matrix(y_t, y_p)
  return cm[1][0]

# To minimize False Negatives, we can play with the threshold to adjust the predictions
def set_threshold_minimize_fn(y_test, y_pred, thresholds=[.35, .375, .4, .425, .45, .475, .5, .525, .55, .575,
  '''
  Model output are float numbers from 0 to 1. This function sets the optimal threshold
  to decide positive and negative results minimizing the later. Thresholds can be set
  '''
  fn = []
  for i in thresholds:
    y_p = np.asarray([0 if j < i else 1 for j in y_pred])
    fn.append(get_fn(y_test, y_p))
  t = thresholds[fn.index(min(fn))]
  return t
```

In [34]:

```
def print_fn(model, X_true, y_true, threshold):
  '''
  Prints threshold, FN and F1-Score given a model, X_true values, y_true values
  and threshold
  '''
  y_pred = model.predict(X_true)
  y_p = np.asarray([0 if j < threshold else 1 for j in y_pred])
  f1 = f1_score(y_true, y_p)
  print('Threshold ->', threshold,
        '\nFalsos Negativos ->', get_fn(y_true, y_p),
        '\nF1-Score ->', f1)

# Set example model to use
model_number = 5

# Using default threshold (.5)
print('Antes de minimizar falsos negativos:')
bm.load_weights('bestmodel'+str(model_number)+'.h5')
t = .5
print_fn(bm, X_test[model_number], y_test[model_number], t)

# Uisng optimized threshold
print('\nDespués de minimizar falsos negativos:')
y_p = bm.predict(X_test[model_number])
t = set_threshold_minimize_fn(y_test[model_number], y_p)
print_fn(bm, X_test[model_number], y_test[model_number], t)
```

```
Antes de minimizar falsos negativos:
Threshold -> 0.5
Falsos Negativos -> 4
F1-Score -> 0.9696969696969696

Después de minimizar falsos negativos:
Threshold -> 0.35
Falsos Negativos -> 3
F1-Score -> 0.9759036144578312
```